

OVERWINTERING SANDHILL CRANES (*GRUS CANADENSIS*) IN NEBRASKA, USA

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ABSTRACT.—Over half a million Sandhill Cranes (*Grus canadensis*) migrate through Nebraska, USA, each autumn and spring, but only a few cranes have been reported in Nebraska during winter. In early winter of 2011, however, an estimated 4,000–5,000 Sandhill Cranes were observed in south-central Nebraska along the Platte River. At that time, we initiated a study to search for and document Sandhill Cranes within the Platte River Valley across three winters and relate winter crane observations for the recent period to historical late autumn, winter, and early spring sightings in Nebraska documented by citizen observers for a century. We observed thousands of Sandhill Cranes along the Platte River in winters 2011–2012 and 2012–2013, but none in 2013–2014. Winters 2011–2012 and 2012–2013 were notable for a combination of mild conditions in Nebraska coupled with severe to exceptional drought in the southern United States and northern Mexico at traditional wintering areas for cranes. Analysis of historical observations indicates such large numbers of Sandhill Cranes have not been documented previously during winter in Nebraska, with the exception of 5,000 cranes near Grand Island, Nebraska, on 15 December 1990 that were not reported again following an arctic blast 2–3 days after the sighting. Reported dates of first spring arrivals have shifted over time, with Sandhill Cranes returning progressively earlier in spring in more recent years. If Sandhill Cranes continue to overwinter and/or arrive earlier in spring, there may be consequences for interspecies interactions with migratory waterfowl, such as competition for waste grains or transmission of disease, within the Platte River Valley, as well as for the timing of habitat-management activities. Ongoing monitoring of cranes during winter and early spring will track these patterns to better inform managers of habitat and food resources to help meet the species' needs. Received 12 September 2014. Accepted 1 February 2015.

Key words: climate, *Grus canadensis*, migration, Nebraska, Platte River, Sandhill Crane, seasonality, winter.

The Platte River and North Platte River valleys and surrounding areas in Nebraska provide essential energetic and habitat resources to Sandhill Cranes (*Grus canadensis*) as they migrate through the Central Flyway of North America each spring (USFWS 1981, Iverson et al. 1987, Tacha et al. 1987, Davis 2003, Krapu et al. 2014). Individuals of the Mid-continent Population of Sandhill Cranes overwinter in the south-central United States and in northern Mexico and migrate to breeding grounds in the north-central United States, Canada, Alaska, and even Siberia (Krapu et al. 2011, 2014). More than 500,000 Sandhill Cranes stop along the Platte River during spring migration (Kinzel et al. 2006), with individuals staying approximately 3–4 weeks (USFWS 1981, Iverson et al. 1987, Krapu et al. 2014) and acquiring lipid resources (Krapu et al. 1985) and other necessary nutrients before continuing migratory journeys that can exceed 6,300 km (extrapolated from Krapu et al. 2011). Most cranes seek refuge in shallow, open waters and sandbars of the Platte and North Platte rivers to

roost (Iverson et al. 1987, Folk and Tacha 1990), and they feed on waste grains, especially corn, in agricultural fields that dominate the surrounding landscape (Reinecke and Krapu 1986, Pearse et al. 2010). Cranes also utilize wet meadows and grasslands where they obtain complementary foods, such as invertebrates and tubers, to supplement a high-carbohydrate, corn-based diet with calcium, protein, and other micronutrients (Reinecke and Krapu 1986, Davis and Vohs 1993). In autumn, migrating Sandhill Cranes fly across Nebraska but typically do not stop long, or at all, en route to wintering grounds (e.g., Krapu et al. 2011).

The wintering grounds of the Mid-continent Population of Sandhill Cranes are a considerable distance from Nebraska, with the nearest high-use wintering area about 800 km away from the Platte River in Texas (Tacha et al. 1984; Root 1988; Seyffert 2001; Krapu et al. 2011, 2014), and they extend to southeastern Arizona, northern Mexico, and the Gulf of Mexico (e.g., Krapu et al. 2011), with some documented wintering areas as far south as central Mexico (López-Saut et al. 2011). Sandhill Cranes have been reported occasionally during winter north of their typical winter range, with reports from Oklahoma (Wood and Schnell 1984, Krapu et al. 2011), Kansas (Thompson and Ely 1989, Krapu et al. 2011), and Nebraska

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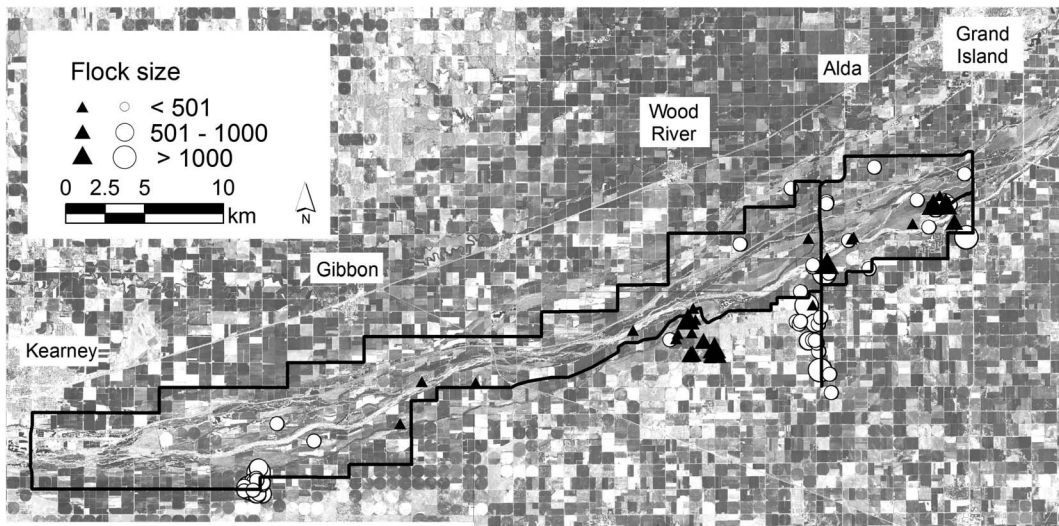


FIG. 1. Map of 180-km route (black line) driven to survey Sandhill Cranes (*Grus canadensis*) during winter in the Platte River Valley in south-central Nebraska, USA, between Kearney (Buffalo County) and Grand Island (Hall County). Circles represent flocks observed the first winter (Jan–Feb 2012), and triangles represent all flocks observed the second winter (10 December 2012 to 6 February 2013). During winter 2012–2013, most cranes were located off the primary survey route, and detection reflects targeted searches and opportunistic sightings. No cranes were detected in the region during winter 2013–2014.

(Shickley 1965, Sharpe et al. 2001, Johnsgard and Shane 2009).

During spring migration, some Sandhill Cranes arrive in Nebraska by late-February (Johnsgard 1980, USFWS 1981), although a few sightings have been noted in January (e.g., Johnsgard 1980, Sharpe et al. 2001, Davis 2003). However, most cranes arrive to the Platte River Valley in mid-March (Krapu et al. 2014). In autumn, last reported sightings of Sandhill Cranes in Nebraska historically ranged from 1 October to 31 December, with a median of 5 November (Johnsgard 1980).

In late autumn and early winter 2011, we observed Sandhill Cranes lingering on the Platte River in south-central Nebraska well past the usual departure date for autumn migration, with about 4,000–5,000 Sandhill Cranes remaining at the end of December and into early January 2012, based on observations of cranes in flight and in fields (GDW, pers. obs.). This timing of occurrence was unprecedented according to published accounts (e.g., Johnsgard 1980, Sharpe et al. 2001, Johnsgard and Shane 2009, Silcock 2012) and recollections by local birdwatchers and conservation professionals. Therefore, we conducted ground-based surveys of Sandhill Cranes during winters 2011–2012, 2012–2013, and 2013–2014

in the Platte River Valley to estimate a minimum known number of birds and to determine locations of occurrence. We also analyzed seasonal records of Sandhill Crane sightings in Nebraska spanning a century, primarily from citizen observers, to determine 1) whether Sandhill Cranes had overwintered previously in Nebraska and 2) whether any shifts in last autumn reports or first spring reports of Sandhill Cranes had occurred over the period of record.

METHODS

Crane Surveys during Recent Winters

To document Sandhill Cranes in winter 2011–2012, we conducted a ground-based search for cranes in agricultural fields and grasslands near the Platte River in Nebraska, USA. We designated a continuous, 180-km route along roads between Kearney (Buffalo County) on the western edge of the route and Grand Island (Hall County) on the eastern edge of the route, which included both the north and south sides of the Platte River (Fig. 1). This route was selected because it provided clear views of day-use sites often occupied by cranes, as discovered from observations of field use by cranes obtained by following birds in flight to fields where they fed and rested earlier in the winter (GDW, pers. obs.). We drove the route

twice weekly from 9 January to 6 February 2012 mid-day (1200 to 1600 Central Standard Time) when birds were off the river, and therefore easier to observe from roads. We also documented large flocks that were detected off the survey route. Upon encountering cranes, we recorded location, counts of individuals, types of fields occupied, and kinds of behavior exhibited by cranes.

During winter 2012–2013, we surveyed the complete 180-km driving route on 10, 17, and 20 December 2012; 2, 9 and 25 January 2013; and 4 and 6 February 2013. We supplemented the driving survey with additional searches by vehicle, as well as recorded opportunistic observations of flying cranes, because cranes were often seen away from the primary survey route. We also conducted an aerial flight of the Platte River on 14 January 2013, searching for cranes in the main river channel and agricultural fields between Shelton (Buffalo and Hall counties) and Highway 281 south of Grand Island (Hall County), Nebraska.

During winter 2013–2014, we drove the complete 180-km survey route on 6 and 17 December 2013 and 1 and 15 January 2014. We also conducted searches for cranes during other field activities and requested information about crane sightings from conservation professionals in the region. We conducted fewer surveys the last year of the study, as there was no indication that any cranes were in the Platte River Valley, based on our own observations and reports from other managers and citizens in the area.

To investigate potential influences of climate on crane behavior, we examined climate data from south-central Nebraska, as well as drought conditions throughout North America during winters (Dec and Jan) 2011–2014. We obtained climate data collected at the Grand Island, Nebraska Regional Airport spanning 1938–2013 from the National Climatic Data Center (NOAA 2013) and for winter 2013–2014 from the National Weather Service (NWS 2014). We extracted maximum and minimum daily temperature, as well as average daily snow depth in December and January of each year. We examined North American Drought Monitor maps, which reflect measurements of climatic, hydrologic, and soil conditions, for December and January of each year to describe drought conditions throughout the central and south-central United States, as well as northern Mexico (NOAA 2014b).

Reports of Cranes from Historical Sightings

We compiled historical sightings of Sandhill Cranes reported in published notes (1914–1932) from Charles S. Ludlow (Ludlow 1935); Nebraska Ornithological Union's *Letters of Information* (1925–1932); *Nebraska Bird Review* (1933–2013); notes of Warren E. Paine spanning 1939–1980 (housed at the University of Nebraska State Museum, Division of Zoology, Lincoln, NE, USA); and Christmas Bird Counts (surveys reported in *Nebraska Bird Review*, *Audubon Field Notes*, and National Audubon Society [2010]). Most information came from fall and spring occurrence reports and summaries of Christmas Bird Counts published in *Nebraska Bird Review*.

From those historical accounts, we determined the date of first and last reported sighting by year. We plotted these first and last reported sightings by year, expressing date of sighting as number of days relative to January 1, and examined relationships between date of sighting and year with regression models. To examine whether there was previous evidence of Sandhill Cranes overwintering in Nebraska, we summarized records of crane sightings from 15 December to 15 January in Nebraska and divided these observations into three categories: probable, possible, and unlikely overwintering Sandhill Cranes. Probable overwintering was defined as multiple birds reported multiple times from the same general location mid-December through mid-January. Possible overwintering was defined as multiple birds reported once from 15 December to 15 January with no other reports during that period. Unlikely overwintering were reports of singleton birds or multiple birds with documented departure and/or exposure to subsequent extreme weather conditions with no subsequent sightings.

RESULTS

Crane Surveys during Recent Winters

Crane Surveys Winter 2011–2012.—Following observations of about 4,000–5,000 Sandhill Cranes in December 2011 in the Platte River Valley (GDW, pers. obs.), we observed large numbers of Sandhill Cranes in January along the river, with minimum known numbers ranging from 1,300 on 23 January 2012 to 4,590 on 11 January 2012, and over 7,000 cranes by 6 February 2012, with the latter likely reflecting early spring arrivals. Flock sizes ranged from three to about 3,000 birds (median = 315 birds;

TABLE 1. Summary of winter (Dec–Jan) weather at Grand Island, Hall County, Nebraska, USA. Values represent means with standard deviations in parentheses for temperature and snow depth. Snow cover represents total number of days with snow on ground in December and January for the focal three winters, as well as mean and standard deviation of total number of days with snow across winters 1938–2014. Sample sizes are 62 days for winters 2011–2012, 2012–2013, 2013–2014 and 76 years for winters 1938–2014.

	2011–2012	2012–2013	2013–2014	1938–2014
Max temperature (°C)	5.7 (6.6)	3.2 (7.4)	3.2 (8.9)	2.0 (2.7)
Min temperature (°C)	–7.0 (5.3)	–8.3 (5.7)	–10.8 (6.1)	–9.8 (2.0)
Snow depth (cm)	2.0 (4.5)	4.0 (5.3)	0.3 (0.8)	3.9 (4.8)
Snow cover (# d)	13	28	8	23.0 (15.2)

$n = 58$ flocks). Cranes were concentrated in two areas: southwest of Gibbon, Buffalo County, Nebraska, south of the Iain Nicolson Audubon Center at Rowe Sanctuary, and southwest of Grand Island, Hall County, Nebraska, south of Mormon and Shoemaker islands near the Crane Trust Wild Rose Ranch, east of Alda Road (Fig. 1). Cranes occupied corn stubble, soybean stubble, and grasslands, where they were observed both foraging and resting. Cranes were not seen on nocturnal roosts, so these locations are unknown, but based on observations of birds in flight, we expect cranes may have been roosting in the Platte River near these day-use sites (Fig. 1).

Crane Surveys Winter 2012–2013.—We detected fewer Sandhill Cranes along the primary survey route during winter 2012–2013; instead cranes were concentrated in an area between the previous year's use sites (Fig. 1). We observed 3,250 and 4,400 cranes on 10 December and 17 December 2012, respectively, in grazed pastures and harvested cornfields south of Wood River, Nebraska, in a region with small hills that afforded protection from wind, but also precluded clear viewing of birds. A snowstorm occurred on 19 December, resulting in 17 cm of snowfall and continuous snow cover through 16 January 2013. No cranes were detected during searches on 20 December 2012 and 2 January 2013 on the primary driving route. However, approximately 830 cranes were seen on 9 January and on a follow-up visit on 10 January 2013, in harvested cornfields south of Wood River; these cranes were concentrated on bare hilltops where wind had blown away snow and exposed bare ground. We did not detect any cranes during an aerial search of the river on 14 January 2013, and suspect that most of cranes had left the river valley to reside in

nearby uplands. We observed 8 cranes on 16 January 2013 in a soybean field south of Wood River, and saw over 650 cranes flying on 22 January 2013 and over 2,250 flying on 25 January 2013 near Mormon and Shoemaker islands, potentially representing early spring arrivals. Over 6,500 cranes were in the area by 6 February 2013 when we terminated ground surveys, and these birds likely included early spring migrants. Again, we are uncertain where cranes roosted at night. Several hundred cranes were seen the evening of 8 January from the Alda bridge flying west, potentially using that section of river to roost, and on several other days cranes were heard on the river or seen flying toward that same area prior to nightfall.

Crane Surveys Winter 2013–2014.—No Sandhill Cranes were observed between Kearney and Grand Island, Nebraska, between 15 December 2013 and 15 January 2014 during our surveys. Additionally, there were no reports of Sandhill Cranes in Nebraska from the 2013 Christmas Bird Count (Paseka 2014) or in the Winter Field Report (Silcock 2014). First reports of Sandhill Cranes in the Platte River Valley in 2014 came on 12 and 13 February of 2 and 4 birds, respectively (B. Taddicken, pers. comm.), which likely represent early spring arrivals. First spring migrants also were reported over North Platte, Lincoln County, Nebraska, on 13 February 2014 (Silcock 2014). With our survey effort plus additional searches, we are confident that if Sandhill Cranes had been present in the study area during late December and early January, our survey method would have detected them.

Climatic Conditions Winters 2011–2014.—The central United States experienced extreme climatic conditions during the period of study. The most severe drought on record in Texas began in 2011,

and severe to exceptional drought conditions extended throughout the traditional wintering range of Sandhill Cranes in Texas, eastern New Mexico, and northern Mexico in December 2011 and January 2012 (NOAA 2014b). In winter 2011–2012, south-central Nebraska was warm with little snow relative to the 76-year record at Grand Island, Nebraska (NOAA 2013; Table 1). Of the 13 days with snow cover, 11 were in the first two weeks of December 2011, leaving the ground snow free most of the 2011–2012 overwintering period. During winter 2012–2013, drought conditions shifted northward into the central United States, with most of Nebraska under exceptional drought, Texas and eastern New Mexico under severe to exceptional drought, and northern Mexico under moderate drought to normal conditions (NOAA 2014b). Winter 2012–2013 was again warm relative to the period of record in south-central Nebraska (NOAA 2013; Table 1), however, minimum temperatures plummeted to -19°C in late December, and snow cover was present from mid-December through mid-January. In 2013–2014 average minimum daily temperatures were colder than the prior two winters, and there was virtually no snowfall in south-central Nebraska (NWS 2014; Table 1). Furthermore, drought conditions were moderated in 2013–2014, especially in the southern portion of the traditional wintering grounds of Sandhill Cranes, relative to the previous two winters (NOAA 2014b).

Reports of Cranes from Historical Sightings (1914–2014)

Overwintering Sandhill Cranes.—In addition to the two years of confirmed overwintering cranes reported herein, we discovered evidence for only three additional years when Sandhill Cranes may have spent the winter in Nebraska (Table 2). The first such record was provided by Shickley (1965), who documented approximately 50 Sandhill Cranes along the North Platte River north of Hershey, Lincoln County, in mid-December 1964, with subsequent sightings of a few cranes through early January. The other winters (1977–1978 and 1994–1995) were inferred from reports of cranes in nearby areas in both December and January. In reference to winter 1994–1995, Silcock (1995:14) stated: “This was an interesting winter season, with some record late and early dates, rarities, and early arrivals of large numbers of migrants....Large numbers of geese, ducks,

notably Northern Pintail, and Sandhill Cranes returned early to Rainwater Basin marshes, which were still largely frozen.”

Additionally, there were 14 years with possible overwintering Sandhill Cranes and seven years with unlikely overwintering, mostly sightings of singletons, between 15 December and 15 January in Nebraska (Table 2). Worth noting was documentation of 5,000 Sandhill Cranes in mid-December 1990 in the Grand Island (Hall County) Christmas Bird Count; the species had not previously been recorded on a Grand Island count (NOU 1991). A severe arctic blast affected Nebraska 2–3 days after this winter count, freezing the previously open water (NOU 1991), and it is unlikely Sandhill Cranes remained in the area following the storm. All other reports of Sandhill Cranes during winter were of small flocks, 1–250 birds, prior to the winter of 2011–2012 (Table 2). Of the combined 26 years with sightings of cranes reported in winter, 77% occurred after 1970 (Table 2).

Trends in Migration Timing.—The record of first reported observations for Sandhill Cranes in spring is more complete and extensive than that of last reported observations in autumn, spanning a century (Fig. 2). Early in the record, reports of first sightings were in late March and early April. By the 1950s, first reports were in mid-February, and January sightings became increasingly common thereafter, with a reduced rate of decline in recent decades ($y = 2.829e+04 - (2.811e + 01)x + (6.990e-03)x^2$; $r^2 = 0.62$, $P < 0.001$; Fig. 2). Only four years prior to 1950 had reports of last observations of Sandhill Cranes, with most of those observations in October, whereas the last reported observations have tended to occur from mid-November through mid-December in recent years (Fig. 2). The record of last reported sightings is not complete enough to analyze statistically, though a trend in later autumn observations is present, but it is highly influenced by the early years of record (Fig. 2).

DISCUSSION

Winters 2011–2012 and 2012–2013 were the first on record with evidence of large numbers of overwintering Sandhill Cranes in Nebraska. Several thousand Sandhill Cranes were seen over the entire winter near the Platte River south of Gibbon and Alda, Nebraska, the first winter; fewer cranes were detected and sightings were more sporadic in the Platte River Valley the

TABLE 2. Summary of winter records of Sandhill Cranes (*Grus canadensis*) in Nebraska, USA. Confirmed overwintering represents strong evidence of birds remaining in the same general location mid-December through mid-January. Probable overwintering was defined as multiple birds reported multiple times from the same general location mid-December through mid-January. Possible overwintering was defined as multiple birds reported once from 15 December to 15 January with no other reports during that period. Unlikely overwintering were reports of singleton birds or multiple birds with documented departure and/or exposure to subsequent extreme weather conditions with no subsequent sightings.

Winter period	Date of sighting	Location	Count	Winter sightings source ^a	Notes and later sightings information	Additional sightings source ^a
<i>Confirmed overwintering</i>						
2011–2012	29 Dec.	Buffalo Co.	3000	NBR 2012 (80:10)	Sightings in same area through Jan.	This study
2012–2013	17 Dec.	Hall Co.	4400	This study	Sightings near Wood River through Jan.	This study
<i>Probable overwintering</i>						
1964–1965	mid-Dec.	Lincoln Co. (Hershey)	50	NBR 1965 (33:28)	Sightings in same area 3 Jan.	NBR 1965 (33:28)
1977–1978	26 Dec.	Lincoln Co.	NR ^b	NBR 1978 (46:26)	Sightings in same county 24 Jan.	NBR 1978 (46:71)
1994–1995	26 Dec.	Buffalo Co. (Gibbon)	20	NBR 1995 (63:18)	Sightings 15 Jan. of 90 birds Kearney Co.	NBR 1995 (63:18)
<i>Possible overwintering</i>						
1946–1947	21 Dec.	Keith Co. (Lake McConaughy)	250	NBR 1947 (15:14)	No subsequent reports in state until March	NBR 1947 (15:66)
1953–1954	1 Jan.	Dawson Co. (Lexington)	NR	NBR 1954 (22:56)	No previous winter reports in area; NBR fall record report not yet started.	
1960–1961	1 Jan.	Kearney CBC ^c	50	AFN 1961 (15:238)	Last report 6 Nov. Webster Co.	NBR 1961 (29:43)
1961–1962	14 Jan.	Lincoln Co.	NR	NBR 1962 (30:60)	Last report 4 Nov. Webster Co.	NBR 1962 (30:44)
1971–1972	31 Dec.	Kearney CBC	200	NBR 1972 (40:18)	Next report 12 Feb. Adams Co.	NBR 1972 (40:75)
1973–1974	8 Jan.	Lincoln Co.	NR	NBR 1974 (42:70)	Last report 17 Nov. Perkins	NBR 1974 (42:26)
1975–1976	24 Dec.	Kearney Co. (Ft. Kearny SP)	24	NBR 1976 (44:7)	Heard 29 Dec. Kearney CBC; next record 11 Feb. Adams Co.	NBR 1976 (44:7.43)
1978–1979	16 Dec.	Scottsbluff Co.	2	NBR 1979 (47:34)	Next report 17 Jan. Lincoln Co.	NBR 1979 (47:46)
1979–1980	17 Dec.	Kearney, NE (Platte River)	NR	NBR 1980 (48:21)	Peak numbers 5 Dec. in this area; next report 19 Feb. Hall Co.	NBR 1980 (48:21.73)
1982–1983	7 Jan.	Lincoln Co.	NR	NBR 1983 (51:69)	Last report 10 Nov. Scottsbluff Co.; next report 18 Feb. Adams Co.	NBR 1983 (51:63.69)
1995–1996	16 Dec.	Hall Co. (Grand Island)	225	NBR 1996 (64:20)	Reports of 2 flying “midwinter”; next report 16 Feb. Buffalo Co. (Gibbon)	NBR 1996 (64:11)
2003–2004	23 Dec.	Scotts Bluff Co.	5	NBR 2004 (72:9)	Next report 18 Feb. Buffalo Co. (Gibbon)	NBR 2004 (72:9)
2005–2006	7 Jan.	Hall Co. (Alda)	24	NBR 2006 (74:10)	No Dec. reports; 8 Jan. Lincoln Co. 12 flying; 1000s central Platte 9 Feb.	NBR 2006 (74:10)
2008–2009	15 Jan.	Lincoln Co. (Hersey/N. Platte)	200	NBR 2009 (77:26)	No previous winter reports; 8000–9000 in same area by 23 Feb.	NBR 2009 (77:26)
<i>Unlikely overwintering</i>						
1958–1959	1 Jan.	Kearney CBC	1	AFN 1959 (13:210)	Singleton; next report 14 Feb. Lincoln Co.	NBR 1959 (27:55)
1976–1977	18 Dec.	Adams Co. (Hastings)	1	NBR 1977 (45:8)	Singleton; injured or old bird being fed corn; next report 9 Feb. Lincoln Co.	NBR 1977 (45:8.37)
1986–1987	27 Dec.	Kearney CBC	1	NBR 1987 (55:5)	Singleton; next report 31 Jan. Adams Co.	NBR 1987 (55:54)
1990–1991	15 Dec.	Grand Island CBC	5000	NBR 1991 (59:3.6)	Arctic blast following sighting; next report 3 Feb. Kearney Co.	NBR 1991 (59:3.70)
1993–1994	11 Jan.	Buffalo Co.	1	NBR 1994 (62:55)	Singleton; cranes became “regular” after 28 Jan.	NBR 1994 (62:55)
1996–1997	21 Dec.	Lincoln Co. (North Platte)	1	NBR 1997 (65:30)	Singleton; next report 16 Feb. Kearney Co. 50 individuals	NBR 1997 (65:21)
2000–2001	6 Jan.	Buffalo Co. (Gibbon)	1	NBR 2001 (69:9)	Singleton in flight; next report 19 Feb. Harlan Co. 40 individuals.	NBR 2001 (69:9)

^a Sources are Nebraska Bird Review (NBR) and Audubon Field Notes (AFN), with publication year, volume, and page number(s)

^b NR indicates details not reported

^c CBC indicates Christmas Bird Count

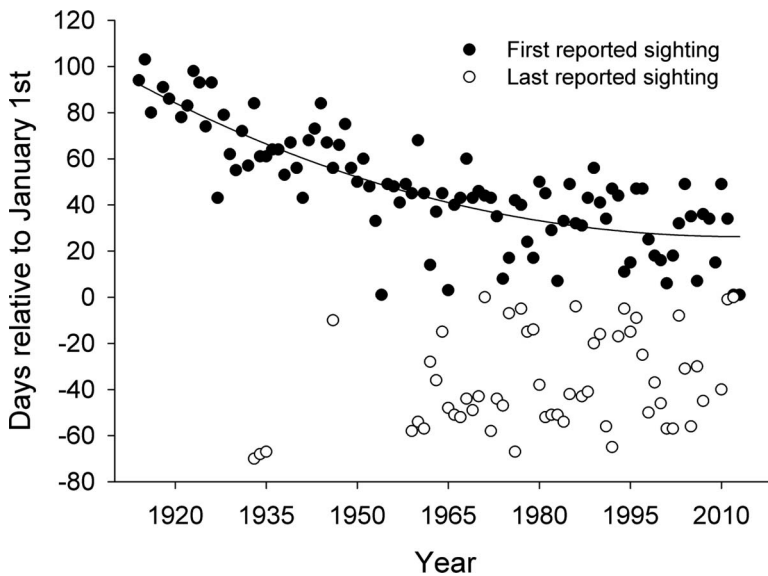


FIG. 2. First (filled circles) and last (open circles) observations of Sandhill Cranes (*Grus canadensis*) by year in Nebraska, USA, reported as days relative to January 1, between 1914 and 2013. Arrival dates show a significant, decreasing trend over period of record ($y = 2.829e+04 - (2.811e+01)x + (6.990e-03)x^2$; $r^2 = 0.62$; $P < 0.001$).

second winter. We suspect Sandhill Cranes responded to unseasonably warm and dry conditions in 2011–2012, and either terminated their southerly migration at the Platte River or continued south and later retreated northward to the Platte River upon encountering severe drought conditions to the south. Individuals in 2012–2013 may have been a subset of birds that overwintered along the Platte River the prior year, but this remains speculation because no individuals were marked or tracked. Additionally, a small flock of Sandhill Cranes, likely early arrivals from the south, were present along the North Platte River near Hershey, Nebraska, on 27 January 2012 (GDW, pers. obs.). Winter of 2011–2012 also was unusual for the wintering distribution of Whooping Cranes (*G. americana*) along the Central Flyway, with at least 13 Whooping Cranes observed away from traditional coastal habitats in Texas, including a family group of Whooping Cranes along the Platte River in Dawson County near Overton, Nebraska, 27 January–2 February 2012 (Wright et al. 2014). Additionally, a Common Crane (*G. grus*) was located in Hall County near Alda, Nebraska, on 27 January 2012 and reported in the area through 25 February 2012 with a wintering group of Sandhill Cranes (Silcock 2012). Such atypical behavior of cranes

during winter across a large geographic area suggests that large-scale factors affected bird activity.

Extreme climatic conditions likely influenced Sandhill Crane behavior during winters 2011–2013 through effects on food availability and habitat resources. The Central Platte River Valley, with its abundance of agricultural waste grains and shallow water roosting habitat, represents a key area where cranes can maximize energy intake and minimize energy expenditure to accumulate lipids to support spring migration and breeding (Krapu et al. 1985, 2014; Tacha et al. 1987). Cranes wintering in Texas generally only maintain lipid reserves, or may even experience loss of lipids when food availability is diminished (Tacha et al. 1987 and references therein). Wintering in more northerly areas, such as Nebraska, requires higher expenditure of energy for thermoregulation due to colder temperatures, and habitat and food resources may be obscured by ice and snow. Staying along the Platte River during the winter of 2011–2012, however, likely outweighed thermoregulatory costs in favor of the benefits of abundant, concentrated, high-energy food resources available due to lack of snow cover. Hence, the combination of drought that likely negatively

affected food and habitat resources in Texas, and one of the warmest winters on record in Nebraska with the known, predictable concentrations of high-energy food resources, may have contributed to this unusual phenomenon. Such a tradeoff might help to explain the lack of Sandhill Cranes during winter 2013–2014 when snow-free, yet cold conditions prevailed along the Platte River, but drought conditions were less severe in Texas. Interestingly, two of three years with evidence of probable overwintering Sandhill Cranes in Nebraska (1964–1965 and 1977–1978; Table 2) had moderate to severe drought conditions in traditional wintering areas (NOAA 2014a), further suggesting that drought-affected habitat conditions may, in part, contribute to northern winter occurrences of Sandhill Cranes.

In addition to these recent winter occurrences, reports of first spring arrivals of Sandhill Cranes in Nebraska have been occurring earlier over the period of record, especially leading up to the mid-1950s (Fig. 2). Progressively earlier spring arrivals may reflect alterations to habitat and land-use in the Platte River Valley (see description in Krapu et al. 2014), as well as increased reporting of cranes by observers, changes in population size of the species, or other factors. While often the only available long-term information to investigate timing of migration, first spring arrival dates (as well as last autumn departure dates) are subject to variability, outliers, and errors, and inferences about trends for the species must be interpreted with caution (see Swanson and Palmer 2009 and references therein). Despite such limitations, others have used them to investigate migration phenology, especially in relation to climate change (e.g., Swanson and Palmer 2009). In South Dakota and Minnesota, first spring arrival dates have become progressively earlier for many avian species, including Sandhill Cranes, with arrival dates often correlated with warmer winter temperatures in recent years (Swanson and Palmer 2009). Johnsgard and Shane (2009), using 40 years of Christmas Bird Count records from 1968 to 2007, demonstrated abundance of Sandhill Cranes increasing during winter in Kansas during the two most recent decades compared to few or no birds the prior 20 years. Along the Platte River, Davis (2003) documented variation in crane migration phenology associated with weather conditions, with milder winters yielding earlier arrivals and colder, snowier winters later arrivals of Sandhill Cranes.

The presence of Sandhill Cranes in Nebraska throughout two consecutive recent winters appears to be an anomalous occurrence, but such overwintering behaviors may become more common under changing climatic scenarios. Rising temperatures are predicted to contribute to more frequent low-snow years in North America (e.g., Romero-Lankao et al. 2014). If conditions, notably presence of open water and low snow cover, become increasingly suitable for cranes during winter or early spring at more northern latitudes, then overwintering and/or early migrating Sandhill Cranes may become a more common occurrence in Nebraska, especially during dry periods in the southern part of their traditional wintering range in the southern United States and northern Mexico. An earlier, and potentially extended, spring staging period or overwintering by Sandhill Cranes on the Platte River has implications for maintaining food and habitat resources, as well as for inter-species interactions. There is already concern that availability of waste corn, which comprises more than 95% of daily food intake by cranes in the Platte River Valley (USFWS 1981, Reinecke and Krapu 1986), is declining as agricultural practices change (Krapu et al. 2004, 2014; Pearse et al. 2010; Sherfy et al. 2011) and as competition intensifies with increasing waterfowl abundances, which may exceed seven million individuals at peak migration in south-central Nebraska (Vrtiska and Sullivan 2009). Increasing abundances of Snow Geese (*Chen caerulescens*) and Sandhill Cranes has contributed to substantially higher energy demands—a predicted increase of up to 87%—in recent decades during the spring staging period in the Platte River Valley (Pearse et al. 2010). Cranes and waterfowl now must feed over larger areas and fly greater distances to reach food resources (Krapu et al. 2004, 2014; Pearse et al. 2010). Overwintering by cranes on the Platte River may result in further reduction of waste corn and could diminish the Platte River Valley's capacity to serve cranes as a refueling site on their northward migration. Changing migration timing also will alter interactions with other migratory species, such as increasing overlap with Snow Goose migration, which could increase potential for transmission of diseases, like avian cholera, which is endemic to the region (Blanchong et al. 2006). A change in the duration or timing of crane presence in Nebraska also has implications for the timing of when habitat management activities are

conducted on the river (such as vegetation removal from sandbars for maintenance of roosting habitat) to ensure that these activities do not overlap with the presence of cranes, and hence, negatively affect the birds.

Collectively, these recent winter observations combined with reports from citizens inform our understanding of when Sandhill Cranes occupy the Platte River Valley and highlight the need to continue monitoring cranes in Nebraska during winter months in view of potential pattern changes. Better understanding the timing of use of the Platte River by Sandhill Cranes will help managers meet energetic and habitat requirements for the species, as well as understand how migration timing may be affected by climatic and additional factors occurring in other parts of the Central Flyway. Furthermore, our study did not extend to the North Platte River, which also receives crane use in the spring, and future monitoring of wintering cranes could extend to this area, especially because cranes have been documented previously there during winter (Shickley 1965). Citizen scientists have played an important role in generating this information, as well as supported many other similar analyses (e.g., Johnsgard and Shane 2009, Swanson and Palmer 2009), and ongoing networks of public reporting of cranes will contribute to such future monitoring activities.

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