Abstract: The breeding range of the Chihuahuan Raven (*Corvus cryptoleucus*) is contracting at its northeastern margin on the southern Great Plains, in a region where the breeding range of the Common Raven (*C. corax*) is expanding. The shift of the Chihuahuan Raven’s range may reflect changes in land use, a decline in prairie dog abundance, fire suppression, and a decline in the number of suitable nest sites (windmills). Common Ravens are expanding not only on the southern Great Plains but across North America and in Europe. The factors driving the Common Raven’s range expansion are unclear, but on the southern Great Plains, the long-term decline in the human population may have contributed to an increase in nest sites (abandoned homes) and a decline in persecution. Although West Nile virus has been implicated in local declines of corvid populations, it does not appear to be the driver of shifts of ranges of the two ravens on the southern Great Plains.

Keywords: Chihuahuan Raven, Common Raven, *Corvus corax*, *Corvus cryptoleucus*, land use, nest sites, range contraction, range expansion

In recent decades, the rural human population of the Great Plains has declined significantly (Rathge and Highman 1998). This decline has occurred during a period of changes in land use, as well as a wide expansion of the U.S. Department of Agriculture’s Conservation Reserve Program (CRP) and other federal, state, and local initiatives to preserve rural agricultural land in the face of volatile commodity prices. During this same period, climate change appears to have triggered expansion of the ranges of a number of Southwestern bird species to the north and east of their historic (mid-1900s) breeding ranges (e.g., Peterson 2003a, Pruett et al. 2011).

In the 1800s, the breeding range of the Common Raven (*Corvus corax*) and Chihuahuan Raven (*C. cryptoleucus*) overlapped on a large portion of the central and southern Great Plains (Allen 1872, Sutton 1967). The ranges of both species contracted sometime following the advent of agriculture on the Great Plains, and especially after the elimination of herds of the American Bison (*Bison bison*) (Allen 1872, Aldous 1942). The ranges of both species of raven appear to have remained relatively static until the 1970s, when the Chihuahuan Raven began disappearing from the northern and eastern portions of its breeding range, and the mid-1990s, when the Common Raven began expanding over an apparently broad front on the Great Plains (e.g., Houston 1996, Nenneman et al. 2009) and elsewhere in North America (Boarman and Heinrich 1999, Coates et al. 2014).

In Oklahoma, Common Ravens nested over a large portion of the state prior to the 1880s but subsequently were found only in a small portion of Cimarron County in the far western Oklahoma panhandle (Sutton 1967). Chihuahuan Ravens formerly nested throughout the panhandle region and also across the western tier of counties in the main body of the state (Sutton 1967, Figure 1). In this paper I review the recent changes in the two species’ breeding ranges on the southern Great Plains and relate those changes to concurrent changes in land use, nest-site availability, and climate change in the region.

METHODS

I studied the ravens’ breeding distributions during the course of a broader study of raptor distribution (Wiggins et al. 2014) in Cimarron County, Oklahoma, from 2006 to 2008, and during raptor surveys on and around the Comanche National Grasslands in southern Baca County, Colorado, from 2002 to 2008 (unpubl. data; Figure 1). These studies were designed to assess the demographics
of raptors of conservation concern on and around the Comanche and Rita Blanca national grasslands. In Oklahoma, surveys were largely in agricultural lands, away from the Rocky Mountain foothills in northwestern portions of the county (where access to private land as well as a lack of roads made surveys difficult). Similarly, surveys in Colorado were on flat grasslands and not in foothill country in the southwestern portion of Baca County. In both areas, biologists surveyed from roads from late April until mid-July. Within the defined study areas, initial (April–May) surveys were made by driving slowly (~35 km/hr) along all primary and secondary roads until the entire study area had been covered. Although surveys focused on locating nests in trees, observers also checked abandoned homes for nests, such as those of the Barn Owl (Tyto alba) and ravens. Further details on methods are in Wiggins et al. (2014).

I obtained data on long-term changes in the abundance of breeding ravens from the Breeding Bird Survey (Sauer et al. 2014). In addition, summaries of regional studies (e.g., Seyffert 2002, Thompson et al. 2011) and correspondence with regional authorities provided more detailed historical data on the ravens’ range shifts. To assess more recent range shifts in Great Plains states other than Oklahoma, I contacted active field ornithologists in Texas, New Mexico, Colorado, Kansas, North Dakota, South Dakota, and Nebraska. I evaluated changes in land use from data on enrollment in the Conservation Reserve Program (Farm Service Agency, U.S. Department of Agriculture). Details of each raven nest site are available from the Colorado Division of Wildlife and the Oklahoma Department of Wildlife Conservation, which sponsored the surveys reported here.

**RESULTS**

**CHIHUAHUA RAVEN**

The breeding range of the Chihuahuan Raven has contracted considerably (~20% reduction in range in the United States) since the 1970s (Figure 2). These ravens now breed only in extreme southwestern Kansas (Morton and Stevens counties, though confirmation of recent breeding is lacking), southeastern Colorado (Baca, Bent, Las Animas, Kiowa, Otero and Prowers counties), and the western panhandle of Oklahoma (Cimarron and, possibly, western Texas counties). In Oklahoma, Chihuahuan Ravens formerly bred throughout the panhandle, and in the southwestern and northwestern corners of the main body of the state (Sutton 1967). There have been no nesting records in the main body of the state since the 1970s, however, and the species is no longer found there during the summer (Tyler 2005, pers. obs.). In the Oklahoma panhandle, surveys for the breeding bird atlas from 1997 to 2001 confirmed nesting only in Cimarron and Texas counties (Patti 2004). In the Texas panhandle, the breeding range has contracted to the south and west (Lockwood and Freeman 2004), whereas in New Mexico and Arizona no range shift is apparent (although the range in the Rio Grande Valley of central New Mexico is still somewhat uncertain; S. Williams pers. comm.).

**Figure 2.** Approximate historical (1900s; to outer line) and current (2015; inner solid line and shaded area) breeding range of the Chihuahuan Raven in the United States. Figure based on information in Kingery (1998), Lockwood and Freeman (2004), Patti (2004), Corman and Wise-Gervais (2005), and Thompson et al. (2011).
Breeding Bird Survey data (Sauer et al. 2014) document a decline in abundance over most of the core range of the species in the United States (i.e., the geographic center and area of greatest abundance, in western Texas and southeastern New Mexico) from 1966 to 2012 (Figure 3). During my surveys I found Chihuahuan Ravens nesting throughout the Comanche National Grasslands in Colorado. In Oklahoma, I found Chihuahuan Ravens nesting primarily in the western half of Cimarron County, where they were most common on and around the Rita Blanca National Grassland. Over 70% of the Chihuahuan Raven nests I observed each year in Baca County, Colorado, and Cimarron County, Oklahoma, were on abandoned (nonfunctioning) windmills (e.g., 10 of 13 nests in Cimarron County in 2006). Other nests were in small trees (n = 8), on artificial nest platforms constructed for Ferruginous Hawks (Buteo regalis) (n = 4), in abandoned sheds (n = 2), and on a decommissioned telephone pole (n = 1).

**COMMON RAVEN**

The breeding range of the Common Raven on the Great Plains has expanded in recent decades. Previously, nesting Common Ravens were restricted in Oklahoma to the mesas and buttes of the extreme northwestern corner of Cimarron County (Sutton 1967). In this study (2006–2008), I found nine Common Raven nests (at seven sites) in areas also used by breeding Chihuahuan Ravens (Figure 4). Six of the seven nest sites were in the attics of long-abandoned, dilapidated homes; another was in a large tree. All Common Raven nest sites were located in areas of low relief dominated by row-crop agriculture, CRP fields (mainly ungrazed grasslands typically planted with alien grass species), and open pastures (i.e., habitat typical of the Chihuahuan Raven in the region).

Incidental observations outside my study areas suggest expansion of the Common Raven's breeding range elsewhere in the Great Plains, including west Texas (west and north of Lubbock, A.
Hewetson pers. comm.) and western (pers. obs.) and central North Dakota (Nenneman et al. 2009). In North Dakota, the range expansion appears to have originated from the northeast, as Common Ravens breed throughout southern Manitoba (Taylor 2003) and northwestern Minnesota (Figure 5). There are also at least four summer records, lacking evidence of nesting, in western and central Nebraska (R. Silcock pers. comm.). Recently, the abundance of the Common Raven has increased not only on the Great Plains but throughout the species’ North American range (Figure 5; Sauer et al. 2014) and in many areas of the species’ range in Europe (PECBMS 2010). This increase in abundance was noted before the shifts in breeding range, suggesting that increased population density may have led to range expansion.

In Morton County in extreme southwestern Kansas, Common Ravens were first noted nesting in 2006, with subsequent breeding records (of a single pair) in 2007, 2010, 2011, and 2012 (Cable et al. 2012). These records represent the first breeding records in Kansas since the late 1800s (Thompson et al. 2011). In nearby Baca County, Colorado, the only Common Raven nest that I found in 7 years of surveying on the Comanche National Grassland was in a cottonwood grove near an abandoned homestead in the southwestern portion of the grassland. While the breeding records for Kansas and Baca County, Colorado, may represent single nesting pairs (and thus limited range expansion), the presence of multiple breeding pairs on agricultural lands in the Oklahoma panhandle suggests a broader push onto the southern Great Plains.

**DISCUSSION**

**CHIHUAHUAN RAVEN RANGE CONTRACTION**

Several authors have suggested that the large retraction of the range of the Chihuahuan Raven in the late 1800s followed the extirpation of bison from the southern plains (e.g., Aldous 1942, Sharpe et al. 2001). The bison provided not only a direct source of food (carrion) but likely enhanced the Chihuahuan Raven’s success in foraging by increasing the amount of heavily grazed grassland (preferred foraging habitat; pers obs.). After that range retraction, Chihuahuan Ravens bred in east-central and southeastern Colorado (Bailey and Niedrach 1965), in west-central and southwestern Kansas (Thompson and Ely 1992), and in western Oklahoma (Sutton 1967). The current breeding range in these states has shifted south and west, and the Chihuahuan Raven is now a very rare
breeding species in extreme southwestern Kansas (Thompson et al. 2011) and absent from most of its former breeding range in Oklahoma. The reason for this recent range retraction is unclear, but a dramatic shift in land use (e.g., conversion of grassland to row-crop agriculture; Parton et al. 2005) has been implicated in the loss of biodiversity on the Great Plains (e.g., Samson and Knopf 1994, Higgins et al. 2002). Samson et al. (2004) suggested that the maintenance of biodiversity in the remaining patches of shortgrass prairie is threatened not only by shifts in land use but also by the loss of prairie dogs and bison and the reduced frequency of fire.

A reduction in the availability of suitable nest sites may be contributing to the retraction of the Chihuahuan Raven’s range on the southern Great Plains. Over 70% of the Chihuahuan Raven nests that I observed each year in Baca County, Colorado, and Cimarron County, Oklahoma, were on abandoned windmills. Although there are no quantitative data to support the idea, I suspect that the number of abandoned windmills has decreased significantly in these areas in recent years, especially on private land. The one exception is in the Comanche National Grassland in Colorado, where windmills are widely used (and maintained) at stock tanks, and older windmills are maintained as platforms for raptor nesting. It is notable that Chihuahuan Ravens rarely use functioning windmills. I observed only one pair of these ravens nesting on a functioning windmill, and the nest was subsequently destroyed by Forest Service personnel maintaining the windmill. Dependence on human-made structures for nest sites has been observed in other parts of the Chihuahuan Raven’s breeding range. At the White Sands Missile Range in southern New Mexico, Brubaker et al. (2003) found Chihuahuan Ravens nesting primarily on decommissioned telephone poles. Thus at least in some parts of its range, the Chihuahuan Raven’s abundance may be limited by the availability of suitable nest sites. In southwestern Oklahoma, however, where before the 1970s the Chihuahuan Raven bred commonly, most nests were placed in mesquite trees (Sutton 1967). Mesquite has expanded widely in western Oklahoma over the past 80 years (Hoagland

**FIGURE 5.** Results of the Breeding Bird Survey for trends in the density of the Common Raven during the breeding season from 1966 to 2012 (Sauer et al. 2014), showing widespread increases in abundance (blue areas).
Studies of Western Birds

Another potential factor in the retraction of the Chihuahuan Raven’s range on the southern Great Plains has been the dramatic decline in the numbers and range of the black-tailed prairie dog (*Cynomys ludovicianus*) in the region (Miller et al. 1994, Samson and Knopf 1994). Throughout the Great Plains, prairie dogs are poisoned on private land and shot for sport (Roemer and Forrest 1996). The prairie dog is considered a keystone species (Miller et al. 1994, Kotliar 2000), and its presence is correlated positively with that of a large number of other species of Great Plains vertebrates (e.g., Anderson et al. 1986, Miller et al. 1994, Desmond et al. 2000, Lomolino and Smith 2003). I frequently observed Chihuahuan Ravens standing in or flying over prairie dog colonies in my study areas. The barren nature of the grasslands within and surrounding prairie dog colonies, together with the high diversity of vertebrates and invertebrates in these areas, may render prairie dog colonies particularly suitable for foraging ravens. Lomolino and Smith (2001) documented a 95% decline in the range of the black-tailed prairie dog from the 1800s to 2000, as well as a significant (>50%) decline in western Oklahoma from 1989 to 1997. As a consequence, the decline in prairie dog abundance across the Great Plains may be contributing to the retraction of the Chihuahuan Raven’s range.

Throughout the Great Plains, fire was historically an important driver of ecological diversity (Anderson 1990, Ford and McPherson 1996). At several landscape scales, fire provides a mosaic of grassland habitats and increases biodiversity (Fuhlendorf et al. 2006), both of which may benefit the omnivorous Chihuahuan Raven. Reduced frequency of fire and the subsequent invasion of woody plants into grasslands may have contributed to the Chihuahuan Raven’s decline in northwestern and southwestern Oklahoma, where ravens were found in large numbers in association with bison herds (Ducey 2000). Similar historical accounts are available for the Prairie Provinces in Canada (e.g., Houston 1977) and the southern Great Plains states (e.g., Oklahoma; Sutton 1967). Following the settling of the Great Plains in the late 1800s and the decimation of bison herds, the range of the Common Raven appears to have retracted and the species no longer occurred in most grassland areas of the Great Plains (Houston 1977).

Recent nesting records in North Dakota suggest an expansion from the northeast, and scattered pairs of breeding Common Ravens are now found across most of North Dakota (Nenneman et al. 2009, D. Svingen pers. comm.). On the southern Great Plains, the Common Raven’s range expansion has been from the Rocky Mountain foothills eastward, recently reaching southwestern Kansas (Cable et al. 2012), western Oklahoma (this study), and west-central Texas (A. Hewetson pers. comm.). An increase in suitable nest sites may have contributed to expansion of the Common Raven’s range in the southern Great Plains. In the Oklahoma panhandle, I found six Common Raven nest sites in attics of long-abandoned farm homes (another was in a large tree). Houston et al. (2007) noted similar nesting in abandoned homes by Turkey Vultures (*Cathartes aura*) expanding onto the prairie in Saskatchewan. Although abandoned farmsteads have been a feature of the landscape in Cimarron County since the 1800s, long-term rural depopulation (Rathge and Highman 1998) has likely increased the number of such sites (pers. obs.). However, the Common Raven’s nesting in trees on the otherwise open landscapes of the high plains (this study, Cable et al. 2012)
suggests that the species may also expand by using such habitat features as the Cimarron River riparian corridor in southwestern Kansas.

**Climate Change as a Trigger?**
The ranges of the ravens on the Great Plains have shifted during a period when the breeding ranges of many Southwestern bird species are expanding to the north and east (Peterson 2003a). Although the precise mechanisms are unclear, climatic factors such as warmer winter and spring temperatures and increasing drought have been cited as contributors to plants’ altered phenologies (e.g., Allen and Breshears 1998) and birds’ range expansions on the southern Great Plains. Such range shifts, however, have been most pronounced among migratory species, not permanent residents like the ravens. Regardless, there appears to be no compelling evidence that climate change has influenced shifts in the ranges of the ravens in the southern plains, or if it has, how it would result in a contraction of the range of one species and an expansion of the other.

Climate change may affect bird distributions through more complex, indirect pathways (Peterson 2003b). For example, climate change is thought to have accelerated the rate and extent of the spread of West Nile virus (WNV) across North America (Soverow et al. 2009). WNV was first identified in North America in 1999 and has caused widespread mortality in a variety of bird species (Rappole et al. 2000, Kilpatrick et al. 2007). Corvids have been more susceptible to WNV than most other groups of birds (e.g., Caffrey et al. 2005, LaDeau et al. 2007), and a significant decline in the American Crow (C. brachyrhynchos) population has been observed in Colorado since 2002 (LaDeau et al. 2007). There is also evidence of WNV in most of the range of the Chihuahuan Raven in Mexico (Estrada-Franco et al. 2003).

Although WNV may have negatively affected Chihuahuan Raven populations, it is not a likely cause of the species’ observed range contraction. First, range contraction appears to have started in the 1980s (in Oklahoma; pers. obs.), well before the appearance of WNV in the Western Hemisphere. Second, the Common Raven’s range expansion onto the Great Plains appears to have begun in the early 2000s, at the same time that WNV was spreading across North America. Therefore, unless the Common Raven is less susceptible to WNV than is the Chihuahuan Raven, it is difficult to attribute continued contraction of the Chihuahuan Raven’s range to WNV, given that the Common Raven was expanding in the same areas during the same period.

**Land-Use Changes**
The recent shifts in the ravens’ breeding ranges on the Great Plains have coincided with a period of decreasing human population, increasing drought, and a dramatic increase in land enrolled in the Conservation Reserve Program (CRP; Figure 6). Although it had existed in other forms, though at a much smaller scale, since the 1950s, the CRP was officially launched as part of the Farm Bill in 1985. Subsequently, land enrollment increased dramatically to over 12 million hectares. With relatively high proportions of the land enrolled in eastern Colorado, western Kansas, and the Oklahoma and Texas panhandles (Figure 7; areas where the Chihuahuan Raven’s range has contracted), the main effect of the CRP program was to change land use from crop production to ungrazed grassland. The increase in CRP enrollment may have negatively affected the Chihuahuan Raven’s breeding success, as this species prefers to forage in relatively short grass with extensive areas of open ground (e.g., grazed grasslands, sand-sage; Dwyer et al. 2013, pers. obs.), whereas most CRP land is relatively dense, ungrazed grassland, often of non-native species. However, a rigorous test of this hypothesis would require comparisons of nest density and reproductive success in areas with differing fractions of CRP land.

**Further Research**
The continuing shifts of the ranges of the ravens on the southern Great Plains present opportunities for investigating the roles of land use and other factors on the species’ demography (a probable driver of range shifts) and breeding distribution.

![Figure 6. Total hectares enrolled in the Conservation Reserve Program since the program’s initiation in 1985.](image-url)
For example, the relationship between the Chihuahuan Raven’s demography (e.g., clutch size, fledging success) and the local extent of CRP land and prairie dog colonies could be carefully quantified. The available evidence suggests that the Chihuahuan Raven’s nest density and breeding success should be positively related to local prairie dog abundance and negatively related to CRP coverage. Another interesting aspect of the current range shifts is the extent to which the Chihuahuan and Common Raven interact competitively during the breeding season (Jollie 1976). Given that these two species have (until recently) rarely been in contact during the breeding season, measuring Chihuahuan Raven nest desertion and depredation of eggs or young by Common Ravens should provide a clue to any such effects. Finally, provision of artificial nest platforms in areas such as southwestern Kansas and the Oklahoma panhandle where Chihuahuan Ravens formerly bred may help clarify the role of nest-site availability on the species’ range retraction in recent decades.

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**LITERATURE CITED**


Differential Breeding Range Shifts of Ravens (Corvus Spp.) on the Southern Great Plains


