

Chapter 8

(from: Apparent rapid range change in South Texas birds: Response to climate change? In Texas Climate 2100 (J. Norwine, and K. John, Eds.), Texas A&M University, Kingsville, Texas.

Apparent Rapid Range Change in South Texas Birds: Response to Climate Change?

John H. Rappole, Gene W. Blacklock, and Jim Norwine

At least seventy species of birds native to tropical, subtropical, or warm desert habitats have shown evidence of northward or eastward extension of their breeding distribution into, within, or beyond the borders of South Texas, ranging from a few to several hundred km over a relatively brief time period (decades). Documentation of these changes in distribution for most species is based largely on sightings rather than specimens of nests, eggs, or young. Nevertheless, the changes are in line with regional climatic warming and possible drying, reported by climatologists in Chapters One and Two of this book, which is anticipated to have an ecological effect over the next century roughly similar to moving the region greater than 160 km to the southwest. If these range shifts are occurring in birds, then they are likely to be occurring in other taxa as well. One likely result of these shifts is the breakdown of boundaries between biotic provinces, in particular between the Tamaulipan and Austroriparian where the border between the subtropical and temperate zones occurs. The ecological and conservation effects of such a breakdown are likely to be profound.

Birds of South Texas

Rapid range change has been reported for migratory birds in Europe and North America, mostly focused on evidence of northward extension of breeding range boundaries for temperate zone migrants (Matthews et al. 2004; Robinson et al. 2005). South Texas possesses biogeographic attributes that make it especially interesting from the perspective of potential range change. First among these is an extraordinary diversity of plant and animal species unique in North America north of the tropics. Biogeographers have long recognized this attribute, and have also recognized the reason for it, namely the fact that the boundaries between three major biota find their limits in the region: warm desert, subtropical, and temperate, titled respectively "Sonoran," "Neotropical," and "Austroriparian" by Cope (1880). Dice (1943) attempted to provide a more rigorous method for recognizing these kinds of regionally-overlapping distributions of plants and animals that are distinct from neighboring regions. He called these regions "biotic provinces," which he defined as areas, "... characterized by peculiarities of vegetation type, ecological climax, flora, fauna, climate, physiography, and soil." Blair (1950), using this definition, defined seven biotic provinces for Texas: Austroriparian, Tamaulipan, Kansan, Navahonian, Chihuahuan, Texan, and Balconian. Rappole et al. (1994), using animal and plant distributions and climatic parameters, recognized five biotic provinces, dividing Blair's "Balconian Biotic Province" between the Kansan and Austroriparian, and lumping his "Texan Biotic Province" into the Austroriparian, due to their lack of distinctive floral and faunal elements (Figure 1). Four major

biotic regions occur in the

The South Texas region as defined by Norwine and John (Chapter 1, this book): Chihuahuan (warm desert), Kansan (temperate grasslands), Tamaulipan (subtropical), and Austroriparian (south temperate forests). In addition, there is a fifth biotic limit, namely that between the tropics and subtropics, i.e., limit of frost-free climate, located about 300 km south of the Texas-Mexico border where the northern end of the Veracruz Biotic Province meets the southern end of the Tamaulipan Biotic Province (Goldman and Moore 1946). As a result of these major biotic boundaries, hundreds of species of animals and plants reach the northern or eastern extent of their ranges in northeastern Mexico or South Texas. The definition of these limits is made relatively clear by the more-or-less regular dissection of the region's coastal plain by rivers, which provide east-west bands of riparian habitat at intervals of 50 to 150 km along the north-south shoreline of the Gulf of Mexico. Historically these bands of riparian habitat were separated by large extents of semi-arid thorn scrub, often replaced now by agricultural crops, e.g. cotton and sorghum. The intervening habitats are unsuitable for riparian species, and vice versa for the thorn scrub species, so the search for range limits can be focused on relatively well-defined areas.

A second factor favoring precise definition of species' breeding ranges in the region is the long history of biological investigation, beginning during the Mexican War (1846-1848), and becoming increasingly systematic and extensive up to the present. These factors help to make establishment of the northeastern edge of the breeding range for tropical, subtropical, and warm desert bird species in the South Texas region at least feasible. An additional factor makes possible the documentation of rapid range change, namely the fortuitous publication of three important works summarizing what was known of Texas bird distribution at well-spaced time intervals covering nearly a century of information on Texas bird distribution: Strecker's The Birds of Texas in 1912; Oberholser's The Bird Life of Texas in 1974; and the Texas Ornithological Society's Handbook of Texas Birds (Lockwood and Freeman 2004). In addition to these, Gehlbach et al. (1976) published a worked focused specifically on defining the northern limit of tropical bird distribution in northeastern Mexico.

In this chapter, we examine evidence of avian range change in northeastern Mexico and South Texas, and consider

what factors might help to explain range shifts for those species in which they apparently have occurred.

Methods

We use historical literature to document bird species' breeding ranges in northeastern Mexico and Texas during the early, mid-, and late 1900s, and compare these accounts with more recent data reported in the literature, personal communication, or personal observation.

Results

Table 1. Former and current northern and eastern extent of breeding range for subtropical, warm desert, and tropical bird species in Texas and northeastern Mexico. References to biotic provinces are abbreviated as follows: A - Austroriparian; C - Chihuahuan; K - Kansan; T - Tamaulipan; V - Veracruz. See Figure 1 for Texas biotic province and county locations.

Northern and/or Eastern Extent of Breeding Range in Texas or Northeastern Mexico Species	Formerly	Currently ¹
Black-bellied Whistling-Duck <i>Dendrocygna autumnalis</i>	T - Lower Rio Grande (Cameron, Hidalgo Counties (1912 ²))	K - Tarrant and Dallas Counties. A - Orange County
Masked Duck <i>Nomonyx dominicus</i>	T - Occasional on the Lower Rio Grande (Cameron County) (1912)	A - Occasional breeding to Jefferson County
Gambel's Quail <i>Callipepla gambelii</i>	C - El Paso County (1912); along the Rio Grande, El Paso, Presidio Counties (1974 ³)	C - El Paso, Presidio, Hudspeth, Jeff Davis, and Culberson County
Least Grebe <i>Tachybaptus dominicus</i>	T - Lower Rio Grande (Cameron and Hidalgo Counties) (1912); Nueces County (1951 ⁴)	A - Harris, Bastrop Counties.; K - Bexar County
Hook-billed Kite <i>Chondrohierax uncinatus</i>	V; T - single breeding record (1964) for Hidalgo County. (1974)	T - Hidalgo and Starr Counties
Gray Hawk <i>Buteo nitidus</i>	T - Occasional along the Rio Grande (Hidalgo County) (1974)	T - Rio Grande (Hidalgo to Webb Counties); rare to casual north to Kleberg County
Short-tailed Hawk <i>Buteo brachyurus</i>	V; T - Unrecorded prior to 1989 when found in Starr County (2004 ⁵)	T - lower Rio Grande Valley
White-tailed Hawk <i>Buteo albicaudatus</i>	T - Refugio County (1974)	A - Harris, Galveston Counties
Red-billed Pigeon <i>Patagioenas flavirostris</i>	T - Cameron and Hidalgo Counties (1912)	T - Kenedy County (1973 ⁶).
White-winged Dove <i>Zenaida asiatica</i>	T - Bee County (1974).	K - Dallas, Tarrant Counties
White-tipped Dove <i>Leptotila verreauxi</i>	T - Cameron and Hidalgo Counties (1912).	T - Refugio County
Green Parakeet <i>Aratinga holochlora</i>	V - Rio Corona, Tamaulipas (1976 ⁷).	T - Cameron, Hidalgo, Starr Counties
Red-crowned Parrot <i>Amazona viridigalis</i>	V - Rio Corona, Tamaulipas) (1976).	T - Cameron, Hidalgo, Starr Counties
Groove-billed Ani <i>Crotophaga sulcirostris</i>	T - Nueces County (1957 ⁸).	A - Gonzales County; K - Bexar County (Mitchell Lake).
Western Screech-Owl <i>Megascops kennicottii</i>	C - discovered along the Rio Grande, 1961, Brewster to Val Verde cos (1974).	K - Kerr County

Table 1 continued.

Northern and/or Eastern Extent of Breeding Range in Texas or Northeastern Mexico Species	Formerly	Currently ¹
Ferruginous Pygmy-Owl <i>Glaucidium brasilianum</i>	T - Lower Rio Grande Valley; Cameron and Hidalgo Counties (1912)	T - Kenedy County
Lesser Nighthawk <i>Chordeiles acutipennis</i>	T - Refugio County (1912)	A - Calhoun County; K - Bexar County
Common Pauraque <i>Nyctidromus albicollis</i>	T - Refugio County (1912).	A - Dewitt, Karnes, Victoria and Matagorda Counties
Common Poorwill <i>Phalaenoptilus nuttallii</i>	C ; K - eastern portion (Baylor, Stonewall, Young Counties); T - northeast to Refugio County	A - Bastrop County

White-throated Swift <i>Aeronautes saxatalis</i>	C - Brewster and Davis Counties (1912, 1974).	C - East to Pecos and Val Verde Counties (1980 ⁹).
Buff-bellied Hummingbird <i>Amazilia yucatanensis</i>	T - Cameron County (1957)	A - Victoria, Matagorda, Karnes, Dewitt Counties
Magnificent Hummingbird <i>Eugenes fulgens</i>	C - southern Brewster County (1974).	C - Culberson County
Lucifer Hummingbird <i>Calothorax lucifer</i>	C - Southern Brewster, Presidio Counties (1974).	C - Davis County
Black-chinned Hummingbird <i>Archilochus alexandri</i>	T - San Patricio County (1974).	T - Goliad, Aransas Counties; A - Dewitt County
Ringed Kingfisher <i>Ceryle torquata</i>	T - Starr and Hidalgo Counties (1974).	T - Refugio County; K - Uvalde County; A- Travis County
Green Kingfisher <i>Chlorceryle americana</i>	A - north to Mason County, east to Travis County; T - Starr County (1974)	T - Refugio County; A - Jackson County
Golden-fronted Woodpecker <i>Melanerpes aurifrons</i>	T - Refugio County; K - north to Armstrong County, east to Foard County (1974).	K - Clay, Bell Counties; A - Calhoun County
Ladder-backed Woodpecker <i>Picooides scalaris</i>	"...west of long. 97°W..." (K - Cooke County; T) (1957)	A- Lavaca, Jackson, Matagorda Counties
Northern Beardless-Tyrannulet <i>Camptostoma imberbe</i>	T - Cameron and Hidalgo Counties (1974)	T - Kenedy County
Black Phoebe <i>Sayornis nigricans</i>	C; K - east to Tom Green County (1912); T - north and east to Llera, Tamaulipas (1950 ⁹).	T - Starr, Hidalgo, Live Oak Counties
Say's Phoebe <i>Sayornis saya</i>	C - east to Pecos County (1974).	K - Midland, Crocket, Val Verde Counties
Vermilion Flycatcher <i>Pyrocephalus rubinus</i>	C; K - north to Midland County; T - northeast to Nueces County (1957, 1974).	K - Jones County; A - Coryell County
Ash-throated Flycatcher <i>Myiarchus cinerascens</i>	K - north to Randall County, east to Wilbarger County; T - San Patricio County (1974)	K - throughout province in state east to Clay County; T - north and east to Goliad County
Brown-crested Flycatcher <i>Myiarchus tyrannulus</i>	T - Hidalgo and Cameron Counties (1957).	A - Dewitt, Victoria Counties
Great Kiskadee <i>Pitangus sulphuratus</i>	T - Nueces County (1957).	A - Dewitt, Karnes, Calhoun Counties
Tropical Kingbird <i>Tyrannus melancholicus</i>	V - Rio Corona, Tamaulipas	T - Lower Rio Grande

Table 1 continued.

Northern and/or Eastern Extent of Breeding Range in Texas or Northeastern Mexico Species	Formerly	Currently¹
Couch's Kingbird <i>Tyrannus couchii</i>	T - Hidalgo, Cameron Counties (1957).	A - Calhoun County ; K - Bexar County; A - Travis cos
Gray Vireo <i>Vireo vicinior</i>	C - east to Brewster and Davis Counties (1974).	K - north to Tom Green County, east to Real County
Hutton's Vireo <i>Vireo huttoni</i>	C - east to Brewster and Davis Counties	K - east to Real, Uvalde, Bexar Counties
Yellow-green Vireo <i>Vireo flavoviridis</i>	V - Rio Corona, Tamaulipas (1957)	T - Cameron, Hidalgo Counties
Green Jay	T - Webb, Starr, Hidalgo, Cameron	T - Karnes, Dewitt, Goliad Counties

<i>Cyanocorax yncas</i>	Counties (1957)	
Western Scrub-Jay <i>Aphelocoma californica</i>	C; K - Kerr, Concho Counties (1912).	K - Cottle County; A - Bell, Williamson, Travis Counties
Tamaulipas Crow <i>Corvus imparatus</i>	T - Magiscatzin, Tamaulipas (1950 ⁸).	T - Cameron County
Chihuahuan Raven <i>Corvus cryptoleucus</i>	C; K - Wichita County; T - northeast to Starr County (1912)	T - Kenedy County
Common Raven <i>Corvus corax</i>	C; A - Llano County (1974).	A - Williamson and Travis Counties
Cave Swallow <i>Petrochelidon fulva</i>	C; K - Edwards, Kerr Counties (1957).	K - Hopkins County; A - Jefferson County
Black-crested Titmouse <i>Baeolophus atricristatus</i>	C; T; K - north and east to Bosque County (1974).	K - Montague County
Verdin <i>Auriparus flaviceps</i>	C; K; T (1974)	K - Baylor County.; A - Bell, Calhoun Counties
Bushtit <i>Psaltriparus minimus</i>	C - Davis, Brewster Counties (1912).	A - Williamson, Comal Counties; K - Randall County, .
Cactus Wren <i>Campylorhynchus brunneicapillus</i>	C; K - Bexar County; T - lower Rio Grande Valley (1912).	K - Floyd County; A - Bell, Williamson Counties; T - Refugio County
Black-tailed Gnatcatcher <i>Poliophtila melanura</i>	C; T - Hidalgo, Cameron Counties (1974).	K - Uvalde; T - Frio, Duval Counties
Clay-colored Robin <i>Turdus grayi</i>	V - Rio Corona, Tamaulipas (1976).	T - Hidalgo, Cameron Counties; A - Gonzales County?
Long-billed Thrasher <i>Toxostoma longirostre</i>	T - Nueces County (1957).	A - Calhoun County; K - Bexar County
Curve-billed Thrasher <i>Toxostoma curvirostre</i>	C; K - Kent, Sutton Counties; T (1974)	K - Lipscomb, Wichita Counties; A - Williamson County
Crissal Thrasher <i>Toxostoma crissale</i>	C - Brewster County	K - Howard, Crockett Counties
Tropical Parula <i>Parula pitaiayumi</i>	T - Starr, Hidalgo, Cameron Counties (1957).	T - Nueces County; A - Calhoun, Victoria Counties; C - Jeff Davis County; K - Val Verde County
Yellow Warbler (Mangrove Warbler race) <i>Dendroica petechia erithachorides</i>	V - southern Tamaulipas (1998 ¹⁰).	T - Cameron County (South Padre Island).

Table 1 continued.

Northern and/or Eastern Extent of Breeding Range in Texas or Northeastern Mexico Species	Formerly	Currently ¹
Olive Sparrow <i>Arremonops rufivirgatus</i>	T - San Patricio County (1912).	A - Calhoun (1983 ¹¹), Dewitt, Karnes Counties
Canyon Towhee <i>Pipilo fuscus</i>	C; K- Tom Green County (1912).	K - Randall County; A - Williamson County
Botteri's Sparrow <i>Aimophila botterii</i>	T - Lower Rio Grande Valley (1912).	T - San Patricio County (1983).
Rufous-crowned Sparrow <i>Aimophila ruficeps</i>	C; K - few localities north to Grayson County (1974).	K - most of province in state north to Lipscomb County
Black-throated Sparrow <i>Amphispiza bilineata</i>	T - Aransas County (1957).	T - Bee County

<u>Pyrrhuloxia</u> <i>Cardinalis sinuata</i>	C; T - largely absent (1912); K - southern portion (1974).	<u>K - Howard County; A - Calhoun County</u>
Varied Bunting <i>Passerina versicolor</i>	T - Cameron, Hidalgo Counties (1912).	C - along the Rio Grande Plain; K - Kimble County; T - Zapata, Starr Counties
Bronzed Cowbird <i>Molothrus aeneus</i>	T - north to Bexar County (1912).	C; K - Bosque County; A - Matagorda County
Hooded Oriole <i>Icterus cucullatus</i>	T - Cameron and Hidalgo Counties (1912).	T - Nueces County
Altamira Oriole <i>Icterus gularis</i>	No records (1912)	T - Zapata, Starr, Hidalgo, Cameron Counties
Audubon's Oriole <i>Icterus graduacauda</i>	T - Starr, Hidalgo, Cameron Counties (1957).	T - Goliad County
Scott's Oriole <i>Icterus parisorum</i>	C (1912)	K - Coke County; A - Travis County
Lesser Goldfinch <i>Carduelis psaltria</i>	C; K - Midland County; A - Bell County; T - Bee County	K - Wheeler County; Wichita County; A - Coryell, Dewitt Counties.; T - Goliad, Nueces Counties

¹ Based on Lockwood and Freeman (2004) supplemented by information from W. Sekula unless otherwise stated.

² Strecker (1912).

³ Oberholser (1974).

⁴ Packard (1951)

⁵ Lockwood and Freeman (2004)

⁶ Fall (1973).

⁷ Gehlbach et al. (1976).

⁸ AOU (1957).

⁹ Friedman et al. (1950).

¹⁰ AOU (1998)

The information summarized in Table 1 indicates that breeding ranges for seventy species that reach the northern and/or eastern edge of their breeding range in Texas have undergone northward and/or eastward shifts. These shifts appear to have occurred over the past century, but the pace of change seems to have accelerated, and many of these species have shown significant changes within the past thirty years. The changes in range are quite variable among species, ranging from a few km for birds like the Golden-fronted Woodpecker (*Melanerpes aurifrons*) and Black-crested Titmouse (*Baeolophus atricristatus*) to hundreds of km for the White-winged Dove (*Zenaida asiatica*) and Cave Swallow (*Petrochelidon fulva*).

These range changes fall into three major categories:

- 1) subtropical species whose ranges have expanded northward and/or eastward within the South Texan subtropical zone (Tamaulipan Biotic Province) or beyond it into the temperate zone (Australoriparian Biotic Province);
- 2) tropical species whose ranges have expanded from the limit of the tropics defined by Gehlbach et al. (1976) at the Rio Corona (a tributary of the Rio Soto La Marina) northward 300 km in the subtropics to South Texas (the lower Rio Grande); and
- 3) warm desert species whose ranges have expanded northward and/or eastward into southern, central, or even eastern Texas.

An example of a species whose range evidently has shifted northward within the subtropics is the Green Jay (*Cyanocorax yncas*) (Figure 2). Strecker (1912) reported its range as restricted to the Rio Grande Valley (Laredo to Brownsville); Rappole and Blacklock (1985) reported its range as extending north into southern Nueces County. At present (March, 2007), there are apparently resident populations on the Welder Wildlife Refuge along the Aransas River, which forms the border between the San Patricio and Refugio Counties (JHR, personal observation). According to refuge personnel, these birds have been present on the refuge for at least the past four years (T. Blankenship, S. Glasscock, L. Drawe personal communication).

The Green Parakeet (*Aratinga holochlora*) is a tropical species listed by Gehlbach et al. (1976) as reaching its northern limit along the Rio Corona. The breeding range for this bird now appears to have shifted northward in riparian and residential areas to include the lower Rio Grande (Lockwood and Freeman 2004) (Figure 3).

The Black-tailed Gnatcatcher (*Polioptila melanura*) is representative of those warm desert species whose populations appear to have shifted northward and eastward over the past century. Strecker (1912) reported the bird, eastern populations of which were then recognized as a separate species, the Plumbeous Gnatcatcher (*Polioptila plumbea*), as an, "Abundant summer resident of the high mountains of the trans-Pecos region, east during the migrations to Rio Grande City." Oberholser (1974) shows the bird as at least present in summer along the lower Rio Grande; Lockwood and Freeman (2004) show the bird as a breeding resident along the entire Rio Grande as well as northward beyond the Rio Grande Plain (Figure 4).

Discussion

Evidence indicating the presence of breeding populations for tropical, subtropical, and warm desert species north and/or east of their historical range has become increasingly common in recent years, as documented in Table 1 of this paper and Figures 2-4. For the most part, such range extensions have been attributed to increased number, vigilance, access, or expertise of field investigators. For instance, Fall (1973:244) in his report on northward range extensions for ten subtropical species in South Texas stated that the area in Kenedy County where his observations were made, "... is inaccessible to the public and as a result has been virtually excluded from both past and present ornithological investigation." These explanations now seem inadequate based on the number of species involved and degree of change.

Unfortunately, in most cases, range change information is based solely on observation of individuals in the appropriate habitat and time period. Actual confirmation of breeding (nest, eggs, recently-fledged young) within the new

range is mostly lacking. Thus, the information is indicative but not yet conclusive evidence of significant and pervasive northward and eastward range shift for a large suite of desert, subtropical, and tropical species.

In some cases, there are species-specific explanations for these shifts. For instance, the recent appearance of tropical psittacids like the Green Parakeet along the lower Rio Grande is often credited to establishment of breeding populations among escaped cage birds (Lockwood and Freeman 2004). Similarly, some authors have attributed the large northward range shift of the White-winged Dove (hundreds of km) to extensive supplemental food now available in Texas cities (Small et al. 2005), and Cave Swallow range expansion has been related to newly available "man made structures" (Lockwood and Freeman 2004). However, for the majority of species, there is no obvious explanation of this sort. In fact, habitat change, which is the usual explanation for changes in breeding bird distribution, would appear to favor contraction of the South Texas breeding range for many species rather than expansion. For instance, in the lower Rio Grande Valley less than 5% of native thorn forest and riparian habitat remain (Purdy 1983).

The fact that ranges for seventy South Texas species appear to have expanded northward and/or eastward during a period when habitat for many of them was declining in the areas into which they were expanding indicates the possibility that range change was favored by some pervasive environmental factor. We suggest that climate change, and specifically increasing mean annual temperatures, could be that factor. South Texas climate is subject to radical short- and long- term fluctuation (Norwine et al. Chapter 2, this book). Thus, it is notoriously difficult to determine trends over a period as short as thirty years. Keeping this caveat in mind, mean annual temperature in South Texas has shown a marked increase over the past three decades, in line with warming trends elsewhere (Norwine et al. Chapter 2, this volume). We suggest that northward range expansion of subtropical bird species in South Texas may be related in ways that are not yet understood to increasing temperature. In any event, we are not aware of any other single environmental factor with which range change for seventy bird species might be correlated.

If our hypothesis is correct, the ecological and evolutionary effects could be profound. Birds are certainly among the most visible parts of the region's biota, as well as being among the most mobile. Nevertheless, if bird ranges are changing, it seems likely that ranges for members of many other groups of both plants and animals also are changing, and probably at rates similar to those of birds in many cases. If this kind of change is occurring across phyla, then major shifts in the boundaries of biomes may be underway.

The evolutionary consequences of biome boundary shifts should be evident quite quickly, especially along the border between the Tamaulipan Biotic Province and the Austroriparian Biotic Province, which is generally sited at the San Antonio River in the Texas coastal plain where the river constitutes the border between Refugio and Calhoun counties (Rappole et al. 1994). Many closely-related taxa of animals and plants reach their range boundaries here, with the temperate representative of super-species complexes reaching the southern terminus of their range and subtropical representatives reaching the northern terminus: for instance, the Black-crested Titmouse (subtropical) and Tufted Titmouse (*Baeolophus bicolor*) (temperate); Florida Woodrat (*Neotoma floridana*) (temperate) and Mexican Woodrat (*N. mexicana*) (subtropical); Black-spotted Newt (*Notophthalmus meridionalis*) (subtropical) and Red-spotted Newt (*N. viridescens*) (temperate) , to mention just a few (Blair 1950; Rappole et al. 1994).

Conclusions

Based on the observational data summarized in this paper, we state the following hypothesis: Rapid (i.e., measured in years rather than decades or centuries) northward and eastward shift in the breeding ranges of several tropical, subtropical, and warm desert bird species in South Texas and northeastern Mexico is occurring due to climatic change. At present, the data necessary to test this hypothesis are largely lacking. Most of the evidence for this change is in the form of reports by untrained observers to the Texas Ornithological Society of birds being seen regularly in places where they were not previously known. Clearly, a concerted effort must be made to test this hypothesis.

If our hypothesis is correct, we make the following predictions, all of which are readily amenable to field and/or laboratory tests:

- 1) Rapid shifts in subtropical, semi-arid, and warm desert bird species' breeding ranges will continue to occur across the Texas region and beyond: largely northward and eastward of the historical range.
- 2) Evidence of northward and eastward shift of breeding range will accumulate for many additional bird species in Texas whose currently-known range limit is located well south or west of the region.
- 3) Evidence of northward and eastward range shifts will accumulate for all other aspects of the region's biota, in

addition to birds.

- 4) Northward and eastward shift of some species native to the Tamaulipan Biotic Province, i.e., those with closely-related congeners in the Austroriparian Biotic Province (e.g. *Baeolophus atricristatus* and *B. bicolor*), will lead to rapid increase in genetic mixing between the two populations.
- 5) Borders between biotic provinces, biomes, and similar biogeographically-defined regional entities will not simply shift. They will break down.

Norwine and John (Preface, this volume) state in reference to the likely future effects of climate change in eastern South Texas, "Imagine picking up the entire region and moving it (a) one hundred or so miles west (i.e., toward the Chihuahuan Desert) and (b) a similar distance south." Based on the observed shifts in bird species' distribution summarized here, it would appear that these changes are well underway. They are likely to have profound consequences for the biota.

Acknowledgments

The following individuals provided information on current ranges for one or more species discussed in this chapter: W. Sekula, D. Muschalek, T. Blankenship, S. Glasscock, and L. Drawe.

JHR thanks the Smithsonian National Zoological Park, in particular J. Seidensticker and S. Monfort, for authorizing sabbatical leave to conduct this research, and the Welder Wildlife Foundation, in particular L. Drawe, for serving as the Texas host institution during that leave.

Literature Cited

- American Ornithologists' Union. 1957. The A. O. U. check-list of North American birds. Fifth Edition. American Ornithologists' Union, Baltimore, Maryland.
- American Ornithologists' Union. 1983. The A. O. U. check-list of North American birds. Sixth Edition. American Ornithologists' Union, Baltimore, Maryland.
- American Ornithologists' Union. 1998. The A. O. U. check-list of North American birds. Seventh Edition. American Ornithologists' Union, Baltimore, Maryland.
- Blair, W. F., 1950. The biotic provinces of Texas. *Texas Journal of Science* 2, 93-117.
- Cope, E. D., 1880. On the zoological position of Texas. *Bulletin of the U. S. National Museum* 17, 1-51.
- Dice, L. R., 1943. The biotic provinces of North America. University of Michigan Press, Ann Arbor, Michigan.
- Fall, B. A., 1973. Noteworthy bird records from south Texas (Kenedy County). *Southwestern Naturalist* 18, 244-247.
- Friedman, H., Griscom, L., and Moore, R. T., 1950. Distributional check-list of the birds of MexiCounty Part 1. *Cooper Ornithological Club, Pacific Coast Avifauna* 29:1-436.
- Gehlbach, F. R., Dillon, D. O., Harrell, H. L., Kennedy, S. E., and K. R. Wilson, K. R., 1976. Avifauna of the Rio Corona, Tamaulipas, Mexico: northeastern limit of the tropics. *Auk* 93, 53-65.
- Goldman, E. A., and Moore, R. T., 1946. The biotic provinces of MexiCounty *Journal of Mammalogy* 26, 347-360.
- Lasley, G. W., and Gee, J. P., 1991. The first nesting record of the Hutton's Vireo (*Vireo huttoni*) east of the Pecos River, Texas. *Bulletin of the Texas Ornithological Society* 24, 23-24.
- Lockwood, M. W., 2001. *Birds of the Texas hill country*. University of Texas Press, Austin, Texas.
- Lockwood, M. W., and Freeman, B., 2004. *The Texas Ornithological Society handbook of Texas birds*. Texas A&M University Press, College Station, Texas.
- Matthews, S. N., O'Connor, R. J., Iverson, L. R., and Prasad, A. M., 2004. *Atlas of climate change effects in 150 bird species of the eastern United States*. U.S. Department of Agriculture, Forest Service, Delaware, Ohio.
- Maxwell, T. C., 1980. Significant nesting records of birds from western Texas. *Bulletin of the Texas Ornithological Society* 13, 2-6.
- Oberholser, H. C., 1974. *The bird life of Texas*. University of Texas Press, Austin, Texas.
- Packard, F. M., 1951. *Birds of the Central Coast of Texas*. Unpublished Manuscript, Archives, Welder Wildlife Foundation, Sinton, Texas.
- Purdy, P. C., 1983. Agricultural, industrial, and urban development in relation to the eastern white-

winged dove. M. S. Thesis, Colorado State University, Fort Collins, Colorado.

Peterson, J. J., and Zimmer, B. R., 1998. *Birds of the Trans PeCounties* University of Texas Press, Austin, Texas.

Rappole, J. H., and Blacklock, G. W., 1985. *Birds of the Texas Coastal Bend*. Texas A&M University Press, College Station, Texas.

Rappole, J. H., Fulbright, T., Norwine, J., and Bingham, R., 1994. The forest-grassland boundary in Texas: population differentiation without geographic isolation, In: PanjabSingh (Ed.), *Proceedings of the Third International Rangelands Congress*, Range Management Society of India, Jhansi, India, pp. 167-177.

Robinson, R. A., Learmonth, J. A., Hutson, A. M., Macleod, C. D., Sparks, T. H., Leech, D. I., Pierce, G. J., Rehfisch, M. M., and Crick, H. Q. P., 2005. *Climate change and migratory species*. British Trust for Ornithology Report #414, British Trust for Ornithology, Thetford, England.

Small, M. F., Schaefer, C. L., Baccus, J. T., and Roberson, J. A., 2005. Breeding ecology of white-winged doves in a recently colonized urban environment. *Wilson Bulletin* 117, 172-176.

Strecker, J. K., Jr., 1912. *The birds of Texas*. *Baylor University Bulletin* 15, 1-69.