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Changes in the number and distribution of Greater Sandhill Cranes in the Eastern Population

Anne E. Lacy,[1] Jeb A. Barzen, Dorn M. Moore, and Kristin E. Norris

International Crane Foundation, P. O. Box 447, E-11376 Shady Lane Rd., Baraboo, Wisconsin 53913, USA

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ABSTRACT. Once nearly extirpated, the Eastern Population (EP) of Greater Sandhill Cranes (*Grus canadensis tabida*) has increased in number and expanded its range in breeding and wintering areas. Data from Christmas Bird Counts (CBCs) and Breeding Bird Surveys (BBSs) were used to delineate changes in the wintering and breeding area distributions during the period from 1966 to 2013. Crane densities were plotted to the centroid of CBC circles or BBS routes, and the Geographic Mean Centers (GMCs) for wintering and breeding populations were calculated. The number of Greater Sandhill Cranes detected during the breeding season has steadily increased since 1966, with just six birds observed in 1966 and 1046 observed in 2013. The GMC of the Sandhill Crane breeding population has remained in Wisconsin during the 47-yr time frame. The total number of Sandhill Cranes counted in the eastern United States during CBCs grew from 423 in 1965–1966 to 46,194 in 2012–2013, with a peak number of 55,826 in 2011–2012. The GMC of wintering Greater Sandhill Cranes was located in Florida during the periods from 1966 to 1977 and 1978 to 1989, but shifted north-northwest by nearly 4° of latitude (into Georgia) by 1990–2001. By 2002–2013, the GMC had shifted an additional degree north as well as almost a degree west in longitude. Greater Sandhill Cranes in the EP may continue to winter further north and remain in more northerly areas later in the fall before migrating further south. Factors such as annual weather, long-term climate change, and changes in land use may influence future population trends and changes in both the breeding and wintering ranges of the EP of Sandhill Cranes.

RESUMEN. **Cambios en el numero y la distribución de *Grus canadensis tabida* en la población del oriente**

Una vez casi extirpada, la población de *Grus canadensis tabida* del oriente, ha incrementado en numero y expandido su rango en área de reproducción e invernales. Datos de Conteos Navideños (CN) y Censos de Aves Reproductivas (CAR) fueron utilizados para delinear cambios en la distribución en el área de invernal y reproductiva durante el periodo desde 1996 hasta 2013. Las densidades de las Grulla fueron graficada al centroide de los círculos de CN y las rutas CAR y fueron calculados los Centros Geográficos Promedio (CGP) para las poblaciones invernales y reproductivas. El numero de *G. c. tabida* detectados durante la temporada reproductiva ha incrementado sostenidamente desde 1996, con solo seis aves observadas en 1996 y 1046 observadas en el 2013. Los CGP de las poblaciones de *G. c. tabida* han permanecido en Wisconsin durante el plazo de 47 años. Los números totales de *G. c. tabida* obtenidos al oriente de los Estados Unidos durante los CN creció desde 423 en 1965–1996 a 46,194 en 2012–2013, con un numero pico de 55,826 en 2011–2012. El CGP invernal de *G. c. tabida* fue localizado en la Florida durante los periodos 1996 a 1997 y 1978 a 1989, pero se desplazo al nororiente por casi 4° de latitud (hacia Georgia) entre 1990–2001. Entre 2002–2013, el CGP de ha desplazado un grado más al norte al igual que casi un grado de longitud al occidente. Las poblaciones orientales de *G. c. tabida* pueden continuar invernando más al norte y permanecen en las zonas más septentrionales más tarde en el otoño antes de migrar hacia el sur. Factores como el clima anual, el cambio climático a largo plazo, y los cambios en el uso del suelo pueden influir en todas las tendencias demográficas futuras, y cambios tanto en la cría como rangos invernales de la población oriental de *G. c. tabida*.

Key words: Breeding Bird Survey, Christmas Bird Count, climate change, Geographic Mean Center, *Grus canadensis tabida*, range expansion

The breeding and wintering ranges of the Eastern Population (EP) of Greater Sandhill Cranes (*Grus canadensis tabida*, hereafter, Sandhill Cranes) are located in the Mississippi and Atlantic Flyways (Van Horn et al. 2010). In the early 20th century, this population was nearly extirpated (Walkinshaw 1960), with perhaps 25 breeding pairs left in Wisconsin in the 1930s (Henika 1936). During the first half of the 20th century, most Sandhill Cranes in the EP bred in the western half of the Great Lakes Region (primarily Wisconsin and Michigan) and wintered in southern Georgia and Florida (Johnsgard 1983). Protection from unregulated hunting and persistence of wetlands in much of their core range allowed the population to recover to a level that exceeded 30,000 birds

[1]Corresponding author. Email: anne@savingcranes.org

by 1996 (Meine and Archibald 1996). Sandhill Crane populations are still expanding (Su et al. 2004, Van Horn et al. 2010) and occupying newly documented breeding (Melvin 2002, 2007, 2010) and wintering areas (McGowan 2003).

During the last two decades, the EP of Sandhill Cranes has increased dramatically, to the extent that the first state hunting seasons on Sandhill Cranes were held in Kentucky (2011) and Tennessee (2013). An increasing number of reports of conflict with farmers has accompanied the increasing population because cranes often use agricultural habitats near their breeding wetlands (Su et al. 2004). Given this dramatic population change, our objectives were to describe where, when, and to what extent changes in the breeding and wintering areas of Sandhill Cranes have occurred as the population has increased.

METHODS

We used two sets of data to define the distribution of the EP since the mid-1960s. First, to delineate changes in the breeding range, we used Breeding Bird Survey (BBS) data (1966–2013). These data were collected through 1-d roadside visual and auditory surveys throughout North America during the breeding season, typically in June (see Sauer et al. 1997). Data from the BBS Eastern Region were selected; the Eastern Region includes states east of the Mississippi River in the lower United States, but also includes forested areas in central Canada. Sites in Manitoba and northern and western Ontario at the eastern edge of the breeding range of the Mid-Continent Population (MCP) of Greater Sandhill Cranes (Krapu et al. 2011) were not used. In addition, BBS sites below 30°N latitude were excluded to remove non-migratory Mississippi and Florida Sandhill Cranes from the analysis.

Densities of cranes counted on each route were plotted using the route start point. The Geographic Mean Center (GMC) was calculated for the entire region for each of four time periods, including 1966–1977, 1978–1989, 1990–2001, and 2002–2013. We used these 11-yr periods because any changes in the GMC would likely occur over longer time periods. GMC was calculated by projecting all geographic coordinates to an Albers Equal Area Conic projection with standard parallels at 29.5° and 45.5° latitude, and calculating the mean x and y values. Counts of cranes at each site were used as a weighting factor. Returned values were converted back to latitude and longitude for easier reference.

To delineate the winter range, we used data from Christmas Bird Counts (CBCs) conducted from December 1965 to January 2013; these years were chosen to match the BBS data used to describe breeding distributions. The count year for CBC data refers to December, that is, 2006 CBC data are from counts conducted in December 2006/January 2007. The CBC is used to monitor the status and migratory trends of bird populations (National Audubon Society 2013, 2014). CBCs are conducted annually from 14 December to 5 January. In addition to all states and provinces east of the Mississippi River, counts from Minnesota, Iowa, Missouri, Arkansas, and Louisiana were included in our study. Data were aggregated into the same four time periods as described above, and GMCs for each year's CBC data were calculated using the same techniques described above except that we used the center of count circles.

To determine if expansion of Sandhill Crane populations to more northern latitudes occurred at a rate similar to the rate at which new CBC sites were added over this time frame (thus influencing the number of Sandhill Cranes counted in northern latitudes), two simple linear regressions were carried out with year and latitudes at which sites were added each year included as variables. A regression for the year a CBC site was first counted (R^2_{Sites}) and for the year a Sandhill Crane was first counted at that site (R^2_{SACR}) was then plotted. A positive relationship in R^2_{Sites} would indicate a disproportional addition of sites at north locations over the years, whereas a positive relationship in R^2_{SACR} would indicate that sites with first time sightings of Sandhill Cranes were disproportionately at northern CBC sites over the years. We assumed that slopes close to zero indicated no relationships.

Cranes are large and often heard from a distance. In breeding areas, they are highly territorial and pairs make frequent unison calls to defend territories (Ellis et al. 1996). In wintering areas, cranes gather in large flocks where food and suitable roosting habitat are available (Van Horn et al. 2010). According to Link and Sauer (1998), biases inherent in count data, such as BBS and CBC, do not allow for direct estimates

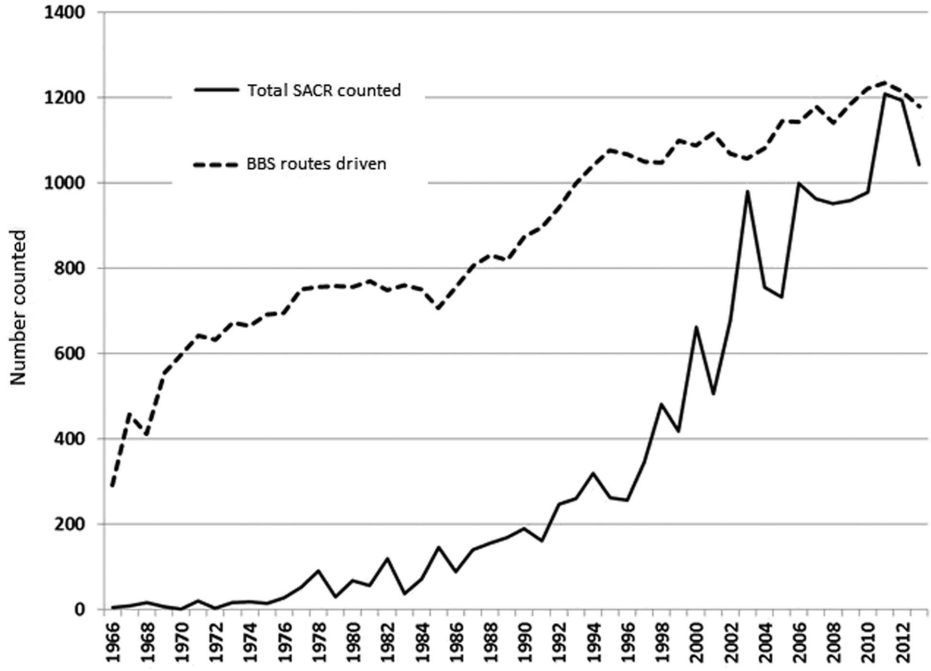

Fig. 1. Number of Breeding Bird Survey routes in the eastern United States and Canada and total number of Sandhill Cranes (SACR) counted on those routes, 1966–2013.

of density. However, at the geographic scale we used, there is consistency in the counting procedure that accurately reflects population change. Because we were not attempting to determine a density estimate, but, rather, a description of population change over time, the BBS and CBC data sets were useful for describing the extent (geographical) and timing (temporal) of changes in the distribution of Sandhill Cranes.

RESULTS

Summer distribution. The number of Sandhill Cranes detected during the breeding season has increased steadily since 1966, as have the number of BBS routes (Fig. 1). Changes in the number of routes and Sandhill Cranes did not, however, occur simultaneously. The number of BBS routes almost tripled during the 1966–1977 time period, whereas the number of cranes counted on BBS routes over the same period exhibited little change. Conversely, the number of Sandhill Cranes counted on BBS routes from 1996 to 2010 increased by 600% and the number of BBS routes increased by only 20% over the same period. Over the entire count period, the number of cranes detected in the Eastern BBS region increased from only six birds (291 routes, 0.02 cranes/route) in 1966 to 1046 birds (1178 routes, 0.89 cranes/route) in 2013.

During summer, the densest concentration of Sandhill Cranes encompasses all of Wisconsin and most of Michigan (Fig. 2); by the 2002–2013 time frame, the core breeding zone also included portions of east-central Minnesota and south-central Ontario (Fig. 2D). During the last time period, Wisconsin had the highest proportion of all cranes counted (66.3%). The GMC of breeding Sandhill Cranes remained in northeastern Wisconsin during the entire 45-yr time frame (Fig. 2), varying by less than 79, 44, and 27 km between periods 1 and 2, 2 and 3, and 3 and 4, respectively, and not moving in any consistent direction.

Winter distribution. The total number of Sandhill Cranes counted in the eastern United States during CBCs grew from 423 in 1965–1966 to 46,194 in 2012–2013, with a peak number of 55,826 in 2011–2012. By the winter of 2012–2013, Sandhill Cranes were recorded on CBCs in 30 eastern states or provinces and,

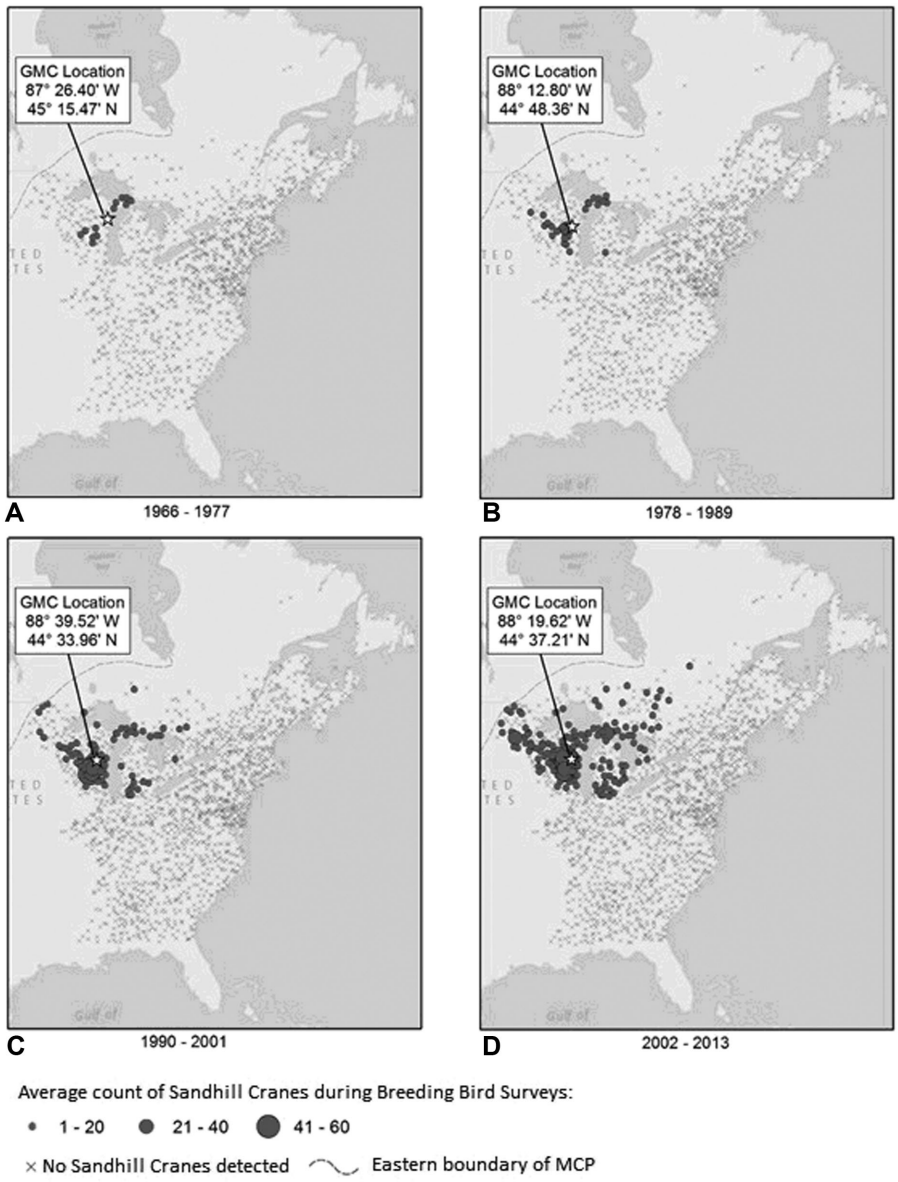

Fig. 2. Average number of Sandhill Cranes recorded on Breeding Bird Survey routes in the eastern region of the United States and Canada during four time periods: (A) 1966–1977, (B) 1978–1989, (C) 1990–2001, and (D) 2002–2013. The eastern boundary of the Mid-Continent Population (MCP) of Sandhill Cranes is from Krapu et al. (2011).

in addition, were observed in Maine during the count week, but not on the day of the count.

Over the years included in our study, Sandhill Cranes greatly expanded their winter range (Fig. 3). During the 1966–1977 time period, most wintering birds were counted in central Florida, with a GMC of 28°54.68′ (Fig. 3A). During the next time frame (1978–1989), the GMC shifted 11.1 km north. However, by the last time period (2002–2013), cranes were counted from central Florida northwestward through Georgia, Tennessee, Kentucky, and

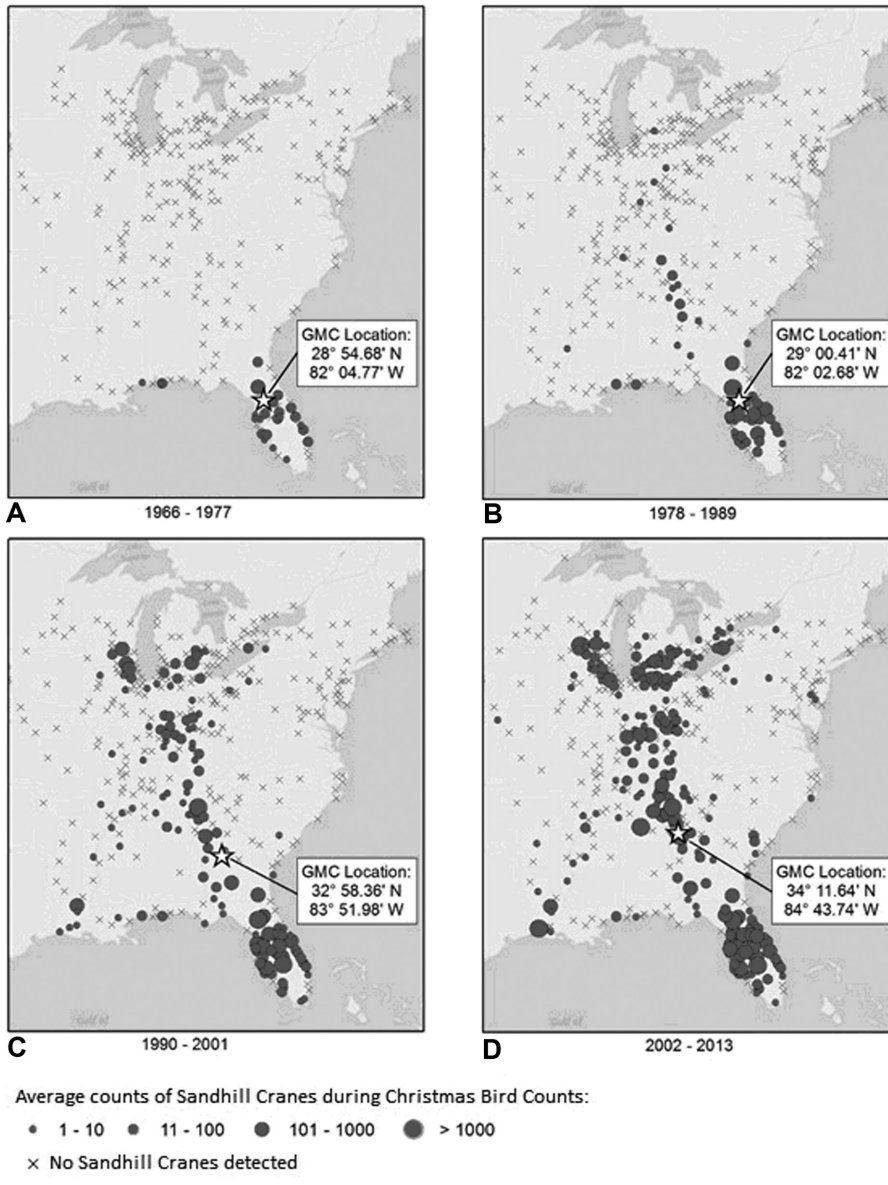

Fig. 3. Average numbers of Sandhill Cranes recorded during Christmas Bird Counts in the eastern United States and Canada over four time periods: (A) 1966–1977, (B) 1978–1989, (C) 1990–2001, and (D) 2002–2013.

Indiana, with concentrations in Wisconsin and Michigan as well (Fig. 3D). The GMC of Sandhill Cranes counted on CBCs was in Florida during the periods from 1966 to 1977 and 1978 to 1989 (Figs. 3A and B), but shifted north-northwest by nearly 4° of latitude (474 km) to Georgia by the 1990–2001 time period (Fig. 3C). The GMC was still in Georgia during the 2002–2013 time period, but had shifted 158 km further northwest as well as almost a degree west in longitude (Fig. 3D). These shifts reflect more birds wintering in the Midwest as well as more birds wintering further west in states such as Alabama and Louisiana (Figs. 3C and D).

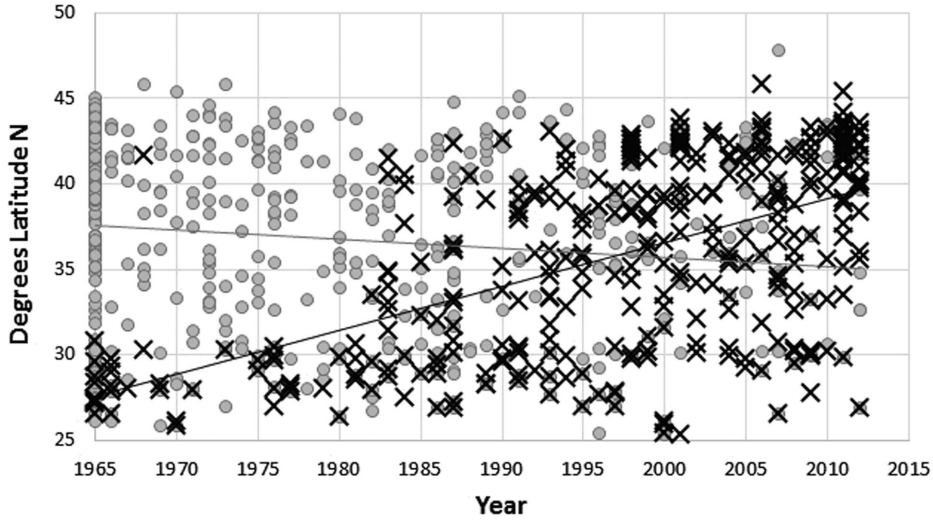

Fig. 4. The first year in which CBCs were conducted at different locations in the eastern United States and Canada (gray circles; $N = 523$) and the year in which Sandhill Cranes were first detected (black X, $N = 350$) at CBC sites by degrees north latitude. R^2 for year when CBC first counted = 0.02, $b = -0.05$; R^2 for year Sandhill Cranes were first detected was 0.33, $b = 0.26$.

The total number of CBCs in the eastern United States increased steadily from 1966 to 2012. We found a positive relationship between latitude and year when Sandhill Cranes were first detected ($R^2_{SACR} = 0.33$, $b = 0.026$, $P < 0.001$; Fig. 4), with more cranes detected at more northern CBC sites in later years. However, this trend was not due to the addition of more CBCs at northern latitude ($R^2_{Sites} = 0.02$, $b = -0.05$, $P = 0.001$; Fig. 4).

DISCUSSION

Summer distribution. Although the number of breeding Sandhill Cranes in the eastern United States has increased from 1966 to 2013 (this study, Van Horn et al. 2010), the increase has been neither constant nor evenly distributed. The rate of increase in the western portion (Michigan, Minnesota, and Wisconsin) of the breeding range was initially rapid, but has since leveled off as suitable habitats were filled (Su et al. 2004). In the eastern portion of their breeding range, Sandhill Cranes have colonized lakeshore habitats and associated wetlands that still persist, where many of the hardwood forests of pre-settlement times have been replaced largely by agriculture (Bird Studies Canada 2014). Breeding Sandhill Cranes benefit where agricultural fields are located near wetlands (Su 2003).

Trend data calculated from BBS counts throughout the survey area indicate that the rate of increase of the Sandhill Crane population in the Eastern Region was 5.88% annually from 1966 to 2013, and 8.39% from 2003 to 2013 (Sauer et al. 2014). Based on relevant Bird Conservation Regions (ecologically defined units on the landscape that are meaningful to bird populations; Bird Studies Canada 2014), the greatest increase in the breeding population of Sandhill Cranes has occurred in the "Prairie Hardwood Transition" biome (Minnesota, Wisconsin, and Michigan), with a rate of increase of 9.63% from 2003 to 2013 and 12.39% from 1966 to 2013 (Sauer et al. 2014).

Breeding Bird Atlas (BBA) data also indicate that Sandhill Crane populations have increased in the Lower Great Lakes/St. Lawrence Plain biome of the BBS (Bird Studies Canada 2014, Sauer et al. 2014, U.S. Geological Survey 2014). This increase, however, began in the late 1980s for the eastern portion rather than in the 1960s as occurred in the core range of Minnesota, Wisconsin, and Michigan. In regions where two BBAs have been conducted (e.g., the Maritime Provinces of Canada, and the states of Massachusetts, New York, and Vermont in the

United States), many records of nesting Sandhill Cranes were detected during the second survey, but not during the first survey (Bird Studies Canada 2014, U.S. Geological Survey 2014). Southeast of the core breeding area for Sandhill Cranes, a similar trend has been observed. Ohio had only one record of Sandhill Cranes on its first BBA, but many breeding pairs were documented by 2013 (Downs et al. 2008, D. Sherman, unpubl. data). Additional expansion in the distribution of Sandhill Cranes in the EP has occurred in southwest Minnesota and Iowa and northern Illinois and Indiana (International Crane Foundation, unpubl. data). New breeding records have also been noted for Missouri (Rowe 2012), although whether these birds originated from the EP or the MCP is unclear. Throughout this extensive expansion in breeding range over the past half century, however, the core summer population of the EP remains centered in Wisconsin, with approximately two-thirds of the entire summer population.

Winter distribution. Although little change in the GMC of wintering Sandhill Cranes occurred during the first two time periods of our study, the GMC did move north and west during the last two time periods. Areas previously considered only stopover sites during fall migration in previous decades (Melvin 1978) were more often used as wintering sites. Many current wintering areas are located at more northern latitudes, such as Jasper-Pulaski refuge in Indiana (J. Bergens, unpubl. data) and the Hiwassee refuge in Tennessee (DeVore 1980, Aborn 2010).

During mild winters, cranes have tended to concentrate further north. Fall and winter surveys in northwestern Indiana have revealed a shift in the average fall peak in numbers of Sandhill Cranes from 31 October (1976–1991) to 21 November (1992–2008; J. Bergens, pers. comm.) and, during the period from 1990 to 2010, the last cranes staging in southern Wisconsin have often remained until the end of December (J. Barzen, unpubl. data). Records of Sandhill Cranes during CBCs in Wisconsin and Michigan at the end of December may represent late-migrating birds rather than wintering birds. Later initiation of fall migration suggests the presence of open water for roosting and access to foods in upland locations not covered by snow. A trend for later fall migration has also been reported for some migratory cranes in Europe, with the number of Eurasian Cranes (*Grus grus*) wintering in France increasing from none in 1976 to 100,000 in 2010 (Salvi 2012). If changes in climate were found to be primarily responsible for causing Sandhill Cranes to shift their winter distribution northward, then management activities could focus on improving habitat quality in more northern areas to ensure adequate habitat necessary to fulfill seasonal needs.

Changes in land use have also contributed to changes in the distribution of wintering Sandhill Cranes. For example, corn was planted in the 1980s to attract migrating waterfowl at the Hiwassee Wildlife Refuge in Tennessee before cranes began to winter in Tennessee in large numbers. Within a decade, however, over 10,000 Sandhill Cranes spent entire winters there (Aborn 2010). Similarly, numbers of Eurasian Cranes increased from 5000 to 30,000 in 14 yr after an artificial feeding program was initiated in the Hula Valley of Israel (Shanni et al. 2012). Land-use changes, and specifically an increase in the amount of land used to grow corn in the eastern United States and Canada, have also been implicated as a major reason for shifts northward in the wintering areas of Canada Geese (*Branta* spp.; Malecki et al. 1988). Corn is also a major component of the diet of cranes in the winter and during migration (Krapu et al. 1984), and increased corn production may have contributed to the increase in the numbers of Sandhill Cranes wintering at more northerly latitudes. If human-caused habitat change is modifying the distribution of Sandhill Cranes, then monitoring land-use changes to ensure that alterations are not removing or degrading needed habitat to their detriment would be appropriate.

If the main reason for a shift in distribution is the increase in size of the EP, hunting may be a core management activity. With increasing crane populations, there have been an increasing number of complaints regarding damage to crops caused by Sandhill Cranes, primarily in the spring (Lacy et al. 2013). The EP management plan, written as a precursor to establishing Sandhill Crane hunting seasons in states of the Mississippi and Atlantic Flyways, calls for maintaining a total EP at 30,000–60,000 cranes to balance societal benefit for having cranes and individual costs that accrue with

burgeoning crane populations (Van Horn et al. 2010). A managed harvest could slow or stabilize population growth, potentially minimizing conflict between farmers and cranes. However, as the winter distribution shifts further north, and as Sandhill Cranes delay their departure from breeding areas in the fall (Miller 2003; ICF, unpubl. data), implementation of hunting seasons in core breeding areas such as Wisconsin and newly colonized areas such as Ohio may expose more locally breeding birds to overharvest. Disproportionate harvest is already a recognized issue with some cranes in the MCP of Greater Sandhill Cranes (Krapu et al. 2011).

Factors such as annual weather, long-term climate change, and changes in land use may influence future population trends and changes in both breeding and wintering ranges and are not mutually exclusive factors. Understanding which factor predominates, however, is important because each factor requires different management responses. Quantifying the increase or decrease in populations of Sandhill Cranes in the EP and their expansion into new areas is an important step in refining management plans in the future, and offers an opportunity to improve our understanding of the recovery of recovering crane populations worldwide, for example, endangered Whooping Cranes (*Grus americana*) at Aransas NWR in Texas (Smith et al. 2014), endangered Red-crowned Cranes (*Grus japonensis*) in East Asia (Amano 2009), and Eurasian Cranes (*G. grus*) in Israel (Shanni et al. 2012).

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