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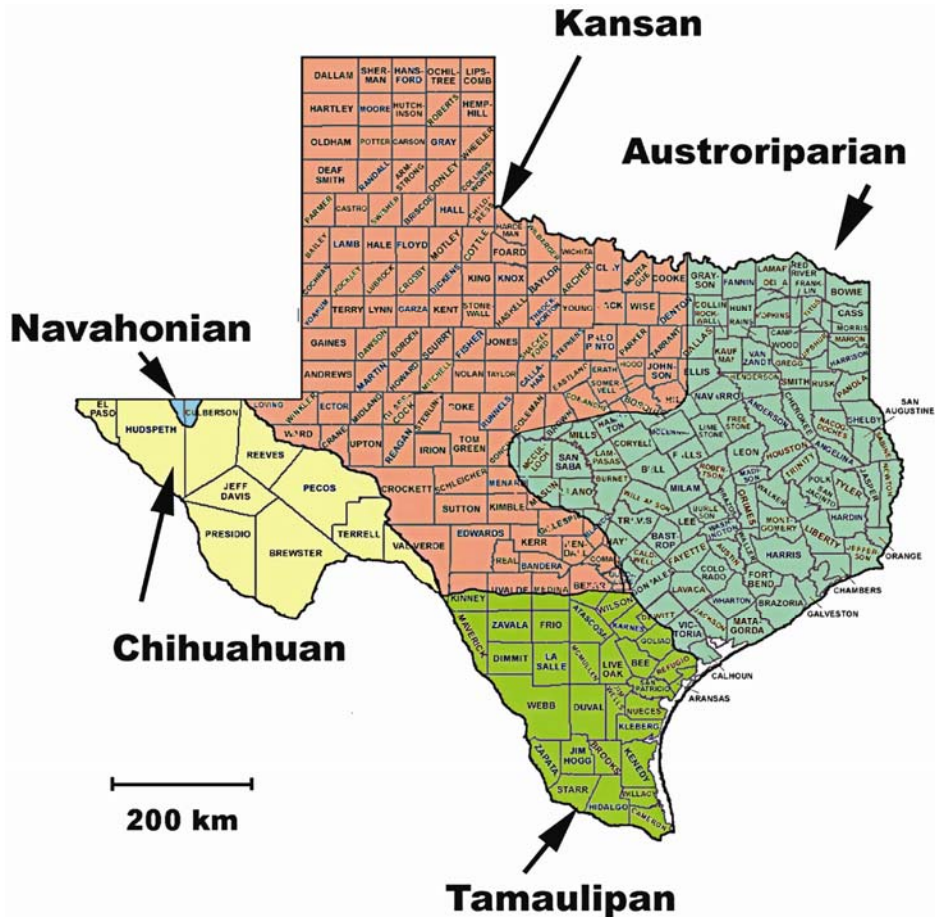
# Apparent Rapid Range Change in South Texas Birds: Response to Climate Change?

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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 South Texas region as defined by Norwine and John (Chapter 1, this book): Chihuahuan



**Figure 1.** Biotic provinces of Texas.

(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.\*

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

Table 1 continued.

Species	Former Extent	Current Extent <sup>1</sup>
<b>Ferruginous Pygmy-Owl</b> <i>Glaucidium brasilianum</i>	T - Lower Rio Grande Valley; Cameron and Hidalgo Counties (1912)	T - Kenedy County
<b>Lesser Nighthawk</b> <i>Chordeiles acutipennis</i>	T - Refugio County (1912)	A - Calhoun County; K - Bexar County
<b>Common Pauraque</b> <i>Nyctidromus albicollis</i>	T - Refugio County (1912).	A - Dewitt, Karnes, Victoria and Matagorda Counties
<b>Common Poorwill</b> <i>Phalaenoptilus nuttallii</i>	C ; K - eastern portion (Baylor, Stonewall, Young Counties); T - northeast to Refugio County	A - Bastrop County
<b>White-throated Swift</b> <i>Aeronautes saxatalis</i>	C - Brewster and Davis Counties (1912, 1974).	C - East to Pecos and Val Verde Counties (1980 <sup>9</sup> ).
<b>Buff-bellied Hummingbird</b> <i>Amazilia yucatanensis</i>	T - Cameron County (1957)	A - Victoria, Matagorda, Karnes, Dewitt Counties
<b>Magnificent Hummingbird</b> <i>Eugenes fulgens</i>	C - southern Brewster County (1974).	C - Culberson County
<b>Lucifer Hummingbird</b> <i>Calothorax lucifer</i>	C - Southern Brewster, Presidio Counties (1974).	C - Davis County
<b>Black-chinned Hummingbird</b> <i>Archilochus alexandri</i>	T - San Patricio County (1974).	T - Goliad, Aransas Counties; A - Dewitt County
<b>Ringed Kingfisher</b> <i>Ceryle torquata</i>	T - Starr and Hidalgo Counties (1974).	T - Refugio County; K - Uvalde County; A - Travis County
<b>Green Kingfisher</b> <i>Chloroceryle americana</i>	A - north to Mason County, east to Travis County; T - Starr County (1974)	T - Refugio County; A - Jackson County
<b>Golden-fronted Woodpecker</b> <i>Melanerpes aurifrons</i>	T - Refugio County; K - north to Armstrong County, east to Foard County (1974).	K - Clay, Bell Counties; A - Calhoun County
<b>Ladder-backed Woodpecker</b> <i>Picoides scalaris</i>	"...west of long. 97°W..." (K - Cooke County; T ) (1957)	A - Lavaca, Jackson, Matagorda Counties
<b>Northern Beardless-Tyrannulet</b> <i>Camptostoma imberbe</i>	T - Cameron and Hidalgo Counties (1974)	T - Kenedy County
<b>Black Phoebe</b> <i>Sayornis nigricans</i>	C; K - east to Tom Green County (1912); T - north and east to Llera, Tamaulipas (1950 <sup>9</sup> ).	T - Starr, Hidalgo, Live Oak Counties
<b>Say's Phoebe</b> <i>Sayornis saya</i>	C - east to Pecos County (1974).	K - Midland, Crocket, Val Verde Counties
<b>Vermilion Flycatcher</b> <i>Pyrocephalus rubinus</i>	C; K - north to Midland County; T - northeast to Nueces County (1957, 1974).	K - Jones County; A - Coryell County
<b>Ash-throated Flycatcher</b> <i>Myiarchus cinerascens</i>	K - north to Randall County, east to Wilbarger County; T - San Patricio County (1974)	K - throughout Kansan Biotic Province in Texas east to Clay County; T - north and east to Goliad County
<b>Brown-crested Flycatcher</b> <i>Myiarchus tyrannulus</i>	T - Hidalgo and Cameron Counties (1957).	A - Dewitt, Victoria Counties
<b>Great Kiskadee</b> <i>Pitangus sulphuratus</i>	T - Nueces County (1957).	A - Dewitt, Karnes, Calhoun Counties
<b>Tropical Kingbird</b> <i>Tyrannus melancholicus</i>	V - Rio Corona, Tamaulipas	T - Lower Rio Grande

Table 1 continued.

Species	Former Extent	Current Extent <sup>1</sup>
<b>Couch's Kingbird</b> <i>Tyrannus couchii</i>	T - Hidalgo, Cameron Counties (1957).	A - Calhoun County ; K - Bexar County; A - Travis County
<b>Gray Vireo</b> <i>Vireo vicinior</i>	C - east to Brewster and Davis Counties (1974).	K - north to Tom Green County, east to Real County
<b>Hutton's Vireo</b> <i>Vireo huttoni</i>	C - east to Brewster and Davis Counties	K - east to Real, Uvalde, Bexar Counties
<b>Yellow-green Vireo</b> <i>Vireo flavoviridis</i>	V - Rio Corona, Tamaulipas (1957)	T - Cameron, Hidalgo Counties
<b>Green Jay</b> <i>Cyanocorax yncas</i>	T - Webb, Starr, Hidalgo, Cameron Counties (1957)	T - Karnes, Dewitt, Goliad Counties
<b>Western Scrub-Jay</b> <i>Aphelocoma californica</i>	C; K - Kerr, Concho Counties (1912).	K - Cottle County; A - Bell, Williamson, Travis Counties
<b>Tamaulipas Crow</b> <i>Corvus imparatus</i>	T - Magiscatzin, Tamaulipas (1950 <sup>8</sup> ).	T - Cameron County
<b>Chihuahuan Raven</b> <i>Corvus cryptoleucus</i>	C; K - Wichita County; T - northeast to Starr County (1912)	T - Kenedy County
<b>Common Raven</b> <i>Corvus corax</i>	C; A - Llano County (1974).	A - Williamson and Travis Counties
<b>Cave Swallow</b> <i>Petrochelidon fulva</i>	C; K - Edwards, Kerr Counties (1957).	K - Hopkins County; A - Jefferson County
<b>Black-crested Titmouse</b> <i>Baeolophus atricristatus</i>	C; T; K - north and east to Bosque County (1974).	K - Montague County
<b>Verdin</b> <i>Auriparus flaviceps</i>	C; K; T (1974)	K - Baylor County.; A - Bell, Calhoun Counties
<b>Bushtit</b> <i>Psaltriparus minimus</i>	C - Davis, Brewster Counties (1912).	A - Williamson, Comal Counties; K - Randall County, .
<b>Cactus Wren</b> <i>Campylorhynchus brunneicapillus</i>	C; K - Bexar County; T - lower Rio Grande Valley (1912).	K - Floyd County; A - Bell, Williamson Counties; T - Refugio County
<b>Black-tailed Gnatcatcher</b> <i>Polioptila melanura</i>	C; T - Hidalgo, Cameron Counties (1974).	K - Uvalde; T - Frio, Duval Counties
<b>Clay-colored Robin</b> <i>Turdus grayi</i>	V - Rio Corona, Tamaulipas (1976).	T - Hidalgo, Cameron Counties; A - Gonzales County?
<b>Long-billed Thrasher</b> <i>Toxostoma longirostre</i>	T - Nueces County (1957).	A - Calhoun County; K - Bexar County
<b>Curve-billed Thrasher</b> <i>Toxostoma curvirostre</i>	C; K - Kent, Sutton Counties; T (1974)	K - Lipscomb, Wichita Counties; A - Williamson County
<b>Crissal Thrasher</b> <i>Toxostoma crissale</i>	C - Brewster County	K - Howard, Crockett Counties
<b>Tropical Parula</b> <i>Parula pitiayumi</i>	T - Starr, Hidalgo, Cameron Counties (1957).	T - Nueces County; A - Calhoun, Victoria Counties; C - Jeff Davis County; K - Val Verde County
<b>Yellow Warbler (Mangrove Warbler race)</b> <i>Dendroica petechia erithachorides</i>	V - southern Tamaulipas (1998 <sup>10</sup> ).	T - Cameron County (South Padre Island).

Table 1 continued.

Species	Former Extent	Current Extent <sup>1</sup>
<b>Olive Sparrow</b> <i>Arremonops rufivirgatus</i>	T - San Patricio County (1912).	A - Calhoun (1983 <sup>11</sup> ), Dewitt, Karnes Counties
<b>Canyon Towhee</b> <i>Pipilo fuscus</i>	C; K - Tom Green County (1912).	K - Randall County; A - Williamson County
<b>Botteri's Sparrow</b> <i>Aimophila botterii</i>	T - Lower Rio Grande Valley (1912).	T - San Patricio County (1983).
<b>Rufous-crowned Sparrow</b> <i>Aimophila ruficeps</i>	C; K - few localities north to Grayson County (1974).	K - most of province in state north to Lipscomb County
<b>Black-throated Sparrow</b> <i>Amphispiza bilineata</i>	T - Aransas County (1957).	T - Bee County
<b>Pyrrhuloxia</b> <i>Cardinalis sinuata</i>	C; T - largely absent (1912); K - southern portion (1974).	K - Howard County; A - Calhoun County
<b>Varied Bunting</b> <i>Passerina versicolor</i>	T - Cameron, Hidalgo Counties (1912).	C - along the Rio Grande Plain; K - Kimble County; T - Zapata, Starr Counties
<b>Bronzed Cowbird</b> <i>Molothrus aeneus</i>	T - north to Bexar County (1912).	C; K - Bosque County; A - Matagorda County
<b>Hooded Oriole</b> <i>Icterus cucullatus</i>	T - Cameron and Hidalgo Counties (1912).	T - Nueces County
<b>Altamira Oriole</b> <i>Icterus gularis</i>	No Texas records (1912)	T - Zapata, Starr, Hidalgo, Cameron Counties
<b>Audubon's Oriole</b> <i>Icterus graduacauda</i>	T - Starr, Hidalgo, Cameron Counties (1957).	T - Goliad County
<b>Scott's Oriole</b> <i>Icterus parisorum</i>	C (1912)	K - Coke County; A - Travis County
<b>Lesser Goldfinch</b> <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

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

<sup>2</sup> Strecker (1912).

<sup>3</sup> Oberholser (1974).

<sup>4</sup> Packard (1951)

<sup>5</sup> Lockwood and Freeman (2004)

<sup>6</sup> Fall (1973).

<sup>7</sup> Gehlbach et al. (1976).

<sup>8</sup> AOU (1957).

<sup>9</sup> Friedman et al. (1950).

<sup>10</sup> 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 (Austroriparian 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 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.

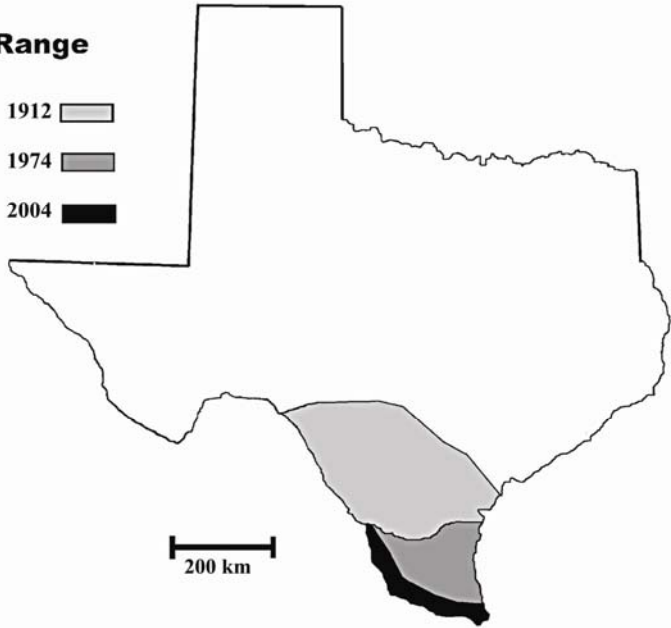
Unfortunately, in most cases, range change information is based solely on observation of individuals in the appropriate habitat and time period. Actual confirmation of breeding (nest, eggs, recently-fledged young) within the new range is mostly lacking. Thus, the information is indicative but not yet 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).

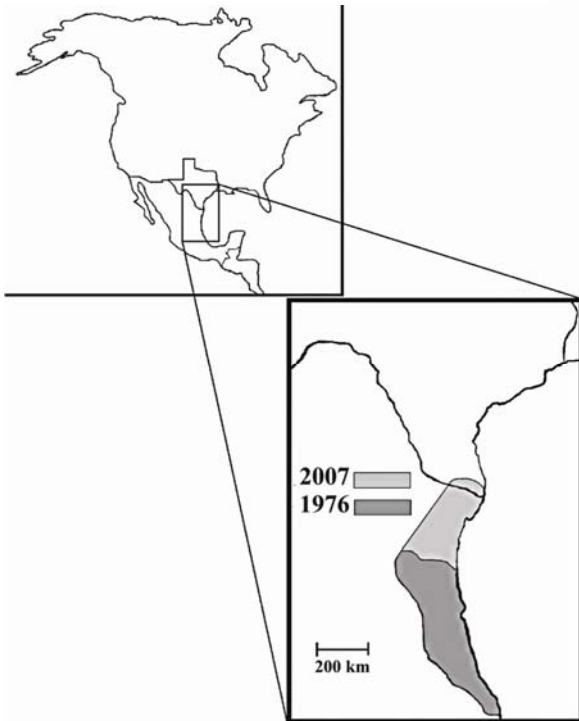
The fact that ranges for seventy South Texas species appear to have expanded northward and/or eastward during a period when habitat for many of them was declining in the areas into which they were expanding indicates the possibility that range change was favored by some pervasive environmental factor. 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**

- 1912 
- 1974 
- 2004 






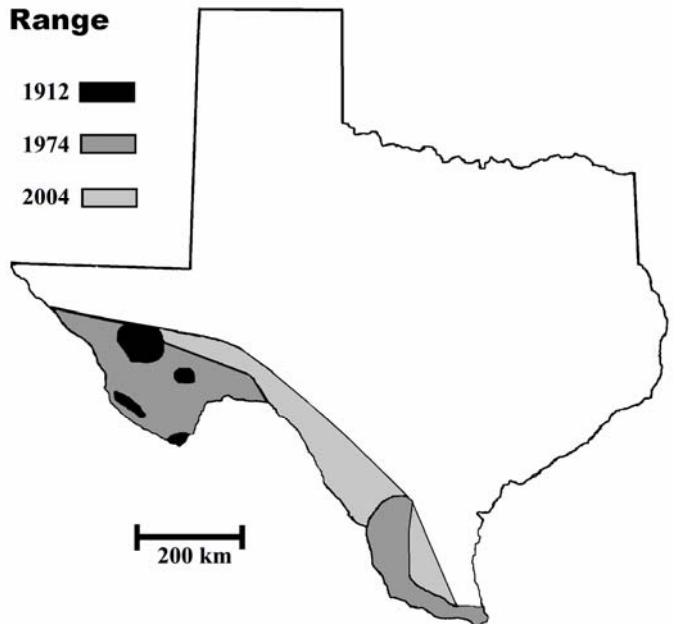
**Figure 2.** Green Jay range change in Texas, 1912 to 2004



**Figure 3.** Green Parakeet range change, 1976 to 2004

**Range**

- 1912 
- 1974 
- 2004 



**Figure 4.** Black-tailed Gnatcatcher range change in Texas, 1912 to 2004

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.

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