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Abstract: Little information exists on the spring migratory habits and breeding distribution of lesser sandhill cranes (*Grus canadensis canadensis*) that winter in west-central New Mexico and southeastern Arizona. To address this question, we captured and attached a total of 6 Platform Transmitting Terminals (PTT) to adult lesser sandhill cranes at 2 sites each in west-central New Mexico and southeastern Arizona during December 2001 and monitored the birds' movements to arrival on their arctic breeding grounds. After departing from their wintering grounds, 2 of the cranes stopped at Monte Vista NWR in south-central Colorado where they stayed for 17 and 23 days. All 6 cranes migrated to Nebraska, where 5 stopped in the North Platte River Valley (2 near Lewellen and 3 near Hershey) and 1 in the Central Platte River Valley near Kearney (mean length of stay = 24.5 days, range 8.5–33). The migration pathways taken to Nebraska by the 6 cranes were, on average, 1,192 km farther than direct flight distances from wintering to breeding grounds. Four cranes were present on the surveyed sites in Nebraska on 26 March, when the U.S. Fish and Wildlife Service conducted their 2002 crane population census; the 2 cranes that stopped at the Monte Vista National Wildlife Refuge did not arrive in Nebraska until about 4 April. From Nebraska, all 6 cranes migrated to western Saskatchewan; 3 later moved to sites in eastern Alberta (mean length of stay in Saskatchewan/Alberta = 21 days, range 12.7–28.0). From Saskatchewan and Alberta, the cranes flew, with a few brief intervening stops, to breeding grounds located on the Yukon-Kuskokwim Delta in western Alaska (n = 2) and the Chukotka Penninsula, Chaun Delta, and Anadyr Delta in northeastern Siberia (n = 4). Use of the Central Platte or North Platte River valleys by all 6 cranes was unexpected given the major increase in flight distance required and reflects the exceptional attachment to Nebraska staging areas by the mid-continent population of sandhill cranes. Spring migration routes, staging locations, and breeding distributions of these 6 cranes suggest that lesser sandhill cranes wintering in west-central New Mexico and in southeastern Arizona are affiliated with the Western Alaska/Siberia subpopulation.

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Key words: Arizona, *Grus canadensis*, migration, New Mexico, North Platte River, sandhill crane, satellite telemetry, Siberia, Yukon-Kuskokwim Delta.

Several thousand lesser sandhill cranes (*Grus canadensis canadensis*) considered to be part of the mid-continent population of sandhill cranes (Tacha et al. 1994) spend part or all of winter in the Middle Rio Grande Valley (MRGV) of west-central New Mexico and on and near the Willcox Playa Wildlife Area (WPWA) and Whitewater Draw Wildlife Area (WDWA) of southeastern Arizona (S. Lawry, personal communication). Spring migration routes, locations of spring staging areas, and breeding distribution of lesser sandhill cranes (lessers) wintering in the MRGV and southeastern Arizona have been largely unknown, prompting MCP sandhill crane managers to request that we conduct research to gain greater insight into these key life history traits. Managers particularly sought insight into whether lessers from the MRGV and southeastern Arizona stop in the Central Platte Valley (CPV), and/or North Platte River Valley (NPV) of Nebraska during spring migration, and if they are present during the annual survey that the U.S. Fish and Wildlife Service (FWS) conducts on the fourth Tuesday of March each year to estimate size of the mid-continent population (Solberg 2002). To help identify spring migration routes and breeding distribution of lesser sandhill cranes that spend winter in the MRGV and southeastern Arizona, we monitored 6 PTT-tagged lessers from departure from their wintering grounds to arrival on their breeding grounds. Specifically, we documented when they departed from their wintering grounds in New Mexico and Arizona, their migration routes, locations of major stopovers and length of stay at each, and locations of breeding grounds.

METHODS

We captured and tagged 3 adult lesser sandhill cranes with PTTs in the MRGV in west-central New Mexico (1 on Bosque del Apache NWR [BANWR], and 2 on private agricultural lands about 25 miles north of the refuge near Lemitar) and 3 in southeastern Arizona (2 on the WDWA near Elfrida and 1 close to the WPWA near Willcox). The New Mexico sites were located in riparian floodplain habitat in the MRGV at the northern edge of the Chihuahuan Desert. Bosque del Apache NWR contains impounded marshes where the lessers roost, and moist soil units and cropland where they feed. The WDWA is within the Chihuahuan Desert in southeastern Arizona. About 50% of the WDWA is floodplain, and cranes roost on wetland habitat on the property and forage primarily on agricultural lands on surrounding farms. Much of the WDWA is being restored to native grassland. The Willcox Playa is a wetland

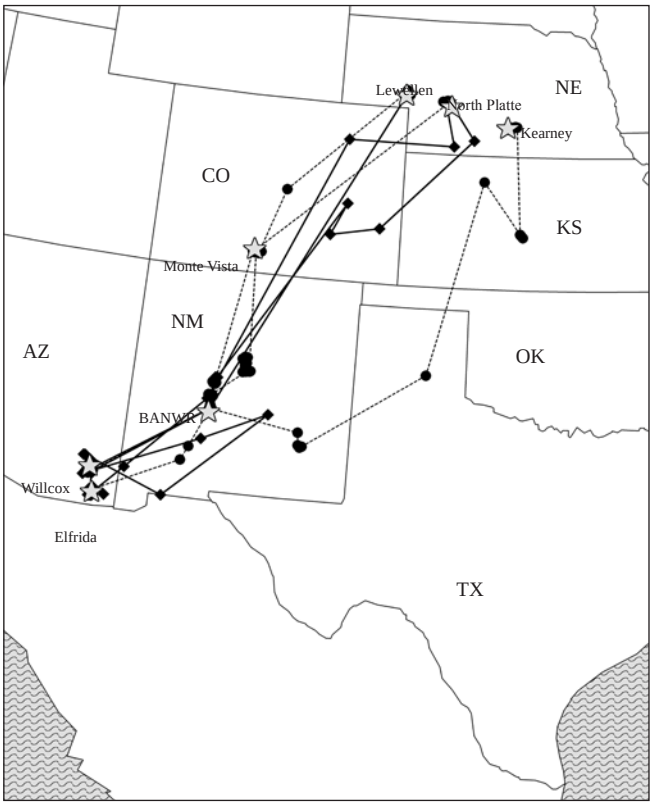

Figure 1. Major movements of 6 PTT-tagged adult lesser sandhill cranes monitored by satellite telemetry, starting at capture in December 2001 on Bosque del Apache National Wildlife Refuge and near Lemitar in the Middle Rio Grande Valley of west-central New Mexico (locations represented by black circles and dashed lines), and near Willcox and Elfrida in southeastern Arizona (locations represented by black squares and solid lines), and continuing to arrival on spring staging sites in the Central Platte River near Kearney, Nebraska, and along the Northern Platte River near North Platte and Lewellen, Nebraska.

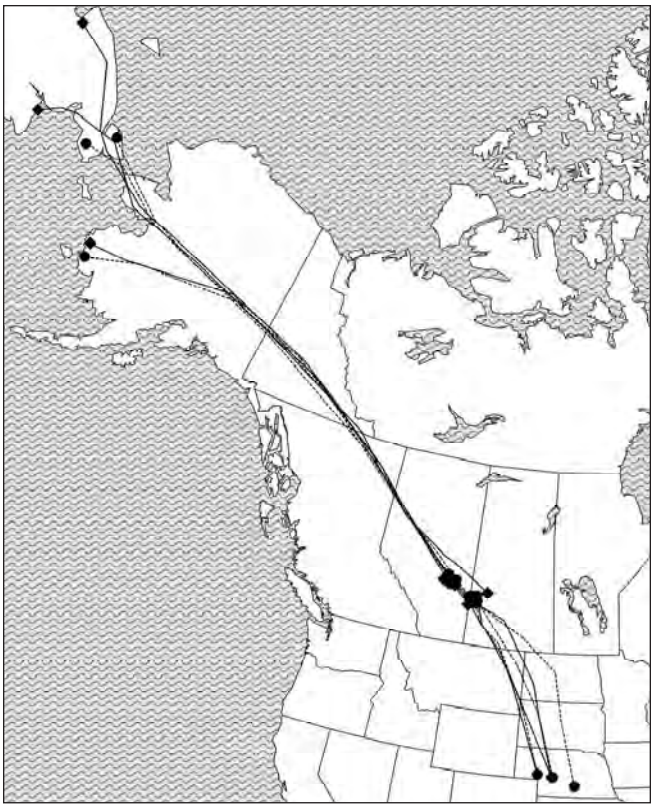

Figure 2. Spring migration routes of 6 PTT-tagged adult lesser sandhill cranes monitored by satellite telemetry during spring 2002 from departure in the North Platte Valley and Central Platte Valley to arrival on breeding sites on the Yukon-Kuskokwim Delta in western Alaska (n = 2) and northeastern Siberia (n = 4). Clusters of locations in western Saskatchewan and east-central Alberta identify where the cranes stopped for several weeks before continuing on migration to their breeding grounds. Lesser sandhill cranes tagged in the Middle Rio Grande Valley of west-central New Mexico and southeastern Arizona are represented by black circles and dashed lines, and by black squares and solid lines, respectively.

within an ancient closed basin and is used primarily for roosting, whereas foraging occurs on nearby farms. Trapping sites were on private agricultural lands.

We captured sandhill cranes using rocket-projected nets following a technique that was first described by Wheeler and Lewis (1972). We attracted cranes to capture sites by deploying a small flock of decoys, i.e., taxidermy mounts, which were positioned to direct cranes to walk or fly to within the throw area of the concealed net. In most cases, capture sites also were baited with corn. We concealed nets and rockets under vegetation of the type occurring at the site to prevent cranes from detecting them. When preparations for trapping were complete, the trapping crew moved to blinds located 200–300 m from the decoy flock to monitor the movement of cranes into the throw area of the net. When the desired number of cranes entered the targeted area, the crew triggered charges which sent the net over the birds.

Upon capture, each trapped crane was removed from under the net and placed in a burlap bag. We promptly measured flattened wing chord, tarsus length, and culmen length post-nares to minimize handling time. We drew a blood sample from the tarsal vein of each crane to establish mtDNA lineage (Rhymer et al. 2001, Jones et al. 2004). We then attached a standard U.S. Fish and Wildlife Service aluminum band on one leg of each captured crane. We next placed a plastic band with a 30-g PTT on the other leg of one adult crane at each trapping attempt where we were successful. Age of the crane selected for PTT-tagging was established based on plumage characteristics (Lewis 1979). Each PTT was received from the manufacturer already fused to the plastic leg band. The leg band came in two parts which we glued and riveted together above the tibio-tarsus (Ellis et al. 2001).

The inside surface of each plastic band was constructed with sufficient diameter to allow for free movement of the band on the leg, and was sanded smooth and lined with closed-cell foam to prevent abrasions during band movement. When all measurements had been taken, and banding and tagging had been completed, each bird was returned to a burlap bag until all cranes had been processed. At that time, they were released simultaneously.

PTTs were manufactured by North Star Science and Technology of Columbia, Maryland, and were programmed to a 4-day duty cycle (repeating sequence of 8 hrs transmission followed by a 95-hr inactive period). PTT transmissions were received by orbiting satellites and then transmitted to ground-tracking stations as part of the ARGOS satellite data collection system. PTT locations are estimated from the Doppler shift in transmitter frequencies received by satellites as they approach and then move away from the PTT. Accuracy of each location was determined by satellite-to-PTT geometry during a satellite pass and the stability of PTT transmission frequency (Argos, Inc. 1996).

RESULTS

Two of the 3 sandhill cranes tagged in the MRGV (#21699 and #21721) had not yet completed their fall migration when we trapped them in early December 2001. By 20 December, crane #21699 had moved to the Estancia Valley about 120 km northeast of the capture site near Lemitar, New Mexico, and spent the rest of the winter at this location. By 16 December, crane #21721 had moved south to near Caballo Reservoir and on 24 December was located in southeastern Arizona near WDWA where it remained until 7 March (Appendix A). All 6 cranes began spring migration during 7–11 March 2002 and stopped for varying lengths of time in Nebraska (Table 1). Five of the cranes migrated northeastward through Colorado while en route to Nebraska (Fig. 1). The 4 cranes that wintered in Arizona stopped early in spring migration at BANWR (Fig. 1, Appendix A). The 2 cranes that were captured near Lemitar, New Mexico, i.e. #21559 and #21699, stopped for 17 and 23 days at the MVNWR southeast of Monte Vista, Colorado (Table 1, Fig. 1). One crane that overwintered in Arizona, #21721, migrated eastward from BANWR, stopping near Roswell in southeastern New Mexico, before flying on to the Texas panhandle (Fig. 1, Appendix A). From Texas, this crane migrated to central Kansas, stopping at Quivira NWR (Fig. 1, Appendix A). When they reached Nebraska, 5 of the 6 cranes settled at sites in the NPRV; 2 near Lewellen at the upper end of Lake McConaughy, and 3 near Hershey upstream from North Platte (Fig. 1, Appendix A). Crane #21721 settled east of Kearney in the CPRV (Fig. 1). The flight paths of the 6 tagged cranes from their wintering grounds to staging sites in Nebraska resulted in these birds, on average, flying an extra 1,192 km from direct flight paths to the breeding grounds. Four of the 6 cranes were in Nebraska on 26 March, the date

Table 1. Chronology of spring migration of PTT-tagged lesser sandhill cranes captured in early December 2001 in the Middle Rio Grande River Valley of west-central New Mexico on Bosque del Apache National Wildlife Refuge and near Lemitar, and near Willcox and Elfrida in southeastern Arizona, to arrival on breeding grounds in western Alaska (Alas.) and northeast Siberia (Sib.). Lengths of stay by individual PTT-tagged sandhill cranes on spring stopovers in Colorado, in the Platte Valley and North Platte Valley, and in western Saskatchewan (Sask.) and Alberta (Alta.) are identified.

Crane number	Winter site	Spring departure date	Length of stay (days)			Arrival on breeding site
			South Colorado	Platte/North Platte Valley	Sask. / Alta.	
21559	N.M.	11 March	20.0	13.5	21.5	21 May (Sib.)
21581	Ariz.	11 March	–	29.0	21.5	19 May (Sib.)
21582	Ariz.	12 March	–	33.0	12.7	14 May (Alas.)
21699	Ariz.	8 March	27.0	8.5	24.5	19 May (Sib.)
21721	N.M.	7 March	–	30.5	21.5	13 May (Alas.)
21854	Ariz.	7 March	–	32.5	28.0	20 May (Sib.)

of the annual population survey (Solberg 2002). The 2 cranes that stopped at MVNWR (crane #21559 and 21699) arrived at their Nebraska stopover near Lewellen on about 4 April (Appendix A).

All 6 tagged cranes left sites used in Nebraska from 4 to 15 April and migrated rapidly to western Saskatchewan (Fig. 2) averaging 4.8 days en route. Three of the cranes after first stopping in Saskatchewan moved approximately 150 km northwest into eastern Alberta (Fig. 2; Appendix A). Combined length of stopovers in Saskatchewan/Alberta averaged 21 days (Table 1). All 6 cranes departed from Saskatchewan and Alberta staging sites during early to mid-May and flew to breeding grounds in western Alaska and Siberia (Fig. 2, Appendix) where they arrived on 13–14 and 19–20 May, respectively (Table 1). Of 3 cranes tagged in the MRGV, 2 migrated to breeding grounds on the Chukotka Pennisula in northeast Siberia and 1 settled on Nelson Island on the Yukon-Kuskokwim (YK) Delta near Nightmute, Alaska (Fig. 2, Appendix A). Of the 3 cranes tagged in Arizona, 2 migrated to breeding grounds in northeast Russia (Chaun Delta and near Anadyr), and 1 to the Yukon-Kuskokwim Delta near Chevak, Alaska (Fig. 2, Appendix A). Mean flight distances (± SD) from their wintering grounds in New Mexico and Arizona to their breeding grounds in Siberia and Alaska were 6,825 ± 724 km (n = 4) and 6,600 ± 566 km (n = 2), respectively (Table 2).

Table 2. Estimated distances (in km) flown by 6 PTT-tagged lesser sandhill cranes between departure from their wintering sites in west-central New Mexico and southeastern Arizona to arrival on breeding grounds in western Alaska and northeastern Siberia are compared to direct line distances between wintering and breeding sites. The difference between actual and direct line flights for each tagged sandhill crane represents the additional cost (in km flown) needed to stop in Nebraska during spring.

		Migration distance (km)		
Crane number	Winter site	Actual	Distance line	Difference
21559	N.M.	6,150	5,550	600
21581	Ariz.	7,500	6,300	1,200
21582	Ariz.	6,200	5,050	1,150
21699	N.M.	6,250	5,450	800
21721	Ariz.	7,000	5,050	1,950
21854	Ariz.	7,400	5,950	1,350
Mean		6,700	5,558	1,192

DISCUSSION

The lengthy increase in flight distances to the breeding grounds required for sandhill cranes wintering in New Mexico and Arizona to stop in Nebraska reflects the exceptionally strong attachment among sandhill cranes in the MCP to sites in the CPV and NPV. This pattern presumably has been influenced by the highly productive foraging conditions that have existed at the Nebraska sites during the past several decades (Reinecke and Krapu 1986), and the presence of wide braided river channels (Williams 1978), a preferred roosting habitat of sandhill cranes (Krapu et al. 1984). Waste corn has been sufficient in Nebraska since the 1940s (Krapu et al. 1995) to allow lessers to acquire large fat reserves in preparation for migration to the breeding grounds and for use during reproduction (Krapu et al. 1985), probably enhancing their survival and reproductive success.

The extended period that 2 tagged cranes captured near Lemitar, New Mexico, spent at MVNWR and adjacent lands suggests this site may be an important conditioning site for part of the lessers wintering in west-central New Mexico and southeastern Arizona. Cranes stopping at the MVNWR arrived in Nebraska after the date of the annual spring population survey, and were located near Lewellen at the upper end of Lake McConaughy which lies outside of the operational March sandhill crane population survey area. As a result, 2 of the 6 tagged lessers wintering in the MRGV and southeastern Arizona were not available to be counted during the March 2002 spring population survey.

The finding that all 6 tagged lesser sandhill cranes settled on the most western breeding grounds of the MCP in western Alaska and Siberia was not surprising given that their wintering sites were located at the extreme western edge of the wintering range of the mid-continent population. The only previous evidence of lessers wintering in west-central New Mexico and southeastern Arizona breeding in the western Alaska/Siberia region is from a lesser juvenile color-marked while flightless during the 1976 breeding season on the Yukon-Kuskokwim Delta and later sighted near Lemitar, New Mexico (Boise 1978). The movement patterns of the 6 lessers we monitored are consistent with those of two cranes we captured and tagged in the NPV (Krapu and Brandt 2002) that subsequently spent the summer in Siberia and western Alaska and over-wintered in southeast Arizona. Together, these patterns suggest that most MCP lessers wintering in west-central New Mexico and southeastern Arizona probably breed in Siberia or western Alaska, and thus, are affiliated with the Western Alaska/Siberia subpopulation.

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Appendix A. Detailed temporal descriptions of movements of 6 PTT-tagged lesser sandhill cranes from capture and tagging at Bosque del Apache National Wildlife Refuge and near Lemitar in west-central New Mexico, and near Wilcox and Elfrida in southeastern Arizona during early December 2001, to arrival on their breeding grounds in western Alaska and northeastern Siberia during May 2002.

Crane Number	Date		Description of Activity and Location
	From	To	
21559	7 December		Captured near Lemitar, New Mexico
	7 December	1 March	Wintering approximately 42 km N. of Bosque del Apache NWR
	2 March	10 March	Moved to approximately 75 km N. of Bosque del Apache NWR
	11 March	28 March	At Monte Vista NWR, Colorado
	31 March		Migrating towards Nebraska
	4 April	14 April	North Platte River near Lewellen Nebraska
	15 April	18 April	Migrating towards Saskatchewan
	19 April	1 May	Near Plover Lake in west-central Saskatchewan
	2 May	8 May	Near Sedgewick, Alberta
	10 May	17 May	Migrating towards Siberia
	19 May		At breeding grounds on Chukotka Peninsula in Siberia
21699	7 December		Captured near Lemitar, New Mexico
	7 December	16 December	Approximately 42 km N. of Bosque del Apache NWR near capture location
	20 December	7 March	In Estancia Valley between the towns of Estancia and Moriarty, New Mexico
	8 March	31 March	At Monte Vista NWR, Colorado
	4 April	9 April	North Platte River near North Platte, Nebraska
	10 April	11 April	Migrating towards Saskatchewan
	13 April	5 May	Near Plover Lake in west central Saskatchewan
	7 May	11 May	Near Fahler, Alberta
	12 May	19 May	Migrating towards Siberia
	20 May		Breeding grounds on Chukotka Peninsula in northeastern Siberia
21721	9 December		Captured on Bosque del Apache NWR
	12 December		At Bosque del Apache NWR
	16 December	20 December	Moving south near Caballo Reservoir then to Uvas Valley southwest of Hatch, New Mexico
	24 December		Near Whitewater Draw State Area south of Elfrida, Arizona
	29 December	18 February	Near Willcox Playa State Area south of Willcox, Arizona
	19 February	28 February	At Bosque del Apache NWR, New Mexico
	2 March	6 March	Southeast of Roswell, New Mexico
	7 March		Migrating northeast through Texas panhandle
	8 March	12 March	In Kansas, 25 km southeast of Great Bend
	15 March	12 April	At Platte River near Kearney, Nebraska
	13 April	15 April	Migrating towards Saskatchewan

Appendix A. Continued

Crane Number	Date		Description of Activity and Location
	From	To	
	2 May	6 May	Near Ryley, Alberta
	7 May	12 May	Migrating towards Alaska
	14 May		At breeding grounds 24 km northeast of Nightmute, Alaska
21581	15 December		Captured at Whitewater Draw State Area south of Elfrida, Arizona
	16 December	10 March	Near Whitewater Draw State Area
	11 March	15 March	Migrating towards Nebraska
	16 March	12 April	At North Platte River near North Platte, Nebraska
	13 April	15 April	Migrating towards Alberta
	17 April	24 April	Near Sibbald, Alberta
	26 April	6 May	Near Sedgewick, Alberta
	7 May	18 May	Migrating towards Siberia
	19 May		At breeding grounds on Chaun Delta in northeastern Siberia
21582	14 December		Captured at Whitewater Draw State Area south of Elfrida, Arizona
	14 December	16 December	Near Whitewater Draw State Area
	20 December	27 February	Near Willcox Playa State Area south of Willcox, Arizona
	28 February	3 March	Wandered east toward Roswell, New Mexico then returned back to Willcox Playa Sate Area
	5 March	11 March	Near Willcox Playa State Area
	12 March		At Bosque del Apache NWR, New Mexico
	15 March	14 April	North Platte River near Lewellen, Nebraska
	15 April	19 April	Migrating towards Saskatchewan
	20 April	1 May	Near Little Tramping Lake south of Handel, Saskatchewan
	2 May	13 May	Migrating towards Alaska
	14 May		At breeding grounds on Yukon-Kuskokwim Delta 30 km southeast of Chevak, Alaska
21584	14 December		Captured near Willcox Playa State Area south of Willcox, Arizona
	15 December	18 February	Near Willcox Playa State Area
	19 February	22 February	At Bosque del Apache NWR, New Mexico
	24 February	27 February	Near Belen, New Mexico
	1 March	5 March	Migrating towards Nebraska
	6 March	4 April	At North Platte River near North Platte, Nebraska
	8 April	10 April	Migrating towards Alberta
	12 April	6 May	Near Heisler, Alberta
	7 May	19 May	Migrating towards Siberia
	20 May		At breeding grounds near Anadyr in northeastern Siberia