

WESTERN BIRDS



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Western Specialty:

Mountain Bluebird



Photo by © Peter LaTourrette of Los Altos, California:

Donner Camp Historical Site, Nevada County, California, 25 June 2015.

In this issue of *Western Birds*, Alisha Ritchie and Myrna Pearman describe the application of electronic technology—passive integrated transponder (PIT) tags and a system that records when a bird wearing a tag approaches an antenna—to explore the family life of Mountain Bluebirds (*Sialia currucoides*) nesting in boxes in Alberta. They recorded two instances of males visiting nests other than their own, one of an adult repeatedly visiting a nest where the resident male had disappeared, the other of a juvenile visiting a neighbor's nest.

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Front cover photo by © Ed Harper of Carmichael, California: Lark Sparrow (*Chondestes grammacus*) near Day, Modoc County, California, 14 July 2018. In this issue of *Western Birds*, Edward R. Pandolfino and Richard W. Hedley reveal the remarkable structure underlying the Lark Sparrow's complex song, which can be interpreted in the framework of a four-level hierarchy.

Back cover photo by © Thomas A. Benson of San Bernardino, California: Cassin's Sparrow (*Peucaea cassinii*), Mojave National Preserve, San Bernardino County, California, 5 May 2019. Forty-one years after an irruption of Cassin's Sparrows reached the Mojave Desert in the spring of 1978, history repeated itself after another wet winter. In the spring of 2019 at least two dozen Cassin's Sparrows were found in the same area of the Mojave Desert as in 1978. Sites of other occurrences in southern California include the San Geronio Pass and San Clemente Island, all reports being evaluated by the California Bird Records Committee.

Western Birds solicits papers that are both useful to and understandable by amateur field ornithologists and also contribute significantly to scientific literature. The journal welcomes contributions from both professionals and amateurs. Appropriate topics include distribution, migration, status, identification, geographic variation, conservation, behavior, ecology, population dynamics, habitat requirements, the effects of pollution, and techniques for censusing, sound recording, and photographing birds in the field. Papers of general interest will be considered regardless of their geographic origin, but particularly desired are reports of studies done in or bearing on North America west of the 100th meridian, including Alaska and Hawaii, northwestern Mexico, and the northeastern Pacific Ocean.

Send manuscripts to Daniel D. Gibson, P. O. Box 155, Ester, AK 99725; avesalaska@gmail.com. For matters of style consult the Suggestions to Contributors to *Western Birds* (at www.westernfieldornithologists.org/docs/journal_guidelines.doc).

Good photographs of rare and unusual birds, unaccompanied by an article but with caption including species, date, locality and other pertinent information, are wanted for publication in *Western Birds*. Submit photos and captions to Photo Editor. Also needed are black and white pen and ink drawings of western birds. Please send these, with captions, to Graphics Manager.

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STRUCTURE OF LARK SPARROW SONG IN CALIFORNIA

EDWARD R. PANDOLFINO, 1328 49th Street, Sacramento, California 95819;
erpfromca@aol.com

RICHARD W. HEDLEY, Department of Biological Sciences, University of Alberta,
116 St. & 85 Ave., Edmonton, Alberta T6G 2R3, Canada

ABSTRACT: We studied the song of the Lark Sparrow (*Chondestes grammacus*) in recordings of 15 individuals from a variety of locations in California. Lark Sparrow song is delivered as variable sequences structured in a hierarchy of four levels: elements, syllables, strophes, and themes. At the simplest level, elements can be distinguished by their appearance on a spectrogram. Birds vary the number of repetitions of each element to produce a syllable and string together several syllables to produce a strophe (mean 5.9 syllables per strophe). Strophes are delivered at an average rate of 5.4 per minute. Strophes can be further classified as belonging to one of a few themes in a male's repertoire, where strophes in different themes are composed of almost entirely distinct elements and syllables. In <6% of strophes did we find elements from one theme mixed with elements from a different theme. Each individual sang one to three themes. The size of the repertoire of strophes is large but we could not quantify it because within a continuous bout of singing any particular sequence of syllables was repeated in only 5% of strophes. Each theme comprised roughly 20–40 distinct syllables. Thus an individual singing three themes could have a repertoire of 60–120 syllables. The number of unique elements per theme ranged from 11 in birds revealing just one theme up to 39 in birds revealing three themes, but longer recordings may have yielded more elements per bird. If our observations for single-themed birds may be extrapolated, birds with three themes might have repertoires of 33–51 elements. In the two comparisons possible, we detected almost no sharing of elements among neighboring birds.

One of the most fascinating aspects of bird behavior is the remarkable range in size of the song repertoire among different species of songbirds (Kroodsma 2005, Catchpole and Slater 2008, Pieplow 2017). Individuals of many species, such as the Chipping Sparrow (*Spizella passerina*; Borror 1959), Ovenbird (*Seiurus aurocapilla*; Lein 1981), and Zebra Finch (*Taeniopygia guttata*; Catchpole and Slater 2008), get by with a single simple primary song that varies little. Others, such as the White-crowned Sparrow

(*Zonotrichia leucophrys*; Baptista 1975), may have a slightly more complex song, but also with almost no variation. Many birds use a few to perhaps a dozen different songs. Examples include the Great Tit (*Parus major*; Krebs et al. 1978), Hermit Thrush (*Catharus guttatus*; Borror 1964), and Song Sparrow (*Melospiza melodia*; Borror 1965, Hiebert et al. 1989). Still others, such as some thrashers, may have hundreds or even thousands of different songs (Kroodsma 2005).

We also see very different means of producing variety. In some birds each successive song differs (immediate variety), whereas others repeat the same song several times before switching to a new song type (eventual variety). Song diversity may be achieved by using many separate elements, including some appropriated from other birds, as in the songs of the Northern Mockingbird (*Mimus polyglottos*; Farnsworth et al. 2011). Other birds, such as the Great Reed Warbler (*Acrocephalus arundinaceus*; Catchpole and Slater 2008), may use fewer elements but vary the organization of those elements within each song. Some birds create further diversity by organizing their repertoires into themes. Themes are subsets of the repertoire characterized by high rates of transitions among elements within the theme, followed by infrequent, often abrupt, transitions to another theme. Such organization by themes has been demonstrated in the Nightingale (*Luscinia megarhynchos*; Todt and Hultsch 1998, Weiss et al. 2014), California Thrasher (*Toxostoma redivivum*; Sasahara et al. 2012), and Cassin's Vireo (*Vireo cassinii*; Hedley 2016).

The structure of the song of the Lark Sparrow (*Chondestes grammacus*), while not well studied, has been described as "trills and sweet notes interrupted by a rather unmelodious churr" (Hoffmann 1927), "a melodious jumble of rich notes and trills ranging in pitch and volume and interspersed with rather unmelodious harsh buzzes or churrs" (Martin and Parrish 2000), "a rapid jumble of trills, sweet notes, and musical warbles" (Beedy and Pandolfino 2013), and "a series of rich, melodious notes and trills and unmusical buzzes" (Dunn and Alderfer 2017). Pieplow (2017) described the general structure as, "consecutive songs usually different, often with many of the same components rearranged." Borror (1961) grouped the Lark Sparrow with other birds showing much intraspecific variation and noted 58 different patterns in a single individual. He also found no examples of individuals sharing a song pattern.

The Lark Sparrow is distinctive among North American sparrows (family Passerellidae). The only member of its genus, it is more boldly marked than most other sparrows, and it reportedly engages in courtship displays more elaborate and complex than those of any other member of this family (Martin and Parrish 2000). We chose to examine the Lark Sparrow's song because of the lack of detailed information about its structure and repertoire size. We also wanted to determine if the Lark Sparrow's song structure is similar to that of other species, and whether similarities in behavior or close taxonomic relationships might be linked to similar song structures. We used recordings made in the breeding season at multiple locations in California to analyze variations in and the structure of individual Lark Sparrow songs.

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METHODS

Terminology

Since authors use a variety of terms to describe parts of bird song (phrase, syllable, element, etc.) in different ways, it is important to specify how one is using such terms for any given analysis. In this case, we follow the terminology suggested by Catchpole and Slater (2008) for terms such as element, syllable, and strophe. Figure 1 shows how we applied these terms for our analyses. An element was the simplest subunit of song, typically appearing as a continuous trace on a spectrogram. We identified each unique element in a given recording on the basis of frequency, range of frequencies, duration, and shape, and assigned it a letter. These features were highly stereotyped within each individual's repertoire, enabling us to consistently identify each element visually (Appendix 1; www.westernfieldornithologists.org/V50A/LarkSpAp1.pdf). A syllable was a repetition of the same element one or more times. We identified syllables with a combination of a letter and a number, the letter signifying the element constituting the syllable, the number signifying the number of times that element was repeated (e.g., syllable B6 in Figure 2 indicates that the syllable consists of six repetitions of element B; in the third strophe syllable B5 comprises five repetitions of element B). A strophe is a string of several syllables in quick succession. Consecutive strophes were easily distinguished because the interval of silence between elements and syllables within a strophe was typically less than 0.2 seconds, while the gap between strophes was on the order of several seconds. We

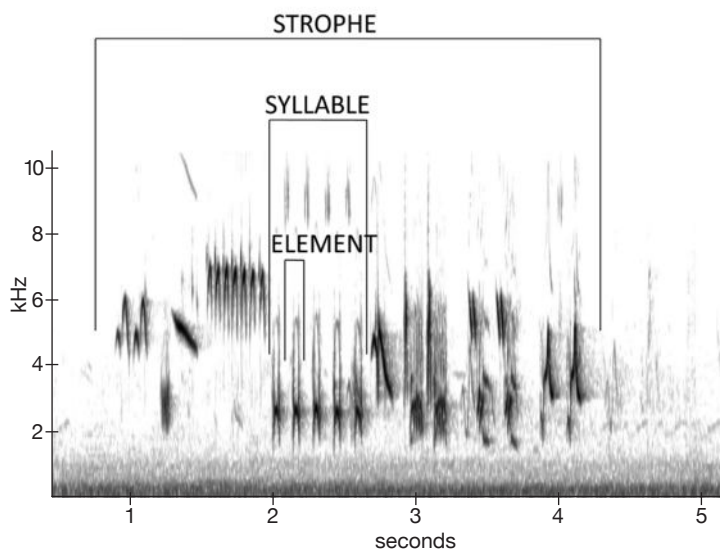


Figure 1. Sample spectrogram of Lark Sparrow illustrating the terminology used for the three lower levels of the four-level hierarchy.

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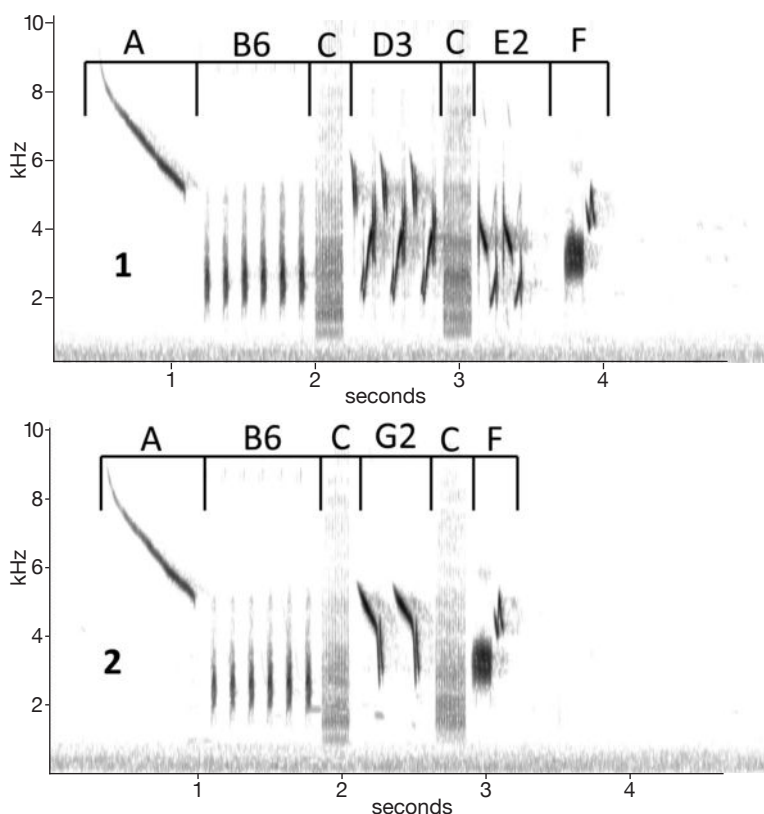


Figure 2. Spectrograms of the first four strophes from recording XC416410. Letters signify elements, and numbers indicate the number of repetitions of an element to produce a syllable (e.g., B6 is a syllable comprising six repetitions of element B). Elements may recur in consecutive strophes (e.g., element B in each strophe), but the composition and order of elements varies from strophe to strophe (parts 3 and 4 on page 62).

chose to use the term strophe, instead of song type, because this term better suggests the wide variation of these subunits in the Lark Sparrow. Figure 2 shows four consecutive strophes of a Lark Sparrow song with the distinct elements and syllables labeled.

We defined themes post hoc after observing that an individual's repertoire could be categorized into up to three subsets that consistently appeared together in sequence (see Results). To confirm the objectivity of these themes, we used the community-clustering algorithm for detecting communities in transition networks described by Pons and Latapy (2006), which we implemented by using the function *cluster_walktrap* in the program *igraph* (Csárdi and Nepusz 2006) in R version 3.4.2 (R Core Team 2016). We then compared the results of clustering with the results of our subjective

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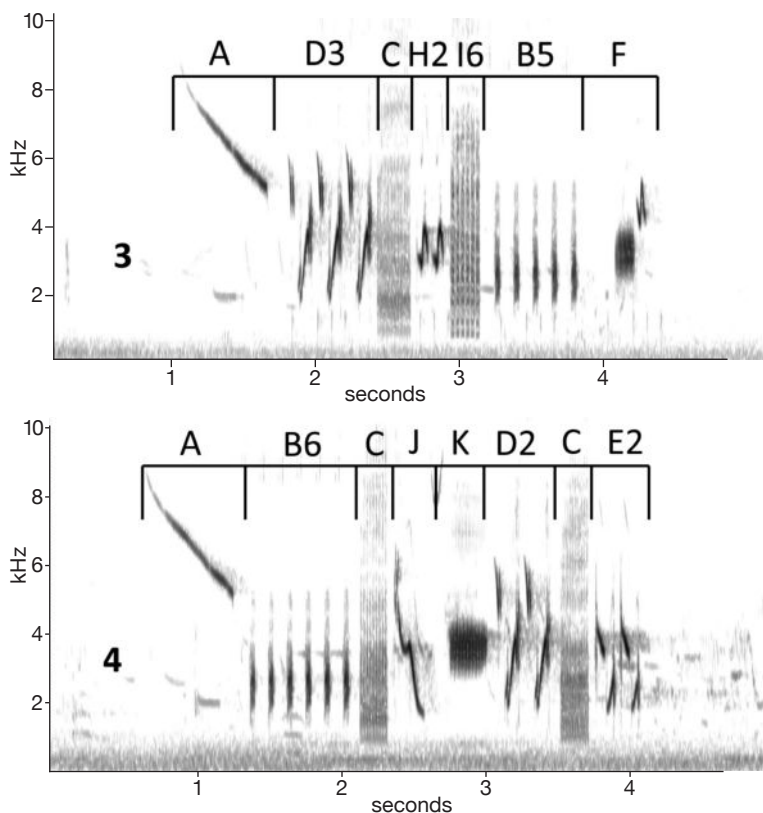


Figure 2 (continued).

assessment of themes for all individuals in whose repertoire we identified more than one theme. Further details can be found in Appendix 2 (www.westernfieldornithologists.org/V50A/LarkSpAp2.pdf).

Recordings

We used all recordings from our personal collections, from the Macaulay Library (www.macaulaylibrary.org), or from www.xeno-canto.org that were made in California during the breeding season (Figure 3; Table 1) and included at least 12 consecutive strophes and were of good quality (signal-to-noise ratio of approximately 5:1 or better). In total, our dataset included songs from fifteen individuals. Recording numbers beginning with ML are from the Macaulay Library, those beginning with XC are from Xeno-Canto. The other two recordings are available at www.westernfieldornithologists.org/archive/V50/LarkSpAp3. If there were pauses during a bout of singing, we used subsequent singing only if we were certain it came from the

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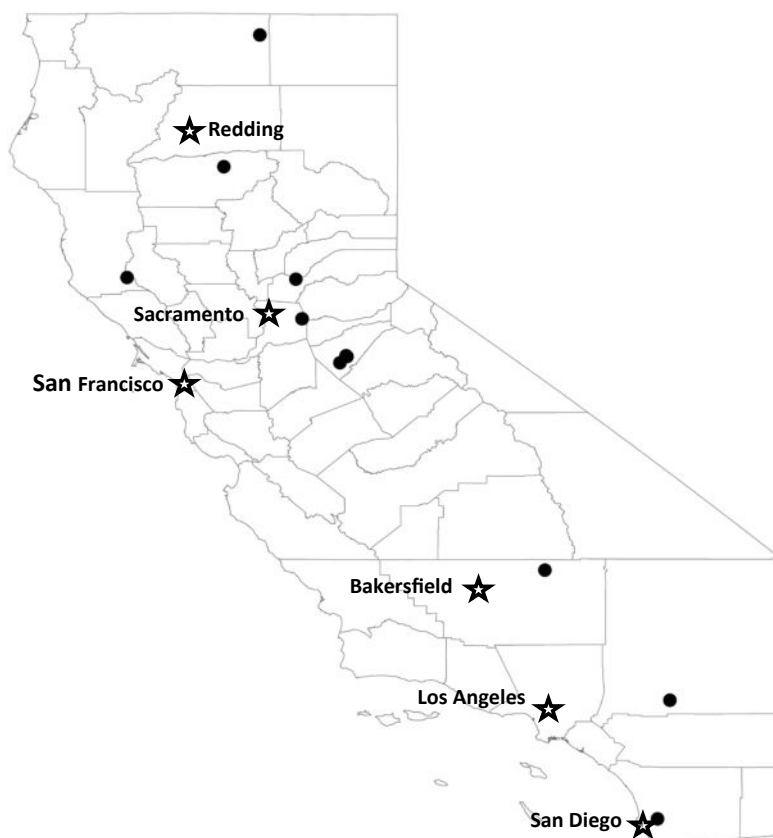


Figure 3. Locations of recordings of the Lark Sparrow analyzed from California.

same individual. Because the individuals recorded were not marked, it was not possible to obtain very large numbers of strophes from any single bird.

We used the software Raven (Cornell Laboratory of Ornithology) to make spectrograms and used printouts of all strophes to identify elements and analyze structure. Appendix 1 (www.westernfieldornithologists.org/V50A/LarkSpAp1.pdf) includes spectrograms of all strophes and the assignments of elements and syllables used for every recording.

RESULTS

Each strophe of a Lark Sparrow song typically consisted of 5–8 syllables (Table 2). Strophes averaged 2.7 seconds in length (range 2.2–3.5) and were given at an average rate of 5.4 per minute (range 3.5–12.1). Note that the most rapid song (12.1 strophes/min) was an outlier, as the rate in the next

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Table 1 Metadata for Recordings of Lark Sparrow Songs Analyzed

Recording ^a	Latitude	Longitude	Date	Time ^b	Recordist
MTRP_3-26-17	32.84	-117.04	26 Mar 2017	07:25 (dawn +41)	B. Rideout
MTRP_6-25-16	32.84	-117.04	25 Jun 2016	07:05 (dawn +83)	B. Rideout
ML118851	39.00	-123.07	22 May 2001	07:21 (dawn +86)	G. Keller
ML22963	35.67	-118.32	16 May 1994	?	W. Fish
ML56920	41.76	-121.56	2 Jun 1991	09:50 (dawn +253)	G. Keller
XC125433-30	34.19	-116.90	3 Jun 2001	07:00 (dawn +82)	R. Webster
XC171192	38.53	-121.08	24 Mar 2014	06:40 (dawn -23)	E. Pandolfino
XC416403	38.53	-121.08	2 Apr 2017	06:47 (dawn -2)	E. Pandolfino
XC416405	38.53	-121.08	4 May 2017	07:32 (dawn +87)	E. Pandolfino
XC416410	40.26	-121.97	9 Apr 2015	07:36 (dawn +57)	E. Pandolfino
XC416413	38.98	-121.15	21 Apr 2017	07:50 (dawn +90)	E. Pandolfino
XC416416	38.03	-120.65	20 Apr 2018	06:41 (dawn +32)	E. Pandolfino
XC416511	38.11	-120.58	20 Apr 2018	08:28 (dawn +139)	E. Pandolfino
XC416515	38.11	-120.58	20 Apr 2018	08:43 (dawn +154)	E. Pandolfino
XC416519	38.10	-120.57	20 Apr 2018	09:33 (dawn +204)	E. Pandolfino

^aEach recording represents one individual.

^bNumber of minutes before (negative) or after local dawn in parentheses.

most rapid song was 6.6 per minute. That outlier song (XC171192) was recorded 23 minutes before dawn, earlier than any other recording used.

Each syllable was composed of one or more repetitions of the same element, and variation in consecutive strophes was generated by use of different elements, altering the order of the syllables, or varying the number of repetitions of an element in a syllable. For some individuals, additional variation in strophe composition was further enhanced by multiple distinct

Table 2 Numbers and Ratios of Components of Lark Sparrow Song by Its Four Levels of Hierarchy

Recording	Strophes	Themes	Elements	Elements/theme			Syllables/strophe
				1 ^a	2 ^a	3 ^a	
MTRP_3-26-17	20	1	11	11			6.4
MTRP_6-25-16	25	2	22	13	9		6.4
ML118851	14	2	24	11	13		6.9
ML22963	36	2	27	13	14		7.0
ML56920	13	2	23	10	13		5.2
XC125433-30	51	3	27	9	10	8	5.5
XC171192	41	1	11	11			5.5
XC416403	26	2	22	11	11		5.5
XC416405	38	2	25	11	14		7.3
XC416410	17	1	14	14			7.6
XC416413	18	2	17	12	6		5.4
XC416416	29	2	26	13	13		5.6
XC416511	17	1	13	13			5.6
XC416515	38	1	17	17			5.2
XC416519	51	3	39	16	12	11	5.0

^aNumber of themes evident in the recording.

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sets of elements (themes). Transitions between themes were abrupt: themes did not grade into one another but were temporally distinct. A given individual might sing a few or many strophes by using elements from one theme before switching to another theme (Table 3, Figure 4). In our sample, individual birds sang one to three distinct themes, each theme consisting of as many as 17 different elements (Table 2). Five birds revealed one theme, eight birds revealed two themes, and two birds revealed three themes. It is likely that some birds would have revealed more themes had longer recordings been available. We found a nonsignificant positive correlation between the number of strophes recorded and the number of themes observed ($n = 15$, $r = 0.46$, $p = 0.09$). Our subjective classification of themes agreed with the result of the more objective community-clustering algorithm. The two methods produced identical results for seven of ten individuals that sang more than one

Table 3 Detailed Structure of a Sample Lark Sparrow Song Consisting of Two Themes (XC416416)

Strophe and theme			Syllables and elements						
Theme 1									
1	A	B	C	D6	E6				
2	C	F5	A	E6	G2	H	I2	J	
3	C	F5	A	E6	G3				
4	A	H2	K9	F4	G3	I3			
5	C	F5	E7	L4					
6	B	A	C	D5					
7	C	E7	G4	H2	A	I2			
8	C	F5	A	E6	G2				
9	A	B	C	D6	E5				
10	C	J	H2	L4	F5				
11	C	F5	A	E7	I4	K7			
12	J	B	A	M	C	D6			
13	A	H2	F5	C	G4	E6	I2		
14	C	F5	G3	E6	A	I2	K8		
15	M	A	D5	L3					
Switch to theme 2									
16	N	O	P	Q4	R4	S5	T3		
17	U	S5	R4	Q3	T2				
18	N	P	V	W	T2	X3	Y4		
19	O	Z3	Q3						
20	N	P	V	W	R5	S4			
21	U	S5	R4	Q	O	Z3			
22	W	V	T2	Y4	O	X3			
23	U	O	P	Q3	T3	Y4			
24	U	S5	R6						
25	U	S5	R5	W	V				
Switch back to theme 1									
26	A	M	C	D5	E4				
27	J	B2	C	F5	A	E5			
28	A	C	I2	F4	A	E3			
29	A	H2	B	C	D5	L3	J		

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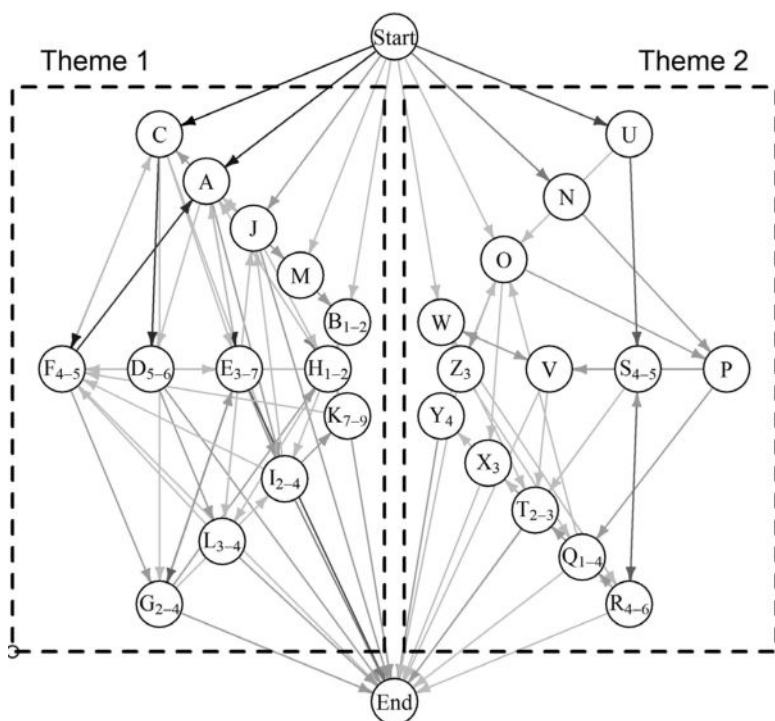


Figure 4. A network representation of the transitions between elements in a typical two-themed song of a Lark Sparrow (XC416416, Table 3) consisting of 29 strophes. The first set of 15 strophes uses 14 different elements (A through M; theme 1), the next set of 10 strophes uses 13 elements (N through Z; theme 2), and the last set of 4 strophes revert back to elements from theme 1 (A through M). To improve clarity, repetitions of the same element are not shown (e.g., syllables G2 and G3 are both included as element G). Darker arrows signify more frequent transitions (1 to 8 instances). Themes 1 and 2 are completely separated, with complex transitions within each theme and no transitions between the themes.

theme and 75–96% agreement for the other three individuals (Appendix 2). This concordance supports our conclusion that organization by themes is a genuine characteristic of the Lark Sparrow's song.

With few exceptions, song structure conformed largely to a specific set of rules:

1. Distinct strophes typically differ in structure (i.e., composition and order of syllables). Of 433 strophes observed, only 22 (5%) were repeated within a recording.
2. Although elements are often repeated within a syllable, elements are very rarely repeated in two or more syllables in a single strophe. Of the 433 strophes, only 15 (3%) used any element in more than one syllable.

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3. Elements from one theme are rarely used in other themes. Of the 300 strophes observed in the songs of the ten birds that revealed more than one theme, only 17 (6%) included an element that occurred in two or three themes. The actual number of such occurrences may even be lower as 9 of the 17 apparent repetitions involved buzzy, polyphonic elements (e.g., element C in Figure 2), which are difficult to classify and may have variations difficult to detect in a spectrogram. If one eliminates those cases, we observed only 8 examples of elements from one theme appearing in another (3%).

Since strophes with the exact same structure were so rare, it was impossible with the sample size available to us to estimate repertoire size at the level of the strophe. Given the variety of elements used, the varying number of repetitions of elements per syllable, variations in the order of syllables, and the use of multiple themes, the potential size of the strophe repertoire is huge. We attempted to estimate repertoire size at the syllable level (Figure 5) by plotting the number of unique syllables vs. the total number of syllables sung. Of birds that revealed only one theme, all individuals appeared to have neared a maximum. For example, in recording XC416515, only six out of 36 (17%) were introduced in the final 50% of the recording, only one (3%) in the final 25% of the recording. The rate of accumulation of syllables among the birds revealing two or three themes suggested that longer recordings of all would yield more unique syllables. It is also possible that longer recordings might reveal additional themes. Taken together, these results suggest that each theme may contain 20–40 unique syllables, yielding a total repertoire of 60–120 syllables for a bird with three themes.

We also examined repertoire size at the level of the element (Figure 6). Among the three individuals whose songs consisted of only a single theme, the number of unique elements reached a maximum, ranging from 11 to 17. For birds revealing two or three themes, only two (XC416416: 2 themes, 26 elements and XC125433-30: 3 themes, 27 elements) might have reached a maximum. The range of unique elements observed was 18–27 for birds with two themes and 27–39 for birds with three themes. As noted above for syllable repertoire, longer recordings might have revealed additional themes.

On the basis of a very limited sample, neighboring Lark Sparrows seem to share very few elements. Recordings XC416511 (one theme, 13 elements), XC416515 (one theme, 17 elements), and XC416519 (three themes, 39 elements) were recorded on the same day within an area of diameter 500 m. Recordings XC415511 and XC 416515 include only two shared elements. Recording XC416519 includes no elements shared with the other two birds. Additionally, recordings XC416403 (two themes, 22 elements) and XC416405 (two themes, 25 elements) were made approximately 800 m apart, and these birds' songs shared no elements.

DISCUSSION

As noted above, the Lark Sparrow is unusual for its family in several ways. The size and structure of its song repertoire are also unusual among the sparrows. In general, sparrows' song repertoires are small, ranging from one or a few song types in the genera *Spizella* and *Zonotrichia* (Pieplow 2017) to

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perhaps as many as 40 for the Bachman's Sparrow (*Peucaea aestivalis*; Borror 1971). The Vesper Sparrow (*Pooecetes gramineus*) is an exception and may have a repertoire as large and a structure as complex as the Lark Sparrow's (Kroodsma 1972). Vesper Sparrows use at least 40 different elements that are rearranged to produce a very large song repertoire (Kroodsma 1972, Pieplow 2017). Interestingly, the Vesper Sparrow was once considered the Lark Sparrow's closest relative (Patten and Fugate 1998). Genetic analysis, however, suggests that the Lark Bunting (*Calamospiza melanocorys*) is the Lark Sparrow's closest relative (Carson and Spicer 2003). Lark Buntings also sing songs composed of a set of distinct elements, but the elements and order in which they are uttered are relatively stereotyped and individuals generally have only one or a few song types (Shane 2000, Pieplow 2017). Stillwell and Stillwell (1955) detected 11 "phrase types" (analogous to syllables as we have defined them) in songs of two individuals. In contrast to the complex, multi-step pre-copulatory courtship displays of the Lark Sparrow, the courtship displays of the Vesper Sparrow and Lark Bunting are much simpler. Male Vesper Sparrows may strut briefly before a female, sometimes displaying and singing briefly in flight (Berger 1968). The Lark Bunting is well-known for dramatic flight-song displays, which may be repeated many times in the presence of a female, but copulation occurs with little further fanfare (Shane 2000). Thus neither the Vesper Sparrow, with a fairly similar song structure, nor the closely related Lark Bunting has courtship behavior as complex as the Lark Sparrow's.

In the simplest sense, birds build large song repertoires by two structural methods. Some, such as the thrashers of the genus *Toxostoma*, produce variety mainly through use of a very large number of elements (Sheppard 2018, Pieplow 2017). Others, such as the Sedge Warbler (*Acrocephalus schoenobaenus*; Catchpole 1976) and Rose-breasted Grosbeak (*Pheucticus ludovicianus*; Lemon and Chatfield 1973) employ a relatively small number of discrete elements which are grouped and rearranged to produce remarkable variety in their songs. The Lark Sparrow's song structure clearly falls into the latter category. It also appears that the order of delivery of song elements is nonrandom and that transitions within certain subsets of the repertoire (themes) are clearly favored. Other species known to organize their songs according to themes include the Black-capped (*Vireo atricapilla*; Gryzbowski 1995) and Cassin's (Hedley 2016) Vireos and the Rock Wren (*Salpinctes obsoletus*; Kroodsma 1975). Even highly complex songs that may appear to be a random succession of elements, such as those of the Nightingale (Weiss et al. 2014) and California Thrasher (Sasahara et al. 2012), have revealed some degree of theme-based organization when subjected to detailed network analysis (Watts and Strogatz 1998). What may set the Lark Sparrow apart is how strictly it adheres to the use of discrete themes, with very little mixing of elements between themes.

Large, complex song repertoires have been correlated with mating success in many species (Catchpole and Slater 2008). Pairing and mating earlier in the breeding season have been linked to larger repertoires in the Northern Mockingbird (Howard 1974) and Sedge Warbler (*Acrocephalus schoenobaenus*; Catchpole 1980). In the Great Tit (Lambrechts and Dhondt 1986), Great Reed Warbler (Catchpole 1986), and Song Sparrow (Hiebert et al. 1989,

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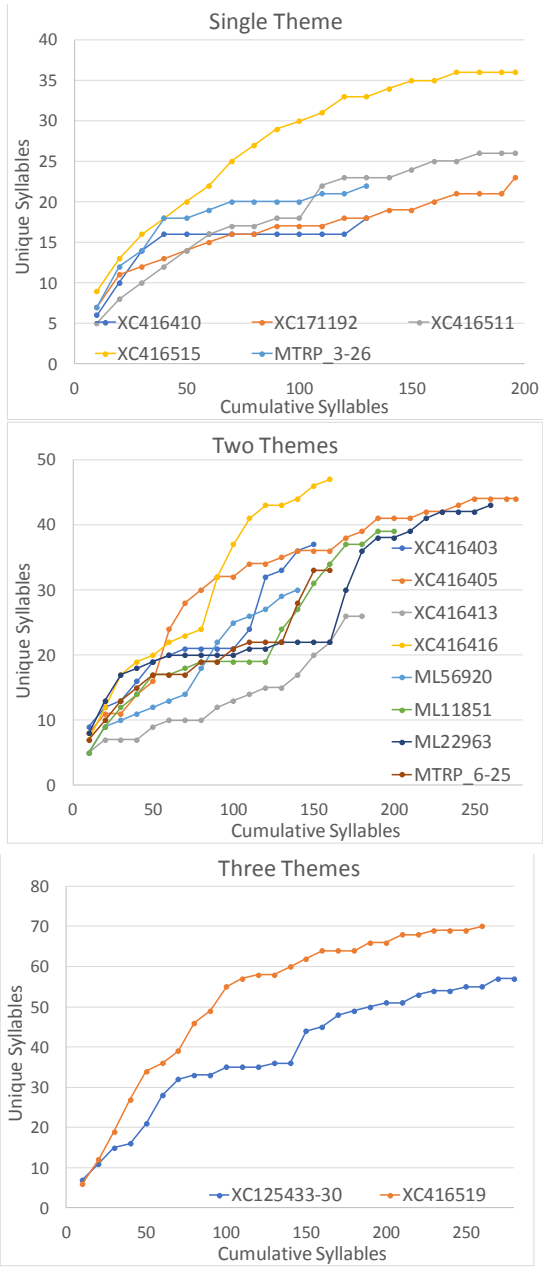


Figure 5. Accumulation of syllable variety with the total number of syllables delivered in recordings of Lark Sparrow song, by number of themes.

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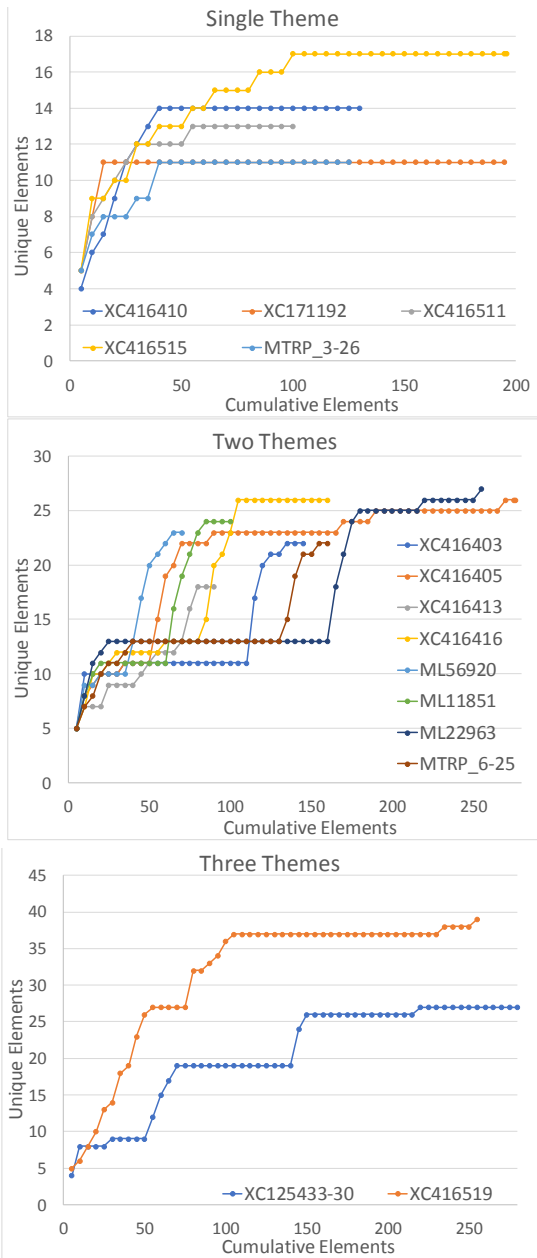


Figure 6. Accumulation of element variety with the total number of elements delivered, in recordings of Lark Sparrow song, by number of themes.

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Potvin et al. 2015) repertoire size and overall reproductive success are positively correlated. Both earlier mating and reproductive success are enhanced by a larger repertoire in the European Starling (*Sturnus vulgaris*; Eens et al 1991). Other indicators of overall fitness such as size and age have also been linked to larger song repertoires in the Pied Flycatcher (*Ficedula hypoleuca*; Lampe and Espmark 1994) and Common Whitethroat (*Sylvia communis*; Balsby 2000). These observations have led many authors to conclude that females' selection for larger song repertoires is the main evolutionary factor driving repertoire size in species with large repertoires (Catchpole and Slater 2008). However, Byers and Kroodsma (2009) argued that the evidence does not support female choice as the primary driver of song complexity.

Two aspects of the organization of the Lark Sparrow's song appear to favor the proposal of Byers and Kroodsma (2009) that female preference for greater song diversity is not the key evolutionary factor driving the development of large repertoires. The lack of mixing of elements between the Lark Sparrow's themes reduces the potential song diversity below what could be achieved if all available elements were used interchangeably. Also, the fact that birds with multiple themes stayed with one theme for some time before switching to another (>20 strophes for MTRP_6-25-16, ML22963, XC416403, and XC416405) suggests that those birds were not trying to reveal their full repertoire as quickly as possible. Byers and Kroodsma (2009) proposed an alternative hypothesis that large repertoires may be the result of the need for more complex messaging in a social context. Perhaps the Lark Sparrow's complex breeding behavior is somehow linked to a need for more complex vocal communication in this species.

Whether or not female selection is a factor in the evolution of the Lark Sparrow's song structure, the fact that Lark Sparrows have large repertoires and seem to follow a set of specific organizational rules with very little deviation (e. g., almost no mixing of elements between themes) suggests that repertoire size and adherence to these rules is important in the species' life history. Further studies with individually marked birds could reveal if factors such as the number of themes, size of the repertoire of elements, or adherence to organizational rules are correlated with age, fitness, or reproductive success.

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TRENDS IN BIRD SPECIES RICHNESS IN THE MIDST OF DROUGHT

BRIAN M. MYERS, Department of Biological Sciences, San Diego State University, 5500 Campanile Drive, San Diego, California 92182; bmyers@mail.sdsu.edu

ERIN J. QUESTAD, MARCUS D. HUBBELL, and DAVID J. MORIARTY, Department of Biological Sciences, California State Polytechnic University, Pomona, 3801 W Temple Ave, Pomona, California 91768

ABSTRACT: Climate change is predicted to exacerbate the effects of disturbances such as drought on numerous wildlife communities. On the basis of surveys from 1981 to 2014, we investigated whether drought altered the species richness and composition of bird communities of coastal sage scrub in two protected areas of southern California. At one site, the Voorhis Ecological Reserve, Pomona, we found that the number of species of permanent residents, but not of summer and winter visitors, was lower during droughts than during periods of at least average rainfall. At the other site, the Bernard Field Station, Claremont, we found that the richness of resident species remained the same in both drought and nondrought periods, and richness of summer and winter visitors increased during times of drought. The difference in patterns between these sites may be explained by the presence of a constructed, permanent water source at the second site. Thus, supplemental water sources embedded in natural areas might be an important resource for native bird species during drought.

Climate change is predicted to increase the frequency of drought in arid regions, threatening avian populations and native ecosystems (National Wildlife Federation 2008, Mastrandrea and Luers 2012). There is a growing body of work on the effects of drought on birds that breed in arid and semi-arid habitats. For example, periods of drought or atypically low rainfall have led to lower levels of species richness and abundance in birds (Albright et al. 2010), reduction of birds' reproductive rates (McCreedy et al. 2015), reproductive failure of passerines (Bolger et al. 2005), a decline of over 60% in density of grassland birds (George et al. 1992), short-term declines in both resident and migratory species (Bock and Bock 1999), and smaller clutch sizes of the California Gnatcatcher (*Poliophtila californica*; Patten and Rotenberry 1999).

Coastal sage scrub is a plant community found in coastal California and northern Baja California, largely below 300 m in elevation. Its species are adapted to winter rains and a summer dry period, in which many plants are deciduous, growing leaves during the wet winter and losing them during the dry summer. The dominant plant species consist of low-growing shrubs such as *Artemisia californica*, *Salvia mellifera*, and *Salvia apiana*. In this region annual variability in rainfall is high, and fire and drought are recurrent. Shrubs characteristic of coastal sage scrub experience increased mortality following drought (Minnich and Dezzani 1998). Of the numerous species of organisms in coastal sage scrub, approximately 100, both animals and plants, require conservation attention according to California and federal wildlife agencies (Atwood 1993, McCaull 1994). Among birds of coastal southern California, the California Gnatcatcher (designated as threatened by the U.S. Fish and Wildlife Service) and Cactus Wren (*Campylorhynchus brunneicapillus*), rely on coastal sage scrub for critical breeding habitat (Barr et al. 2015, Rubinoff

2001). As a result of urban development and fragmentation, this habitat is one of the most endangered in the United States, reduced to less than 10% of its original range (Taylor 2005), with many species relying on it in decline (Chase et al. 2000, Rubinoff 2001, Barr et al. 2015). The effects of climate change, including longer and more severe droughts, may further threaten southern California's declining, fragmented coastal sage scrub (Griffin and Anchukaitis 2014).

From 2012 to 2016, southern California experienced one of the most severe droughts in recorded history (Griffin and Anchukaitis 2014, Wang et al. 2014, Robeson 2015). The California Department of Water Resources (2015) declared it a "state of emergency" that caused significant economic losses and threatened native wildlife and ecosystems. Protecting and restoring native ecosystems affected by this drought poses a critical conservation challenge. Here, on the basis of long-term data on the bird community in two remnants of coastal sage scrub in Los Angeles County, we consider whether avian species richness changed significantly during drought. We predicted that species richness should decline during drought, especially richness of migratory species that might avoid drought-affected habitat (Albright et al. 2010).

METHODS

Our study is focused on two patches of coastal sage scrub along the urban-wildland interface of inland Los Angeles County, the Voorhis Ecological Reserve and the Robert J. Bernard Biological Field Station (Figure 1). Precipitation averages 545 mm per year, although from the year 1900 through 2000 the number of days of rainfall per year decreased (36 to 29), while the average precipitation during each storm increased from 7 to 11 mm (U.S. Geological Survey 2005, Goldstein and Suding 2014). Both the Voorhis Ecological Reserve and the Bernard Field Station have experienced periodic wildfire.

Study Areas

The Bernard Field Station is located in Claremont on an alluvial outwash from the San Gabriel Mountains (Figure 1; 34.11° N, 117.71° W, elevation 356 m). It covers approximately 35 ha and contains an artificial pond and wetland that are managed as a source of permanent water for wildlife. The wetland consists of 0.2 ha of marsh with water up to 2 m deep and a 0.4-ha pond up to 6 m deep. The pond is kept full, even during dry periods. The dominant plant community consists of coastal sage scrub and alluvial fan sage scrub, with some oak woodland and grassland. The reserve also contains small areas of riparian woodland and artificial vernal pools. The portion in coastal sage scrub is mostly undeveloped, with some areas categorized as "recovering" after 5.5 ha burned in an accidental fire in September 2013 (Wallace Meyer pers. comm.).

The 31-ha Voorhis Ecological Reserve is located in the middle of the San Jose Hills in Pomona (34.06° N, 117.83° W, elevation 300 m) approximately 22.5 km from the Bernard Field Station. It is an important wildlife corridor that connects the San Gabriel and Santa Ana mountains (Figure 1).

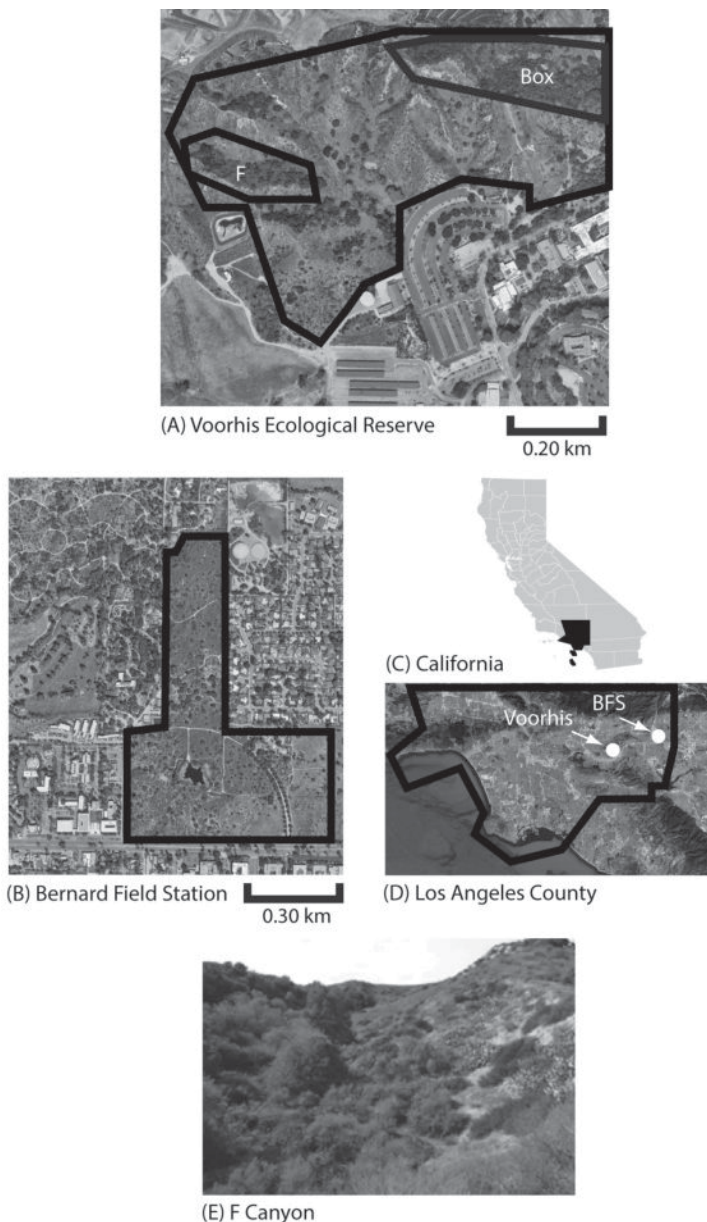


Figure 1. Study areas in Los Angeles County, California (C, D; from Google Earth). (A) Voorhis Ecological Reserve, Pomona (34.059, -117.828, elevation 300 m). Polygons indicate Box Canyon and F Canyon survey sites. (B) Bernard Field Station, Claremont (34.110, -117.710, elevation 356 m). The permanent lake is shown in the center of the area. (E) View of F Canyon in the Voorhis Ecological Reserve, showing typical vegetation patterns.

Photo by Brian Myers

The Voorhis Reserve contains undeveloped coastal sage scrub and has been designated as a “significant ecological area” by Los Angeles County. Like the Bernard Field Station, the Voorhis Reserve is dominated by coastal sage scrub and mixed oak woodland, although the Voorhis Reserve also includes invasive annual plants and some chaparral species. It lacks permanent water but is adjacent to areas with artificial ponds and watered landscaping. The distance to the nearest water source is 0.55 km. The reserve has burned several times, most recently in 1981 (a portion of the reserve) and 1989 (the entire reserve). The 1989 fire was limited to the Voorhis Reserve and small adjacent areas; it did not significantly alter the composition of the reserve’s bird community (Moriarty et al. 1985, Moriarty 2013).

Sampling

The results of monthly bird surveys of the Bernard Field Station by Catherine McFadden from 2000 to 2014 were recorded at www.ebird.org, from which we extracted these data. She completed a four-hour survey over the same route around the perimeter of the 35-ha site on each date (Catherine McFadden and Wallace Meyer pers. comm.). We used only presence/absence data to ensure comparability with results from the Voorhis Ecological Reserve.

From the Voorhis Reserve we used data by Moriarty (2013) based on 265 surveys from January 1983 to December 2003. Each survey covered two canyons (Box Canyon and F Canyon) from a fixed location in each canyon at approximately sunrise for 30 minutes each; which canyon was surveyed first each day alternated. In each canyon the area surveyed was approximately 1.25 ha, 0.4 km apart, south-facing, and similar in vegetation structure. According to the protocol of Moriarty (2013), species within the boundaries of the canyon were recorded as present, but birds flying above the canyon to another location were not counted. During a year of exceptional drought, approximately twice per week year round from February 2013 to February 2014, we replicated these surveys from nearly the same positions as Moriarty (2013), for a total of 89 surveys. We followed the same protocol, except in Box Canyon our survey point was about 9 m above that of Moriarty because recent growth of vegetation impaired visibility from the previous survey point. The large number of these surveys allowed us to examine how drought altered community diversity by month rather than just by season. Both sites were surveyed at the same time, allowing us to compare their species richness.

Classification

Following Moriarty (2013), we categorized the surveys as summer (April through September) or winter (October through March), defining the seasons by the most significant differences observed in the presence and absence of migratory birds. We classified each species as a year-round resident, transient, or migrant, and separated migrants into two subcategories, summer visitors and winter visitors. Migratory birds were classified as summer visitors if found within or near our field sites during the summer season and classified as winter visitors if normally observed within or near our field sites during the winter season, on the basis of information provided in the Los Angeles

Breeding Bird Atlas (Allen et al. 1994) and occurrence records at www.eBird.org. We categorized species as breeding at our sites (resident or summer) if recorded adjacent to or within atlas block "SAD" in Allen et al. (1994). Further descriptions within each species account assisted with classification as resident or summer breeding birds. For species that were ambiguous, not listed in the atlas, or for those that breed in habitats beyond our study sites, we first consulted Allen et al. (1994), then eBird for the time of year in which a species was observed most often. This was necessary for several species, including the Pacific-slope Flycatcher (*Empidonax difficilis*), Townsend's Warbler (*Setophaga townsendi*), and Phainopepla (*Phainopepla nitens*).

The distributions of some species changed through the course of our study, as in the cases of the Allen's Hummingbird (*Selasphorus sasin*), Eurasian Collared-Dove (*Streptopelia decaocto*), Dark-eyed Junco (*Junco hyemalis*), and Mountain Chickadee (*Poecile gambeli*). For these species, which have all recently forged their way into our study areas, we based categorizations on current distributions and patterns, because these species were either never observed in any survey at either site before they colonized the area and became residents (Eurasian Collared-Dove, Allen's Hummingbird), or were observed with the same regularity at our study sites before and after their expansion (Eurasian Collared-Dove and Mountain Chickadee; eBird). We categorized birds as transient if they were observed only intermittently passing through a site during migration. Our use of "migrants" unqualified encompasses summer visitors and winter visitors combined. We included only birds using coastal sage scrub, excluding those found in other habitats at the Bernard Field Station, to ensure that comparisons with the Voorhis Reserve were meaningful.

Drought

To quantify the effect of drought, we adapted the Palmer Drought Index, based on monthly departures of precipitation and temperature data from long-term averages (Palmer 1965). Values of -4 and below represent "extreme drought," -3 to -3.99 "severe drought," -2 to -2.99 "moderate drought," -1.99 to 2.99 "mid-range," 2 – 2.99 "moderately moist" conditions, 3 – 3.99 "very moist," and 4 – 3.99 "extremely moist." The Palmer Drought Index is a widely used way to analyze fluctuations in drought data over time (Palmer 1965, NOAA 2017). To simplify the index, we reduced the values to categories, then ranked them on a scale from 0 to 6, 0 for extremely moist, 1 for very moist, 2 for moderately moist, 3 for mid-range, 4 for moderate drought, 5 for severe drought, and 6 for extreme drought.

Data Analysis

We used three datasets to examine the effects of drought and season on species richness: (1) long-term data from the Bernard Field Station, 2000–2014, (2) long-term data from the Voorhis Reserve, 1983–2003, and (3) 2013–2014 data from both sites. For the Voorhis Reserve we pooled results from the two canyons for each date to generate a single list of species. We tested separate models for the following dependent variables: total richness of bird species, richness of resident species, and richness of migratory species in each long-term dataset (1 and 2). At both sites the sampling on which

the long-term data were based was not consistent from month to month. To standardize the data for variation in sampling effort, we calculated the mean species richness over all sampling dates for each month, then used the value for each month as one data point.

We used general linear mixed models to test the effects of the factors drought level (adapted Palmer Index), season, and year on species richness from the two long-term datasets. We included year as a random variable; all other factors were fixed. We also included the interaction term season $\times$ drought level because drought might have a greater effect on the community in winter or summer. We tested the models with the data from the two sites separately and log-transformed data when needed to improve the normality and homogeneity of variance. We analyzed all models in R version 3.4.3 (R Core Team 2015).

RESULTS

The numbers of species of year-round residents, winter migrants, summer migrants, transients, and all categories pooled were higher at the Bernard Field Station than at the Voorhis Reserve (Figure 2). The 93 species observed from 2013 to 2014 at the Bernard Field Station comprised 48 resident species, 29 migrants (16 winter visitors, 13 summer visitors), and 16 transient species. The 66 species observed over the same interval at the Voorhis Reserve encompassed 41 residents, 20 migrants (8 winter visitors and 12 summer visitors), and 5 transient species. Ninety-nine species were observed over 265 surveys from 1983 to 2003 in the Voorhis Reserve (55 residents, 12 winter visitors, 11 summer visitors, and 21 transients); 122 species were observed over 160 surveys from 2000 to 2014 at the Bernard Field Station (62 residents, 16 winter visitors, 14 summer visitors, and 30 transients). Several species, both residents and migrants, at both the Bernard Field Station and the Voorhis Reserve, were observed during surveys before the drought but not after the drought (Table 1).

Species Richness

At the Voorhis Reserve, total species richness varied by season, being higher in summer than in winter (Table 2; significant effect of season). There were no other significant factors affecting richness of total species at either study site, although the effect of drought level on richness of resident species was significant at both sites (Table 2). The number of resident species was higher during wet conditions (drought indices 0–2) and lower during drought conditions (drought indices 4–6), with the trend more pronounced at the Voorhis Reserve than at the Bernard Field Station (Figure 3a, d). The number of migrant species recorded at the Voorhis Reserve did not differ significantly by drought level, whereas at the Bernard Field Station it was higher during drought (index classes 5 and 6) than during wetter conditions (Table 2, Figure 3e). The number of migrant species was higher in summer than in winter at both sites (Table 2, significant effect of season, Figure 3b, e). Overall, richness of resident species was higher during wetter periods than during drought at both study sites, while that of migrant species at the Voorhis Reserve in drought and nondrought periods did not differ.

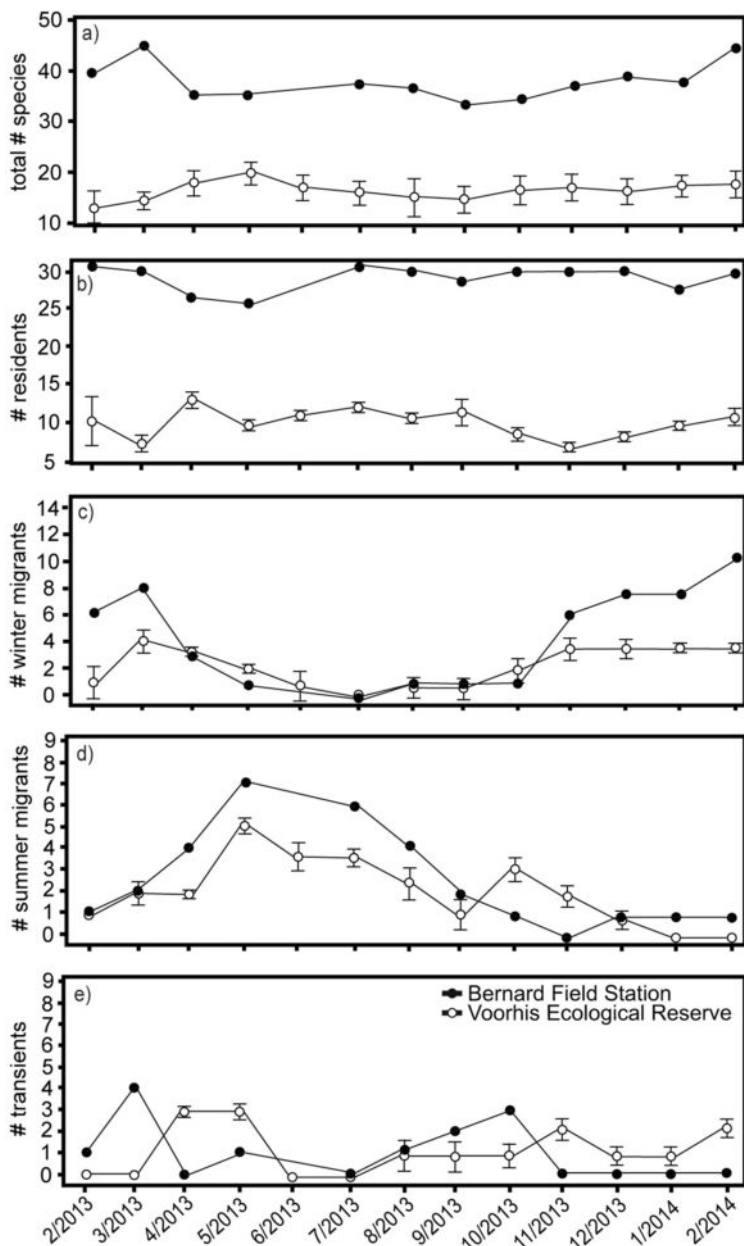


Figure 2. Number of bird species recorded at the Voorhis Ecological Reserve and Bernard Field Station by month from February 2013 to February 2014: (a) total species richness; (b) richness of resident species; (c) species richness of winter visitors; (d) species richness of summer visitors; (e) richness of transient species. Symbols indicate group means; error bars are one standard error. There are no error bars for Bernard Field Station data because each point represents one instance of sampling.

TRENDS IN BIRD SPECIES RICHNESS IN THE MIDST OF DROUGHT

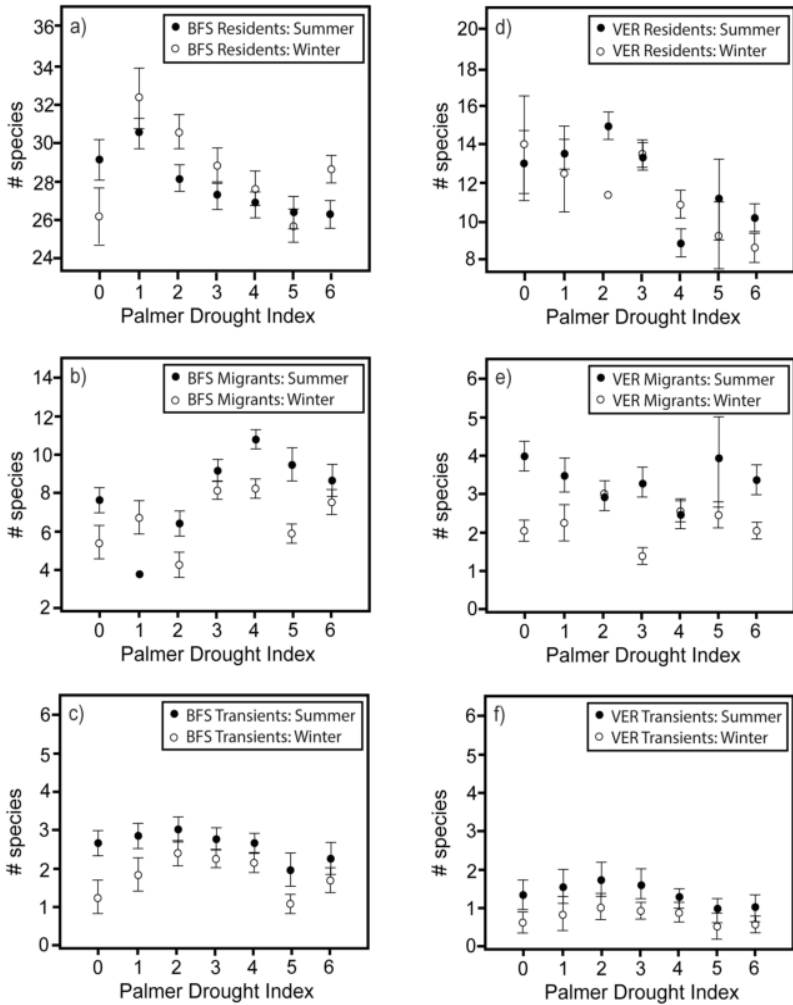


Figure 3. Bird species richness by drought index and season (a) for resident species from 2000 to 2014 at the Bernard Field Station (BFS), (b) for all migrant species from 2000 to 2014 in the Bernard Field Station, (c) for transient species from 1983 to 2003 at the Bernard Field Station, (d) for resident species from 1983 to 2003 at the Voorhis Ecological Reserve (VER), (e) for all migrant species from 1983 to 2003 at the Voorhis Ecological Reserve, and (f) for all transient species from 1983 to 2003 at the Voorhis Ecological Reserve. Palmer drought index scores of 4–6 indicate drought conditions. Symbols indicate group means; error bars are one standard error.

TRENDS IN BIRD SPECIES RICHNESS IN THE MIDST OF DROUGHT

Table 1 Categorization of Status and Occurrence of Birds before or during Drought at the Bernard Field Station and Voorhis Ecological Reserve, Southern California, 1981–2014

Species	Status	Bernard		Voorhis	
		Pre-drought	Drought	Pre-drought	Drought
California Quail (<i>Callipepla californica</i>)	Resident	X	X	X	X
Rock Pigeon (<i>Columba livia</i>)	Resident	X	X	—	—
Band-tailed Pigeon (<i>Patagioenas fasciata</i>)	Resident	X	X	X	—
Eurasian Collared-Dove (<i>Streptopelia decaocto</i>)	Resident	X	—	—	—
Spotted Dove (<i>Streptopelia chinensis</i>)	Resident	—	—	X	—
Mourning Dove (<i>Zenaidura macroura</i>)	Resident	X	X	X	X
Greater Roadrunner (<i>Geococcyx californianus</i>)	Resident	X	—	X	—
Common Poorwill (<i>Phalaenoptilus nuttallii</i>)	Transient	—	—	X	—
Vaux's Swift (<i>Chaetura vauxi</i>)	Transient	X	X	X	—
White-throated Swift (<i>Aeronautes saxatalis</i>)	Resident	X	X	X	—
Black-chinned Hummingbird (<i>Archilochus alexandri</i>)	Summer	X	X	X	X
Anna's Hummingbird (<i>Calypte anna</i>)	Resident	X	X	X	X
Costa's Hummingbird (<i>Calypte costae</i>)	Summer	X	X	X	X
Rufous Hummingbird (<i>Selasphorus rufus</i>)	Transient	X	X	X	—
Allen's Hummingbird (<i>Selasphorus sasin</i>)	Resident	X	X	X	X
Calliope Hummingbird (<i>Selasphorus calliope</i>)	Transient	X	—	—	—
Great Blue Heron (<i>Ardea herodias</i>)	Resident	X	—	—	X
Turkey Vulture (<i>Cathartes aura</i>)	Resident	X	X	X	X
White-tailed Kite (<i>Elanus leucurus</i>)	Resident	X	—	X	—
Northern Harrier (<i>Circus hudsonius</i>)	Resident	X	—	X	X
Sharp-shinned Hawk (<i>Accipiter striatus</i>)	Winter	X	X	X	X
Cooper's Hawk (<i>Accipiter cooperii</i>)	Resident	X	X	X	X
Red-shouldered Hawk (<i>Buteo lineatus</i>)	Resident	X	X	—	X
Swainson's Hawk (<i>Buteo swainsoni</i>)	Transient	X	—	—	—
Red-tailed Hawk (<i>Buteo jamaicensis</i>)	Resident	X	X	X	X

(continued)

TRENDS IN BIRD SPECIES RICHNESS IN THE MIDST OF DROUGHT

Species	Status	Bernard		Voorhis	
		Pre-drought	Drought	Pre-drought	Drought
Golden Eagle (<i>Aquila chrysaetos</i>)	Transient	—	—	X	—
Barn Owl (<i>Tyto alba</i>)	Resident	X	—	—	—
Great Horned Owl (<i>Bubo virginianus</i>)	Resident	X	X	X	X
Acorn Woodpecker (<i>Melanerpes formicivorus</i>)	Resident	X	X	X	—
Red-breasted Sapsucker (<i>Sphyrapicus ruber</i>)	Winter	X	X	—	—
Nuttall's Woodpecker (<i>Dryobates nuttallii</i>)	Resident	X	X	X	X
Downy Woodpecker (<i>Dryobates pubescens</i>)	Resident	X	X	—	—
Northern Flicker (<i>Colaptes auratus</i>)	Resident	X	X	X	X
American Kestrel (<i>Falco sparverius</i>)	Resident	X	X	X	X
Merlin (<i>Falco columbarius</i>)	Winter	X	X	—	—
Prairie Falcon (<i>Falco mexicanus</i>)	Transient	—	—	X	—
Red-crowned Parrot (<i>Amazona viridigenalis</i>)	Resident	X	—	—	—
Olive-sided Flycatcher (<i>Contopus cooperi</i>)	Transient	X	X	—	—
Western Wood-Pewee (<i>Contopus sordidulus</i>)	Transient	X	—	X	—
Willow Flycatcher (<i>Empidonax traillii</i>)	Transient	X	X	—	—
Hammond's Flycatcher (<i>Empidonax hammondi</i>)	Transient	X	X	—	—
Gray Flycatcher (<i>Empidonax wrightii</i>)	Transient	X	—	X	—
Pacific-slope Flycatcher (<i>Empidonax difficilis</i>)	Summer	X	—	X	X
Black Phoebe (<i>Sayornis nigricans</i>)	Resident	X	X	X	X
Say's Phoebe (<i>Sayornis saya</i>)	Resident	X	X	X	X
Ash-throated Flycatcher (<i>Myiarchus cinerascens</i>)	Summer	X	X	X	X
Cassin's Kingbird (<i>Tyrannus vociferans</i>)	Resident	X	X	X	X
Western Kingbird (<i>Tyrannus verticalis</i>)	Summer	X	X	X	X
Loggerhead Shrike (<i>Lanius ludovicianus</i>)	Resident	X	—	X	X
Hutton's Vireo (<i>Vireo huttoni</i>)	Resident	X	X	—	—
Cassin's Vireo (<i>Vireo cassinii</i>)	Transient	X	X	—	X
Plumbeous Vireo (<i>Vireo plumbeus</i>)	Transient	—	—	X	—
Warbling Vireo (<i>Vireo gilvus</i>)	Transient	X	—	X	—

(continued)

TRENDS IN BIRD SPECIES RICHNESS IN THE MIDST OF DROUGHT

Table 1 (continued).

Species	Status	Bernard		Voorhis	
		Pre-drought	Drought	Pre-drought	Drought
Bell's Vireo (<i>Vireo bellii</i>)	Summer	X	—	—	—
California Scrub-Jay (<i>Aphelocoma californica</i>)	Resident	X	X	X	X
American Crow (<i>Corvus brachyrhynchos</i>)	Resident	X	X	X	X
Common Raven (<i>Corvus corax</i>)	Resident	X	X	X	X
Tree Swallow (<i>Tachycineta bicolor</i>)	Transient	X	—	—	—
Violet-green Swallow (<i>Tachycineta thalassina</i>)	Transient	X	X	X	—
Northern Rough-winged Swallow (<i>Stelgidopteryx serripennis</i>)	Summer	X	X	X	X
Cliff Swallow (<i>Petrochelidon pyrrhonota</i>)	Summer	X	X	X	X
Barn Swallow (<i>Hirundo rustica</i>)	Summer	X	X	—	—
Mountain Chickadee (<i>Poecile gambeli</i>)	Transient	X	X	X	X
Oak Titmouse (<i>Baeolophus inornatus</i>)	Resident	X	X	X	—
Bushtit (<i>Psaltiriparus minimus</i>)	Resident	X	X	X	X
White-breasted Nuthatch (<i>Sitta carolinensis</i>)	Transient	X	X	—	—
Rock Wren (<i>Salpinctes obsoletus</i>)	Resident	X	—	X	—
House Wren (<i>Troglodytes aedon</i>)	Resident	X	X	X	X
Bewick's Wren (<i>Thryomanes bewickii</i>)	Resident	X	X	X	X
Cactus Wren (<i>Campylorhynchus brunneicapillus</i>)	Resident	X	—	X	X
Blue-gray Gnatcatcher (<i>Polioptila caerulea</i>)	Resident	X	X	X	X
California Gnatcatcher (<i>Polioptila californica</i>)	Resident	—	—	X	X
Ruby-crowned Kinglet (<i>Regulus calendula</i>)	Winter	X	X	X	X
Wrentit (<i>Chamaea fasciata</i>)	Resident	X	X	X	X
Western Bluebird (<i>Sialia mexicana</i>)	Resident	X	X	X	X
Swainson's Thrush (<i>Catharus ustulatus</i>)	Transient	X	—	X	X
Hermit Thrush (<i>Catharus guttatus</i>)	Winter	X	X	X	X
American Robin (<i>Turdus migratorius</i>)	Resident	X	X	X	X
California Thrasher (<i>Toxostoma redivivum</i>)	Resident	X	X	X	X
Northern Mockingbird (<i>Mimus polyglottos</i>)	Resident	X	X	X	X

(continued)

TRENDS IN BIRD SPECIES RICHNESS IN THE MIDST OF DROUGHT

Species	Status	Bernard		Voorhis	
		Pre-drought	Drought	Pre-drought	Drought
European Starling (<i>Sturnus vulgaris</i>)	Resident	X	X	X	—
Cedar Waxwing (<i>Bombycilla cedrorum</i>)	Winter	X	X	X	—
Phainopepla (<i>Phainopepla nitens</i>)	Summer	X	X	X	X
Northern Red Bishop (<i>Euplectes franciscanus</i>)	Resident	X	—	—	—
Scaly-breasted Munia (<i>Lonchura punctulata</i>)	Resident	X	—	—	—
House Sparrow (<i>Passer domesticus</i>)	Resident	X	X	X	—
House Finch (<i>Haemorhous mexicanus</i>)	Resident	X	X	X	X
Purple Finch (<i>Haemorhous purpureus</i>)	Winter	X	X	X	—
Pine Siskin (<i>Spinus pinus</i>)	Winter	X	X	—	—
Lesser Goldfinch (<i>Spinus psaltria</i>)	Resident	X	X	X	X
Lawrence's Goldfinch (<i>Spinus lawrencei</i>)	Transient	X	X	X	—
American Goldfinch (<i>Spinus tristis</i>)	Resident	X	X	X	X
Spotted Towhee (<i>Pipilo maculatus</i>)	Resident	X	X	X	X
Rufous-crowned Sparrow (<i>Aimophila ruficeps</i>)	Resident	—	—	X	X
California Towhee (<i>Melospiza crissalis</i>)	Resident	X	X	X	X
Chipping Sparrow (<i>Spizella passerina</i>)	Winter	X	X	X	X
Brewer's Sparrow (<i>Spizella breweri</i>)	Transient	X	X	—	—
Lark Sparrow (<i>Chondestes grammacus</i>)	Resident	X	X	X	—
Bell's Sparrow (<i>Artemisiospiza belli</i>)	Resident	—	—	X	—
Savannah Sparrow (<i>Passerculus sandwichensis</i>)	Transient	X	X	X	—
Fox Sparrow (<i>Passerella iliaca</i>)	Winter	X	X	X	—
Song Sparrow (<i>Melospiza melodia</i>)	Resident	X	X	X	X
Lincoln's Sparrow (<i>Melospiza lincolni</i>)	Winter	X	X	X	—
White-throated Sparrow (<i>Zonotrichia albicollis</i>)	Winter	X	X	—	—
White-crowned Sparrow (<i>Zonotrichia leucophrys</i>)	Winter	X	X	X	X
Golden-crowned Sparrow (<i>Zonotrichia atricapilla</i>)	Winter	X	X	X	X

(continued)

TRENDS IN BIRD SPECIES RICHNESS IN THE MIDST OF DROUGHT

Table 1 (continued).

Species	Status	Bernard		Voorhis	
		Pre-drought	Drought	Pre-drought	Drought
Dark-eyed Junco (<i>Junco hyemalis</i>)	Winter	X	X	X	X
Yellow-breasted Chat (<i>Icteria virens</i>)	Summer	X	X	—	—
Western Meadowlark (<i>Sturnella neglecta</i>)	Resident	X	X	X	X
Hooded Oriole (<i>Icterus cucullatus</i>)	Summer	X	X	X	X
Bullock's Oriole (<i>Icterus bullockii</i>)	Summer	X	X	X	X
Red-winged Blackbird (<i>Agelaius phoeniceus</i>)	Resident	X	X	X	—
Brown-headed Cowbird (<i>Molothrus ater</i>)	Resident	X	X	X	X
Brewer's Blackbird (<i>Euphagus cyanocephalus</i>)	Resident	X	—	—	—
Great-tailed Grackle (<i>Quiscalus mexicanus</i>)	Resident	X	—	—	—
Orange-crowned Warbler (<i>Oreothlypis celata</i>)	Resident	X	X	X	—
Nashville Warbler (<i>Oreothlypis ruficapilla</i>)	Transient	X	X	—	—
MacGillivray's Warbler (<i>Geothlypis tolmiei</i>)	Transient	X	—	X	—
Common Yellowthroat (<i>Geothlypis trichas</i>)	Resident	X	X	—	—
Yellow Warbler (<i>Setophaga petechia</i>)	Summer	X	—	X	X
Yellow-rumped Warbler (<i>Setophaga coronata</i>)	Winter	X	X	X	X
Black-throated Gray Warbler (<i>Setophaga nigrescens</i>)	Transient	X	X	—	—
Townsend's Warbler (<i>Setophaga townsendi</i>)	Transient	X	—	X	—
Hermit Warbler (<i>Setophaga occidentalis</i>)	Transient	X	—	—	—
Wilson's Warbler (<i>Cardellina pusilla</i>)	Transient	X	X	X	X
Summer Tanager (<i>Piranga rubra</i>)	Transient	X	—	—	—
Western Tanager (<i>Piranga ludoviciana</i>)	Transient	X	X	X	X
Black-headed Grosbeak (<i>Pheucticus melanocephalus</i>)	Summer	X	X	X	X
Blue Grosbeak (<i>Passerina caerulea</i>)	Summer	—	X	—	—
Lazuli Bunting (<i>Passerina amoena</i>)	Summer	X	—	X	—

Table 2 *F* Statistics from Generalized Linear Mixed Models of Bird Species Richness from 1983 to 2003 at the Voorhis Ecological Reserve and from 2000 to 2014 at the Bernard Field Station, Los Angeles County, California^a

Response variable and site	Drought level	Season	Drought level × season
Degrees of freedom	6	1	6
Total richness			
Voorhis	1.346	5.322*	0.847
Bernard ^b	2.004	0.387	1.742
Richness of residents			
Voorhis	2.418*	0.124	1.468
Bernard	2.455*	9.125**	1.869
Richness of migrants			
Voorhis ^b	1.707	18.231***	0.477
Bernard ^b	2.055	10.865**	1.466
Richness of transients			
Voorhis	2.111	0.542	1.009
Bernard	1.057	0.238	0.955

^aLevels of significance: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; error df were 98 for the Voorhis Ecological Reserve and 121 for the Bernard Field Station.

^bData were log-transformed to improve normality.

DISCUSSION

At the Bernard Field Station, where during the drought the total number of species and the numbers of migrant species and of transients were greater than at the Voorhis Reserve, birds had access to a reliable water source. Drought may alter bird communities by depressing the availability of resources, and the effect of drought varies in different communities. Various studies have shown the negative effect drought has on bird occurrence (Faaborg 1982, Herremans 2004, Stracey 2010, Bennett et al. 2014). In a study based on Breeding Bird Survey data from the central U.S., Albright et al. (2010) found the most negative effects of drought in more arid regions, with species migrating to the tropics affected the most. They suggested that the decline of migrants during drought was due to migrants having the option to pass over unfavorable sites and select better locations, although this might vary with the availability and distance of such better habitat, the pull of site fidelity, which is often strong in long-distance migrants (Berthold 2001), and other factors. Both resident and migrant birds vary in how they react to changes in the environment. Some species are readily able to occupy new habitat under adverse conditions, while others are more heavily driven by site fidelity and return to the same locations year to year (Sedgwick 2004, Winter and Hargrove 2004, Barr et al. 2015). Albright et al. (2010) claimed that resident species in semiarid regions were affected less drastically, possibly because they are adapted to the environmental stresses characteristic of their habitats. Our results did not support these patterns.

During drought, we observed lower richness of resident species at both of our study sites. There are several possible explanations for this. It is possible that higher temperatures and less precipitation during drought

lead to a reduction in available resources, making productivity and survival more difficult (Bolger et al. 2005). Birds may also move to other parts of the landscape where water is artificially supplemented, although this may not be likely in the region we studied, as urbanized habitat is a barrier to dispersal of many resident birds of coastal sage scrub (Bolger et al. 1991). For species that are more dispersive or migratory, however, some examples of movement in response to drought are known in southern California. The two largest invasions of the White-breasted Nuthatch (*Sitta carolinensis*) in San Diego County outside of its breeding range occurred in 1961 and 2002, after the two of the driest years in that county's history (Unitt 2004). Migrating Lazuli Buntings (*Passerina amoena*), normally scarce in urban areas of coastal southern California, were common in the city of San Diego in spring 2006, after the very dry winter of 2005-06 (P. Unitt pers. comm.)

In the absence of suitable refugia, resident species may succumb because of increased mortality and/or reduced reproductive output over several years (Craig and Chapman 2003). During extended droughts, clutches of birds with access to supplemental water may not decline as steeply (Hudgens et al. 2009). Even at the Bernard Field Station, however, with its supplemental water source, the number of resident species declined somewhat during the drought, although the decline was greater at the Voorhis Reserve, which lacks supplemental water. Thus, the presence of supplemental water may help alleviate drought stress in resident birds (Crooks et al. 2004). Reductions in reproductive output and increased mortality during drought may also be due to a reduced food supply for birds (Bolger et al. 2005).

Reduced detectability is another possible explanation for the reduction in number of resident species during drought: as birds reduce reproductive behavior, they may become more cryptic and difficult to detect (Bolger et al. 2005). With the data available, we are not able to determine whether declines in species richness are due to decreased detectability, decreased abundance, or true presence or absence. Investigation of the exact mechanisms causing such reductions remains a subject for future study.

Decreased reproductive output during a drought presents another factor affecting population persistence. Extended droughts that depress reproductive output in several consecutive years may lead to population declines and push small isolated populations over the brink of extirpation. For example, coastal southern California was in either a "severe" or "extreme" drought from June 2012 to January 2017 (Palmer 1965, NOAA 2017). Drought and heat stress intensified by climate change contribute to the decline and extirpation of species (Cahill et al. 2012), as exemplified by a 16-year study of the Burrowing Owl (*Athene cunicularia*) near Albuquerque, New Mexico, which found a correlation between drought and delayed breeding, decreased mass of both adults and young, and a 98% decline of the population (Cruz-McDonnell and Wolf 2015).

The number of species of migrants at the Voorhis Reserve in drought and nondrought periods did not differ significantly, and at the Bernard Field Station the richness of migrant species increased during drought, possibly because of the availability of supplemental water. Regardless of the presence of drought, species richness of migrants was much higher at the Bernard Field Station (7.7 species per survey) than at the Voorhis Reserve (1.6

species per survey). We suggest these results could illustrate an influence of supplemental water, which may provide migrants refugia from drought.

The effects of climate change on southern California landscapes are leading to profound changes in native communities. Intensified drought means that resident bird species will need to either acclimate to these conditions or disperse to areas with more favorable habitat. Restoration and management, such as providing supplemental water, may be an important consideration for maintaining the diversity of bird species in some regions. Our study provides analyses of long-term data that demonstrate how bird communities respond to a changing environment over time.

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Common Ravens

Sketch by Teodelina Martelli

NOTES

RADIO TRACKING MOUNTAIN BLUEBIRDS VISITING NEIGHBORS' NESTS

ALISHA RITCHIE and MYRNA PEARMAN, Ellis Bird Farm, Box 5090, Lacombe, Alberta, T4L 1W7, Canada; ralisha2309@gmail.com, mpearman@ellisbirdfarm.ca

All three species of North American bluebirds are secondary cavity nesters that readily accept nest boxes. Typically, all three are socially monogamous, with a single male and a single female defending a territory against intruding conspecifics and alone raising their offspring (Guinan et al. 2008, Gowaty and Plissner 2015, Johnson and Dawson in press). Both parents provision nestlings for 17–22 days, and the young continue to rely on the parents for protection and food for several weeks post-fledging (Guinan et al. 2008, Gowaty and Plissner 2015, Johnson and Dawson in press). Pairs that raise a first brood early enough in the season usually make a second attempt (Guinan et al. 2008, Gowaty and Plissner 2015, Johnson and Dawson in press).

Visits to nests by individuals other than the breeding pair have been documented in all three species. In some cases, these visitors, often young males from a previous nesting, help rear offspring. Such “cooperative breeding” has been most widely documented in the Western Bluebird (*S. mexicana*), although helping behavior occurs in some populations but not others (Dickinson et al. 1996), perhaps because of a female-biased sex ratio resulting in local competition for mates (Guinan et al. 2008). Cooperative breeding is very rare in the Eastern Bluebird (*S. sialis*) and Mountain Bluebird (*S. currucoides*). In the former, there are a few reports of either juvenile helpers entering the nest cavity when adults are feeding later broods (Pinkowski 1975) or adult helpers, usually the second-year son of current breeders, irregularly helping feed young (Pinkowski 1976).

There are three published accounts of cooperative breeding in the Mountain Bluebird (Johnson and Dawson in press). In two cases, juveniles from the parents' first brood of the season were suspected of helping feed the parents' second brood (Mills 1931, Johnson and Dawson in press). In the third case, two pairs of adults attended a single nest. Both females fed the young, as did one male who also repeatedly chased the other male away (Cannings et al. 1987).

In other species of secondary cavity nesters, such as the Common Goldeneye (*Bucephala clangula*), Collared Flycatcher (*Ficedula albicollis*), and Tree Swallow (*Tachycineta bicolor*), cases of conspecific visitation at active nests have been described as individuals prospecting for future nesting sites (Reed et al. 1999). Prospecting is thought to allow a bird to assess the habitat's quality so it can select an optimal territory and nest site for the following breeding season (Doligez et al. 1999, 2004a, b, Reed et al. 1999, Kivela et al. 2014). Competition among secondary cavity nesters for limited nest sites may also drive prospecting behavior (Brawn 1984, Lombardo 1987). Juvenile Western Bluebirds have been observed to defend inactive nest boxes adjacent to their natal nest box, perching on or near the box but not roosting in it (Brawn 1984).

Instances of conspecific nest visitation, be it the result of rare cooperative breeding, prospecting for the future, or for some other reason, are undoubtedly underreported because documenting such behavior requires that marked breeding pairs be monitored nearly continuously. We describe here two instances of conspecific nest visitation in the Mountain Bluebird documented by means of radio frequency identification (RFID) technology during a study of parental provisioning behavior.

Our study took place near Lacombe, central Alberta, Canada (52° 28' 06" N, 113° 44' 13" W, elevation 855 m above sea level). Since 1982, the staff of Ellis Bird

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Farm have monitored bluebird boxes located in habitat appropriate for the Mountain Bluebird within an area (a “management area”) of approximately 250 km² (16 × 16 km). Since our monitoring of the Mountain Bluebird at Ellis Bird Farm began in 1982, we had observed no instances of a Mountain Bluebird visiting a neighbor’s nest until we began deploying RFIDs in 2018.

RFID technology entails the use of a passive integrated transponder (PIT) tag and a receiving antenna. Each PIT tag contains a unique 15-digit identification number, which is logged along with the time and date (called an “event”) by the antenna each time the tag comes within range of the antenna (approximately 2 cm). In our study we equipped nest boxes with an antenna and Mountain Bluebirds with PIT tags. Thus the antenna logged an event each time a bird entered, exited, or perched at the nest box’s entrance. Since both entrances and exits log an event, and long strings of events are logged when a bird is perched at the entrance, we counted all events logged within a one-minute period as one “visit.” To attach PIT tags, we 3-D printed plastic leg bands each with a compartment for a PIT tag 8 mm long (Figure 1). A circular antenna, also generated by a 3-D printer and painted the same color as the nest box, was secured to the front of the nest box around the entrance (Figure 2). The unit was powered by a 12-volt battery.

In 2018, we set up RFID units at 11 nest boxes located within a 70-km² (8.5 × 8.5 km) portion of the management area (Figure 3). We monitored eight first nest attempts and five second and/or late nest attempts at these boxes. At two nest boxes, both the first and second nesting were monitored. Nest boxes with RFID units were an average 5.1 km apart (range 268 m to 9.7 km). Where feasible, both sexes at these boxes were banded with PIT tags, although at some nests only the female was banded because the male was either not present or would not enter the trap-set nest box. We banded a total of 20 adult birds with PIT tags. All 48 nestlings at boxes

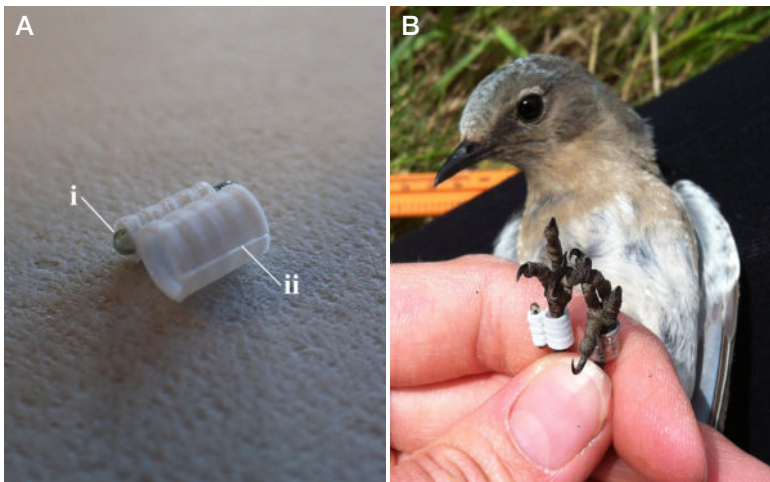


Figure 1. Radio-frequency identification (RFID) used in our study of the Mountain Bluebird. (A) Close-up of 3-D-printed color leg band showing (i) the passive integrated transponder (PIT) inserted and (ii) the slit allowing for banding with a plastic-color-band spreader. (B) White leg band with the RFID placed on the right tarsus of a female Mountain Bluebird.

Photos by Myrna Pearman (A) and Alisha Ritchie (B)

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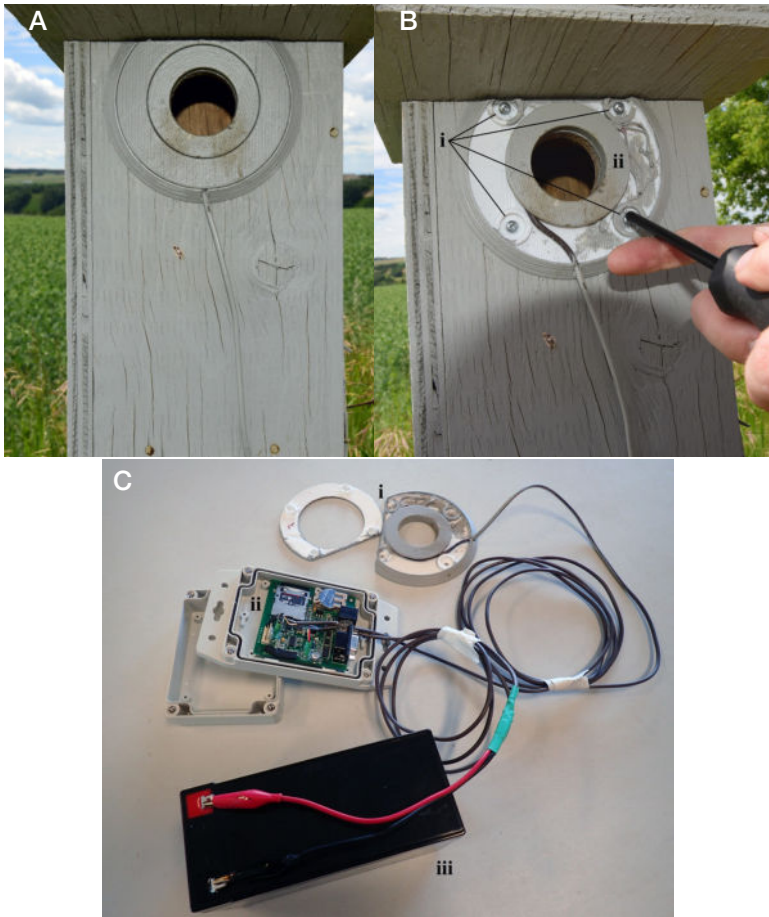


Figure 2. (A) 3-D-printed antenna case at entrance of nest box with clip-on cap in place, and (B) removed to show (i) the screws used to secure the antenna to the nest box and (ii) the spool around which copper wire was wound to form the antenna. (C) All components needed for the RFID to function, including (i) the antenna in a 3-D-printed case, (ii) the RFID logger with Secure Digital (SD) card for memory storage in a water-tight case, and (iii) the 12-volt battery to power the system.

Photos by Myrna Pearman

monitored were banded with a PIT tag when they were 8–16 days old, and all but one of the banded nestlings successfully fledged.

The RFIDs recorded two instances of males visiting the next nearest neighboring box with an active Mountain Bluebird nest. These two cases involved visitation between the two closest pairs of nest boxes (146–145 and 10.78–16.03, Figure 3) in the study area, which were located <300 m apart. The next closest pair of active nest boxes (125–148, Figure 3) were 390 m apart, but the nest in one of those boxes

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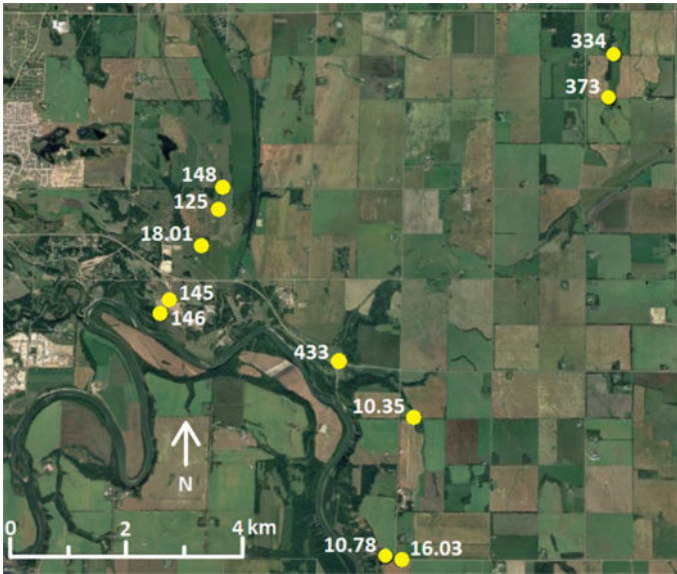


Figure 3. Study area at Ellis Bird Farm, Lacombe, Alberta. Yellow circles, locations of all nest boxes monitored with RFID units within the management area of nest boxes monitored by Ellis Bird Farm. Numbers next to each point represent the nest box's identification number.

failed when the nestlings were six days old. The next closest pair of boxes (373–334, Figure 3) both of which had successful nests were located 812 m apart.

In the first instance, a second-year male (V2M), which was provisioning a second or late brood in a nest box he controlled, visited a neighboring nest box 287 m away on three separate days, 28 June, 29 June, and 16 July 2018, when nestlings at the neighboring nest were zero (hatch day), one, and 18 days old, respectively. No male was observed at the neighboring nest throughout the nestling period. A male was seen multiple times at this nest up until June 14 but was not seen when the nest was rechecked on June 22 or any time thereafter, including extended (>30 min) monitoring after nestlings had hatched. We cannot rule out polygyny because we did not observe a male at each of these nest boxes on the same day.

On 28 June, V2M made a total of 38 visits between 10:19 and 20:31. It is not known whether V2M simply perched at the entrance or entered the box. He made no visits to his own nest that day, even though his own nestlings were four days old. On 29 June, V2M made six visits between 05:45 and 07:14, during which time he again made no visits to his own nest. At 8:30, he returned to his own nest and subsequently made 83 visits until his last activity at 22:31. On 16 July 2018, the day after the nestlings at his own nest fledged, he made a single visit to the neighboring nest at 14:02. At the time of V2M's first visit to the neighboring nest, the resident female made a visit six seconds before and seven seconds after V2M's visit. After that, however, only 10.9% of the visits by V2M and the resident female were within the same minute. All hatched young were observed in the nest after V2M's last visit on 29 June. On 9 July, however, when we banded them, only five of the seven nestlings remained, and subsequently fledged.

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In the second instance, a juvenile fledged from a first brood (VJM) made a single visit to a neighboring box 267 m away, which contained 18-day-old nestlings. The visit was at 7:28 on 1 August 2018. The resident male at that nest made a visit 68 minutes before and 44 minutes after VJM's activity and thus may never have seen VJM. The resident female of the nest made a visit 15 minutes before and 23 seconds after VJM's visit, which is possibly why there was only a single visit. We do not know, however, if the female had any interaction with the juvenile male.

Our results indicate that Mountain Bluebirds of different ages do visit the territories and nest cavities occupied by other individuals. Because the technology used in this study records only the presence/absence of individuals at a nest site, we do not know the behaviors of the two bluebirds during their visits to the two nests and so cannot infer the visits' purpose. However, given the number of visits, the length of time over which visits were made, and that there was no activity by V2M at his own nest even though it contained nestlings, it is possible that V2M may have provided the young in the visited box with some kind of parental care, such as feeding them. Since extra-pair mating is common in the Mountain Bluebird (O'Brien and Dawson 2011, Johnson and Dawson in press), it is possible that V2M fathered one or more of the nestlings in the box visited. The possibility that V2M was providing parental care at the nest of an extra-pair mate is intriguing because males feeding young of extra-pair mates has rarely, if ever, been documented in bluebirds, potentially because cuckolded males are usually present to drive off the extra-pair father. In this case, however, the resident male had disappeared. Experiments in which resident males are held temporarily in captivity while the response of nearby males is observed could be enlightening, especially if combined with paternity analyses. Another possibility is that this male entered the neighboring territory to seek extra-pair copulations or some other purpose and, when encountering nestlings, was stimulated to provision them instead of those in his own nest, at least for a time.

The single visit by the recent fledgling (VJM), may have involved prospecting behavior, although this male was not detected at other nests in the area (the next nearest nest with an RFID was 2.4 km away from his natal nest box). After fledging, juvenile Western Bluebirds from first broods have been observed to defend boxes near their natal nest box (Brawn 1984). An attempt at such defense could account for VJM visiting the nest box nearest his natal box. But finding it occupied he was unable to defend it and moved on. Alternatively, some fledglings appear to leave their natal territories, whether voluntarily or after being driven away by their parents (Power and Lombardo 1996), to join other bluebirds in post-breeding flocks. VJM may have begun searching for a post-breeding flock and was attracted to the begging activity at the nearby nest.

In conclusion, we documented for the first time that Mountain Bluebirds visit neighboring nest cavities controlled by other individuals. Because the sample of nests and individuals that were monitored was small, yet we documented two examples of such visitation, it is likely part of this species' behavioral repertoire. Further examination of this behavior in the Mountain Bluebird is warranted to determine how routine it is in the species, how its frequency varies by sex and age, and its function.

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VIDEO SURVEILLANCE OF NESTING CLAY-COLORED THRUSHES IN SOUTH TEXAS

JORDAN C. GIESE, JARED D. HALL, and HEATHER A. MATHEWSON, Department of Wildlife, Sustainability, and Ecosystem Sciences, Tarleton State University, Box T-0050, Stephenville, Texas 76402; jgiese@iastate.edu

Along the lower Rio Grande in Texas, an estimated 95% of native vegetation has been destroyed through urban and agricultural expansion, leaving only isolated remnants of once continuous woodland (Jahrsdoerfer and Leslie 1988). Although some bird species have declined because of habitat loss and alteration, other species have increased. In recent decades, the Clay-colored Thrush (*Turdus grayi*) has expanded its range north into south Texas and is now considered common in the lower Rio Grande valley (Brush and Conway 2012), a subtropical region comprising the state's four southernmost counties.

The increase of the Clay-colored Thrush in the lower Rio Grande valley coincides with the increasing urbanization of the region. From 1993 to 2003, urbanization of Cameron, Hidalgo, and Willacy counties increased by an average of 46% (Huang and Fipps 2011). Brush (2000) hypothesized that the continued growth of urban vegetation provides the Clay-colored Thrush with more suitable nesting sites. Major cities to the north, such as Corpus Christi and San Antonio, seem to provide vegetation suitable for breeding as well, but it is unclear if food resources and winter climate will allow colonization (Brush and Conway 2012). By the early 2000s, the Clay-colored Thrush had already expanded upriver to Laredo, Webb County (Brush and Conway 2012). Despite the increase in south Texas, little research has been devoted to the species' nesting ecology where it has already become established.

During the summer of 2016, we studied the nest ecology, survival, and longevity of the White-tipped Dove (*Leptotila verreauxi*) at Estero Llano Grande State Park, Hidalgo County, Texas (Giese 2016, Giese et al. 2018). While searching for dove nests, we located a Clay-colored Thrush nest, cued by the adults' behavior. Estero Llano Grande is a 97-hectare publically accessible park located roughly 7 km north of the Rio Grande. The park is made up of restored wetlands, shrublands, and remnant woodlands.

The thrush nest was positioned 4.2 m above the ground in a live oak (*Quercus virginiana*). Upon locating the nest, we deployed a camera system similar to that described by Cox et al. (2012) to monitor parental behavior. Our camera system comprised a continuously recording infrared-emitting camera and digital video recorder, powered by a 12-volt marine battery housed in a plastic tote. We changed the secure digital (SD) card in the camera system every 2 or 3 days and checked the camera's position by means of a video monitor with a liquid-crystal display.

After retrieving the SD cards, we transferred the video recordings to an external hard drive for later viewing in Microsoft Windows Media Player. Once nest monitoring was complete, we watched all the video to quantify parental behavior. We developed a time budget for the nest and recorded the time each parent took a recess, the amount of time elapsed during a recess, feeding of the nestlings, and disturbances. We distinguished between the sexes by differences in behavior and parental responsibilities.

We monitored the nest from 4 July to 12 July 2016 and obtained 189 hours of video. Monitoring began with three eggs in the nest and terminated after predation by Tawny Crazy Ants (*Nylanderia fulva*) following the hatching of the second egg.

As found by Sanchez et al. (2018), both adults contributed to parental care. During incubation, the nest was attended primarily by the presumed female (Figure 1A), while the presumed male was often observed near the nest to defend it from predators. Incubation was fairly consistent as the female incubated throughout the night and

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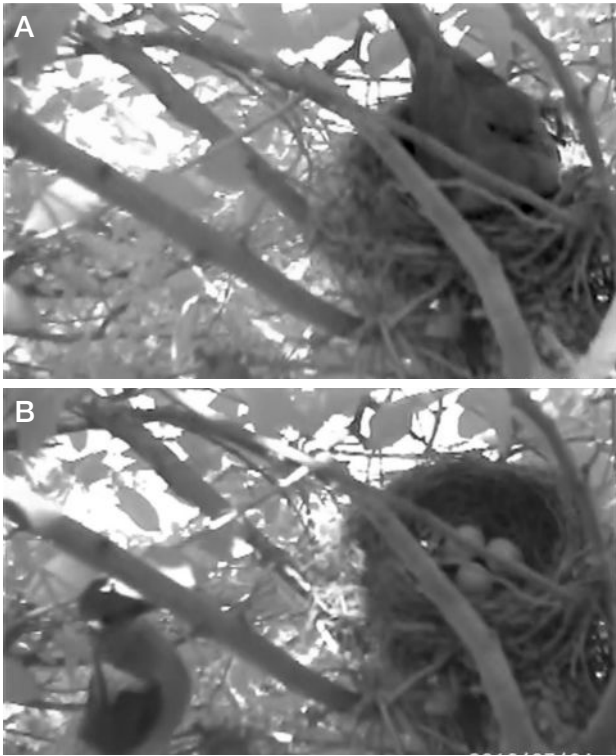


Figure 1. (A) Presumed female Clay-colored Thrush incubating eggs at nest in Estero Llano Grande State Park on 4 July 2016. (B) Presumed male perching near the nest on 4 July 2016.

Photos from continuously running video recorder

awaited arrival of the male before taking a recess. Those recesses occurred on average every 40.32 min (SD [standard deviation] = 11.42 min, $n = 76$) and lasted 6.91 min (SD = 2.67 min, $n = 76$). The female's recesses typically began each morning at dawn (~06:30 Central Standard Time) upon the arrival of the male, although we documented recesses beginning as early as 03:35. Her recesses continued intermittently until dusk (~20:30), when she returned to incubate for the night.

Following hatching of the first egg, the female carried off all shell fragments. She then made foraging flights at intervals similar to those observed during incubation. After hatching, the female took recesses every 41.70 min (SD = 10.18 min, $n = 21$) for an average 6.32 min (SD = 1.51 min, $n = 21$). The male augmented nestling feeding by delivering the brooding female unidentified insects, which she then fed to the nestling. During the female's longer recesses, the male perched on the rim of the nest until she returned (Figure 1B), occasionally feeding the nestling. Upon pipping of the second egg, Tawny Crazy Ants infested the nest and preyed on the pipping egg and on the previously hatched nestling. Shortly after the ants' predation, the parents departed, returned the next morning, and carried away the remaining intact egg.

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In addition to food items parent thrushes brought to the nest, they also ingested unidentified prey items opportunistically as they entered the vicinity of nest. We could identify prey only superficially, as spiders, mosquitoes, and gnats. Although this nest failed, the Clay-colored Thrush is expected to continue to increase in south Texas as urbanization continues. Our observations of parental care in the Clay-colored Thrush are similar to those reported by Sanchez et al. (2018), but our use of video surveillance allowed for more thorough inspection of parental care at a single nest as well as the positive identification of a nest predator.

We made these observations during research supported by Texas Parks & Wildlife and Tarleton State University. We thank Estero Llano Grande State Park for kindly hosting our research. Kelton Mote and Daniel “Chuck” Wilcox provided field assistance.

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FOOD PROVISIONING, PREY COMPOSITION, AND NESTING SUCCESS OF OSPREYS IN NORTHWESTERN CALIFORNIA

MICHAEL ACADEMIA, Humboldt State University, One Harpst Street, Arcata, California 95521; mha23@humboldt.edu

The Osprey (*Pandion haliaetus*), with a nearly worldwide breeding distribution and a tolerance for both fresh and salt water, feeds almost exclusively (99+%) on fish (Grove et al. 2009). The availability of prey is an important factor influencing its productivity (Van Daele and Van Daele 1982, Harmata et al. 2007). Time spent on foraging is a function of prey availability, and success in breeding may be related to food provisioning (Dykstra 1995) as well as the food supply (Croxall et al. 1988). Under favorable conditions, provisioning rates are elevated, and birds fully meet their own energetic requirements and those of their chicks (Cairns 1987, Weimerskirch 1998). Proximate causes of nest failure include bad weather, avian and nonavian competitors, and predation, as well as insufficient care by inexperienced parents. If the weather is bad, the adults may be unable to forage (Hudson 1985). However, the ultimate cause of nest failure may often be food shortage (Steenhof and Newton 2007); for example, a female unable to provision her chicks abandons her brood, which is then vulnerable to predation.

Identification of prey is a foundational element of animal ecology (Errington 1935), and, for raptors, the types of prey and their distribution can affect population shifts (Newton 1979). Hence an understanding of diet is fundamental for the successful management and conservation of these birds (Giovanni et al. 2007). Here I report on the composition of the prey of Ospreys nesting along the coast of northwestern California and measure the relationship between nesting success and food-provisioning rates.

From 15 May through 15 August 2018, I spent 145.63 hours observing six nests along the coast of Humboldt and Del Norte counties (to quantify rates of provisioning and fledging; Figure 1) and 119.75 hours at the mouth of the Klamath River (to observe foraging). Ospreys were observed by means of a Barska 30–90 × 90 Waterproof Colorado Spotter spotting scope and Wingspan Optics Nature Pro HD 8 × 42 binoculars. I used a Panasonic Lumix DMC-FZ300K digital camera to photograph prey. With the assistance of Andrew Kinziger of Humboldt State University's Fisheries Program, I identified each fish to the lowest taxonomic level possible (at least to family).

I defined successful foraging as a male Osprey returning to the nest with prey and successful provisioning as delivery of that prey to the female and chicks. Other behaviors noted included failed attempts at foraging, defense against predators, territorial defense, perching, preening, resting, nest refurbishment, incubating, and abandonment (neither adult present).

I calculated nest success and productivity by the method of Steenhof and Newton (2007). Nest success is the proportion of nesting pairs that raise young to the age of fledging, on the basis of well-grown offspring observed in the nest at some point before fledging. I divided the number of successful nests by the total number of active nests observed. Productivity is calculated per territorial pair as the number of young produced that reach the minimum age acceptable for assessing success (Steenhof and Newton 2007). Therefore, I divided the number of fledglings by the total number of active nests observed.

I compared the time allocated to provisioning and other activities between successful and failed nests, and calculated the standard deviation of this difference. With RStudio 3.5.2, I used a Pearson's chi-squared analysis with Yate's continuity contingent to determine if there was a significant difference between provisioning of successful versus failed nests.

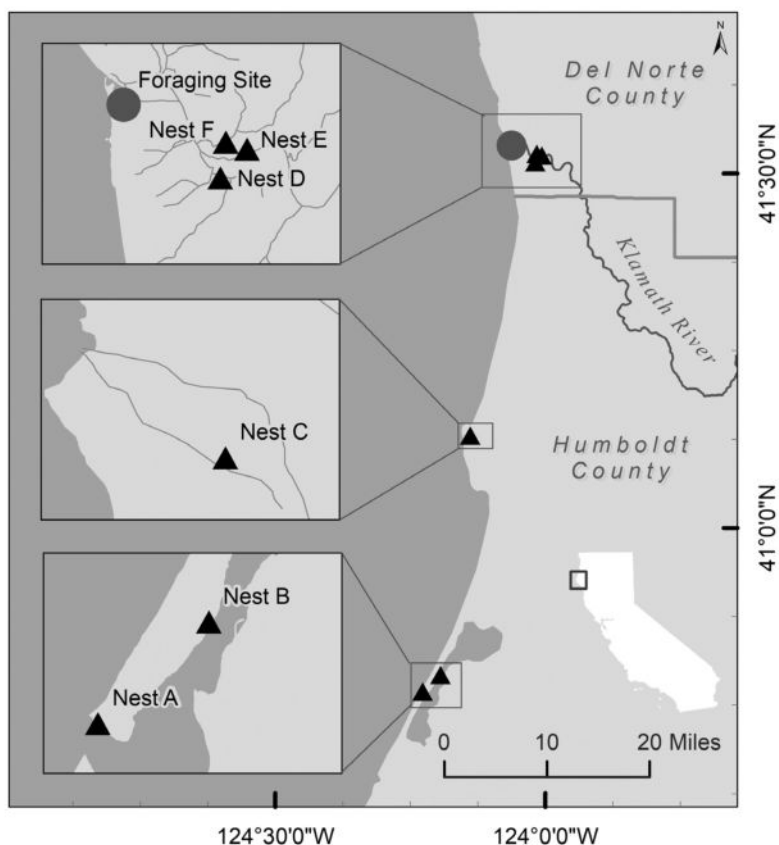


Figure 1. Location of the six Osprey nests monitored and the mouth of the Klamath River, site of observations of Osprey foraging, in Humboldt and Del Norte counties, northwestern California.

Table 1 Prey of Ospreys Observed in Humboldt and Del Norte Counties, California

Prey species	Number of prey items	Percent of total
American shad, <i>Alosa sapidissima</i>	105	20.4
Jacksmelt, <i>Atherinopsis californiensis</i>	19	3.7
Pacific lamprey, <i>Entosphenus tridentatus</i>	50	9.7
Salmon and trout, Salmonidae	130	25.3
Sculpins, Cottoidea	7	1.4
Smelt, Osmeridae	35	6.8
Starry flounder, <i>Platichthys stellatus</i>	4	0.8
Surfperch, Embiotocidae	52	10.1
Unknown	112	21.8
Total	514	

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Table 2 Time Spent in Provisioning and Other Activities by Ospreys Monitored in Humboldt and Del Norte Counties, California

Breeding status	Activity (minutes)		Total
	Provisioning ^a	Other ^b	
Successful	3756	2258	6014
Failed	618	2465	3083
Total	4374	4723	9097

^aSuccessful foraging and prey consumption by adults and young.
^bFailed attempts at foraging, perching, preening, resting, defense, incubating, nest refurbishing, and abandonment (neither adult present).

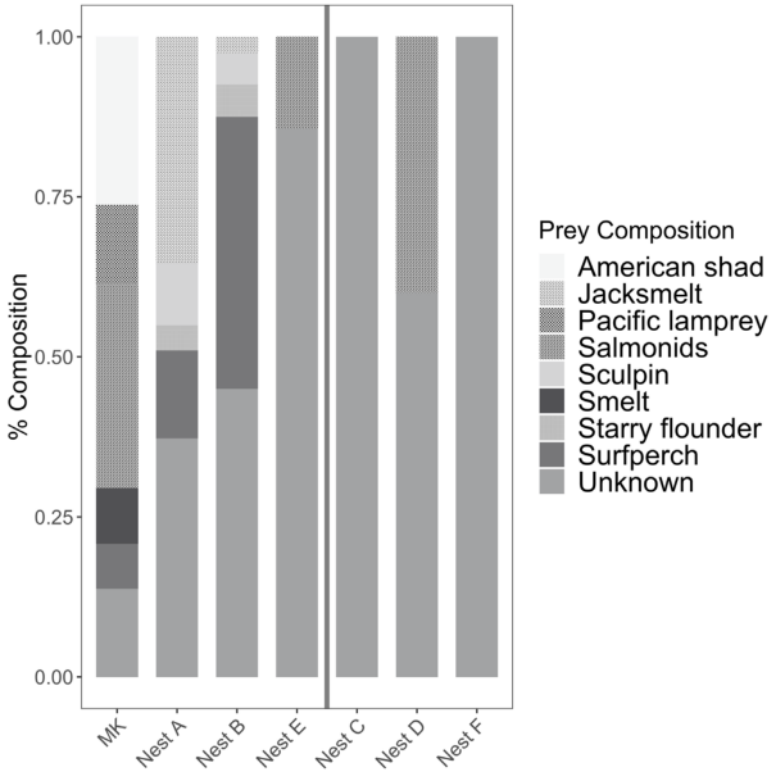


Figure 2. Percent composition of the prey of Ospreys foraging at the mouth of the Klamath River (MK) and brought to six nests in Humboldt and Del Norte counties, California. Nest A fledged two young, nest B three, and nest E one. Nests C, D, and F failed.

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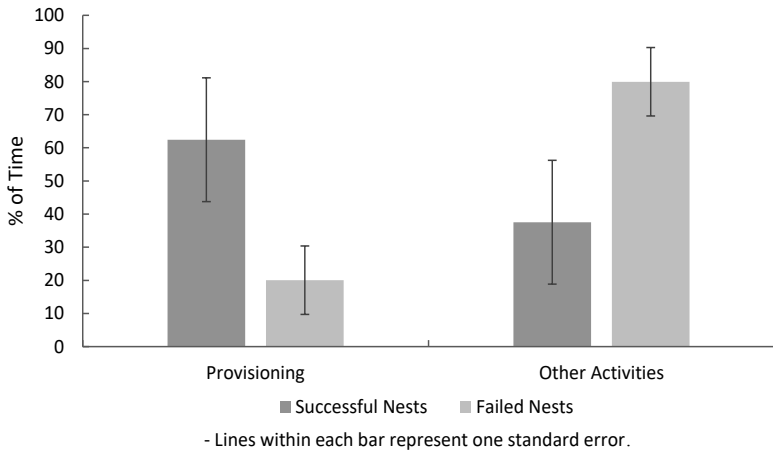


Figure 3. Percentage of time that Ospreys devoted to provisioning and to other activities at three successful nests (SD = 18.7) and three failed nests (SD = 10.3). Lines within each bar represent one standard error.

The identified prey consisted primarily of the non-native American shad (*Alosa sapidissima*), salmon and trout (Salmonidae), Pacific lamprey (*Entosphenus tridentatus*), surfperch (Embiotocidae), and jacksnelt (*Atherinopsis californiensis*; Table 1, Figure 2). The time spent provisioning was greater at successful nests than at failed nests ($\chi^2 = 1466.7$, $df = 1$, $p < 0.001$; Table 2, Figure 3). Three of the six nests fledged young (50% nesting success), and productivity was 0.83 young per active nest.

At successful nests, Ospreys spent more time on successful food provisioning, while those at failed nests spent more time on other activities, such as defense against predators, perching, and preening (Figure 4). According to Pearson's chi-squared test, the difference was strongly significant, suggesting that a nest's success is associated with greater success in foraging and higher rates of provisioning ($p < 0.001$; Table 2). For maintenance of a stable Osprey population, long-term productivity must average 0.95–1.30 young per active nest (Henny and Wight 1969, Henny 1977), so the pairs I monitored may have had a poor year in 2018, in spite of the Osprey's recent trend of vigorous population increase (Sauer et al. 2017).

In evaluating the expansion of forage fisheries, managers may use data on prey composition. My study may inform ecosystem-based fisheries management, a holistic management approach that considers trophic interactions (NMFS 2016). In the Klamath River, the proliferation of a dominant prey species, the non-native American shad, introduced from 1871 to 1881, could have implications for native salmonids. It is uncertain if the shad is a harmful invasive species or a benign introduction (Hasselman et al. 2012), as interactions between it and native salmonids have not been studied (Brown and Sax 2007).

Special thanks to Darren Ward, Andre Buccheister, Jose Marin Jarrin, Andrew Kinziger, and Desiree Early of Green Diamond Corporation, who granted me access to private property, to Kenneth Burton and Chet Ogen for nest locations, to Melissa Collin for the study area map, to Max Blasdel for the prey-composition figures, and to Benjamin P. Skillman for the RStudio analysis. Thanks to Daniel Cooper, Ryan Terrill, and an anonymous reviewer for improvements to the initial version.

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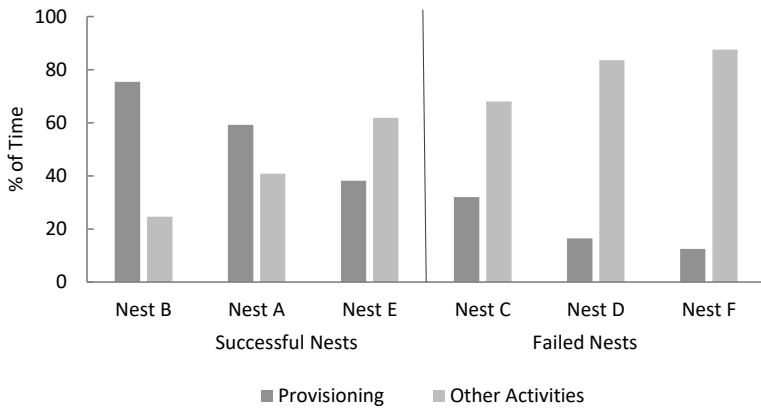


Figure 4. Percentage of time Ospreys devoted to provisioning and to other activities at the six nests monitored in Humboldt and Del Norte counties, California. Nest B fledged three young, nest A two, and nest E one. Nests C, D, and F failed.

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Field Guide to Bird Sounds of Western North America, by Nathan Pieplow. 2019. Houghton Mifflin Harcourt. 633 pp. Many drawings, photos, figures, spectrograms. Recordings and spectrograms of all the sounds also available as supplemental material at www.petersonbirdsounds.com. Paperback, \$28.00. ISBN 978-0-547-90557-0.

Like many of you, I have bookshelves overflowing with all sorts of bird books—to the point where I have adopted a personal policy of buying a new one only if it replaces one I have, or if it represents a unique contribution. When Nathan Pieplow's earlier eastern version of this guide appeared, there was no question that it met the second requirement. That book sits within arm's reach of my desk. Living in the West, however, I have been eagerly awaiting the completion of the set with the publication of a western version.

Pieplow has created the first comprehensive publication covering the sounds made by North America's birds. But that does not represent his most valuable contribution. That lies in the introductory material. In those sections he gives us a systematic way to listen to bird sounds, to describe them, to remember them, and to communicate with others about them. Most of us distinguish the trilled songs of the Chipping Sparrow and Dark-eyed Junco by the junco's song having a ringing, more musical quality than the somewhat mechanical sound of the chippie. But Pieplow shows us what those subjective descriptions mean in objective, visible terms. That sort of information can be applied to a variety of comparisons of similar songs and calls. He gives us five basic and easily remembered ways to describe a single note's pitch pattern. This not only makes it easier to recognize notes, it allows us to explain to others what to listen

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for when learning a new bird sound. Using simple stylized spectrograms, he shows exactly why we call some sounds whistles, others ticks, or others buzzes. Why does that nuthatch call sound nasal? What produces the ethereal sounds of many thrush songs? All of this is demystified in a few easily digested pages.

Of course, most of us rely on mnemonics based on human speech to represent, learn, and remember bird sounds. These can be highly personal (I think our Audubon's Yellow-rumped Warblers say "chimp," but no one else seems to hear it that way...). Here again, Pieplow removes much of the subjectivity by showing exactly why one bird's call is a "peep" while another's is a "keek." This takes away much of the personal variation and gets us closer to having a common language for many of these sounds. Pieplow also provides a more systematic way of characterizing songs into types such as warbles, trills, series, and phrases. This way of describing a song can be readily grasped: Horned Lark songs start with a few distinct phrases and proceed into a warble; the Black-chinned Sparrow's song begins as a series of musical notes, accelerates into a trill and then into an unmusical buzz.

The effort that must have been expended to compile and organize all the information in the species accounts is simply mind-boggling. Terms such as "comprehensive" or "exhaustive" seem almost inadequate. The Savannah Sparrow account is typical of how each species is treated. It includes spectrograms and verbal descriptions of the most common song types with information about repertoire size, regional variation, time of year heard, and similar songs. Examples of six different calls include the common thin, high-pitched call ("tsew"), a metallic "tink," and that flat "chip" I have sometimes mistaken for a junco call. He also includes three more unusual calls associated with specific behaviors (whine series: "By both sexes in same-sex aggression, or in response to predators"). I challenge even the most devoted student of bird song to NOT learn something new in almost every account. At the top of each page is a color drawing of the species with a small range map and a short description of typical habitat. While this repeats information available from many other sources, it may be helpful to someone trying to determine if the sound they heard might be from that species.

My main criticism of the book, the lack of a bibliography of sources, stems directly from the very thoroughness of the species accounts. It is clear that Pieplow has scoured the published literature on North American bird song like no one before him. Therefore, it would great if most of those sources were cited. I understand why a publication intended for a general audience precludes citations within the text. However, a bibliography of sources organized by family would have been a useful addition.

The color-coded "Index to Bird Sounds" at the back of the book, coupled with a summary of terms on the inside back cover, is Pieplow's ambitious attempt to create something akin to a botanical identification key. That is, a method for identifying an unknown sound by working from a given note or song type down to the candidate species. I suspect most users will find this a bit cumbersome. In most cases, the source of an unidentified sound can be narrowed down to a short list on the basis of habitat, time of year, and qualities of the sound. Also, as with any identification key, if you don't start with the correct category of sound type, you will never get to the correct answer.

These very minor concerns aside, whether you are just beginning to learn or are hoping to improve your knowledge of and ability to communicate about bird song, you need to make room on your shelves for this book—preferably just above your desk.

Edward R. Pandolfino

Birds of Prey of the West: A Field Guide, by Brian K. Wheeler. 2018. Princeton University Press. 360 pp., 175 illustrations, 58 maps, numerous habitat photographs. Flexibound, \$27.95. ISBN 978-0-691-11718-8.

Raptors can be a challenge to identify, particularly because of their variability, but with practice it becomes easier and clearer. Numerous identification guides are

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available for the raptor enthusiast, hawk watcher, or biologist to use in the field, as a reference on a library shelf, or now as an app on a smart phone. The new *Birds of Prey of the West* is a complement and update to Wheeler's 2003 book *Raptors of Western North America*, now out of print (reviewed by David Lukas in *Western Birds* 34:252–253, 2003). At first glance, this new version has the feeling of a standard field guide, but deeper reading reveals that this is a field guide for the advanced raptor enthusiast.

In the introduction, Wheeler outlines the book's scope, format, and the color scheme of the plates, and provides terminology for raptor anatomy and plumage. His discussion of recent genetic studies informing our understanding of avian taxonomy is what stands out in the introduction and makes this section a must-read. He notes, "it is difficult to dispute multiple DNA studies that have arrived at the same conclusion" (p. 17). The introduction also provides a discussion of age classification and molt stages, the latter in layperson's terminology. For readers interested in how to age raptors more precisely, the figure on page 49, "In-Flight Field-Visible Wing and Tail Molt" will be helpful. *Raptors of Western North America* also describes these molt patterns, but *Birds of Prey of the West* provides supplemental data in picture form by showing waves of molt. Wheeler worked with Peter Pyle to develop several plates and ensure accuracy in depiction of molt sequences. In the illustrations directional arrows from molt centers allow the reader to follow along with a description as complicated as "there are 2 molt centers and 3 molt units. The 1st molt center is on the mid wing, at s5" (*Falconiformes*, secondary molt, p. 45; illustration, p. 49). This series of illustrations, which covers seven species, is much more informative to the visual learners than a simple list of locations of molt of the primaries and secondaries.

Species accounts begin with the common name listed in the top left corner, making it easy for the reader to flip quickly through the book for the raptor of choice. Each page has a plate number, common and scientific names, and age as the header, above information on age classification, color morphs, size, habits, food, flight, and voice. This is all opposite of the illustrations, saving the reader from flipping back and forth to a separate plate section. After the plates, an account of natural history describes each species' habitat, status, nesting, and movements, and compares it to similar-looking species.

Wheeler admits to reusing some of the range maps from *Raptors of Western North America*, but the maps in this latest version are larger and updated. They include irregular sightings but not migration routes. If they had, the maps for the long-distance migrants might have ended up at a much larger scale. Migration is discussed briefly under the "Movements," adjacent to the range maps. A person reading the section on movements and looking at the range map but unfamiliar with western raptors could conclude the Broad-winged Hawk to be a rarity in the West, but raptor-migration sites in the West do count Broad-wings during the fall, sometimes in good numbers. For example, the icon indicating that the Broad-winged Hawk is irregular in the San Francisco Bay Area is misleading because a few hundred Broad-wings pass through every fall. On the plus side, the photographs of a species' typical habitat are a great addition because it is handy to visualize where the bird can be found. All the information provided is extremely thorough, though the font is small, which might make it hard to read in low light.

Field guides can be photographic or illustrated, and both approaches have their pros and cons. I agree with Wheeler that "illustrated guides make for a far better education tool." Completing such illustrations, however, can be a lengthy process: Wheeler spent 13 years working on this comprehensive illustrated field guide. In a photograph, "field marks are easily masked by irregular lighting or distorted angles of view" (p. 11). Nevertheless, photographic guides, if put together properly, can be valuable as well. For example, Jerry Liguori's *Hawks from Every Angle: How to Identify Raptors in Flight* (reviewed by Steve Howell in *Western Birds* 37:58–59,

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2006) and *Hawks from a Distance: Identification of Migrant Raptors* use photographs to depict raptors in various situations and angles of lighting.

Birds of Prey of the West is a beautifully illustrated field guide and includes all the age, sex, and color-morph plumage characteristics a raptor fanatic will want and more. The time Wheeler spent on developing this book shows, and for its purpose the choice of illustrations over photographs is the correct one. The paintings show characteristics that could be missed in a photograph. Wheeler based his illustrations on museum specimens, allowing for a level of detail impossible with photographs. Having worked up close with raptors for about two decades, I was impressed by depiction of details I have noticed only with a bird in hand, not in flight. One characteristic that confused me, however, is the “spot” on the back of the head or nape in the illustrations of the Rough-legged Hawk, plates 42 and 43. It isn’t as prominent as the illustration suggests.

The preface provides the reader with a look into Wheeler’s artistic background and enriches the experience of viewing the illustrations. Wheeler drew and painted all the plates, which are visually stunning and impressively detailed. There are many beautiful illustrations, but the plates that stand out to me are on molt of birds in flight on page 49, the kestrels on plate 60, and the three subspecies of the Merlin on plates 61, 62, and 63. To make it easier to compare similar species, the figures are drawn with the bird posed in the same positions. Birds are illustrated perched positions and in four positions in flight. Illustrations of each species are arranged from youngest to oldest. Subspecies are placed on separate plates. Close-ups of heads and tails are presented in either dorsal or ventral views. Some plates have illustrations of specific feathers, for example, a secondary of the Broad-winged Hawk, a breast feather of a juvenile Red-shouldered Hawk, or the undertail coverts of a Cooper’s Hawk as flared in courtship. These are small details but stand out as an example of this field guide’s dedication to detail.

The amount of detail in each illustration is amazing—you can tell that Wheeler has been drawing, painting, and studying birds his entire life and enjoys it. The illustrations of the California Condor on plates 4 and 5 are of specific individuals, including their wing tag, and specify the date of hatching and the year photographed. Plate 12, on the Sharp-shinned Hawk, includes a variety of ventral tail figures, showing the differences between the tails of the male (more squared) and female (more rounded), which could aid the reader in understanding why you can’t always rely on a square-shaped tail to tell a female Sharp-shinned Hawk from a male Cooper’s Hawk. The white tips of the tail, which might otherwise be lost on a white background, show up nicely against the neutrally colored background. In contrast to the practice in many field guides, Wheeler places species on backgrounds of rich blue, orange-tan, brown, blue-gray, blue-green, and green, to “allow for an easy-on-the-eyes natural-world viewing scenario” and to accentuate some of the white tips of the wing and tail feathers. I think this color scheme represents another artistic aspect of this guide.

The species that stands out the most in this book is the Red-tailed Hawk. There is a book within a book on the Red-tailed. In the most comprehensive account of the Red-tailed Hawk’s subspecies I have seen, six subspecies are described: the Eastern, Krider’s, Western, Harlan’s, Fuertes’, and Alaskan, with a plate and text on juveniles and adults for each of the first four listed. Fuertes’ and Alaskan are grouped together on a single page. There is also plate with accompanying text for leucistic and other variants. Because of new data discovered during the writing of the account of the Eastern Red-tailed, two essays following the natural history text discuss that subspecies’ plumages and distribution in depth. Although some readers may glance through this section because of its density, *Buteo* enthusiasts will find it fascinating.

One confusing point for me was that the accounts of the Red-tailed and Red-shouldered Hawks both begin with the eastern subspecies. Why, when this edition highlights western raptors? Although the subspecies of both hawks should be com-

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pared, for the purpose of this book it would have made more sense to lead with the western subspecies.

Following the species accounts for the raptors more widespread in the West, there is a regional section, "Southwestern specialty species," which addresses ten species: the Hook-billed Kite, Swallow-tailed Kite, Common Black Hawk, Harris's Hawk, White-tailed Hawk, Gray Hawk, Short-tailed Hawk, Zone-tailed Hawk, Crested Caracara, and Aplomado Falcon. Following the Aplomado Falcon account is an interesting essay, "Reasons for the Aplomado Falcon's Demise and Difficulties in Reestablishing Populations."

This might not be the best field guide for the novice birder to start with, but is a great addition to the advanced raptor devotee's library. Wheeler's earlier *Raptors of Western North America* is a great reference book because of the photographs of birds and extensive glossary, but *Birds of Prey of the West* is a better field guide. However, even though it could be used in the field because of its size, detailed illustrations, and large range maps, it is a valuable reference book because it is so comprehensive. The details will be appreciated by people who want to develop their advanced skills, such as aging raptors in flight aging skills or understanding the Red-tailed Hawk's subspecies. I think *Birds of Prey of the West* paired with Liguori's *Hawks from Every Angle* or *Hawks from a Distance* should be the books I carry in the field because they balance each other out. The detailed illustrations in Wheeler's book plus the photos of birds in flight in Liguori's books give a birder the resources to figure out those difficult-to-identify hawks. *Birds of Prey of the West* is truly comprehensive, beautifully detailed, and is a good read while being small enough to fit in a day pack.

Teresa Ely
Golden Gate Raptor Observatory

How to Know the Birds: The Art & Adventure of Birding, by Ted Floyd. 2019. National Geographic. 303 pp., 45 black-and-white illustrations by N. John Schmitt. Hardback. \$37.00. ISBN 978-1-4262-2003-6.

In his inimitable style—articulate, eclectic, and thoroughly readable—Ted Floyd unfolds the stages, events, and epiphanies of a lifelong interest in bird study. Two hundred epistles organized in six chapters are arranged by season of the year and growing length and depth of experience: January–February, "Spark Bird"; March–May, "After The Spark"; June–July, "Now What?"; August–September, "Inflection Point"; October–November, "What We Know"; and December, "What We Don't Know." In a baker's dozen examples chosen almost at random, these chapters include subjects such as (16) If It Walks Like a Duck, (17) A Colorless, Shapeless, Amazing Bird, (22) The Value of Local Experience, (33) Do the Checklist Shuffle, (40) The Absolute Best Way to Learn Birdsong, (62) The Logic of Migration: A Tale of Two Teals, (83) Whither the Field Notebook?, (119) What Is Molt Anyway?, (121) Two for The Price of One, (161) On The Origins of Knowledge: Bird Banding, (164) On the Origins of Knowledge: Scientific Collecting, (177) Schrödinger's Hawk, and (200) Who Knew?

You cannot go wrong here. I think that anyone's interest in bird study will only be enhanced, and often clarified, by reading this book. And John Schmitt's handsome illustrations punctuate the work at every turn.

Daniel D. Gibson

Wing Your Way to the...

**Western Field Ornithologists
44th ANNUAL CONFERENCE
21-25 August 2019**

ALBUQUERQUE, NEW MEXICO

The 44th annual conference of the Western Field Ornithologists will be held at the Crowne Plaza Hotel, in Albuquerque from August 21 to 25 2019. The conference brings together amateur and professional ornithologists from throughout the West for four days of field trips, scientific presentations, bird-identification panels, and camaraderie. New Mexico supports a wide variety of high desert, mesa, mountain, riparian, grassland, and wetland habitats. As of January 2019, 546 species representing 67 families had been verified in the state. Field trips will explore great birding spots throughout New Mexico.

Albuquerque sits in the high desert at 5300 ft. elevation. Directly to the east, the spectacular Sandia Mountains rise to over 10,600 ft. The modern downtown core contrasts with the Old Town, which dates to the city's founding as a Spanish colony in 1706. Old Town is filled with historic adobe buildings, cafés, and outdoor eateries. Nearby, the Indian Pueblo Cultural Center traces the area's tribal history. Other attractions that conference attendees will enjoy in and near the city are the BioPark, Garden and Zoo; the New Mexico Museum of Natural History and Science; Sandia Park Tram; Petroglyph National Monument; and the Rio Grande Nature Center. Miles of hiking and birding trails border both sides of the Rio Grande as it flows along the edge of the city. Albuquerque is also home to the University of New Mexico, a world-class university with about 26,000 students and a large and diverse program in biology and the natural sciences.

This conference's events include:

- Tour of the Museum of Southwestern Biology and reception at the University of New Mexico
- Field trips to 25 locations, including an evening owling trip
- Post-conference field trip to the Sacramento Mountains
- Workshops on warbler identification, identifying birds by sound, preparing museum specimens; birding in the digital age, data mining, and bird sketching
- Two afternoons of talks on recent research throughout the West
- Keynote address by Dr. Christopher Witt on his studies of bird speciation and the role of parasites
- Our famous panels of experts and team challenges on bird identification by sight and sound, led by the incomparable Nathan Pieplow and Ed Harper
- Silent auction to benefit the WFO's activities, including publications and the Mike San Miguel Student Scholarship Fund
- Vendors and artists offering optics, books, and original art

See you in Albuquerque!

WESTERN BIRDS

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President: Kurt M. Leuschner, 70065 Sonora Rd. #267, Mountain Center, CA 92561;
kleuschner@collegeofthedesert.edu

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92107; obeach@cox.net

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Swarth

Editor: Philip Unitt, San Diego Natural History Museum, P. O. Box 121390, San
Diego, CA 92112-1390; birds@sdnhm.org

Assistant Editor: Daniel D. Gibson, P. O. Box 155, Ester, AK 99725

Associate Editors: Kenneth P. Able, Matthew J. Baumann, Daniel S. Cooper,
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Graphics Manager: Virginia P. Johnson, 4637 Del Mar Ave., San Diego, CA 92107;
gingerj5@juno.com

Photo Editor: Peter LaTourrette, 1019 Loma Prieta Ct., Los Altos, CA 94024;
platourrette@comcast.net

Featured Photo: John Sterling, 26 Palm Ave., Woodland, CA 95695;
jsterling@wavecable.com

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Photo by Michael Academia of Arcata, California:

Osprey (*Pandion haliaetus*) eating an American shad (*Alosa sapidissima*) at the mouth of the Klamath River, Del Norte Co., California, 21 June 2018.

The American shad is native to the Atlantic coast of North America but was introduced to the Pacific in the 1870s. It is now abundant along the Pacific coast, constituting a major portion of the diet of the Osprey. In an analysis of 514 fish taken as prey by Ospreys observed in northwestern California, Michael Academia found the shad to constitute 20%, as he reports in this issue of *Western Birds*.

