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Abstract: The Oregon Department of Fish and Wildlife (ODFW) Ladd Marsh Wildlife Area in northeast Oregon hosts a small group of nesting greater sandhill cranes (*Grus canadensis tabida*). There were no data on where these birds wintered, and we had no understanding of how these birds fit into the larger picture of western sandhill crane population delineation. ODFW began color-banding pre-fledging colts in 2007 and added satellite tracking with platform transmitter terminals (PTTs) in 2015. To date, we have captured 15 colts and 13 adults and marked them with color bands. We also fitted 1 colt and 8 adult cranes with PTTs. In fall 2015, all 3 PTT-marked birds traveled to wintering grounds in the Central Valley and Central Coast ecoregions of California. In fall 2016, of 5 PTT-marked cranes, 4 traveled to the Central Valley and Central Coast ecoregions of California. The fifth individual migrated south through Idaho and Nevada to the Lower Colorado River Valley. The PTT data from our study highlight the need for additional research on the validity of current western sandhill crane population divisions.

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Key words: Central Valley Population, *Grus canadensis tabida*, Lower Colorado River Valley Population, northeast Oregon, sandhill crane.

Small numbers (15-20 pairs) of greater sandhill cranes (*Grus canadensis tabida*) nest at the Oregon Department of Fish and Wildlife's (ODFW) Ladd Marsh Wildlife Area (LMWA) in northeast Oregon. No documentation existed on the wintering locations of these greater sandhill cranes (hereafter cranes), and resource managers assumed the cranes nesting in northeast Oregon were affiliated with the Central Valley Population (CVP; Littlefield and Thompson 1979, Pacific Flyway Council 1997). The geographic location of the LMWA is east of most known CVP nesting areas and northwest of known nesting areas for cranes in the Lower Colorado River Valley Population (LCRVP). Therefore, the LMWA cranes could be affiliated with either population and winter in either the Central Valley of California or the Lower Colorado River Valley of southwest Arizona and southern California (Gary Ivey, International Crane Foundation, personal communication). Moreover, it is unclear how these cranes fit into the larger picture of crane population delineation and management in western North America. Banding and telemetry studies of both CVP (Ivey et al. 2005, 2014) and LCRVP (Collins et al. 2015) cranes did not provide evidence linking LMWA nesting cranes with either population.

In response to uncertainty regarding the population affiliation of LMWA cranes, the ODFW began marking pre-fledging crane colts with color bands in 2007. Our objectives were to identify the population affiliation as well as migration routes and stopover sites of cranes nesting on LMWA. As of 2015, we had received no re-sighting reports of banded cranes observed in winter, and we therefore began attaching platform transmitter terminals (PTTs) to leg bands on select captured cranes. In this paper we describe the results of 2 years (2015-2016) of satellite telemetry on LMWA cranes.

The LMWA is located in the Grande Ronde Valley in southern Union County, Oregon. Wet meadow and emergent wetland habitat comprised about half of the 2,436 ha on LMWA. Upland habitats included grassland, mixed shrubs, and coniferous forest. Wetland hydrology of the area is dynamic and unpredictable; most wetland cells dry out most years and flooding is common in spring. Emergent wetlands were dominated by hardstem

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bulrush (*Schoenoplectus acutus*) and common cattail (*Typha latifolia*) with a variety of other wetland species depending upon soil type and water depth. Several wet meadows contained dense stands of common camas (*Camassia quamash*) along with reed canarygrass (*Phalaris arundinacea*) and other grasses. Meadows were hayed in late summer to provide early spring foraging habitat for Canada geese (*Branta canadensis*) and cranes.

We used a rocket net to capture adult cranes in spring 2015 and 2016 (Wheeler and Lewis 1972, Urbanek et al. 1991). We monitored crane flocks feeding on LMWA to determine their preferred locations and baited sites with loose, whole kernel corn beginning up to 2 weeks before capture. Grass and straw were laid out ahead of time to simulate net placement and allow the cranes to become accustomed to the rocket-net set up. Rocket-netting was conducted in March when cranes were present but nesting pairs were not yet spending significant time on or defending their territories. We attempted to hand-capture pre-fledging colts in summer 2015 and 2016 by locating family groups with 1 or more colts near fledging age and flushing the adults, causing the colt(s) to hide in the grass, and then searching the area for the colt(s).

If 2 adults were captured together and their behavior suggested a mated pair, 1 was fitted with a 22-g solar PTT (Microwave Telemetry, Inc., Columbia, MD, USA) attached to a 2-part flange-type plastic leg band engraved with an alpha numeric code. The 2 halves of the leg band were joined with aluminum rivets. The opposite leg of each crane was marked with a unique combination of colored plastic bands and a size 9 aluminum U.S. Geological Survey (USGS) band. Bands were placed above the tibio-tarsal joint (Ivey et al. 2005, Krapu et al. 2011). In 1 instance, 4 cranes were captured and PTTs were placed on 2. Pre-fledging colts were fitted with PTTs when a PTT was available. We only attempted to capture colts that were within 1 week of fledging to ensure they were large enough to hold the bands and to maximize the probability of survival to fledging. Transmitters deployed in 2015 were enabled with global positioning system (GPS) and programmed to record 5 locations each day. Those used in 2016 were refurbished solar-powered Argos transmitters that recorded up to 8 locations per day. We downloaded GPS data weekly from the Argos website (https://argos-system.clsamerica.com/cwi/Logon.do) and parsed it into KML (Keyhole Markup Language, Google Earth, Google.com) and text files using GPS data parsing software (Microwave Telemetry, Inc., Columbia, MD, USA). Locations that were lost or compromised due to drained batteries or used 2 dimensional (2D) fixes, no fix, or low voltage to collect data were removed from analyses. Locations were mapped digitally with both Google Earth (www.Google.com) and ArcGIS (Esri, Redlands, CA, USA). All other cranes captured during the project were marked using the same banding scheme but without the PTT. All capture and handling methods were approved by the Texas Tech University Institutional Animal Care and Use protocol #16023-03.

We captured 3 adult cranes and 1 colt in 2015. Adults captured were marked as LM010 and LM013, both fitted with solar GPS PTTs, and LM015, fitted with color bands only. The colt was marked as LM014 and fitted with a GPS PTT. Movement data from LM014's PTT indicated it fledged the day after capture; it was located over 2 km from the natal territory the next day. Subsequent locations showed daily movements to and from the natal territory and harvested grain fields on private land until the onset of fall migration. LM014 was observed with 2 adults prior to fall migration.

Adults LM015 and LM010, a mated pair, occupied a nesting territory on LMWA in 2015 and 2016. The breeding status of adult LM013 was unknown. It remained on LMWA throughout the summer 2015 and was found dead on LMWA after its return in spring 2016.

We captured 10 adult cranes in 2016, including 4 mated pairs (A43 and LM016, LM017 and LM018, A44 and A11, LM019 and A10) and 2 birds of unknown status (A09 and A14). Six cranes were fitted with solar Argos PTTs (numbers preceded by "A") and 4 were only color banded (numbers preceded by "LM"). The pair A43/LM016 was observed in September 2016, prior to fall migration, with a fledged colt. A11 was found dead in southeastern Washington in October 2016. The PTTs on A09 and A14 failed prior to the onset of fall migration; both cranes were observed with the fall staging flock.

In 2015, the 3 PTT-marked cranes departed LMWA on 2 (LM014) and 3 (LM010, LM013) October. LM010 and LM013 spent 2 days and LM014 spent 5 days in migration before arriving in traditional CVP wintering areas near Chico, California, on 5 and 7 October (Fig. 1). LM013 moved in mid-December from the Chico area to the Sacramento-San Joaquin Delta (Delta) area west of Stockton and remained there until moving north in spring. These cranes returned to LMWA between 12 February and 1 March, having spent 3-17 days in migration. LM014, now a second-year bird, spent summer 2016 using mountain meadows within 24 km of LMWA.

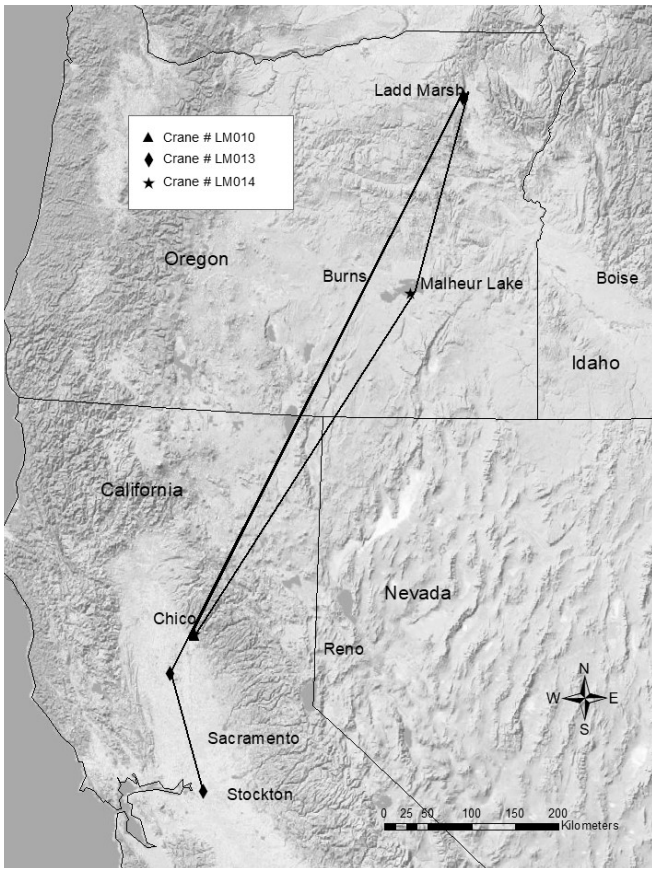

Figure 1. Fall 2015 migration stopover sites and endpoints in the Central Valley and Delta regions of California of 3 greater sandhill cranes captured and marked with platform transmitter terminals (PTTs) on Ladd Marsh Wildlife Area, Oregon. Multiple locations in 1 area have been simplified to a single point.

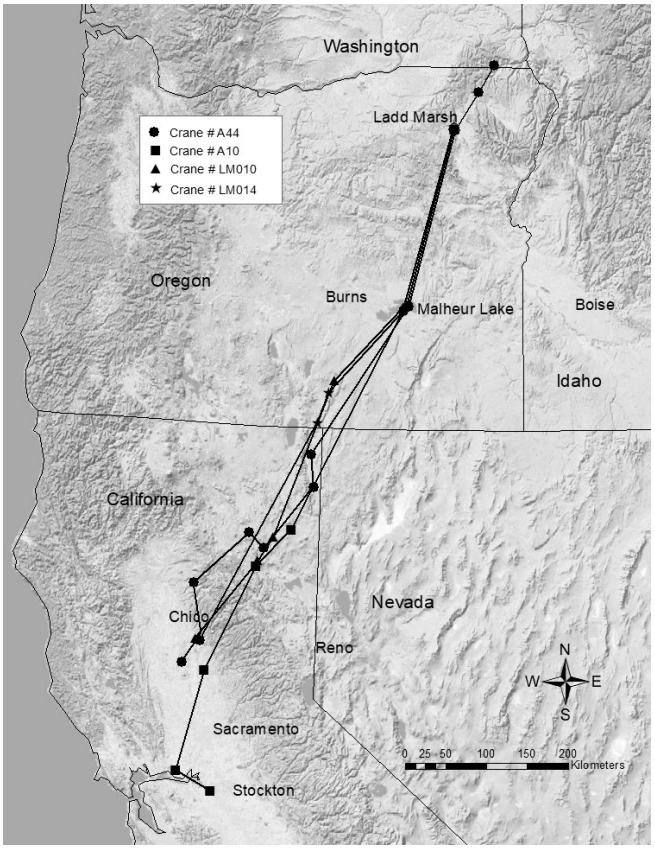

Figure 2. Fall 2016 migration stopover sites and endpoints in the Central Valley of California of 4 greater sandhill cranes captured and marked with platform transmitter terminals (PTTs) on Ladd Marsh Wildlife Area, Oregon. Multiple locations in 1 area have been simplified to a single point.

Five PTTs were transmitting at the time of fall migration in 2016: LM010, LM014, A43, A44, and A10. As in 2015, LM014 left 2 October and the other cranes left 3 October. Two cranes, LM010 and LM014, ended fall migration in the Chico, California, area after 3 and 10 days, respectively (Fig. 2). One crane (A44) went to Gray Lodge Wildlife Area after a 25-day stopover in northeast California and a total of 31 days in migration (Fig 2). Crane A10 traveled to the Delta after 4 days in migration (Fig. 2). Crane A43, which had been observed earlier that fall with a mate and fledged colt, went east after leaving LMWA and spent 45 days in the Payette River Valley of Idaho where LCRVP cranes are known to stage (Fig. 3; Kruse et al. 2017, Pacific Flyway Council 2017). From there, A43 moved south with stops in Nevada before arriving in the Colorado River Indian Reservation area near Parker, Arizona, which is associated with the LCRVP (Fig. 3). The PTT failed shortly after the crane's arrival in Arizona.

The same 5 cranes, LM010, LM014, A43, A44 and A10, were observed on LMWA in spring 2017. The pair A43/LM016 nested on LMWA again in 2017 but did not fledge young. In 2016 and 2017, this pair occupied a nesting territory on LMWA that had been used by cranes for at least a decade.

The PTT data collected to date suggest that greater sandhill cranes nesting on LMWA are affiliated with both the CVP and the LCRVP. This is the second documented case of cranes from more than 1 wintering area mixing in a nesting area (Collins et al. 2015) and could have important implications for crane management in the western United States by changing our understanding of population divisions. That, in turn, may affect management efforts based on those divisions including population monitoring and harvest management.

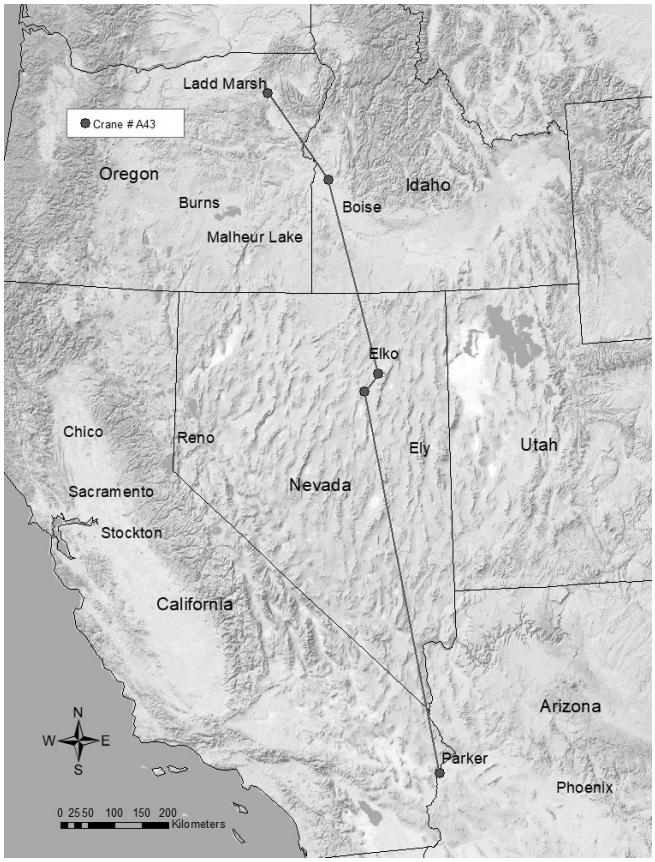

Figure 3. Fall 2016 migration stopover sites and endpoint in the Lower Colorado River Valley of 1 greater sandhill crane captured and marked with a platform transmitter terminal on Ladd Marsh Wildlife Area, Oregon. Multiple locations in 1 area have been simplified to a single point.

Given the small sample of PTT-marked cranes in this study, it is unknown what proportion of Ladd Marsh nesting cranes winter with the CVP versus the LCRVP. We anticipate deploying additional PTTs in 2018 and into the future to investigate this question.

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