CRANE MIGRATION IN NORTHERN NEW MEXICO

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Abstract: Greater sandhill cranes *(Grus canadensis tabida)* and foster-reared whooping cranes *(G. americana)* were monitored on a 345 km migration between their traditional stopover in southcentral Colorado and their winter grounds in central New Mexico during 4 autumns (1984-87) and 1 spring (1985). Autumn sandhill crane counts totaled 17,363 in 1984, 9,317 in 1985, 29,053 in 1986, and 26,552 in 1987. Peak flights of over 7,000 cranes in 1 day were recorded in both 1986 and 1987. More than 50% of the cranes were counted on just 4 days in 1984, 1986 and 1987. At least 27% of the sandhill cranes counted stopped overnight in 1984, 58% stopped in 1986, and 46% in 1987. Most completed 225 to 280 km of the journey and roosted on rivers and mesas north of Albuquerque. Stopover rates were affected by wind speed/direction and solar radiation, but were most highly correlated with frontal movements. During the 1985 spring migration 25,890 cranes were counted. Aided by southerly winds, over 95% apparently completed the northward journey in 1 day.

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Greater sandhill crane migration has been extensively studied during the last 2 decades. Through the use of colormarkers and radiotelemetry, migration routes have been delineated for major populations in the Rocky Mountains (Drewien & Bizeau 1974, 1981) and the Great Lakes (Toepler & Crete 1979), as well as for several smaller populations (Drewien et al. 1976, Littlefield & Thompson 1979). Migration ecology of sandhill cranes has also been described (Melvin & Temple 1982). However, the dynamics of the movement of an entire population along a portion of its migration route has not been extensively studied.

This report details the 1984-87 autumn and 1985 spring migrations of the Rocky Mountain greater sandhill crane population between their traditional autumn/spring stopover in the San Luis Valley, Colorado, and their major wintering grounds in the Central Rio Grande Valley of New Mexico (Fig. 1). The presence of whooping cranes, cross-fostered by sandhill crane parents *(Drewien & Bizeau 1981)*, in this population increased the importance of understanding their migration patterns.

ACKNOWLEDGMENTS

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STUDY AREA AND METHODS

Rocky Mountain cranes spend from 4-8 weeks each spring and autumn at a traditional migration stopover in the San Luis Valley, Colorado. Their principal wintering grounds are in the Rio Grande Valley of central New Mexico (Drewien & Bizeau 1974). The minimum distance between the two areas is 345 km. Bosque del Apache National Wildlife Refuge (NWR), New Mexico is 460 km south of Monte Vista NWR, Colorado; the 2 refuges are important use areas for these cranes.

The direct route between these areas crosses uplands of pinyon juniper woodland and sagebrush grassland. Wetland habitat, preferred by cranes for roosting, is virtually nonexistent between the Colorado-New Mexico border and the Rio Chama, 190 km south of Monte Vista NWR. The Rio Chama, the Jemez River (280 km south of Monte Vista), and portions of the Rio Grande between these 2 major tributaries are potential aquatic overnight roost sites for migrant cranes (Fig. 1). My study area was

this 90 km segment of the crane migration corridor.

Crane migration was monitored from a series of observation points between Espanola and Bernalillo, New Mexico. I conducted autumn 1984 and spring 1985 counts near White Rock and Espanola and 1985-87 autumn counts near Bernalillo. I concentrated my counting efforts between 25 October and 20 November during autumn and between 12 February and 5 March in spring. Counts by others from White Rock and Albuquerque supplemented my data. Autumn migrants had completed 61% of their minimum journey at Espanola, 68% at White Rock, and 85% at Bernalillo. White Rock was also the midpoint of the 90 km long study area.

Several hilltops were used to observe cranes in the Espanola-White Rock area. Cranes were counted near Bernalillo as they (1) passed over the area during mid- to late afternoon and continued on to the wintering grounds, (2) arrived at the Jemez Roost in late afternoon and evening, and (3) departed the study area the following morning from roosts other than the Jemez Roost. I could move along State Highway 44, an east-west roadway, and remain near the cranes' flight line under most conditions.

Migrating cranes were found by listening for their distinctive call, then finding them with binoculars. Even when cranes could not be heard, the sky to the north (autumn) and south (spring) was scanned at regular intervals. Sandhill cranes were counted, whooping cranes were noted, and the time and direction of flight of each flock were recorded. When cranes were migrating in large numbers, flock sizes were estimated. To get a correction, the number of cranes in passing flocks was estimated, then counted during lighter periods of migration, and estimated and actual numbers compared with a x^2 test. Estimating was greatly curtailed in 1987, resulting in more conservative counts but less potential for estimation error.

During 1984 and 1985 the frequencies of radio transmitters attached to whooping and sandhill cranes (Drewien & Bizeau 1981) were monitored with a scanning receiver. This allowed documentation of the passage of individual birds and, more importantly, the movement of cranes even when flocks were not sighted. Finally, early morning helicopter flights were used 9-11 November 1984 and 9 February 1988 to locate major crane roosts.

Weather data for the autumns of 1984-87 were taken from monthly summaries for National Weather Service stations at Alamosa, Colorado and Albuquerque, New Mexico and for a Los Alamos National Laboratory station at White Rock, New Mexico. The effect of weather on cranes choosing to either stopover within or overfly the study area was tested using stepwise regression. Factors tested included wind speed and direction at 1100 (Alamosa), 1400 (White Rock), and 1700 (Albuquerque) hours, percent cloudcover (and thus thermal activity) in the morning (Alamosa) and afternoon (Albuquerque-White Rock mean), and the position of cold fronts in relation to the study area. The sample was stratified over several levels of migration intensity. A variable had to have a 0.15 significance level for entry into the model.

RESULTS

Autumn Migration – Autumn counts of migrating sandhill cranes totaled 17,363 in 1984, 9,317 in 1985, 29,053 in 1986, and 26,552 in 1987 (Figs. 2-5). Eighteen whooping cranes were documented in 1984, 8 in 1985, 15 in 1986, and 9 in 1987. The Rocky Mountain greater sandhill crane population was estimated at 17,000 to 20,000 while the western whooping crane population declined from 32 to 22 over the same period (R. Drewien pers. comm.).

Although some migration occurred in October of each year, the majority of the cranes migrated during the first 3 weeks of November. In fact a large proportion of the birds migrated in only a few days. A flight of 7,557 cranes on 9 November 1986 was 26% of the 1986 total count while 7,395 cranes on 8 November 1987 was 29% of that autumn's total count. During 1986 and 1987, when coverage was most complete, 71% and 77%, respectively, of the cranes were counted in just 4 days (Figs. 4 & 5). In 1984 the highest 4 days accounted for 50% of the total count (Fig. 2).

An important aspect of this study was the documentation of preferred overnight roost sites along this migration corridor. In the northern half of the study area the Rio Chama and Rio Grande are relatively narrow (< 75 m) and cottonwoods *(Populus fremontii)* line channels in most areas. Where viewing distances were acceptable, however, cranes did stop over . Between 29 October and 13 November 1984, 765 sandhill cranes and 2 whooping cranes were documented roosting on the two rivers. Another 220 sandhill cranes and 1 whooping crane were found roosting on the open mesas to the west of the Rio Grande. Upland roosting by both species had been previously documented (Drewien & Bizeau 1981; Ward & Anderson 1987).

Roost sites north of White Rock were not monitored after 1984. Some cranes were counted at White Rock in the mornings during both 1985 and 1986 (Figs. 3 & 4), further documenting crane use of northern roosts. On the morning of 10 November 1986 approximately 1,500 of the previous day's flight of 7,557 sandhill cranes were counted at White Rock.

Over one-half (53%) of the cranes counted in 1984 passed White Rock after 1530h, or within 2h of sunset (Fig 6). Since sandhill cranes migrate at 35-55 km/hr and usually discontinue migration before sunset (Melvin & Temple 1982), it seemed likely that a major overnight roosting area existed in the southern half of the study area. On early morning helicopter flights on 10-12 November, we located several roosting areas between Cochiti Reservoir and Bernalillo (Fig. 7). Sandhill crane use of these southern roosts during the autumns of 1984-87 is depicted in Figs. 2-5. Four whooping cranes also roosted there in late 1984, 4 more in 1985, 9 in 1986 and 2 in 1987.

The most heavily used of these southern roosts was the Jemez River above Jemez Reservoir (Fig. 7). Over 21,000 sandhill cranes, 54% of those documented roosting overnight, stopped there during the 4 autumns. The river has a wide (250-350 m) sandy channel. It also carries a shallow, narrow, but meandering stream during autumn. The channel is lined with tamarack *(Tamarix cninensis)*. Cranes also used a sandbar at the head of the reservoir, especially in 1987. Conversely, the Rio Grande exiting Cochiti Reservoir is confined to a relatively narrow (50-100 m), sometimes braided, channel for most of its 30 km run to Bernalillo. Tall cottonwoods line both banks. On the 1984 helicopter flights, 467 cranes were found roosting in the wider sections of the Rio Grande.

A minimum of 2,200 cranes roosted on the Santa Fe River portion of Cochiti Reservoir during 4 autumns. The peak count there was 600 sandhill cranes on 27 October 1987. This roost was not regularly censused during the study. We also counted 158 cranes roosting on mesas between Cochiti and Jemez reservoirs during the 1984 helicopter surveys. It was not possible to regularly count cranes roosting on mesas during the remainder of the study, but on several mornings we counted cranes flying over Jemez Dam that had roosted on mesas to the north; i.e., 130 sandhill cranes on 10 November 1986.

On 4 November 1987, 275 sandhill cranes were found roosting in the Rio Grande within the city of Albuquerque. This river section was not a part of the study area and was not regularly monitored. The river channel south of Bernalillo is broad (>200 m) and the gallery forest of cottonwoods provides some protection from the noise and human activity of Albuquerque and nearby communities.

A major portion of the sandhill cranes counted each autumn roosted overnight in the study area. In 1984, 27% of the 17 thousand cranes counted were documented in overnight roosts. Moreover, 53% of the cranes counted passed White Rock after 1530 MST in 1984, and most probably stopped in the southern roosts.

The 1985 crane count was incomplete. During the final two years of the study, when coverage was most complete, 59% (1986) and 46% (1987) of the cranes counted stopped overnight within the study area.

Weather influences crane decisions of whether to complete this 345 km journey in 1 or 2 days. On 49 days, I recorded crane flights of more than 100 birds; 32 days with flights of more than 500 cranes and a summary of weather conditions on those dates are in Table 1. A series of stepwise regressions were run at 4 levels of migration intensity utilizing direct counts and the stopover/overflight ratio (Table 2). Frontal position (approaching or past) contributed to 11 of 12 models and was largest in 10 models. It was most important for flights of >1,000 cranes where the majority overflew the study area (r^2 = 40.3) and for the stopover/overflight ratio (r^2 = 64.4) on flights of >1,000 cranes. In the model for a >2,000 crane stopover in the study area, winds at 1400h and afternoon sunshine had a combined r^2 of 51% while for a >2,000 crane overflight, morning winds contributed an r^2 of 56.6% to the model.

Reverse migration was documented during the autumns of 1986 and 1987. During the week of 27-31 October 1986, 497 sandhill cranes were counted migrating northward over White Rock. A flock of 29 cranes flew northward over White Rock on 29 October 1987, and 145 northbound cranes were observed at Bernalillo and Albuquerque between 28 October and 15 November 1987.

Spring Migration – A total of 25,890 sandhill cranes and 14 whooping cranes were counted in the spring of 1985. Cranes were first observed migrating northward over the study area on 7 February 1985 (Fig 8). The major movement of cranes occurred between 20 and 25 February. During 5 of 6 days, southerly winds dominated and 18,489 cranes were counted (3,698/day). Mean wind speed and direction at 1100h at Albuquerque for

those 5 days was 5 m/s at 202°. The flow of cranes ceased only on 23 February when 10-15 cm of snow fell during the passage of a cold front.

Although spring migrants were counted only 1 season, the 1985 migration was apparently similar to previous spring flights for this population. In 1977, 22,263 sandhill cranes were counted passing White Rock with a peak flight of 4,215 on 3 March (Travis, J. R. 1977. Sandhill crane migration watch, Los Alamos, NM 1974-77. Typescript). Massive departures of cranes from the wintering grounds typically occur in this population (R. Drewien pers. comm.).

Most spring migrants were propelled by favorable southerly winds to Colorado in 1 day. For example, on 20 February 1985, several thousand sandhill cranes left Bosque del Apache NWR at 0930h. Four thousand cranes were counted over White Rock between 1200h and 1400h and many cranes were seen entering the San Luis Valley at 1700h that evening (M. Nail pers. comm.).

Pre-frontal winds, though favorable to northward migration, do push the cranes toward inclement weather. On several occasions in the spring of 1985, I watched crane flocks skirting or flying through snow squalls. On the morning of 8 February 1980, 340 sandhill cranes were counted retreating southward near White Rock after an all-night snowstorm. Over 1,700 northbound cranes had been counted the previous afternoon (T. Johnson pers. comm.).

Poor conditions after a storm can also short-stop cranes on the spring journey. Following the storm of 23 February 1985, snowcover limited thermals and winds were low. One hundred fifty sandhill cranes stopped along the Rio Grande north of Espanola the afternoon of 24 February and about 500 were seen in the sagebrush uplands west of Taos (Fig. 1) the next morning. It is likely that many of the 2,968 cranes counted that day had to stopover short of the San Luis Valley that night.

Some use of the Jemez and Cochiti roosts also occurs in the spring. On a 9 February 1988 helicopter flight, 40 sandhill cranes were observed in the Jemez roost and 150 more were seen at Cochiti Reservoir. There had been no recent storms, so these birds had apparently departed the wintering grounds late in the day and only completed a portion of their journey.

DISCUSSION

Counts – Brown et al. (1987) estimated that there were between 17,000 and 20,000 greater sandhill cranes in the Rocky Mountain population between 1982 and 1984. Systematic aerial counts (Benning & Johnson 1987) in the spring of 1985 in the San Luis Valley resulted in an estimate of 21,800 birds (Benning, D. S. 1986. Spring survey, Rocky Mountain population of greater sandhill cranes. U. S. Fish and Wildlife Service, typescript). The population probably declined to about 17,000 by 1987 due to poor reproduction and higher mortality (W. Brown pers. comm.). The total of 29,053 I recorded in the autumn of 1986 exceeds 21,800 by 33% and 17,000 by 71%. The 1987 count of 26,552 exceeds these population estimates by 22% to 56%.

Prior to late autumn 1986, these differences were not evident. Since crane numbers were often estimated during peak flights, over-estimation could have led to the high 1986 total count. My estimates for 56 flocks at Bernalillo in 1986 were not significantly different from the actual numbers ($c = .001$, $x2 = 38.96$) However, these estimates and comparative counts were conducted mostly on flocks containing fewer than 100 cranes. Only 12 of the 56 flocks had more than 100 and only 1 flock had more than 200 cranes. During some major flights of 1986, when estimates of 300 to 800 cranes were made, I (and cooperating counters) could have been over-impressed by large flocks of cranes, leading to a systematic over-estimation of crane numbers.

To examine this possibility, I separated the cranes I actually counted, 13,391, from the total, leaving 15,662 where some unknown level of estimation error existed. Table 3 presents several potential ranges of estimation error by myself and cooperators, leading to lower population estimates. Only at a 50% error level does the total autumn 1986 count fall below 21,800 cranes and only at 75% error does it approach 17,000. Such error levels seem excessive, and I believe that more than 22,000 cranes migrated through the study area in 1986.

In 1987 I estimated only as a last resort. I decreased the estimation proportion of the total count from 54% in 1986 to 11% (2,750 cranes) in 1987. I was also pointedly conservative in my estimates, counting cranes in groups of 10, 25, and at most 50 when large flocks were overhead. Still there were considerably more cranes migrating along this route than are in the Rocky Mountain population. Rocky Mountain greater sandhill cranes are counted in late March when virtually all of them are in the San Luis Valley (Benning, op. cit.). It is unlikely that there are 5-10 thousand more cranes than the official 1982-87 estimates.

Reverse migration could account for a portion

of the overcount. Nearly 500 sandhill cranes were counted migrating northward over White Rock during the autumn of 1986 and 176 northbound birds were counted, mostly at Bernalillo, in 1987. Even more cranes may have returned to the San Luis Valley, to be recounted on their second journey to New Mexico. However, large northward movements of cranes were not noted during autumn, and this phenomena at the documented level cannot account for the large difference between migration and population estimates.

The most logical reason for the higher counts of migrants is that lesser sandhill cranes (*G. c. canadensis*) are also using this migration corridor. Estimates of lesser sandhill cranes in the San Luis Valley in October were 2.8% in 1989 and 2.1% in 1990 (W. Brown, pers. comm.). Two to 3% of my 1986 and 1987 counts of 26,000-29,000 cranes would only be 500-600 cranes. Therefore, if lesser sandhill cranes are moving through the San Luis Valley, they are not staying long enough to be documented. Further, entry into the San Luis Valley or the Rio Grande drainage north of the study area requires an otherwise unnecessary mountain crossing. It seems more likely that lesser sandhill cranes migrating across the Great Plains turn westward south of Albuquerque and reach the Middle Rio Grande Valley without crossing the Sangre de Cristos, which terminates near Santa Fe (Fig. 1). The large difference between autumn migration counts and systematic spring aerial counts cannot be satisfactorily explained.

The spring 1985 count of 25,890 sandhill cranes was also 19% higher than the 1985 aerial count. Many lesser sandhill cranes that winter along the Rio Grande apparently join in the flight to the San Luis Valley. Though more lesser sandhill are seen there in the spring than in the autumn, usually < 10% of the cranes there in March are lessers (W. Brown pers. comm.). It seems likely, however, that the lessers do not stopover long in the San Luis Valley but quickly move on to the Platte River in Nebraska.

Consistent Use Of Nontraditional Stopovers – Despite unexplained population differences, the most important result of this study is the documentation of heavy use of overnight roosts within the study area. Melvin and Temple (1982) defined such roosts as nontraditional stopovers. They recognized that favorable roosts were consistently used each year, although not by all cranes or even the same cranes each year. They hypothesized that favorable roosts along migration routes are known by older cranes and sought out near the end of the day.

Cranes often approached the Jemez Roost by angling across the mesa from the northeast even before the river was in sight. An even stronger indication of the attraction of this roost to the cranes was encountered on some evenings with strong northwest winds. On 10 November 1986, strong northwest winds helped 2,782 cranes (Fig. 4) overfly the study area, although all were blown well to the east of the Rio Grande. At about lh before sunset, crane flocks began to break from the eastern flight line and angle to the west. Nearly 1,800 cranes entered the Jemez Roost that evening, flying more than 12 km into a strong northwest headwind (Fig. 7). On 6 other occasions between 1985 and 1987, smaller numbers of cranes (r = 19-150) were observed approaching the Jemez Roost under similar conditions.

Part of the attraction of the Jemez and Cochiti roosts may be the absence of human activity there. Public access to Jemez Reservoir is limited to an observation point near the dam, 3 km from the roost. A paved road passes about 0.8 km from the principal roost, while the sparsely inhabited old pueblo of Santa Ana is 1.2 km upstream. The road is only lightly traveled. At Cochiti Lake public access is also limited to the dam and a paved road; both are at least 400 m from areas where cranes have roosted.

Despite the presence of these "popular" roosts, cranes apparently regularly roost in uplands. One flock of 110 sandhill cranes and 1 whooping crane roosted on a mesa 5 km west of Espanola on 7 November 1984, even though the Rio Grande was clearly visible to the flying birds. Documented upland roosts were generally far (>0.5 km) from traveled roads or occupied houses.

Roosting on the Rio Grande within the Albuquerque metropolitan area was documented late in this study. Unconfirmed reports of cranes roosting in this area had been received previously and late birds counted as 1 day migrants might well have roosted south of Bernalillo but north of the wintering grounds. The gallery forest along the river provides some protection from the noise and human activity of the city. Both documented roosts were more than 0.8 km from streets or houses.

Weather and Autumn Crane Miqration– Another important result of this study was the analysis of the impacts of weather on migration. A combination of factors influence the speed and timing of crane migration in northcentral New Mexico.

Season is an important factor; most cranes remain in Colorado through October even if favorable conditions for migration occur. About 75% of the cranes migrate after November 1 (Figs. 2-5).

Departure time from the San Luis Valley is also important, but could not be quantified in this study. Flocks departing late in the morning would travel less in a day and therefore be more likely to stop overnight during the journey. Favorable morning winds (r^2 = 56.6) were associated with large numbers of cranes (>2,000/day) overflying the study area (Table 2).

Weather impacts migration once the cranes are underway. Winds and, to a lesser extent, thermal activity (sunshine) affect the distance cranes travel after they leave Colorado. Unfavorable southerly winds generally force cranes to stop overnight in the study area. Favorable northerly winds push them over the area in 1 day. The effects of thermal activity are less apparent, but spiraling, then gliding is an integral part of crane migration (Melvin & Temple 1982).

Cold fronts are important because they directly affect wind speed and direction and thermal activity. Winds ahead of a front blow perpendicular to it, causing unfavorable southwesterly winds in the study area. Cranes that leave Colorado ahead of a front, although they avoid bad weather there, must fly into headwinds and are forced to stopover 1 night enroute. Birds that wait until after a front passes ride northwesterly tailwinds to the wintering grounds in 1 day, even though these winds push them well to the east of the direct line route over the study area (Fig. 7).

Reverse Migration - Autumn – On the evening of 25 October 1986, an estimated 3,600 sandhill cranes (Fig. 4) flew over the study area and arrived on the wintering grounds. That evening and the following day, a Sunday, were part of the first legal sandhill crane hunt in the Middle Rio Grande Valley in 70 years. About 300 hunters were licensed for that portion of the hunt and many were afield that weekend. During the following week, 497 sandhill cranes were counted migrating northward over White Rock. It is likely that, having flown this far north, these cranes were returning to the San Luis Valley. It would seem that a major disturbance, probably the hunt, caused the cranes to return to Colorado. This caused these cranes to make 3 autumn trips instead of the usual.

The experimental crane hunt continued in October 1987, but there was no regular observer at White Rock. A flock of 31 cranes flew northward over White Rock on 29 October, and 145 northbound cranes were observed at Bernalillo or Albuquerque between 28 October and 15 November. Some local movement of wintering birds may have been involved, but these limited observations indicate that reverse migration continued to occur in 1987.

RECOMMENDATIONS

Melvin and Temple (1982) discouraged the acquisition and management of migration stopover refuges because the distances cranes travel in a day can vary greatly. Although not as important as traditional stopovers, consistently used overnight roosts such as the Jemez River should be protected and managed to benefit migrant cranes. The presence of the foster flock of whooping cranes at this and other roosts in northcentral New Mexico heightens the importance of these areas.

Most overnight roosting areas documented herein are on Indian reservations and are relatively isolated from human disturbance. However, the growing population of Albuquerque places greater economic incentives on these pueblos to provide a variety of recreational opportunities. Illegal crane hunting was observed on several reservations during this study. Education and better law enforcement are needed to curb this activity. It is important that state and federal agencies work with tribal officials so that these stopover roosts will continue to be available to migrant cranes.

Although these roosts are on Indian lands, water management is the responsibility of the U. S. Army Corps of Engineers (COE). Both the Jemez and Cochiti roosts are within the floodpools of COE reservoirs and water management can directly affect their quality. Consideration of crane roosting habitat should be a part of all water management decisions made by COE and the New Mexico State Engineer.

This study has documented the importance of consistently-used overnight roosts to this population. Similar use of certain stopover sites by Rocky Mountain cranes between the San Luis Valley and the summering areas has also been found (H. Heusser & R. Drewien pers. comm.). Important stopover roosts on the migration routes of other sandhill and whooping crane populations should also be located. Lingle (1987) contended that suitable nontraditional stopover roosts might be a limiting factor on the Wood Buffalo-Aransas whooping crane population. The results of this study are

most applicable to those crane populations that migrate short distances (<500 km) between traditional stopovers and wintering or summering areas. As the distance migrated increases, cranes can be expected to spread out and be less likely to concentrate at particular intermediate stopovers. The use of known overnight stopover roosts by migrating cranes should be included in the management decisions at those sites on public lands. Cooperative agreements should be pursued at sites on private land.

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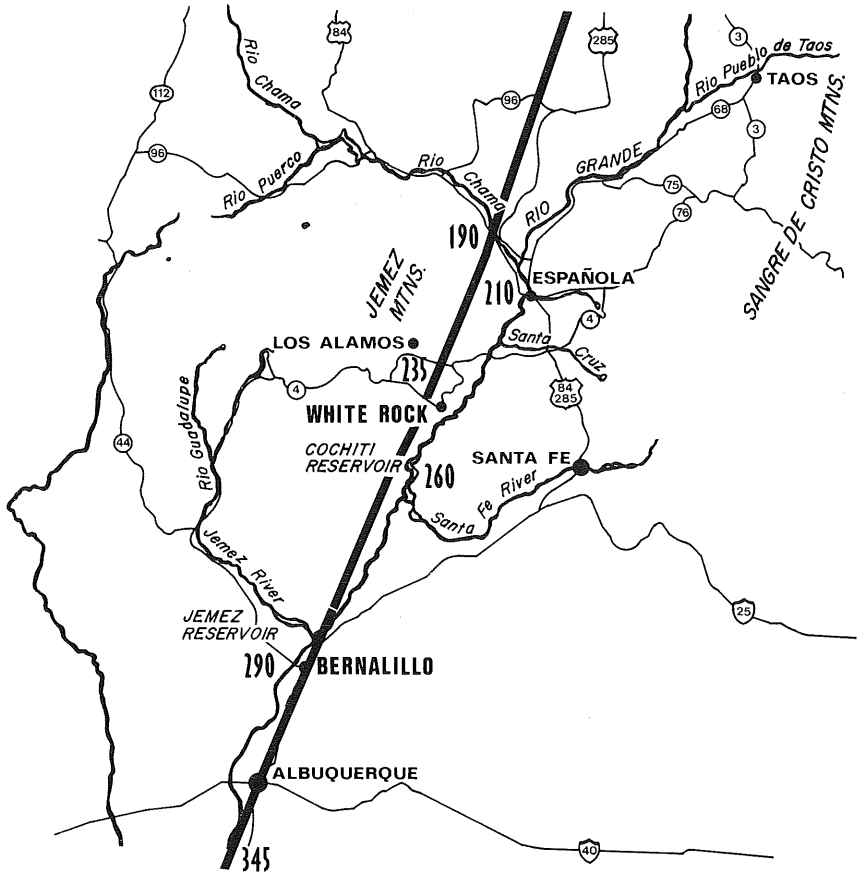

Figure 1. The migration route of greater sandhill and whooping cranes through northcentral New Mexico. Numbers indicate km from Monte Vista NWR, Colorado.

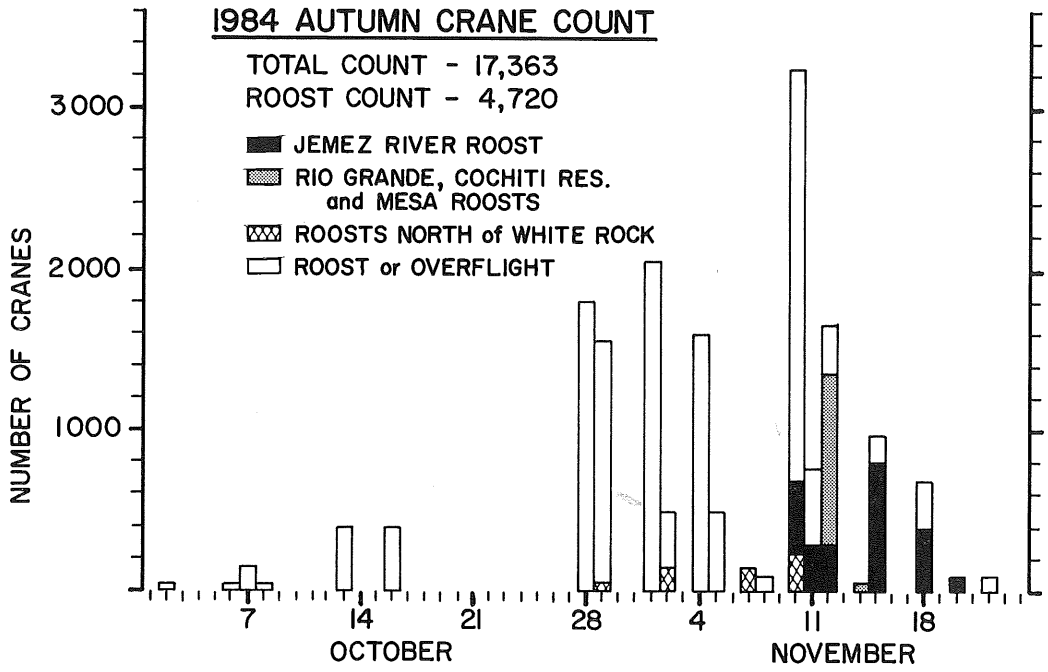

Figure 2. The 1984 autumn sandhill crane count conducted at White Rock, New Mexico.

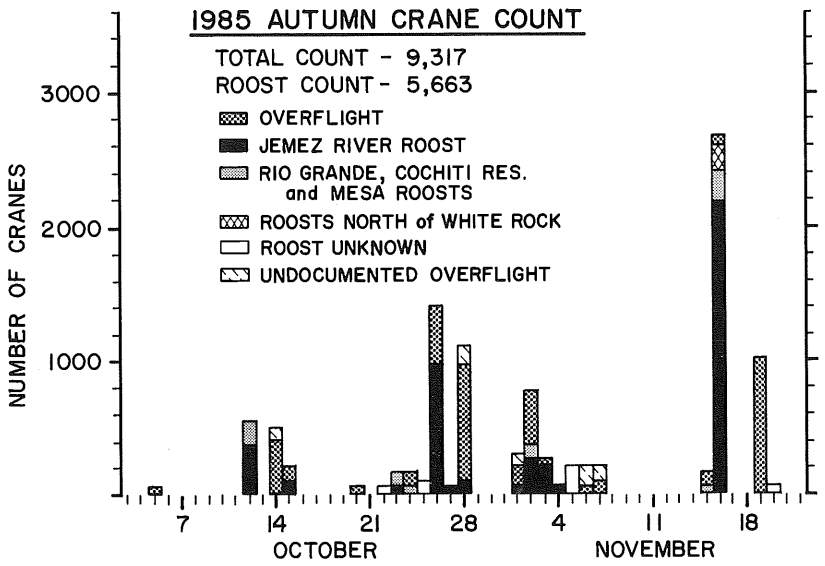

Figure 3. The 1985 autumn sandhill crane count conducted at Bernalillo, New Mexico.

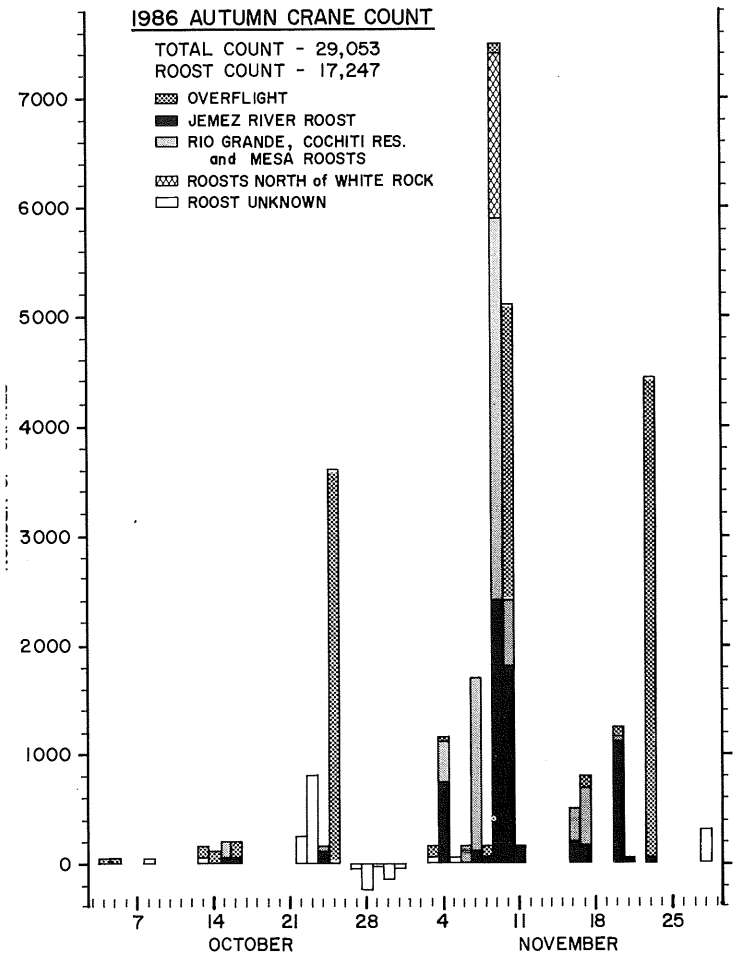

Figure 4. The 1986 autumn sandhill crane count conducted at Bernalillo, New Mexico.

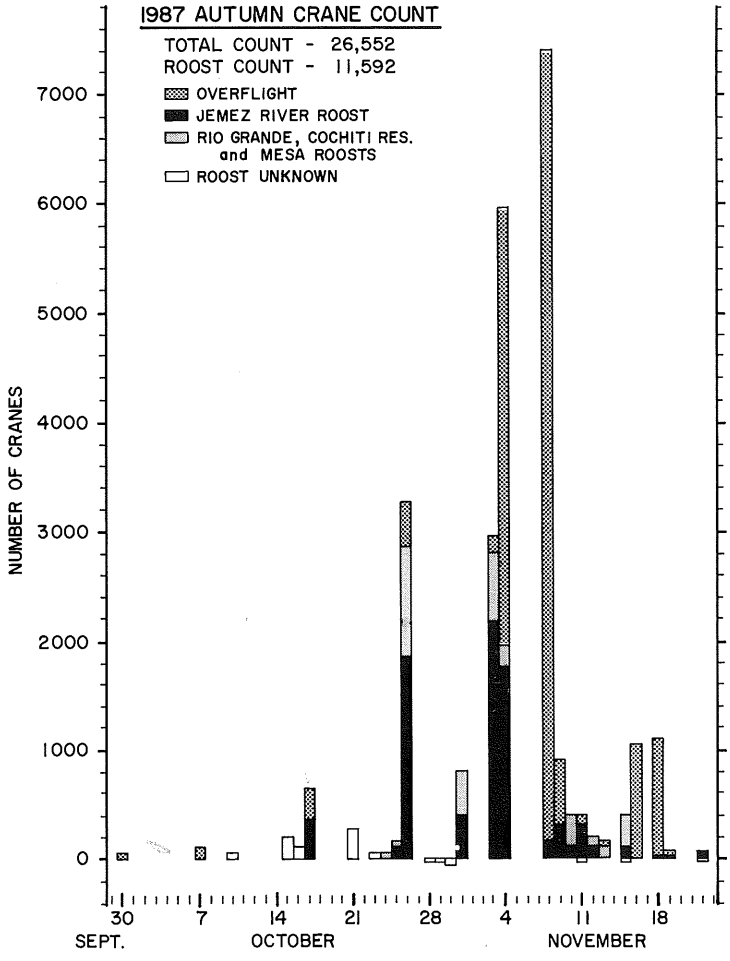

Figure 5. The 1987 autumn sandhill crane count conducted at Bernalillo, New Mexico.

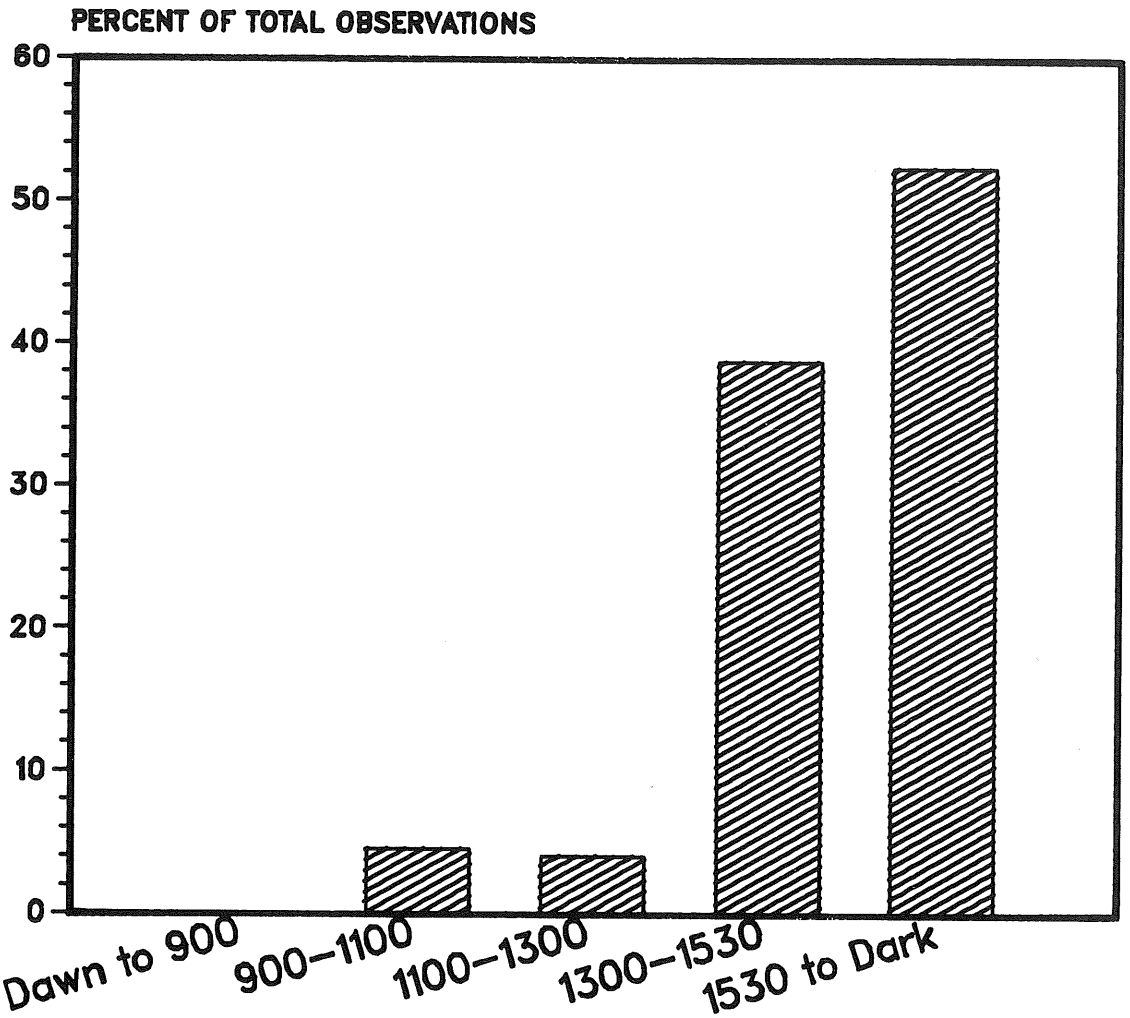

Figure 6. The distribution of the fall 1984 sandhill crane count at White Rock, New Mexico by time of day.

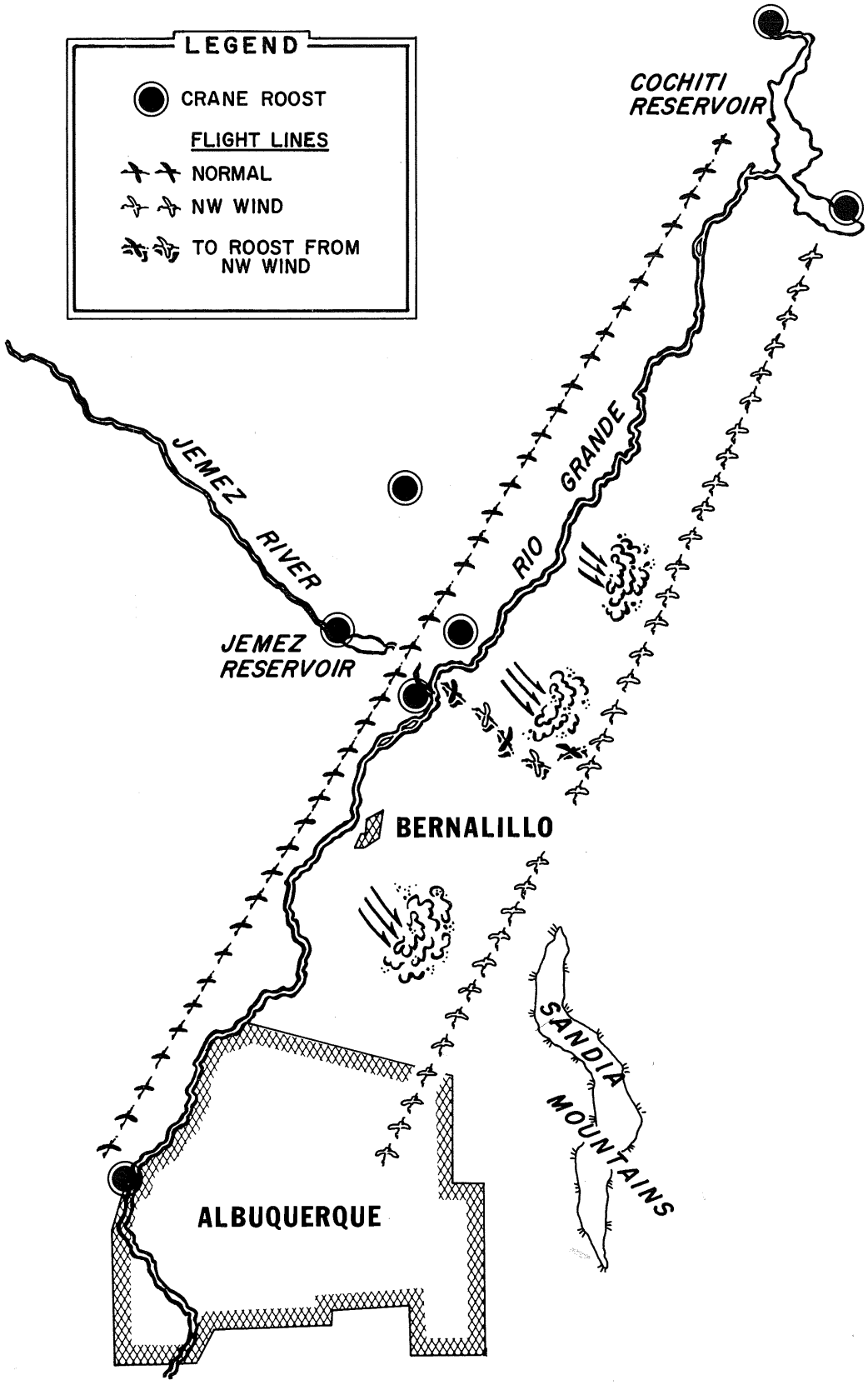

Figure 7. Documented overnight roosts and flight routes of sandhill cranes in northcentral New Mexico.

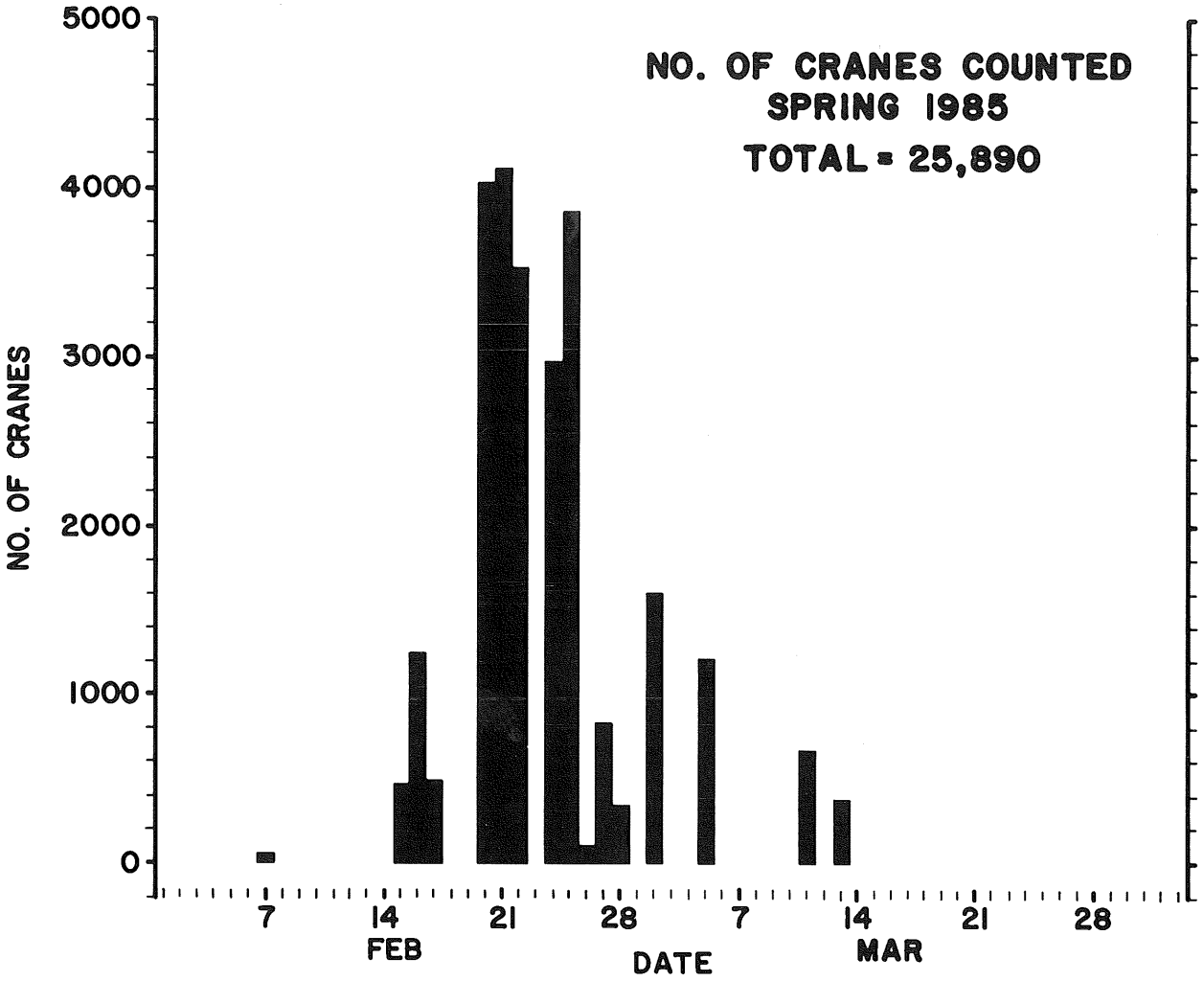

Figure 8. The 1985 spring sandhill crane count conducted at White Rock, New Mexico.

STATUS, PRODUCTION AND MIGRATION OF GREATER SANDHILL CRANES ON AGASSIZ NATIONAL WILDLIFE REFUGE, MINNESOTA

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Abstract: Greater sandhill cranes (*Grus canadensis tabida*) nesting at Agassiz National Wildlife Refuge (NWR) in northwestern Minnesota were studied from 20 April 1984 to 10 December 1985. Local birds were monitored to determine population size and age structure, reproductive success, and migration routes and wintering grounds. Forty-two pairs were identified. Thirty-four were breeding pairs and 3 were subadult (nonbreeding) pairs. Twenty nests were found; pairs at 13 of these hatched at least 1 young. Forty-three pairs hatched a minimum of 62 young, and 28 pairs fledged 42 of 47 young. Fifteen birds were color-marked, 8 of which were radio-tagged and followed through parts of their migration. Unlike cranes nesting in eastcentral Minnesota, these birds entered the Central Flyway. One bird was traced to east Texas wintering grounds.

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Once found throughout Minnesota, exclusive of the northeast (Johnson 1976a), greater sandhill cranes presently exist as 2 separate breeding populations within the state, one in the northwest, the other in eastcentral Minnesota. Both populations have expanded in recent years and the separation between them has become less distinct. Migrating cranes are also seen in Minnesota at traditional migration staging areas in northwestern and westcentral parts of the state.

A history of nesting sandhill cranes in Minnesota has been provided by Johnson (1976a), and accounts of their status and distribution have been given by Johnson (1976a), Grewe (1977), D. Murphy (Prelim. Rept. Sandhill Cranes in northwestern Minn., St. Cloud State Univ., St. Cloud, Minn., 1978), and C.L. Henderson (Minn. Sandhill Crane Rept., Minn. Dept. Nat. Resour., St. Paul, 1979). Most recently, the eastcentral population has been estimated at 87-109 pairs, and the northwest population at 760-1160 pairs (M. C. Tacha & T. C. Tacha, Status and Distribution of Sandhill Cranes in Minn., Minn. Dept. Nat. Resour., St. Paul, 1985).

Data on the ecology of summering cranes in Minnesota are limited. Johnson (1976b) studied the biology of nesting cranes in the eastcentral population. Crete & Toepfer (1978) determined the migration route and wintering grounds of this population, demonstrating their affiliation with the eastern (Great Lakes) population of greater sandhill cranes.

The affiliation of the northwest population has been less certain. The close proximity of the 2 populations could suggest that these birds are also a part of the eastern population, as has generally been assumed. This idea was supported by the sighting of 2 color-marked birds in Manitoba, and another in western Minnesota, that had previously been marked on Florida wintering grounds (Nesbitt & Williams 1979).

Conversely, there has been evidence to suggest that these birds are more accurately associated with the mid-continent population of sandhill cranes (includes *G. c. rowani* and *G. c. canadensis*). When tabida was first identified on east Texas wintering grounds, it was suggested that they may have come from southeastern Manitoba and northern Minnesota (Lewis 1974). Melvin & Temple (1980) later demonstrated that sandhill cranes from the Interlake Region of Manitoba do, in fact, migrate through the Central Flyway to winter along the Texas coast. However, the subspecific designation of those birds is not certain (Lewis 1977). The presence of the Canadian subspecies (*G. c. rowani*) in migrant flocks in Kittson County, Minnesota (Johnson & Stewart 1973), led Johnson (1976a) to suggest that local cranes in northwestern Minnesota would be unlikely to separate from migrant flocks

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to travel in a different direction. The major fall staging area for cranes from eastcentral Minnesota is Crex Meadows State Wildlife Management Area in Burnett County, Wisconsin (Crete & Grewe 1982), but peak fall numbers there do not account for the much higher number seen in northwestern Minnesota. In addition, there are no crane migration records that would link the northwest and eastcentral populations.

This study was initiated to provide information on the breeding biology of cranes in the northwest Minnesota population, and to identify the migration routes, stopover areas, staging grounds, and wintering grounds of this population. The study was done in partial fulfillment of the requirements for the degree of Master of Arts at St. Cloud State University.

Work on this study was done at Agassiz NWR, under a cooperative agreement (USDI No. 14-16-0003-84-926) with the U. S. Fish and Wildlife Service (USFWS) that provided refuge housing, office space, use of a refuge vehicle and some field assistance. St. Cloud State University (SCSU) Department of Biological Sciences provided miscellaneous field and laboratory equipment. Cedar Creek Bioelectronics Laboratory donated radio transmitters. The discovery of a dead color-marked bird on a crane wintering area was reported by T. Moran of Houston, Texas. Texas Parks and Wildlife Department flew an aerial telemetry search of crane wintering areas. Partial funding was provided by SCSU, SCSU Alumni Association, SCSU Foundation, Friends of Belwin, Minnesota Zoological Society, and International Wild Waterfowl Association. This manuscript was improved by the critical review of earlier drafts by R. T. Eberhardt, A. K. George, A. H. Grewe, Jr., B. K. Seefeldt, C. W. Seefeldt, Jr., and the workshop editors.

STUDY AREA

Agassiz NWR encompasses 24,868 ha of eastern Marshall County in the extreme northwestern corner of Minnesota. The refuge is situated in a relatively narrow aspen parkland transition zone, between prairie to the west and forest to the east. Located on the bed of a former bay of glacial Lake Agassiz, the terrain is extremely flat, varying only 20-40 cm/km. Originally the area contained prairie and marshes with scattered aspen (*Populus* spp.) islands, but massive drainage efforts in the early 1900s converted much of the land to agricultural purposes. By the early 1930s, high drainage costs, combined with poor economic conditions, threatened the financial stability of Marshall County, allowing for governmental purchase of lands and eventual establishment of the refuge.

Marshes have been restored on the refuge through the construction of numerous dikes and water control structures. Approximately 2/3 of the refuge is now wetlands. Remaining cover types include a mix of grassland, brushland, woodlots, and a small amount of cropland. The refuge is bordered by extensive small grain farms, with the exception of adjacent State Wildlife Management Areas on the southern and southeastern boundaries. The primary objective of Agassiz NWR is waterfowl production and maintenance.

From the establishment of the refuge in 1937 and throughout the 1940s and 1950s, cranes were only known as spring and fall migrants. During the 1960s, cranes began to appear as rare to uncommon summer residents, but evidence of production was not detected until 1970 when 1 flightless young was observed. There was a slow increase in the number of local birds through the 1970s, reaching an estimated 6 breeding pairs in 1979. The first documented nest record was in 1980. That year also marked the beginning of a relatively rapid year-to-year increase in the number of summer residents. By 1983 an estimated 25 breeding pairs occurred on the refuge.

The increase in summer residents coincided with an increase in the use of Agassiz NWR by migrating cranes. Prior to 1959, peak numbers of fall migrants were generally 200 or less. From 1959 through the late 1970s the number varied up to 1000 birds per year. In recent years up to 2000 cranes have used Agassiz NWR in the fall. Peak numbers of spring migrants are considerably less.

MATERIALS AND METHODS

Local cranes were studied from 20 April 1984 to 10 December 1985. Territorial pairs were located by random auditory censusing during daily peak vocalization periods, and by visual surveys of likely feeding and loafing areas. In addition to listening for spontaneous crane calls, responses were elicited by broadcasting tape recorded crane vocalizations (Bennett 1978). Birds exhibiting nesting behavior were considered breeding pairs, including pairs in which only a single bird was seen on the territory during the nesting period, pairs for which a nest was found, and pairs later observed with young. Pairs that occupied and defended a territory, but failed to initiate nesting, were considered subadult pairs.

Nest locations were determined by triangulation of unison calls, by visual observation of nonincubating birds returning to nest sites, and by searching areas known to have contained nests in previous years. Actual nest sites were found on foot or, in a few cases, with the use of an airboat. To avoid nest abandonment, only nest measurements, water depth, and egg dimensions were recorded during initial visits. After hatching, nests were revisited to determine success, to collect shell fragments, and to record information on surrounding vegetation and habitat types.

Pairs were periodically monitored for any indications of nesting attempts and subsequent production of young. Territories thought to contain young were searched on foot once the young were large enough to hold leg bands. As these birds had been included in the management plan for the eastern population (Coord. Comm. E. Sandhill Cranes, Manage. Plan E. Pop. Greater Sandhill Cranes, 1982), color marking per the protocol proposed by the Coordinating Committee for Eastern Sandhill Cranes (D. L. Shroufe, Chairman, A Proposed Color Marking Protocol for the East. Population of Greater Sandhill Cranes, Coord. Comm. East. Sandhill Cranes, 1984) was employed. In 1984 birds were marked with a 5 X 15 cm green vinyl leg streamer with a white alpha-numeric code. The streamer was attached with a split ring to a No. 9 USFWS locking leg band. Bands were placed above the tarsal joint. In 1985 leg streamers were complemented with more durable 50 mm tall green plastic leg bands, inscribed with the same alpha-numeric code, and attached above the tarsal joint of the other leg. Above each of these bands was placed a 20 mm tall plastic band of 1 of 7 colors. The color combination of the 2 short bands was coded to correspond to the alpha-numeric code on the tall band and streamer.

Selected birds were fitted with single pulse radio transmitters in the 164 Mhz frequency range. Selection was based on spacial distribution of a limited number of transmitters within the refuge. Transmitters used in 1984 were powered by lithium organic batteries, averaged 124 gm, and were attached in a backpack fashion similar to that described by Crete & Toepfer (1978). Two types of leg band transmitters were used in 1985, battery-powered transmitters averaging 46 gm, and solar-powered units with nickel cadmium battery backup, averaging 31 gm. Transmitters were attached to the tall plastic leg bands. Solar-powered transmitters had a shorter range than battery-powered units, but did function overnight and through extended periods of overcast weather. Moreover, they had considerably longer life expectancy than the 240 days of the battery-powered transmitters. Radio transmitters and other telemetry components were obtained from Cedar Creek Bioelectronics Laboratory (Univ. Minn., Bethel, MN 55005).

Radio-tagged birds were monitored on the breeding grounds with standard telemetry triangulation techniques, using a receiver and hand held yagi antenna. Cranes leaving on their southerly migration were followed with an antenna-and-receiver-equipped private vehicle. A maximum (peak) signal antenna was used to track birds while they flew, and a null peak antenna system was used to locate and monitor birds after they landed. Flocks containing radio-tagged birds were kept in sight for much of the time while they flew, and locations were plotted on maps. When out of sight, locations were estimated from signal strength and direction.

RESULTS AND DISCUSSION

Breeding pairs began to return to Agassiz NWR by late March of both years, with most pairs on their territories by the first week of April. Forty-two territorial pairs were identified at Agassiz NWR (Fig. 1). At least 34 were breeding pairs and 3 were subadult pairs. The status of the remaining 5 pairs was uncertain. An additional 48 pairs, of which 27 were known to be breeding pairs, were located on adjacent and nearby state and private lands (Fig. 2).

Shortly after the return of breeding adults, small flocks of migrating cranes were seen, mostly around refuge agricultural units and in croplands off the western boundary of the refuge. Spring migrants peaked at about 200 birds in mid- to late April of each year.

Small groups of nonbreeders were occasionally seen into early May, but by mid-incubation only territorial pairs remained on the refuge. Other than rare, short appearances during the nesting season, groups of nonbreeding cranes were not seen on the refuge again until late summer after the young had fledged. It is not certain where these nonbreeding birds spend their summer, but several flocks of 20-50 birds were observed in croplands near the refuge in eastern Marshall and northwestern Beltrami counties.

Incubation began in mid-April and peaked by the end of April. Late nesting and renesting attempts began as late as early June. Approximately

10-16 days elapsed between nest failures and initiation of second attempts. Eight nests were found on the refuge in 1984 and 12 in 1985. Pairs at 9 nests were successful in hatching 2 young, 4 hatched 1 young, and 7 failed to produce any. The majority of clutches hatched by the end of May, but some late nests were still being incubated in early July. Of the 7 initial nest attempts that failed, 3 were abandoned before eggs had been laid, 2 were abandoned with eggs, 1 was destroyed, and 1 contained infertile eggs. At least 2 of these pairs successfully renested and produced young.

Sixty-two flightless young, and 47 fledged young, were observed on the refuge during 1984-85. Six breeding pairs failed to hatch any young, and 3 pairs that successfully nested failed to fledge any young. Hatching and fledging success were determined for 47 pairs that nested on, or near, the refuge (Table 1). Cranes at Agassiz NWR commonly fledge 2 young. Of 25 pairs known to have fledged young during this study, 17 fledged 2 offspring.

Fifteen flightless young were marked during this study. In 1984, 6 birds were color-marked with leg streamers, 3 of which were also fitted with backpack radio transmitters. One radio was removed prior to migration because the harness had been set too tight. The next year, 9 cranes were marked with a combination of the streamers and colored leg bands. Five of those were equipped with leg band transmitters.

Fall migrants began to arrive at Agassiz NWR in mid-August, reaching a peak of up to 2,000 by late September or early October. Local cranes varied in their reactions to the influx of migrants. Pairs on the perimeter of the refuge abandoned their territories and joined with migrant flocks as soon as they arrived. Pairs in the interior of the refuge remained on their territories longer and mixed with migrants gradually. Some interior pairs left their territories to feed with migrants during the day, but continued using territorial roosts for several nights before completely abandoning their territories. Other interior pairs began roosting with migrants at night, while returning to their territories to feed during the day. In some cases, local pairs did not mix with migrants prior to their own migration. One pair defended its territory up to, and including, the day it left.

On 22 October 1984, 2 local family groups, including 1 radio-tagged and 2 color-marked birds, left Agassiz NWR on their migration southward (Fig. 3). The first day, they flew 210 km to a staging area near Rothsay, Wilkin County, Minnesota. They remained there for 5 days in the company of over 800 other cranes. On the morning of 28 October, the radioed bird and its family left Rothsay with several hundred other cranes and flew 130 km southwesterly before stopping for the night near Crandall, Clark County, South Dakota. The following day (29 October), they continued for 120 km, making an overnight stop near Miller, Hand County, South Dakota. The next day (30 October), the cranes were followed 400 km farther southward. Fifteen minutes after sunset, and after 10 hours of continuous flight, the birds were still flying high while passing over the Platte River near Gothenburg, Dawson County, Nebraska. Radio contact was lost at that point because of equipment failure. Areas to the south of the last radio contact were searched the next morning (31 October), as well as the Platte River between Hershey and Grand Island, Nebraska, but radio contact was not reestablished. It is likely that the birds continued for some distance before landing the previous evening.

The radio-tagged crane from the family monitored in the fall of 1984 was seen at a Platte River staging area during the return migration the following spring. On 27 March 1985, the bird was seen with other cranes in a field near Wood River, Hall County, Nebraska (T. C. Tacha pers. comm.), and the following day (28 March) radio contact was established while the bird roosted in the Platte River (Fig. 3). Subsequent efforts to locate the bird after it returned to northwestern Minnesota were unsuccessful.

A family group with 2 radio-tagged siblings was followed southward from Agassiz NWR in the fall of 1985 (Fig. 3). On 14 October, the birds left, with another family group, and flew 37 km from the refuge, where they spent the night roosting in a wet drainage ditch. The following morning (15 October) they traveled another 92 km southward and merged with over 1000 other cranes staging near Ada, Norman County, Minnesota. They remained there for 9 days, during which time (19 October) another radio-tagged crane from Agassiz NWR arrived. On 24 October, the family with the radio-tagged siblings left Ada in the company of 19 other cranes and flew southeasterly, bypassing the point where the birds had flown into South Dakota the previous year. Covering 378 km in 8.5 hours, the birds landed 2 hours after dark in the southwestern corner of Minnesota near Windom, Cottonwood County. The following day (25 October), they backtracked 172 km northward to near Morris, Stevens County. The cranes headed south-

westerly the next morning (26 October). Vehicle delays, caused by road construction while still in Minnesota, allowed the birds to gain an insurmountable lead on the tracking vehicle. After 8 hours, covering 455 km across southwestern Minnesota, southeastern South Dakota, and central Nebraska, the signal was lost at sunset near Albion, Boone County, Nebraska. The next day (27 October), a ground search of the birds' expected path through central Nebraska and Kansas failed to reestablish radio contact. A quick return to Ada, Minnesota to locate the third radioed crane that had been there, was also unsuccessful.

Eleven days after radio contact was lost in Nebraska (6 November), 1 of the radio-tagged siblings was found dead at Katy, Fort Bend County, Texas. A subsequent (18-26 November) ground search of crane wintering areas in portions of Fort Bend, Waller, Austin, and Wharton counties, Texas, as well as the Texas coast from Galveston to Corpus Christi, failed to locate any radio-tagged or color-marked cranes from Agassiz NWR (Fig. 4).

On 9-10 December 1985, Texas Parks and Wildlife Department Wildlife Biologists searched for radio-tagged cranes while conducting the Mid-coast portion of the December Goose Survey (R. R. George, Tex. Parks Wildl. Dept., Austin, pers. comm.). Two observers were in the aircraft, each continually monitoring separate receivers. Unfortunately, the aircraft mounted antennae were not properly tuned for the frequency of the transmitters, and continued overcast weather resulted in unreliable reception conditions. In spite of this, both observers believed they heard brief, faint signals from separate birds in the area of Louise and Ganado, approximately 95 km from where the dead bird was found and 50 km from the nearest area ground searched in November (Fig. 4). These reports could not be confirmed.

Because of the results of the 1984 field season, the birds counted at Rothsay, Minnesota were not included in the 1984 Eastern Greater Sandhill Crane Census (L. E. Schumann, U.S. Fish Wildl. Serv., East Lansing, Mich., pers. comm.). The sample of marked birds in this study was small, but when combined with existing evidence, and lacking stronger evidence to the contrary, it would seem that nesting cranes in northwestern Minnesota should more appropriately be considered associated with the mid-continent population of sandhill cranes than with the eastern population of greater sandhill cranes. Four separate populations of greater sandhill cranes are currently recognized (Lewis 1977): Eastern, Rocky Mountain, Colorado River Valley, and Central Valley. Birds from southern Manitoba and northwestern Minnesota are now considered part of the eastern population, but as new information accumulates, it may be advisable to recognize a fifth distinct population of mid-continent greater sandhill cranes.

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Table 1. Hatching and fledging success of greater sandhill cranes nesting on Agassiz NWR and adjacent areas of eastern Marshall and northwestern Beltrami counties, Minnesota, 1984-85.

Year	Location	No. pairs	No. hatched	No. fledged	No. hatched/ pair	No. fledged/ pair	% fledged
1984	On refuge	18	28	25	1.6	1.4	89.3
	Off refuge	8	11	11	1.4	1.4	100.0
1985	On refuge	16	19	17	1.2	1.1	89.5
	Off refuge	5	7	7	1.4	1.4	100.0
Total	On refuge	34	47	42	1.4	1.2	89.4
	Off refuge	13	18	18	1.4	1.4	100.0
	Combined	47	65	60	1.4	1.3	92.3

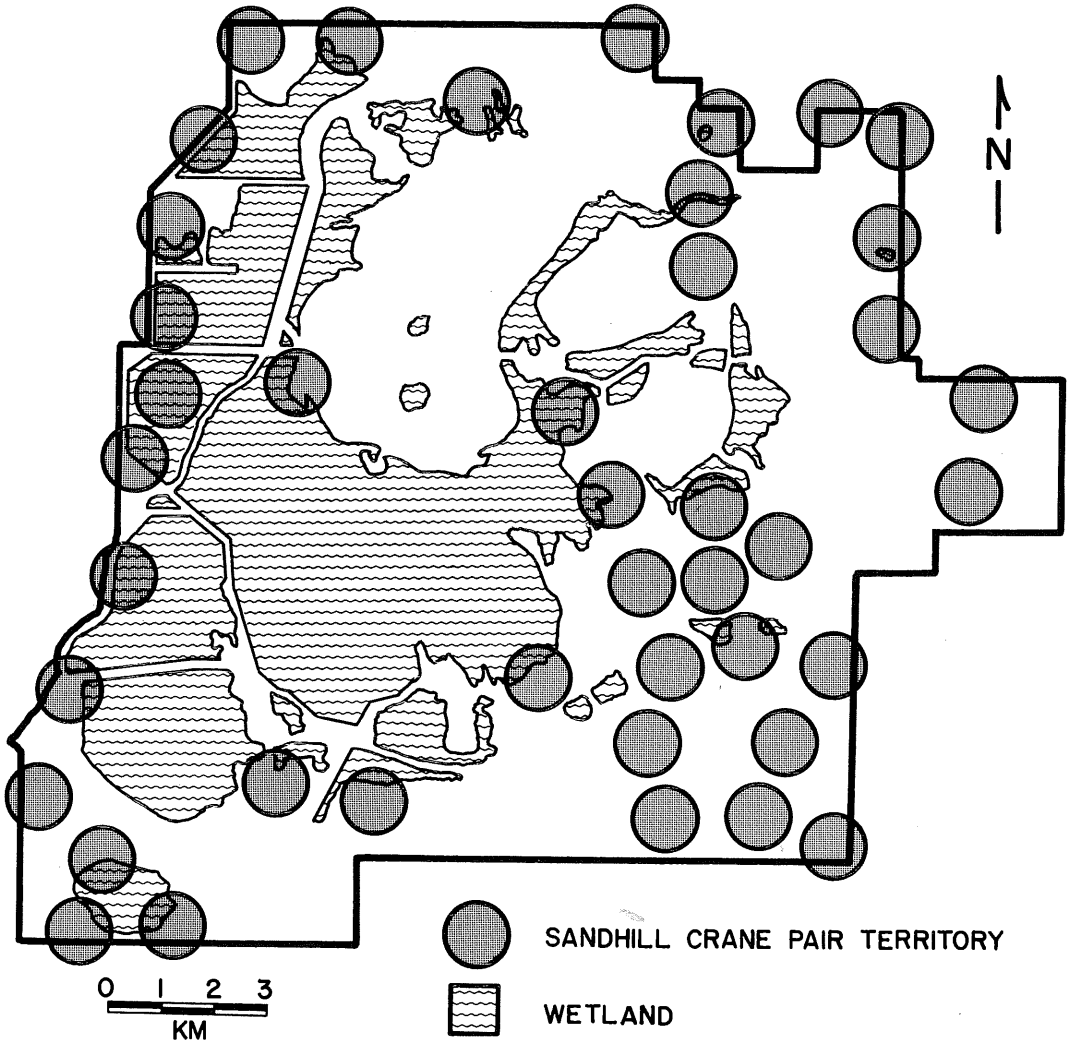

Figure 1. Distribution of sandhill crane pair territories on Agassiz NWR, 1984-85.

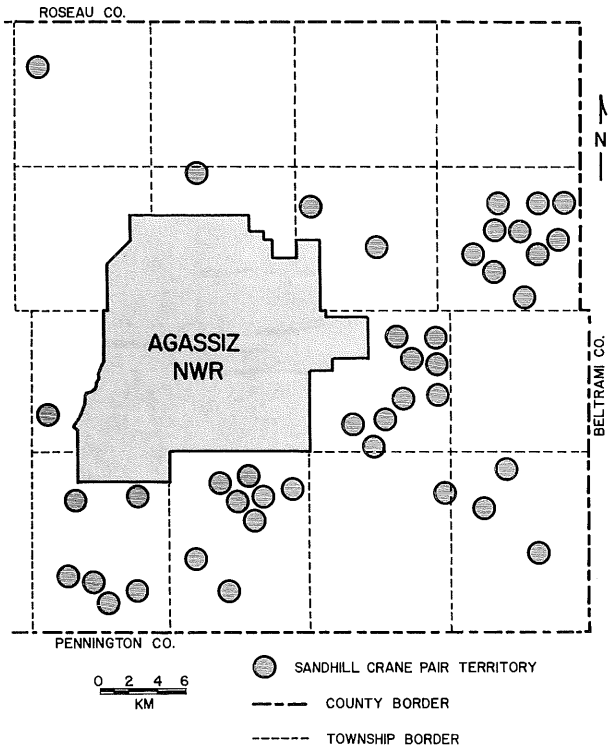

Figure 2. Sandhill crane pair territories in eastern Marshall Co., Minnesota, 1984-85.

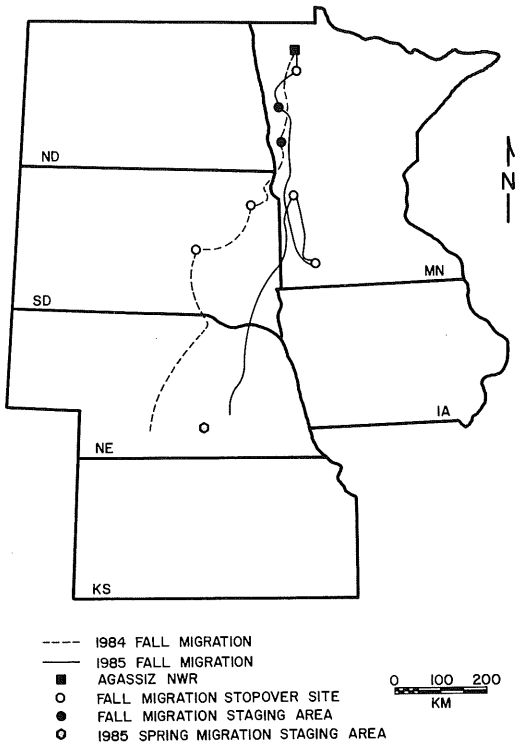

Figure 3. Migration routes of radio-tagged sandhill cranes from Agassiz NWR, 1984-85.

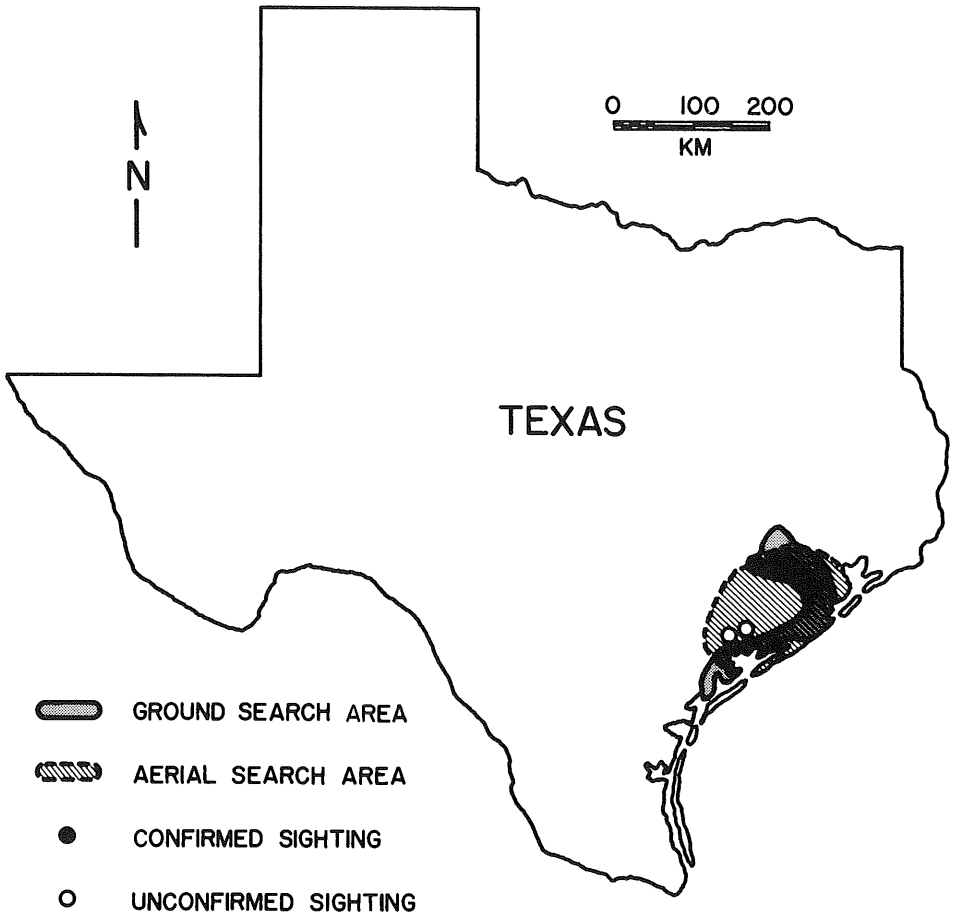

Figure 4. Search areas and locations of radio-tagged sandhill cranes on east Texas wintering areas, 1985.

SURVIVAL OF JUVENILE GREATER SANDHILL CRANES AT MALHEUR NATIONAL WILDLIFE REFUGE, OREGON

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Abstract: Greater sandhill crane *(Grus canadensis tabida)* recruitment rates in southeast Oregon have generally been low since the mid-1970s. To identify causative factors for low chick survival, transmitters were placed on 21 flightless young in 1983 and 18 in 1984. Of the chicks monitored in 1983, contact was lost with 4, 13 were lost to predators, 1 died of parasitic pneumonia,1 drowned and 2 fledged. In 1984, 8 chicks were monitored, 4 were lost to predators, 1 drowned, and 3 died from unknown causes. Of 10 transmitters which malfunctioned, 8 were on chicks known to have died. Predation was determined to be the major mortality factor on Malheur NWR, with coyotes *(Canis latrans)* being the most serious predator.

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This 2-year study was initiated in May 1983 to identify the factors causing high mortality rates of unfledged greater sandhill cranes on Malheur National Wildlife Refuge (NWR), Harney County, Oregon. Recruitment rates in southeast Oregon have been low since the mid-1970s, resulting in a decline in the number of nesting pairs on the refuge (Littlefield & Thompson 1987). This was the first attempt to monitor cranes from shortly after hatching until individuals either died or fledged.

The study was a cooperative effort between Oregon Department of Fish and Wildlife and the U.S. Fish and Wildlife Service. Numerous employees from these two organizations helped organize and participated in the study. In particular, we would like to thank Gerald Farstvedt and James Lemos (ODFW) who spent considerable time and effort in obtaining funds and transmitters, and who also helped in the field. U.S. Fish and Wildlife Service personnel involved in the study included Jon Anderson, Brad Ehlers, Ellen Kelley, Gary Ivey, David Paullin and William and Marcia Radke. Also involved were several people from Malheur Field Station. Most important were Gaylin and Roland Holloway who helped capture and monitor chicks. Without the help and support of these people, the study would not have been possible.

STUDY AREA

Malheur NWR is located in the northestern portion of the Great Basin at a relatively high elevation (1240 m). Precipitation occurs mainly from November through January, but May and June have greater monthly totals. Summers are generally dry with maximum temperatures seldom exceeding 35°C, while winters are cold with below 0° C temperatures for several weeks in most years. For a description of the refuge see Littlefield (1976) and Littlefield and Thompson (1987).

MATERIALS AND METHODS

Greater sandhill crane chicks younger than 30 days were fitted with hermetically sealed Telemetry Systems, Inc. CRZ-N transmitters. Transmitters (164 MHz) were placed around the neck with a 0.63 cm wide elastic collar. Elastic collars had a 3:1 stretch ratio. Transmitters were painted to match crane chick plumage; the white elastic was dyed in very strong hot tea mixed with 3 tablespoons of instant coffee granules. when elastic resembled the color of young cranes it was removed from the solution, dried, and attached to the trans-

mitters with super glue.

Upon equipping a chick, a small amount of super glue was placed on each side of the transmitter and attached to the down feathers on the lower neck. This prevented the transmitter from sliding to the neck's ventral surface until chicks had attained sufficient height to avoid impediment of movements. Usually within 1 week transmitters had shifted to the ventral neck region. Transmitter package weight was about 6g. After 30 days, or when chicks had attained sufficient height, a Telemetry Systems, Inc. RS50-2TM-3X-S (45-65 g) solar-powered transmitter attached to a plastic leg band (Insulfab Plastics, Inc.) was placed above the tibial-tarsal joint. Transmitter attachment was identical to that described by Melvin et al. (1983)

Nests were found between 15 April and 20 May 1983, and 21 April and 14 June 1984. Nests were examined at the expected time of hatching, and if chicks were present, transmitters were attached. Older chicks were equipped after being found from an auto or by searching on foot. Ground searching was conducted when a crane pair performed "broody" behavior.

Chick monitoring was accomplished from an auto or on foot, using a Yagi hand-held antenna and Telonics TR-1 receiver. Chicks were monitored every 1 to 3 days in 1983 and 1 to 5 days in 1984. Transmitters were equipped with mortality sensors and when signals became constant, a ground search was initiated to find the chick, chick remains, or transmitter. In 1984, considerable time and effort were spent searching for 10 chicks after their transmitters malfunctioned. Dead chicks which were recovered were sent to the National Wildlife Health Laboratory (NWHL), Madison, Wisconsin for necropsy.

Transmitters were placed on 21 chicks beteen 24 May and 8 August 1983, and 18 chicks between 14 May and 27 June 1984. Most chicks were equipped shortly after hatching but 10 of 39 were not equipped until they were 14 days or older.

RESULTS

Transmitter-equipped Sandhill Crane Chicks-1983

Twenty-one greater sandhill crane chicks were equipped in 1983 (Table 1). Unfortunately, transmitters were not obtained until 21 May, 1 week after the hatching peak. Contact was lost with 4 chicks, 13 were known lost to predators, 1 died of parasitic pneumonia, 1 drowned and 2 fledged. Two chicks with which contact was lost (chicks 153 and 173) were known to have died before fledging. Therefore, total mortality of chicks was 89.5%. Mammalian predators accounted for 64.7% of the 17 chicks, while great horned owls (*Bubo virginianus*) were suspected of taking at least 2 (10.8%). Thirteen chicks were equipped within 4 days after hatching. Two chicks were captured within 1 week of fledging, while 6 were tagged when 14 to 30 days old. The average survival period for the 13 chicks instrumented shortly after hatching was 19.3 days (r=1-54). Five chicks captured when 14 to 56 days old survived an average of 15.8 days (r=5-30). One chick equipped on 8 August fledged 12 August. The history of each 1983 transmitter-equipped chick is presented in Appendix A.

Transmitter-equipped Greater Sandhill Cranes-1984

Eighteen unfledged crane chicks were transmitter-equipped in 1984 (Table 2). Transmitters arrived in ample time for the hatching, but many nests which were being monitored were destroyed by predators. Additional problems developed in 1984; 10 transmitters malfunctioned shortly after being placed on chicks, and the transmission range was usually between 10 and 15 m in 1984, compared to 220 and 440 m in 1983. These problems resulted in repeated disturbance of family groups and often delayed periods between monitoring. Fates of 8 chicks were determined. Four were lost to coyotes, 1 drowned, and 3 died from unknown causes. Of the 10 transmitters which malfunctioned, 8 chicks were known to have died. Therefore, total mortality was at least 88.9%.

Twelve chicks were equipped within 4 days after hatching, while 3 were 1 week old, 1 ca. 2 weeks old, and 2 ca. 4 weeks old. Recently hatched chicks survived an average of 8.8 days (r=1-14). Chicks which were ca. 7 days old survived 8 days (r=2-14 days), and the 2 which were ca. 4 weeks survived 7.5 days (r=2-12). No equipped chicks were known to have fledged. The history of the 18 chicks is presented in Appendix A.

DISCUSSION AND CONCLUSION

Although transmitter malfunctions in 1984 resulted in only a few chicks being monitored for their entire lives, the study was successful in determining major factors involved in chick mortality.

From information collected in 1983, and limited information in 1984, predation was determined to be the major chick mortality factor. Of 25 chicks whose fates wsre determined, 68.0% were lost to predators. Predation was particularly high for chicks less than 4 weeks old. So few chicks survived past their first 4 weeks, it was impossible to ascertain if other potential mortality factors, such as early meadow mowing, disease, starvation, accidents or brood strife were contributing to chick losses.

Coyotes were suspected in most predation losses, destroying 13 chicks (52.0%), 9 of the 17 chicks in 1983 and 4 of 8 in 1984. Great horned owls are abundant on Malheur NWR, and were known to have preyed on 2 young cranes and possibly another. A raccoon (*Procyon lotor*) was implicated in 1 loss, although raccoons are common on the refuge and in some years may contribute significantly to crane chick mortality.

Since studies were initiated on the refuge in 1966, 2 instances of predation by mink (*Mustela vison*) were detected. Presently, minks are uncommon on Malheur and it is doubtful the species has contributed to many losses. Golden eagles (*Aquila chrysaetos*) have killed and consumed at least 3 adult sandhill cranes in recent years, and certainly the species has the potential for capturing young cranes. During this study no chicks were known lost to eagles.

One chick has provided information on a mortality factor which could be prevalent in the local crane population and perhaps other populations as well. Gapeworms (*Syngamus* spp.) were first reported from sandhill cranes in Florida (Forrester et al. 1974), but were found in small numbers. The death of Chick 43 was the first record we are aware of for a sandhill crane death resulting from an infestation of gapeworms.

Since 1966, many chicks have been heard making "gurgling" noises (Littlefield pers. observ.). It was assumed respiratory "gurgling" was because of Aspergillus fumigatus, which had previously been reported from cranes on Malheur NWR in the early 1960s (E. Boeker unpubl. ms.). However, symptoms for aspergillosis are not accompanied by "gurgling" (Davis et al. 1971). Rapidly growing gapeworms obstruct the lumen of the trachea, resulting in suffocation. The inability to breathe causes a bird to gape which is an early symptom of infection. Affected birds also emit short, whistling sounds (Davis et al. 1971) . These whistling sounds can be described as "gurgling," indicating young cranes heard in the past may have been infected by the parasite.

Upon reexamination of the necropsy report from a chick which had apparently died of aspergillosis in 1961, an unidentified nematode engorged with blood was found in the trachea. Another chick which died after being captured in 1961 also had several unidentified nematodes engorged with blood in the trachae (E. Dickinson pers. comm. to R. Erickson). It is likely these unidentified nematodes were gapeworms.

These parasites would be readily available to sandhill cranes as the intermediate host is the earthworm, a common food source for cranes on Malheur NWR. Gapeworms may be an important mortality source for greater sandhill cranes on the refuge. In addition, gapeworms may predispose crane chicks to predation. Unfortunately, chick 124 was mostly consumed by turkey vultures (*Cathartes aura*) before it was located, resulting in an inconclusive necropsy. Symptoms were somewhat similar to those of chick 43, therefore chick 124 could have died from this parasite.

In 1984, some information was collected on crane chicks in relation to water management. Water deficiences on portions of the refuge resulted in considerable chick movement. Limited irrigation resulted in chicks concentrating in a small meadow where water overflowed from a canal. Three chicks were transmitter-equipped at this ca. 9 ha area, but none was known to have hatched in the immediate vicinity. Excessive movements often results in increased predation, and none of these chicks was known to have fledged. Chick 64 had moved ca. 1.6 km within 24 hours of being transmitter-equipped. Once water receded in the meadow, no additional crane use was noted.

In another area, a broken dike provided an abundance of water through the early crane brooding period. Chicks 24 and 34 were being monitored in this field. Chick 24 was in the southeast corner, and chick 34 in the east-central portion. Six coyotes were seen regularly in the drier northeast portion, but both chicks were separated from the coyotes by several deep channels. As water levels receded in the Blitzen River, water flowed rapidly from the field. Tracks indicated coyotes immediately moved into the newly accessible areas and both chicks disappeared within 48 hours.

To some extent, transmitters were believed responsible for some chick mortality. The 2 chicks which drowned were likely the result of transmitter weight. This mortality factor could have been reduced or avoided by (1) equipping chicks which have been produced only from large eggs and (2)

not placing transmitters on recently hatched chicks when temperatures exceeded 30° C.

Chick 164 weighed only 100 g when equipped, and had been hatched from the smallest egg (85.5 X 61.0 mm) located on Malheur NWR in 1984. The chick was found dead 10 m from the nest and had apparently drowned while attempting to swim to shore. Chick 53 was transmitter-equipped when temperatures exceeded 30°C. The chick was later located near the nest and had apparently left the site prematurely because of the excessive heat. Transmitter weight likely prevented the chick from reaching shallow water before tiring and subsequently drowning.

Malfunctions in 1984 prevented an evalution of transmitter influence on chick mortality, but in 1983 there was some indication transmitters caused increased mortality. Refuge mortality of unmonitored chicks in 1983 was 84.4%, compared with 89.5% for those monitored. Even though some chicks were lost because of transmitters, considerable information was obtained during the study, and this information has been useful in making decisions for the management of greater sandhill cranes on Malheur NWR.

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APPENDIX A. THE HISTORY OF MONITORED GREATER SANDHILL CRANE CHICKS ON MALHEUR NWR, OREGON (1983-1984).

1983

Chick 13 – Chick 13, with its sibling (chick 23), left the nest on 20 May 1983 . It was captured and equipped on 24 May (after hatching 19 May). By 25 May, the adults and chicks had crossed ca. 1. 2 km of big sagebrush (*Artemisia tridentata*) and black greasewood (*Sarcobatus vermiculatus*) uplands, and were eventually relocated adjacent to a marsh northwestly of the nest site. This family group was using an ecotone between the marsh and uplands for feeding. Coyotes also used the ecotone. On 26 May, the transmitter, with attached down feathers, was located beneath 7. 5 cm of water within 1 m of shore. Fresh coyote tracks were evident along the shore leading into water where the transmitter was located. There was no sign of the chick or chick remains. An active coyote den was within 0.4 km of the transmitter, and pups were regularly seen in the vicinity.

Chick 23 – Chick 23, the sibling of chick 13, was probably the oldest of the brood and likely hatched on 18 May. Its movements were identical to chick 13. Upon locating chick 13's transmitter, a weak signal was received from chick 23's transmitter, but it was not located until 27 May. Similar to chick 13, only the transmitter was found, in a greasewood flat ca. 0.4 km northeasterly of the area being used by the family group on 25 May. The transmitter was in the area where coyote pup activity had been most evident during the proceeding days. Tracks and scats near the transmitter indicated both chicks 13 and 23 were killed and consumed by coyotes, likely on 26 May.

Chick 33 – Chick 33 hatched on 23 May 1983 and was equipped on 24 May. Its sibling was found dead near the nest, having died at hatching or shortly thereafter. After leaving the nest site, the family group moved 0.4 km southeasterly into a moist meadow. On 27 May, the chick was in the same general area, but had moved onto an ecotone between meadow and a greasewood upland. Shortly afterward, the southern portion of Malheur NWR became flooded as the Blitzen River overflowed its banks. From 1 through 8 June no signals were received as water remained high in the pair's territory. Water receded by 9 June and the chick was seen on its former feeding meadow. Appar-

ently, the adults moved the chick to higher ground during the run-off period, likely southeastward of their original territory. Adults were heard calling from that area in early June. The chick's remains were located among sedges (*Carex* spp.) in the feeding meadow on 10 June. Gnawed bones and fresh blood were near the transmitter, indicating the chick was consumed by a mammalian predator. Unlike other transmitters found after a chick had been consumed, the collar had been chewed and the antenna bent. Three long bone ends and coagulated blood were located within 20 cm of the transmitter. The substrate was moist, covered with dense sedge, 2m from a hardstem bulrush (*Scirpus acutus*) stand. No tracks or scats were found near the chick's remains, but raccoon predation was suspected.

Chick 43 – On 26 May 1983, chick 43 was captured and fitted with a transmitter along with its sibling chick 53. After leaving the nest site the family group moved ca. 50 m SSE where it remained through 31 May. By 1 June, the adults had moved the chick northeastward where they came in contact with a neighboring crane pair. Numerous unison calls were given by the 2 pairs, indicating a territorial dispute was in progress. By 4 June, the family group had moved to the eastern edge of their territory, feeding in a greasewood upland-meadow ecotone, but on 5 June the chick was in an irrigated meadow southerly of the upland. Minor movements continued through 8 June in the southern portion of their territory. The pair and chick moved to within 50 m of a well-traveled road on 9 June where they fed in a dense creeping wildrye (*Elymus triticoides*) stand through 16 June. On 17 June, the chick was found dead in 16 cm of water. Both adults were within 10 m indicating the chick had recently died. The carcass was collected and shipped to NWHL for necropsy. Diagnosis determined the chick had died from parasitic pneumonia and tracheitis. Over 20 gapeworms, both male and female, were located in the trachea and lungs. Chick 43 was the first record we are aware of for a sandhill crane death resulting from an infestation of this nematode.

Chick 53 – Chick 53 (sibling chick 43) hatched on 27 May and was transmitter-equipped shortly afterward. Temperatures were above normal on both 27 and 28 May. The chick was found dead on 28 May, ca. 2 m from the nest, apparently having drowned. Excessive heat likely caused the chick to leave the nest prematurely, and transmitter weight could have prevented the chick from reaching shallow water before tiring. The specimen was analyzed at NWHL and was reported as normal. However, the liver was shriveled and had a whitish coating over the surface, and the lungs and intestine had the consistancy of bloody pus. The peritoneal cavity was filled with yolk material which was normal for a chick this age. The final diagnosis from NWHL was--cause of death undetermined.

Chick 63 – On 31 May 1983, this chick was transmitter-equipped at the nest. It weighed 128 g and had hatched on 30 May. Shortly after leaving the nest the adults moved the chick into a creeping wildrye stand in a flooded meadow/greasewood ecotone. By 5 June, chick 63 had moved 0.25 km eastward. This eastward movement continued and on 28 June the family group was ca. 0.8 km ESE of the nest site. Movement into this area occurred after a neighboring pair had lost their 2 chicks chicks (chicks 73 and 83). That pair had abandoned its territory shortly after their chicks were lost, thus allowing the chick 63 family to move into the area. The family group returned to their own territory 29 June and remained there until contact was lost on 9 July.

Chick 73 – Chick 73, with its sibling, chick 83, was equipped on 31 May 1983. The chicks, together ca. 10 m from the nest, had hatched on 29 and 30 May. Chick 73 weighed 110 g when equipped and was apparently the younger of the brood. Flooding on 3 June stranded the family on a greasewood upland where it remained through 9 June. After water levels receded, the birds moved southward to adjoining uplands where they fed in a meadow upland ecotone. On 21 June, the group moved 0.4 km northward and on 24 June, 0.25 km southwesterly near an adjoining pair's territory. This was the last live contact. On 27 June, the carcass was found on a willow (*Salix* sp.) upland. The chick had been decapitated which is indicative of predation by a great horned owl. An owl pair nested within 0.4 km from where the remains were located. The NWHL diagnostic report showed massive traumatic tissue tearing lesions throughout thc thoracic cavity and the lungs were torn apart,

Chick 83 – Sibling to chick 73, chick 83 weighed 122 g when instrumented on 31 May. Unlike other pairs during the study, the adults kept the chicks relatively close together throughout the monitoring period, Movements within the territory were similar to chick 73. Chick 83 was found dead on 27 June ca, 2 m from chick 73; it had also been decapitated. Both chicks were apparently killed at the same time by a great horned owl. The NWHL diagnostic report showed the chick had multiple

trauma regions along the back, and the ribs were crushed. One lung was torn and puncture wounds were present through the skin. The gizzard contained unidentified seeds, indicating the chick was healthy at the time of death.

Chick 93 – Both chicks 93 and 103 (siblings) were captured on 1 June 1983. Chick 93 weighed 106 g and was captured 5 m from the nest swimming in 75 cm of water. Both adults were present, leading the young to a dry dike 15 m west. The 2 chicks appeared chilled and were quivering. These 2 chicks were not monitored on 2 June, but on 3 June the transmitters were found near a dike near the release site. Coyote tracks and scats were nearby; Chick 93's collar was intact and located with the attached transmitter in water 12.5 cm, westerly of the dike.

Chick 103 – Chick 103 weighed 112 g when captured. It had been on a bulrush mat ca. 6 m from shore. Size and activity indicated this was the oldest chick and had probably hatched on 20 May. The transmitter and collar were found on a dike near ths release site on 3 June ca. 0.75 m from the nearest water. The collar was stained with blood. Probably the same coyote captured both chicks shortly after transmitter attachment.

Chick 113 – Chick 113 was equipped while on a nest on 1 June 1983. It weighed 119 g and was extremely active. Also in the nest was a cracked egg being incubated by an adult. On 3 June, the chick was located on a dike ca. 30 m northwesterly of the nest site, accompanied by both adults. The transmitter, with attached collar, was located below willows 50 m east of the nest site on 4 June. Transmitter condition and nearby tracks indicated the chick had been consumed by a coyote.

Chick 123 – Chick 123 was captured on 1 June ca, 50 m from a well-traveled road, 2.4 km westerly of Malheur NWR Headquarters. The adults had apparently nested near Malheur Lake's southern shore, and were likely moving the chick to favorable feeding habitat further south. The chick was estimated to be 30 days old. The family group had moved south of the road and was feeding along a dike on 2 June. The signal was lost from 3 until 9 June. On 9 June, the chick was feeding in a meadow ca. 0.4 km SSE of the capture site. On 12 June, the transmitter was located on a dike 0.4 km southerly of the capture site. A coyote was present, feeding on the carcass. Chick feathers were scattered over a 1 m area. The transmitter had been removed with collar intact, similar to others where coyote predation was suspected. Not enough chick remains were available for necropsy.

Chick 133 – On 2 June 1983, chick 133 was captured and transmitter-equipped. It was estimated to be 3 weeks old and weighed 300 g. Both adults were in attendance. The chick had apparently hatched from a nest 0.8 km easterly of the capture site. By 3 June, the family had moved 0.4 km southwestward and was feeding at a meadow's edge adjacent to a greasewood upland. However, chick 133 had moved back near the capture site by 6 June. Contact was lost between 10 and 15 June, but was reestablished on 16 June ca. 0.5 km southerly of the capture site. This was the last contact.

Chick 143 – Chick 143 was chick 63's older sibling and had already left the nest when chick 63 was equipped and released. Both chicks were together 3 June, but shortly afterward the adults separated, each taking a chick. Throughout much of the monitoring period the adults kept the chicks separated, feeding in different areas usually 30 to 50 m apart. Chick 143 was seen on several occasions on a dike ca. 200 m easterly of the nest site in early July. The chick was active on 10 July, but no contact was made on 12 July. On 13 July, the chick's remains and transmitter were located east of the Blitzen River ca. o.8 km easterly of the nest site. The remains were on a greasewood-wildrye upland. There were 4 distinct feather piles as the predator apparently dragged the chick, stopping occasionally to feed. Bone chips and both legs were also present. The chick was apparently captured by a coyote and drug from the meadow, across the Blitzen River and road, to the upland, before being consumed.

Chick 153 – Chick 153 was 4 to 5 weeks old when captured on 7 June 1983. The transmitter malfunctioned 10 June, and it was recaptured 12 June and the transmitter replaced. The chick fed along a moist dike where habitat was limited. On 21 June the adults had moved the chick off the dike's southern end. Habitat there was also limited as deep water and dense Baltic rush (*Juncus balticus*) predominated. The family group had returned to the dike by 24 June. The group again left the dike and moved onto residental lawns at refuge headquarters on 26 June. The transmitter malfunctioned at this time and close observation indicated the antenna was not present (B. Ehlers pers. comm.). No signal was received on 27 June and the chick was not seen or heard again. B. Ehlers dispersed the chick from a refuge lawn on 26 June. About 2 to 3 hours later a great horned owl was perched in a tree ca. 15 m away and could have been responsible for the chicks disappearance.

Chick 163 – Chick 163 hatched on 27 May 1983,

but because of inaccessibility was not equipped until 15 June. When captured, the chick was ca. 100 m westerly of the nest site, being fed by both adults in an ecotone between moist meadow and a wildrye upland. The family group remained on or near the ecotone through 28 June, but by 29 June had begun to drift southward as water levels receded. They remained in the southern extremity of their territory until mid-July when they moved northwestward apparently searching for favorable feeding habitat. By 17 July, the meadow was mostly dry with only a few moist spots in the deeper depressions. Contact was not made on 19 July, and on 20 July the transmitter was located among chick feathers and bone fragments ca. 0.4 km easterly of the last contact point. The transmitter's condition was similar to others in which coyote predation was suspected, but no coyote tracks or scats were noted.

Chick 173 – Chick 173 (ca. 4 weeks old) was captured with its sibling (chick 183) on 23 June 1983. Upon release the chick ran southwesterly into a dense hardstem bulrush stand. The transmitter malfunctioned before or during attachment, and the chick was not seen or heard after release. Efforts were unsuccessful in relocating the chick.

Chick 183 – Chick 183 was transmitter-equipped on 23 June. It was the smallest of the 2 chicks. After capture, the family moved southeasterly 0.4 km. By 30 June, the group had moved southeastward 0.4 km from the previous data point. On 14 July, chick 183 was recaptured and the transmitter was replaced with a leg-band transmitter. The adults and chick were located 0.8 km northerly and 0.4 km easterly of the last data point on 23 July. When approached, the chick was hiding among common cattail *(Typha latifolia)* but shortly afterward flew and joined the adults. On 25 July, the group was back on its nesting territory where it remained through 29 July. The adults and chick subsequently left the territory and moved NNW 4.8 km where they were located on 31 July. This northern movement continued until the group arrived at a grain field 11.2 km northerly of the nesting territory. They were still in this area in late September, along with 57 other greater sandhill cranes. Two data points were obtained from the wintering area, where chick 183 was seen on the Faith Ranch (ca. 16 km west of Modesto, Stanislaus Co., California) on 24 and 28 December 1983 (T. Pogson pers. comm.). The transmitter had malfunctioned and the chick was not seen subsequent to 28 December.

Chick 193 – Chick 193 was equipped 29 June 1983 when less than 1 week old. It weighed 155 g and had no sibling. The adults and chick remained within 10 to 50 m of a well-traveled road through early July. Most activity occurred within 0.4 km of the road. Feeding habitat remained in excellent condition well into July because of high water levels in Malheur Lake. Chick 193 was alive on the morning of 12 July, but that afternoon the transmitter was located in cattails and rushes 15 m from a newly mowed hay swath; some down feathers were attached and the transmitter was scraped and worn. Coyotes had been consistently seen for ca. 2 weeks in the area and coyote predation was believed responsible for the chick's demise.

Chick 203 – Chick 203 was near fledging when instrumented with a leg-band transmitter on 5 August 1983, ca. 8.0 km WNW of Diamond, Harney County, Oregon. The chick had first been seen on 4 August, but no adults were in attendance. Upon capture, the chick did not attempt to hide or flee. The chick was captured in a recently mowed meadow, and continued to feed alone in the same area through 9 August. On 19 August, chick 203 was found dead 10 m from the edge of a meadow being mowed. Canine tracks were evident around the carcass and a few feathers were missing but there was no evidence any portion of the bird had been consumed. The carcass was shipped to NWHL, where laboratory diagnosis revealed massive tissue tearing of the musculature, rib fractures and internal bleeding in the right thoracic area. There was a deep penetrating wound which may have been attributed to a canine tooth in the right pectoralis major. Massive hemorrhage and bruising of the breast muscles were evident. The lesions were consistant with a predatory mammal such as a coyote or dog. The bird weighed 2930 g and appeared healthy. Mouse fur, likely montane vole *(Microtis montanus)*, was found in the gizzard, which indicated the chick had recently fed. The area where the chick was located is well known for free-roaming dogs, but coyotes also frequent the area. It was suspected the chick was killed by a dog since it was not consumed.

Chick 213 – Chick 213 was captured and equipped with a leg-band transmitter on 9 August 1983 in a grain field. The chick was near fledging when captured. Through September, the adults and chick 213 remained in the vicinity of the capture site, and on 11 October migrated. It was located on the wintering area near Thornton, San Juaquin County, California on 22 October 1983 (T. Pogson pers. comm.). During the winter 58 data points accumulated. Chick 213 was relocated in Diamond Valley, Harney County, Oregon on 21

March 1984 where it remained until mid-April. On 27 April, it moved ca. 19 km SSW of Diamond Valley where it remained through mid-May, but was not seen again on Malheur NWR until autumn. On 27 and 28 September, it was seen ca. 11 km northward of Frenchglen, Harney County, Oregon, moving northward ca. 16 km on 3 October. Chick 213 left the refuge on 15 October and was resighted near Thornton on 28 October 1984. Somewhere between Malheur NWR and Thornton the transmitter was lost, but the color-band combination on the bird continued to provide a means for identification.

1984

Chick 14 – Chick 14 was captured and instrumented on 14 May 1984. High water from the Blitzen River covered much of the parent pair's territory from 16 through 30 May. On 27 May, the family moved ca. 0.25 km southwesterly to a sagebrush-covered slope where it remained for 1 day before moving back to the original capture site. The chick was killed shortly after returning. The transmitter was retrieved on 2 June among sagebrush west of the Blitzen River. Tracks indicated the chick had been killed by a coyote. As a result of high water most feeding was confined to a narrow ecotone between open water and rimrocks. The family was often seen feeding among sagebrush on a steep slope below the rimrock.

Chick 24 – On 19 May 1984 chick 24 was captured. Its male parent had been banded (599-01477) and color-marked on 16 April 1982. After being equipped, the chick was not relocated until 25 May, ca. 0.4 km northeasterly of the capture site and where it remained through early June. A neighboring pair, also with a transmitter-equipped chick, disappeared in early June resulting in chick 24's family moving onto their territory on 6 June. The area was completely flooded during this time, but on 10 June most water had drained from the field and chick 24 disappeared shortly thereafter. The adults were seen feeding ca. 3 km northwesterly of their territory on 11 June, but no chick was present. The transmitter malfunctioned on the day the chick was lost, so the causative factor was undetermined. Possibly, as the chick was killed, the transmitter was damaged.

Chick 34 – Chick 34 and its sibling chick 44 were equipped on 21 May 1984. The male parent had been banded (599-01309) and color-marked on 4 August 1983. This chick's transmitter failed after 26 May, but it it was located alive on 7 June on a small island adjacent to a dugout pond. Chick 34 was lost at approximately the same time as its neighbor, chick 24. Water levels dropped rapidly in the field after flows from the Blitzen River and tributaries receded. By 11 June, the island became connected with uplands. Fresh coyote tracks and scats were evident where the chick was last observed. There was little doubt that the chick was killed and consumed by a coyote. The adults were located on 11 June feeding on an upland ca. 0.8 km southwesterly of the brooding area. Neither adult gave any indication of broodiness.

Chick 44 – Chick 44, sibling to chick 34, was equipped with a transmitter on 21 May 1984. On 24 May, chick 44 was still in the nest vicinity, but had moved to an island northerly of the site on 28 May. The decomposed chick remains were located 7 June near a broad-fruited burreed (*Sparganium eurycarpum*) stand ca. 10 m northerly of a crane brooding platform. The remains were sent to NWHL, but the carcass was unsuitable for examination because of extensive post-mortem autolysis.

Chick 54 – On 22 May 1984, chick 54 was captured and fitted with a transmitter. Water had overflowed from a canal and provided excellent crane brooding habitat from mid-May through 10 June. Chick 54, along with 2 other broods, was captured in this area. Approximately 1 week old, the chick remained in the field through 23 May at which time its transmitter malfunctioned.

Chick 64 – After locating chick 54 on 23 May 1984, chick 64 was captured ca. 0.4 km southerly in the same field. After extensive searching, on 24 May, chick 64 was relocated ca. 1.6 km southeasterly of the capture site. The pair was feeding on a dry dike surrounded by dry meadows. The chick could not be relocated between 25 and 29 May, but on 30 May the family was located on a small wet area ca. 0.8 km SSE of the capture site. The transmitter was producing a weak signal and it malfunctioned shortly afterward. No adults were seen in the area after this date and apparently the chick died around 1 June.

Chick 74 – Chick 74 had recently hatched when it was equipped at a nest on 23 May 1984. On 24 May, the chick had left the nest when its sibling (chick 84) was equipped. On 26 May, a coyote was reluctant to leave as Littlefield approached the nest. The transmitter was located ca. 15 m from the nest and the chick had apparently been consumed by a coyote.

Chick 84 – Chick 84 was the sibling of chick 74 and was equipped with a transmitter on 24 May

1984. The chick was apparently removed by a coyote shortly after hatching. The transmitter was located under 25 cm of water, 3 m from the nest. A coyote was present near the site and had to be driven away.

Chick 94 – This was the third chick captured in the flooded field where chicks 54 and 64 were transmitter-equipped. Chick 94 was captured on 26 May 1984. The family group had been observed earlier ca. 0.4 km northwesterly of the site. Shortly after capture, the group moved back to their original site where the chick was located 28 May. The transmitter malfunctioned shortly afterward, but the pair was present on their territory on 30 May. The pair showed no "broody" behavior and had left the area in early June.

Chick 104 – Chick 104 was recently hatched when equipped on 27 May 1984 and was from the same pair which produced chick 113 in 1983. The transmitter malfunctioned shortly after placement, However, the pair was easily monitored until the chick was lost. By 30 May, the family had moved to a dry meadow easterly of the nest, where they remained until 5 June and then moved to a small wet area ca. 0.4 km northeasterly of the nesting site. On 11 June, the adults performed distraction behavior, but on 12 June the adults were no longer on their territory. The chick was apparently lost during the evening of 11 June or morning of 12 June. Coyotes were heard near the family on 11 June.

Chick 114 – Chick 114 was instrumented when still on the nest 31 May 1984. The pair was one of which had relocated after high water in Malheur Lake had inundated their original territory. Their habitat was limited to a narrow ecotone between a slough and sagebrush upland. Coyote tracks were evident throughout the ecotone, and the chick was evidently lost to coyotes before 9 June.

Chick 124 – Chick 124 was ca. 4 weeks old when captured on 13 June 1984 in a dry area which provided little crane feeding habitat. The chick either died on the evening of 14 June or morning of 15 June. The chick's remains were located being consumed by turkey vultures. All internal organs except for one piece of intestine and all musculature were stripped from the carcass. The brain had also been removed. No diagnosis could be made by NWHL because the carcass was unsuitable. General appearance indicated the chick had died, with no indication the bird had been killed by a predator.

Chick 134 – On 14 June 1984, chick 134 was captured and equipped with a transmitter when ca. 4 weeks old. Unfortunately, the transmitter malfunctioned shortly after attachment and the chick was assumed lost because the capture site was only ca. 0.4 km from an active coyote den which contained 6 pups. However, on 27 June the chick was observed ca 0.4 km westerly of the capture site. The family was in the same location on 6 July, but disappeared shortly afterward. Examination of the area showed a well-traveled coyote trail where the chick was last seen.

Chick 144 – Chick 144 was ca. 4 days old when captured on 14 June 1984. It was in the same general area on 15 June, but by 19 June had moved 0.25 km northwesterly across a large body of water and willow grove to a meadow which contained several uplands. The transmitter malfunctioned on 20 June, and on 22 June the adults were located near the capture site feeding in a meadow-basin wildrye (*Elymus cinereus*) ecotone. The chick had apparently been killed or died.

Chick 154 – This 4 day old chick was captured on 14 June 1984 among a dense stand of Baltic rush. The chick's remains were found floating in 30 cm of water on 17 June, 10 m from the capture site. The NWHL found nothing significant upon necropsy. The internal organs were rather decomposed, but there was no internal infection. There was no indication of pneumonia and the stomach had food remnants present.

Chick 164 – This chick was transmitter-equipped in the nest on 18 June 1984. Its sibling hatched on 19 June. Upon reexamination on 19 June, chick 164 was found dead ca. 1 m from a dry meadow. The NWHL reported that the chick had likely drowned. The chick was an unusually small female. Its stomach contained egg membrane and shell fragments. Its sibling was also dead at the nests edge and sent to NWHL for necropsy. Its stomach was empty, but this chick was much larger, weighing 125 g. The yolk sac had not been totally resorbed. The NWHL could find nothing significant, and cause of death could not be determined.

Chick 174 – Chick 174 hatched on 22 June 1984 from a nest on a flooded island. At the time of capture on 26 June the chick had swam 0.25 km to dry land. Signals were received until 6 July,but the transmitter malfunctioned afterward and the chick was never relocated. The chick did not survive and the adults had abandoned the area by 23 July.

Chick 184 – Chick 184 was instrumented 27 June 1984. The transmitter malfunctioned shortly after placement and the chick was never relocated. On 28 June, the adult pair was present and did per-

form minor distraction displays. However, by 29 June, the adults had left the area. A pair was consistently seen through 5 July ca. 0.4 km easterly of the capture site, but it was not determined if this was the pair with chick 184.

Table 1. Suspected fates of 21 greater sandhill crane chicks transmitter-equipped in 1983.

Chick No.	Date Equipped	Date Lost	Suspected Fate
13	24 May	26 May	Coyote
23	24 May	26 May	Coyote
33	24 May	10 June	Raccoon
43	26 May	17 June	Disease
53	27 May	28 May	Drowned
63	31 May	9 July	Lost Contact
73	31 May	27 June	Great Horned Owl
83	31 May	27 June	Great Horned Owl
93	1 June	3 June	Coyote
103	1 June	3 June	Coyote
113	1 June	3 June	Coyote
123	1 June	12 June	Coyote
133	2 June	16 June	Lost Contact
143	3 June	13 July	Coyote
153	7 June	27 June	Lost Contact
163	15 June	20 July	Coyote
173	23 June	23 June	Lost Contact
183	23 une	28 Sept.	Fledged
193	29 June	12 July	Coyote
203	5 Aug.	10 Aug.	Canine
213	9 Aug.	11 Oct.	Fledged

Table 2. Suspected fates of 18 greater sandhill crane chicks transmitter-equipped in 1984.

Chick No.	Date Equipped	Date Lost	Suspected Fate
14	14 May	28 May	Coyote
24	19 May	10 June	[1]Lost Contact
34	21 May	7 June	[1]Lost Contact
44	21 May	28 May	[2]Died
54	22 May	23 May	Lost Contact
64	23 May	30 May	[1]Lost Contact
74	23 May	26 May	Coyote
84	24 May	25 May	Coyote
94	26 May	28 May	[1]Lost Contact
104	27 May	12 June	[1]Lost Contact
114	31 May	9 June	[1]Coyote
124	13 June	15 June	[2]Died
134	14 June	6 July	[1]Lost Contact
144	14 June	22 June	[1]Lost Contact
154	14 June	17 June	[2]Died
164	18 June	19 June	Drowned
174	22 June	6 July	[1]Lost Contact
184	27 June	28 June	Lost Contact

[1] Transmitter malfunctioned, but chick was known not to have survived.

[2] Carcass shipped to NWHL, but cause of death could not be determined.

DISTRIBUTION AND STATUS OF GREATER SANDHILL CRANES IN NEVADA

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Abstract: Nesting habitat of the Lower Colorado River Valley Population (LCRVP) of greater sandhill cranes (*Grus canadensis tabida*) was censused in northeastern Nevada from 1983 through 1986. Ninety-two nesting pairs and 594 cranes were located. Eighty-two percent were observed in central Elko County. Cranes were marked from 2 summer range locations and from the Lund, Nevada traditional spring migration stopover with patagial streamers. Cranes marked on summer range wintered on the lower Colorado River, in the Imperial Valley near Brawley, California and on the Gila River in southwestern Arizona. Cranes marked at the stopover were observed on summer range in Elko County and lower Colorado River winter range. Two cranes marked at the stopover were also observed on Rocky Mountain Population (RMP) fall staging and wintering areas indicating a portion of cranes using the stopover are members of the RMP. Spring stopover counts are not a valid measure of LCRVP trend because an unknown number of cranes from at least 1 other population also use the stopover, peak periods of use vary from year to year and peak numbers using the stopover can fluctuate drastically between years. The only method currently used to monitor the size and trend of the entire LCRVP are censuses conducted on winter range. The LCRVP probably numbers between 1800 and 2000 birds. If significant numbers of cranes from adjacent populations also winter with the LCRVP, winter range counts would be rendered invalid.

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Most of the Lower Colorado River Valley Population (LCRVP) of greater sandhill cranes nest in northeastern Nevada (Fig. 1). A segment of the population may also nest in extreme northwestern Utah, south-central Idaho and Malheur County, Oregon (Brown 1983).

Only limited investigations have been conducted to determine the distribution and status of cranes summering in Nevada. Drewein et. al. (1976) captured and color-marked 6 juvenile cranes from 2 Elko County, Nevada locations in the early 1970's, and subsequent observations indicated they wintered along the lower Colorado River near Poston, La Paz County, Arizona and made use of a spring migration stopover at Lund, White Pine County, Nevada before migrating to summer range. Small numbers of cranes wintering 11 km southeast of Brawley, Imperial County, California and along the Gila River between Buckeye and Gila Bend, Maricopa County, Arizona were also suspected to be members of the LCRVP (Bron 1983).

LCRVP population estimates and trends have been based on counts conducted by the Nevada Department of Wildlife (NDOW) at the Lund spring migration stopover, fall age ratios obtained by NDOW and upon intermittent counts of cranes on winter range by various individuals and agencies.

In 1983 NDOW launched a study through its nongame wildlife program to determine the distribution and numbers of cranes summering in Nevada, further identify LCRVP winter ranges and review the validity of surveys traditionally conducted by NDOW to monitor the population.

METHODS

Most suitable nesting habitat in northeastern Nevada was surveyed with a helicopter in spring 1983 and with fixed wing aircraft in spring 1984 through 1986 (Fig. 2). NDOW observation records were used to estimate the number of cranes using locations not aerially surveyed. Breeding pairs were identified by the presence of nests or young.

Forty-nine cranes were captured and color-marked with patagial streamers: 23 from 2 summer range locations in Ruby and Lamoille valleys, Elko County in fall 1984 and 1985, and 26 from the Lund spring stopover in 1985 and 1986 (Fig. 3). Different colored markers and marker codes were used to identify trap locations and individual cranes.

Aerial and ground surveys to locate marked cranes were conducted on Nevada summer range in spring 1985 and 1986, at the Lund spring stopover in February and March 1985 through 1987, and on suspected wintering areas in January 1986. Observations of marked cranes were also solicited from agencies and individuals responsible for crane management throughout the western United

States.

Population counts were conducted at the Lund spring stopover from 1976 to 1987, and in spring 1985 and 1987 simultaneous counts were conducted by NDOW at the stopover and on wintering areas by the Arizona Department of Game and Fish, California Department of Fish and Game and the U.S. Fish and Wildlife Service.

Surveys were conducted by NDOW in fall 1977 through 1983 to determine percent young in the population as an expression of annual post-fledging recruitment to the LCRVP.

RESULTS AND DISCUSSION

Nevada Distribution

Ninety-two nesting pairs and 594 cranes were located in northeastern Nevada (Table 1). Eighty-two percent of all cranes were observed in central Elko County along the Humboldt River, the upper North Fork of the Humboldt River drainages, and in Independence, Ruby, Lamoille, Huntington and Starr valleys. The southernmost observation of cranes was made in Lake Valley, Lincoln County, and the westernmost in Squaw Valley near Midas, Nevada in western Elko County (Fig. 2).

A considerable amount of what appeared to be suitable crane nesting habitat was unoccupied. Most areas were aerially surveyed during unusually high water years, therefore some locations which appeared to constitute nesting habitat may be unsuitable during normal or low water years.

Marked Crane Observations

Ruby Valley marked cranes (6) were subsequently observed in fall 1985 through 1987 on summer range in Ruby and Lamoille valleys. Three of those were observed at the Lund spring stopover, and on winter range, 1 was observed on the Colorado River Indian Reservation near Poston, Arizona, 2 on the Cibola National Wildlife Refuge, La Paz County, Arizona and 3 along the Gila River near Gila Bend, Arizona (Fig. 3, Table 2).

Lamoille Valley marked cranes (17) were subsequently observed in Ruby and Lamoille valleys in 1985 and 1986, and in summer 1985, 1 individual was observed on the Mary's River, Elko County approximately 32 km northeast of the Lamoille Valley capture site. Eight Lamoille Valley cranes were observed at the Lund spring stopover, and on winter range, 1 was observed 11 km southeast of Brawley, California, 6 on the Cibola National Wildlife Refuge and 5 along the Gila River (Fig. 3, Table 2).

Two of the 26 cranes marked at the Lund spring stopover were observed in spring 1985 in Ruby Valley and 1 was observed near North Fork, Elko County, Nevada in spring 1986. One Lund crane was observed in fall 1986 in Ruby Valley and 4 individuals were observed in Lamoille Valley. Six Lund cranes were observed at the stopover in years following capture. During fall migration, 1 Lund marked mortality was recovered from the Key-Pittman Wildlife Management Area near Hiko, Lincoln County, Nevada and 1 Lund crane was observed near Alamosa, Rio Grande County, Colorado (R. Drewein pers. comm.) on a fall staging area used greater sandhill cranes comprising the Rocky Mountain Population (RMP). Four Lund cranes were observed in January 1986 on the Colorado River Indian Reservation and the Cibola National Wildlife Refuge. Lund cranes were not observed at the Brawley and Gila River wintering areas. At least 2 Lund cranes wintered near Polvadera, Socorro County, New Mexico and on the Bosque del Apache National Wildlife Refuge, Socorro County, New Mexico (R. Drewein pers. comm.), both wintering grounds for the RMP (Fig. 3, Table 2).

Observations of color-marked cranes indicate most, if not all, cranes summering in Ruby and Lamoille valleys use the Lund spring stopover and winter along the Gila River, the lower Colorado River and the vicinity of Brawley.

Observations of Lund cranes on Colorado fall staging and New Mexico wintering areas indicate some portion of the cranes using the Lund stopover are members of the RMP. Some RMP cranes currently winter near Wilcox, Cochise County in southeastern Arizona (Drewein & Bizeau 1974). Although marked cranes were not observed at Wilcox, some cranes using the stopover may winter here as well, since the Wilcox wintering area is nearer Lund than wintering areas in New Mexico.

Some mixing of the LCRVP and RMP may also occur on summer range. In 1974 a juvenile crane marked on summer range in the Bear River Valley near Cokeville, Lincoln County, Wyoming was observed on the Mary's River north of Deeth, Elko County, Nevada (Drewein et. al. 1976).

Collectively, observations of marked cranes indicate LCRVP and RMP crane range probably overlap to some degree on the eastern fringe of the LCRVP's range. It is conceivable a similar exchange may occur between members of the Central Valley Population (CVP) and the LCRVP on

the western fringe of the LCRVP's range.

Population Estimates and Trend

The most exhaustive counts of wintering LCRVP cranes were conducted by Perkins & Brown (1981) during the winters of 1978-79 through 1980-81 (Table 3). Wintering populations ranged from 1601 in 1978-79 to 1807 in 1980-81. In January 1986, in this study, approximately 50 more cranes were observed at the Brawley and 80 more on the Gila River wintering grounds than in previous high counts for those areas.

Cranes traditionally arrive at the Lund spring stopover in early February and usually abandon in mid-March. The largest number of cranes observed at the stopover was 1459 in 1984. The results of simultaneous stopover and wintering ground counts were 1690 and 1736 cranes observed in 1985 and 1987, respectively. Peak numbers of cranes using the stopover can fluctuate drastically between years. In 1986, crane numbers declined from 1427 in 1985 to 340; possibly attributable to unseasonable mild weather on summer range in February and March 1986. Peak periods of use varied by as much as 2 weeks since counts were initiated in 1976.

Between 1800 and 2000 cranes probably comprise the LCRVP. Current understanding of the LCRVP suggests conducting counts on LCRVP winter range is the most reasonable strategy for monitoring the population. Stopover counts are not reliable indicators of population size because peak numbers and peak periods of crane use can vary between years and an unknown number of cranes using the stopover are members of the RMP.

Fall Age Ratios

Percent young in the population ranged from a low of 2.2 in fall 1977 to a high of 14.8 in fall 1979 averaging 6.9% over the 7 year period. In 1984 NDOW abandoned the use of age ratios as a determinant of recruitment due to an inability to classify an adequate number of cranes per the sampling formula of Czaplewski et. al. (1983) (NDOW, on average, was classifying less than 41% of the required sample of cranes) and because the application of age ratios in a population with several subadult cohorts indistinguishable from adults does not, in itself, reflect the reproductive success of breeding pairs or the upward or downward trend of a population (Caughley 1974).

Management

In Nevada cranes are not hunted and management activities have been limited to delineating and monitoring the population. Most Nevada crane nesting habitat is located on private lands, and currently NDOW is working with The Nature Conservancy to acquire a portion of Franklin Lake, a major nesting area, in Ruby Valley.*

Loss of winter roosting habitat on the lower Colorado River is a major concern. In 1981, Cibola National Wildlife Refuge initiated construction of an 8.1 ha roost site and plantings of cereal crops for forage (Brown 1983). In recent years, 700 to 1200 cranes have annually wintered at Cibola, but depredations of crops on private lands adjacent to the refuge have developed (W. Martin, Rufuge Manager, pers. comm.). In 1987 the Pacific Flyway Council recommended that the U.S. Fish and Wildlife Service purchase croplands in the vicinity of Cibola to alleviate depredation problems and secure foraging habitat for the population. These acquisitions are proceeding (W. Martin pers. comm.).

CONCLUSIONS

Results of summer and winter range inventories suggest the LCRVP is currently stable or increasing. The disparity between the number of cranes observed summering in Nevada and the number of cranes on identified winter range may be attributable to 2 factors: a large number of LCRVP cranes may summer in Idaho and/or significant numbers of cranes from adjacent populations may use LCRVP winter range. If a significant number of cranes from other populations share LCRVP winter range, identification of LCRVP cranes as a distinct population based solely on winter range distribution becomes questionable and winter range counts would be invalidated as a method for monitoring the population. Since winter censuses are the only method currently available to monitor the LCRVP, managers responsible for the population need to investigate and determine the degree of mixing between populations on winter range. If significant overlap between populations on winter range does occur, alternate methods of monitoring will need to be explored, developed, and implemented.

Although only the most cursory nesting habitat investigations have been conducted, it appears a considerable amount of habitat is unoccupied.

*Acquired in spring 1988.

Until the habitat elements which must be present for cranes to successfully nest in Nevada are known, it is not possible to determine how much nesting habitat is actually available. Factors limiting reproductive success in the LCRVP have not been investigated, although specific causes of significant nesting failure and prefledging mortality have been identified in the adjacent CVP (U.S. Fish & Wildlife Service 1978). NDOW will attempt to answer these questions in the future and will continue to work with the LCRVP flyway subcommittee to monitor the population, identify management concerns and develop management strategies to ensure the population's well-being.

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Table 1. Number of known breeding pairs and largest numbers of cranes observed prior to fall staging by location in Northeastern Nevada, 1983-86

LOCATION	BREEDING PAIRS[a]	LARGEST No. OBSERVED[b]
Elko County		
Humboldt River	1	27
Mary's River	2	19
Upper North Fork Drainage	12	63
South Fork Owyhee River	1	6
Susie Creek	1	2
Salmon Falls Creek	1	13
Horse Creek	1	2
Thousands Spring Creek	0	10
Penrod Creek	1	2
Goose Creek	1	2
Bruneau River	1	2
Yankee Bill Creek	1	2
Independence Valley	14	110
Ruby Valley	25	182
Huntington Valley	7	37
Lamoille Valley	4	59
Starr Valley	6	12
Squaw Valley	0	2
Metropolis	2	4
White Pine County		
Steptoe Valley	6	17
North Spring Valley	0	8
South Spring Valley	1	2
Newark Valley	3	13
Lincoln County		
Lake Valley	1	2
Total	92	594

[a] Based upon presence of nests or young.
[b] Excluding young.

Table 2. Minimum number of different marked cranes observed by location in Nevada from 1984 to 1987.

LOCATION OBSERVED	TRAP LOCATION	MINIMUM NO. of ARKED INDIVIDUALS
Spring Stopover		
Lund, NV	Ruby Valley	3
	Lamoille Valley	8
	Lund, NV	6
Summer Range		
Ruby Valley, NV	Ruby Valley	2
	Lamoille Valley	3
	Lund, NV	3
Lamoille, NV	Ruby Valley	1
	Lamoille Valley	5
	Lund, NV	4
Mary's River, NV	Lamoille Valley	1
North Fork, NV	Lund, NV	1
Fall Migration		
Alamosa, CO	Lund, NV	1
Key Pittman WMA, NV	Lund, NV	1
Winter Range		
Brawley, CA	Lamoille Valley	1
Colorado River IR	Ruby Valley	1
	Lund, NV	1
Cibola NWR, AZ	Ruby Valley	2
	Lamoille Valley	6
	Lund, NV	3
Gila River, AZ	Ruby Valley	3
	Lamoille Valley	5
Polvadera, NM	Lund, NV	2[a]
Bosque del Apache NWR, NM	Lund, NV	2[a]

[a]At least 1 of these cranes wintered in both areas in successive years.

Table 3. Selected winter observations of LCRVP cranes in Nevada from wintering locations currently used by the populations.

LOCATION	NUMBER OF CRANES	WINTER OF:	SOURCE
California			
SE of Brawley	60	1951-52	Salton Sea NWR Narrative Report (Brown 1983)
	49	1970-71	C.D. Littlefield (Brown 1983)
	205	1980-81	Perkins & Brown (1981)
	283	1985-86	NDOW
Arizona			
Colorado River IR	210	1960-61	L.D. Hatch (Brown 1983)
	800	1970	C.D. Littlefield, W.H. Mullins (Brown 1983)
	1349	1979-80	Perkins & Brown (1981)
	416	1985-86	NDOW
Cibola NWR	61	1966-67	Cibola NWR Narrative Report (Brown 1983)
	120	1975-76	Cibola NWR Narrative Report (Brown 1983)
	258	1978-79	Perkins & Brown (1981)
	759	1983-84	Cibola NWR
	481	1985-86	NDOW
Gila River (between Buckeye and Gila Bend)	85	1949-50	V.H. Householder (Brown 1983)
	18	1955-56	V.H. Householder (Brown 1983)
	50	1970	C.D. Littlefield (Brown 1983)
	79	1980-81	Perkins & Brown (1981)
	155	1985-86	NDOW

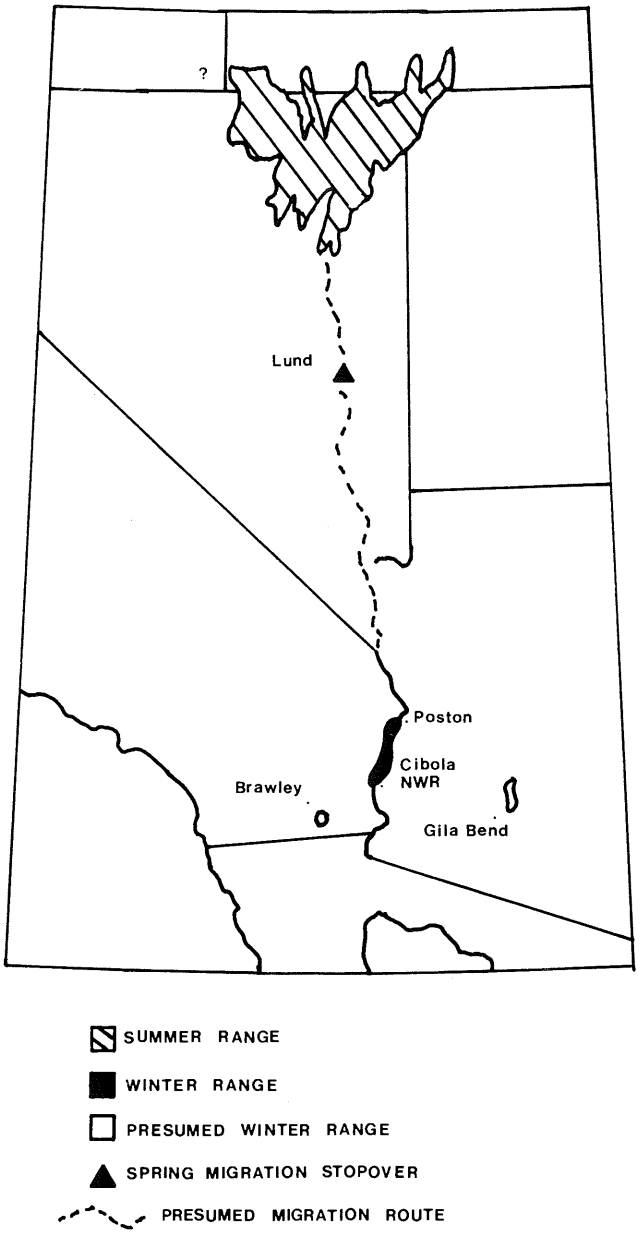

Figure 1: LCRVP distribution as identified in the 1983 LCRVP flyway management plan (modified from Brown 1983).

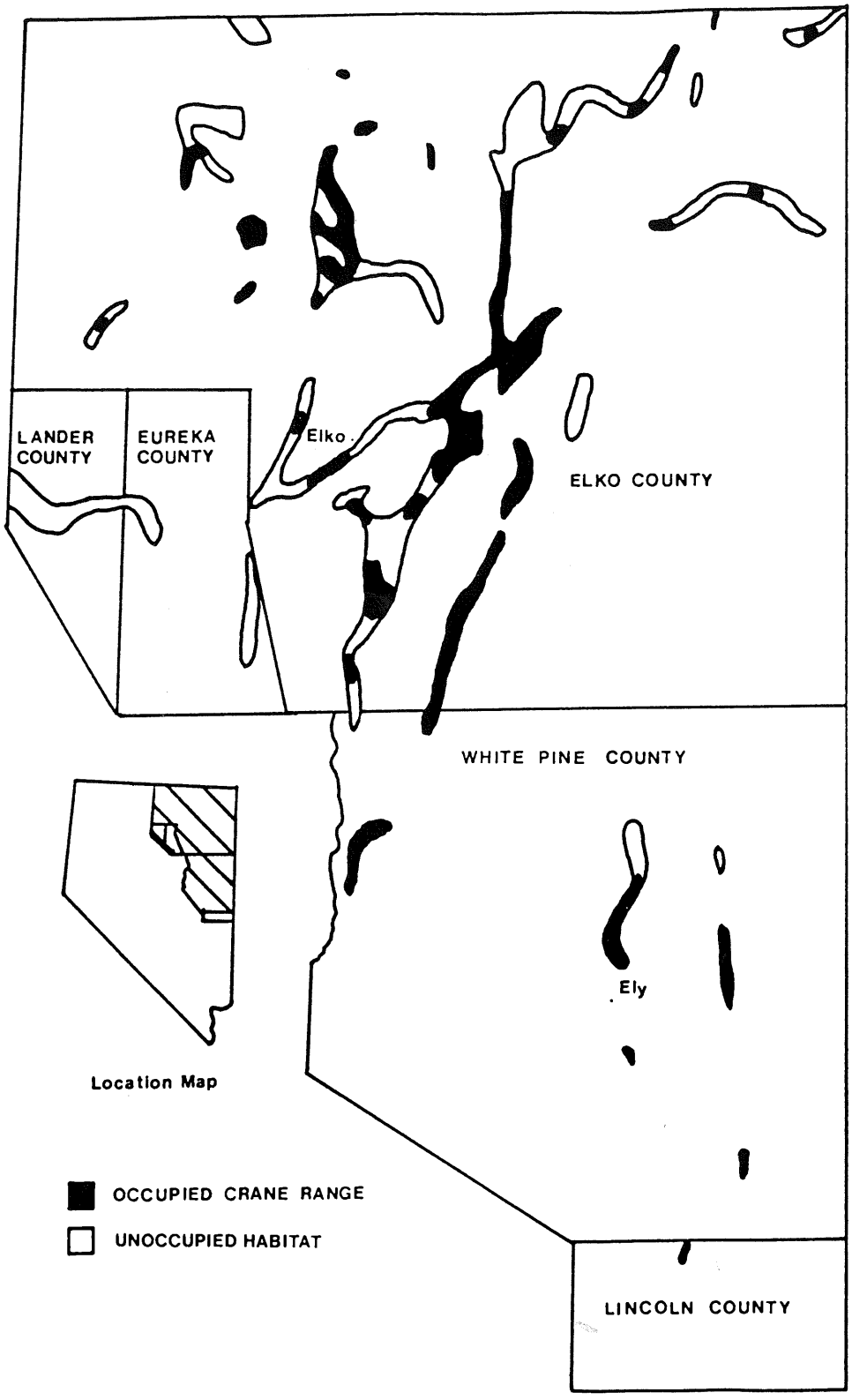

Figure 2. Occupied and unoccupied crane habitat in northeastern Nevada.

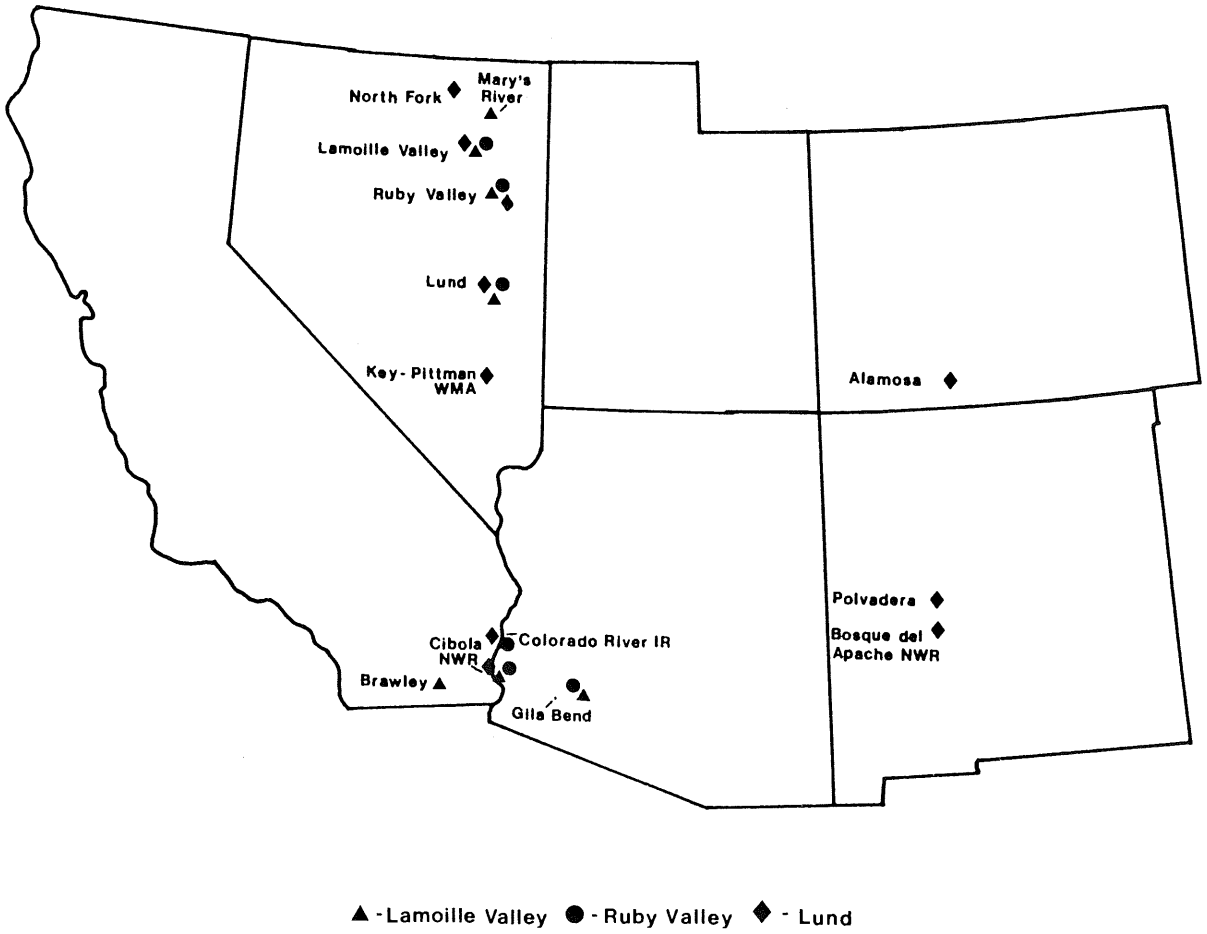

Figure 3. Observations of cranes marked from Lamoille Valley, Ruby Valley and the Lund Spring Stopover.

AN INDIVIDUALIZED MARKING SCHEME FOR SANDHILL CRANES AND ITS USE TO DETERMINE FALL MIGRATION INTERVAL

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Abstract: A color-band based marking scheme was used for individually marking sandhill cranes in Florida. The band-loss rate was 2.8% per year between 1977 and 1988. Band loss was greatest on bands placed below the ankle joint and occurred most frequently during years 2 to 5. Color-marked individuals monitored during fall migration averaged 6.2 days (r=5-13 days) between the Jasper-Pulaski Fish and Wildlife area in northwestern Indiana and wintering areas in northern Florida.

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The distinctive marking and subsequent observation of individual animals has been a standard tool for wildlife study (Trippensee 1941; Balham and Elder 1953; Knowlton et al. 1964). We report here on an application and the persistence of an individual color marking scheme for sandhill cranes. In 1974, we began individually marking Florida sandhill cranes *(Grus canadensis pratensis)* captured in northern Florida with a distinctive combination of colored leg bands. This marking scheme was expanded in 1977 to include greater sandhill cranes *(G. c. tabida)* wintering in Florida.

METHODS

In addition to the U.S. Fish and Wildlife Service sequentially numbered metal leg bands, each bird was banded with 2 to 5 wrap-around, colored plastic (Darvec) leg bands. The birds were banded on either or both legs, above and/or below the intertarsal (ankle) joint. Bands in 5 colors (blue, green, red, white, and yellow) obtained from J. Warner (Observatory Cottage, Potters Bank, Durham City, England, DH 13RR) were used. After being applied, the bands were sealed with P.V.C. cement. Through retrapping, band returns, or by reading the numbered bands in the field, a comparison of the number of birds with intact combinations and those that had lost bands (band-loss rate) was possible.

Individual band combination sequences were recorded beginning with the upper left (UL) position and proceed clockwise to lower left:

UL	UR
LL	LR

Records of initial capture, band number, color combination, sex (when known), subspecies (when known), date and location of all subsequent sightings were kept for each individual on 5"x 8" index cards.

Observations were made with several types of telescopes: Bushnell Spacemaster (25X), Bausch and Lomb (25X), and Mead (15-60X) refracting telescopes, as well as a Celestron C8 and Questar Field model reflecting telescope both with 50 and 80X interchangeable eye pieces. To rectify the reversed imaging inherent in the reflecting scopes, both were equipped with a porro prism. The use of a quality tripod and a fluid-dampened pan head improved the performance of the more powerful telescopes.

Under usual circumstances, cranes migrate by day (starting mid-morning [Nesbitt 1975]) and stopover each night (Crete & Toepfer 1978; Ander-

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son et al. 1980; Melvin & Temple 1981). They may remain on the ground at these stop-overs during periods of bad weather (Melvin & Temple 1981). The migration route for the population of greater sandhill cranes that winters in Florida has been well documented (Anderson et al. 1980; McMillen et al. in press; Melvin & Temple 1981; Nesbitt & Williams 1979; Toepfer & Crete 1979). The Jasper-Pulaski (J-P) Fish and Wildlife Area in northwestern Indiana is the traditional stopover used by a majority of the sandhill cranes migrating between the Great Lakes region and winter areas in Florida (Melvin & Temple 1981; Shroufe 1976). Cranes stop over at J-P for varying lengths of time and are easily observed while feeding in agricultural fields and at pre-roost gatherings. During a portion of the fall migration of 1983-1986, we observed cranes at J-P on a daily basis. Simultaneously, the arrival of birds at major wintering areas was being monitored in North Florida, approximately 1350 km south. Some individuals were seen daily during the fall at J-P and again after arrival in Florida. The time between when a bird was last seen at J-P and first seen in Florida was the estimated migration interval.

RESULTS

Band loss

From 1974 through 1988, 789 sandhill cranes were individually color-marked, 34.2% Florida and 65.8% greater sandhill cranes. Most (76%) were resighted at least once, 6 months or more subsequent to initial capture. Twenty-four marked individuals were seen 10 years or more after initial capture and color-marking.

Average band-loss rate for years 1-7 was 2.8% per year, with most of the loss occurring during years 2-5 (Table 1). Band-loss rate dropped to 0.5% after year 5 and to O.O after year 6. Band loss, which included USF&WS bands as well as the plastic bands, was most likely to occur with bands below the intertarsal joint, only 9% of the total loss occurred with bands above the joint.

Fall migration

The first fall arrival of greater sandhill cranes to north Florida wintering areas usually occurred during the last week in October or the first week in November (Table 2). The mean earliest arrival date was 31 October. Numbers of cranes have been seen moving south at altitudes ≥ 300 m until 15-28 December, so the last arrival of new fall migrants probably occurs during mid- to late December.

Sixteen greater sandhill cranes were seen regularly prior to departure from J-P and again after arrival in Florida, (6 males, 4 females, 6 unknown). We only considered birds that were marked in all 4 positions to avoid any possibility of error due to band loss.

DISCUSSION AND RECOMMENDATIONS

The mean interval between sightings in J-P and Florida was 6.2 days, the minimum 5 days, and the maximum 13 days (Figure 1). Six and 7 days were the most frequent intervals. The mean interval we observed for cranes migrating between J-P and northern Florida was consistent with the mean fall flight distance travelled per migration day (267 km ± 153 [SD]) reported by Melvin and Temple (1981) from their own and other studies. If cranes consistently travel at the mean daily rate (267 km/day, [Melvin & Temple 1981]), they would accomplish the J-P to Florida trip in 5.1 migration days. At the maximum rate (740 km/day [Melvin & Temple 1981]), they would complete the trip in 1.8 migration days. At the mean rate +1 SD, they would complete the trip in 3.2 migration days, and at the mean rate -1 SD, they would complete the trip in 11.81 migration days. At the minimum (48 km/day) rate reported by Melvin & Temple (1981), the trip would be accomplished in 28.1 migration days.

Under continued optimal conditions, cranes would be able to cover the distance between J-P and Florida in less than 5 days. However, variations in fall weather conditions would make this unusual. Spring migration might proceed more rapidly due to the greater likelihood of prolonged, favorable weather conditions in the spring and a difference in underlying motivation for migration (Farner 1955). In the spring, cranes are returning to a nesting or natal area rather than migrating from an unfavorable environment as they are in the fall. The cranes do not congregate at J-P in the spring in the same numbers that they do in the fall, making spring interval calculations more difficult.

Marking systems dependent on wing tags, neck collars, leg bands, etc., that incorporates an alphanumeric code are difficult to read under less than ideal field conditions or at distances beyond a few hundred meters. Also, within a few months, some markers would become so faded, worn, or dirtied as to be unidentifiable. A four-position color marking scheme resulted in a large number of individu-

ally marked cranes quickly and easily identified in the field. The primary drawback is that bands in the low position sometimes were difficult to see in the field when vegetation obscured the birds' feet. However, if birds are actively feeding or walking, the lower bands eventually are revealed. Banding in high positions only would increase ease and speed of band-reading and decrease band-loss rate, but substantially limits the number of possible combinations. If it is necessary to individually mark only a few individuals, banding only the high positions would be preferable.

Stacking of multiple bands in one position would be one way to introduce new combinations to a high position only marking scheme. But when we tried stacking bands they tended to slip into one another. We reduced this problem by separating 2 color bands with a lock-on USF&WS band, the flange of the lock-on band preventing them from slipping together.

Our use of several colors concurrently would not preclude other researchers from using similar colors. There were at least 5 other ongoing research projects using color banding to identify individual cranes in eastern North America. Some colors were used simultaneously by separate studies, but materials, combinations, and sizes varied and each researcher's combinations were easily distinguished.

Quality optics were important to the success of our individualized marking system, in addition to observers being familiar with the particular system and its components. The widely used 20-25X field scope was satisfactory only at moderate distances and under ideal light conditions. A more powerful scope with better resolution, color correction, and light gathering capabilities produced results under less than ideal conditions. Color bands could be identified at 1.5 km with the Celestron or Questar scope even when lighting conditions were poor.

The multiple color banding system initiated in 1974 proved satisfactory for our needs. Though some band loss occurred, it was not excessive nor did it prevent us from obtaining a large number of multi-year observations of many individuals. As others have reported (Williams 1981, Hoffman 1985) we observed no adverse effect on survival or behavior from color-banding cranes.

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Table 1. Band loss among cranes color banded in Florida: 1974 through 1986.

Years of contact	Number of banded birds encountered	Loss occurring during the interval (%)	Total losses rate since banding (ib)
1-2	245	3.2	3.2
2-3	185	4.3	6.5
3-4	141	4.3	9.0
4-5	98	6.1	11.4
5-6	58	1.7	11.8
6-7	32	0.0	11.8
7-12	12	0.0	11.8

Table 2. Earliest fall arrivals of greater sandhill cranes[a] at north Florida wintering areas.

Year	Date
1981	1 November
1982	11 November
1983	1 November
1984	27 October
1985	6 November
1986	1 November
1987	23 October
1988	19 October

[a]*Birds sighted in Great Lakes Area subsequent to capture and color-marking in Florida.*

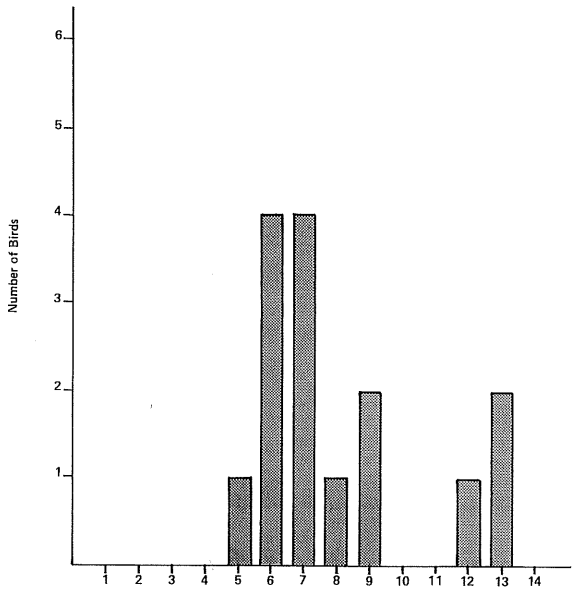

Figure 1. Migration interval (days) between J-P and north Florida wintering areas.

AUTUMN SANDHILL CRANE MIGRATION IN SOUTHEASTERN OREGON

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Abstract: Each autumn, from 2,000 to 3,000 greater sandhill cranes (*Grus canadensis tabida*) of the Central Valley Population congregate on Malheur National Wildlife Refuge. Migratory behavior, flock sizes and arrivals and departures from this important autumn use area were observed for 13 years (1970-1986). Average size of flocks arriving from the north was 15.7, with those arriving from the southwest averaging 7.4. Flocks departing for California wintering areas averaged 9.2, but as smaller groups merged, flock sizes increased to 24.8 (35 km southwest from the departure area). Most flights were at speeds ranging from 56 to 88 kmh^{-1}, at altitudes ranging from 150 to 900 m. If favorable habitat and weather conditions occurred in September and October, *en masse* migrations generally did not occur until November. Most southward departures occurred when winds aloft were from a northerly quadrat but wind direction was less important for birds arriving onto the refuge.

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Malheur National Wildlife Refuge (NWR), Harney County, Oregon is the most important autumn use area for the Central Valley Population of greater sandhill cranes. In July and August, cranes begin congregating on refuge grain fields and by mid-October, 2,000 to 3,000 are often present (Littlefield 1986). Depending on food supplies, roost site availability, weather conditions and human disturbance, cranes have lingered into mid-November and on rare occasions into December. If inclement weather "grounds" cranes for periods in late October or early November, a spectacular migration frequently occurs once favorable migratory conditions return. On days after these periods, a major percentage of these birds often migrate *en masse* for their California wintering areas.

Williams (1970) and Nesbitt (1975) reported on the spring departures of sandhill cranes in Florida, while Walkinshaw (1960), DeVore (1972) and Patterson (1978) discussed spring and autumn flock sizes in the midwest and eastern United States. But little information has been available on migratory behavior, flock size and arrivals and departures of sandhill cranes from autumn staging and traditional use areas.

The U.S. Fish and Wildlife Service has provided financial support for sandhill crane studies on Malheur NWR for the past 21 years, and I am extremely grateful. In addition, staff and students at Malheur Field Station helped in various ways during the study. I would like to express my appreciation to these, in particular Gaylin Holloway and Susan Lindstedt.

STUDY AREA

The primary study area was in the Blitzen Valley, which extends 60 km southward from refuge headquarters. Within the narrow valley occur numerous marshes and meadows, interspersed with shrub-grass uplands. Normally about 325 ha of cereal grains are planted annually, and cranes congregate on these grain fields in autumn, and at least 80% of the Central Valley Population spend some time on the refuge before migrating.

The climate on the refuge is semi-arid with most precipitation occurring November through January, and May and June. Average annual precipitation is 23 cm. Summer temperatures seldom exceed 35°C. The hottest, driest months are normally July and August, with cooler temperatures and increased precipitation beginning in September. By December, all waters, except those fed by springs, become ice covered. The last sandhill cranes usually migrate southwarci as soon as ice begins forming on roost sites.

Adjacent to the Blitzen Valley on the west, Jackass Mountain rises to 1,648 m over which cranes must fly to reach Catlow Valley. Catlow Valley has mostly level terrain, sloping upward to Hart Mountain, Lake County, on the west. In the south-central portion of the valley, Beattys Butte, Harney

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County, provides a prominent landmark and cranes migrate between the butte and Hart Mountain.

METHODS

Since 1970, data have been collected on autumn crane use at Malheur NWR, with extensive observations in 1970 and 1982. Little information was collected in 1971, 1972, 1973, 1976 and 1986.

During the study, observations were confined to an area from Malheur NWR Headquarters (ca. 30 km south of Burns, Oregon), south to Catlow Valley (ca. 70 km south of refuge headquarters). The area within these limits included both arrival and departure corridors, major feeding areas and most roost sites.

Observations were primarily with 7 X 35 binoculars. When weather conditions were conducive for migrating, cranes were examined for migratory activity at their concentration areas. If cranes initiated soaring, an observation point was established south of the area and flock sizes were recorded. On occasion, flocks were followed by vehicle to Catlow Valley. Observations were terminated in north Catlow Valley because of inaccessibility. All times were recorded as Pacific Standard Time (PST).

Weather data were obtained from the NOAA Station in Burns, Oregon and personnel observations.

RESULTS

Movement Onto Staging Area

Sandhill cranes have been observed flying toward Malheur NWR autumn use areas as early as 5 August (1977), when 8 birds were observed flying southward 13 km west of headquarters. Several hundred cranes frequently congregate in this region before moving onto the primary staging area. Drought conditions, accompanied by poor cereal grain production, persisted through the 1977 growing season and this likely contributed to this early flight.

Cranes moving onto the staging area from the north usually appeared from mid-September through mid-October. Of 145 arriving flocks, 27 (18.6%) were seen in September and 118 (81.4%) in October. In addition, Brad Ehlers (pers. comm.) observed 5 cranes on 5 October 1981 and 2 on 1 October 1983 moving onto the refuge from the east-northeast.

Usually birds arrived from the north over an extended period with no mass movements onto the staging area. An exception occurred on 28 September 1982, when an estimated 450 passed over Headquarters at 0700 hours, arriving at the staging area at 0745 hours. A frontal system which moved through the area at 0500 hours, accompanied by strong northwesterly winds and cooler temperatures, was believed responsible for this flight. During years when cranes lingered in agricultural regions north of the refuge, a pronounced increase in flocks onto the staging area occurred on opening day of the waterfowl season.

Arriving flocks from the north have been recorded between 0700 and 1740 hours, with the majority between 1200 and 1300 hours (Table 1). Smallest average flock size occurred between 1100 and 1200 hours ($\bar{n}$=9; N=37). The average between 1000 and 1100 hours was 13. 9 (N=23) and between 1200 and 1300 hours 15.2 (N=52). There was little difference in average flock sizes in September (15.7) and October (14.4).

Cranes entering the staging area from the southwest arrived earlier in the season than those from ths north. Flocks of 2 to 21 individuals ($\bar{x}$=7.4) have been seen arriving at the southern portion of the refuge from 24 August through 13 September. Unlike cranes arriving from the north, these birds did not arrive until mid-afternoon. The earliest arrival was 1500 hours, the latest 1653 hours. These individuals likely had left south Warner Valley, Lake County, Oregon (130 km southwest) in the late morning.

Migration From the Staging Area

The earliest departure from the staging area was noted on 13 September 1970. However, before this study began, cranes had been observed leaving in late August (Littlefield 1986). Of departing flocks, 4.6% left in September, 65.4% in October and 30.0% in November. Although October had a larger number of departing flocks, departing flight sizes increased in November. In September, 174 (3.4%) cranes were observed leaving the staging area, in October 2, 220 (43.6%) and in November 2, 695 (53.0%)

Earliest recorded departure was 0915 hours, while the latest was 1153 hours. Of 1,569 cranes that left, 12.2% departed between 0900 and 1000 hours, 63.7% between 1000 and 1100 hours and 24.0% between 1100 and 1200 hours (Table 2). Percentage of flocks leaving was 4.7% between 0900 and 1000 hours, 75.2% between 1000 and 1100 hours and 20.1% between 1100 and 1200 hours.

Flock sizes increased as distances from the staging area increased. Average flock size of all cranes leaving the area was 9.2 (Table 3), but approximately 35 km southwest of the staging area average flock size increased to 24.8. Combined flock sizes averaged 14.9 birds and totaled 5,275 individuals. DeVore (1972) reported the average flock size for cranes migrating over Tennessee as 26.9 birds, while flocks over Georgia averaged 22.8 (Patterson 1978). Extensive data presented by Walkinshaw (1960) through the eastern United States showed an average flock size of 24.5 birds, very similar to the 24.8 birds recorded southwest of the Malheur NWR staging area.

Migration Behavior

Typical crane behavior on days of migration was similar to that described by Williams (1970) for spring migration from Florida. Cranes left on earl y morning feeding flights, after which they began spiraling upward, accompanied by calling. Small flocks, family groups, pairs and single birds initiated soaring and as cranes gained altitude smaller groups combined. However, some family groups of 3 or 4 did not join and migrated as a unit. Although surface winds would often be favorable, those aloft were not and when such conditions occurred cranes typically aborted the migration effort and returned to loafing sites. Otherwise, they would form a line or chevron and fly rapidly southward. Periods of soaring continued at points along the route. Little vocalization was noted when birds were in straight flight, but soaring was accompanied by considerable calling.

Soaring was often associated with mountainous regions and was particularly evident as flocks crossed Jackass Mountain before entering Catlow Valley. Northeasterly winds uplifted against the escarpment provided ideal soaring conditions. Most flights through the Blitzen Valley were at altitudes ranging from 150 to 300 m, but once birds migrated into Catlow Valley altitudes increased to 300-900 m. Estimated flight speed ranged from 56 to 88 kmh^{-1} (clocked by vehicle) depending on wind speed and direction. Flock leaders were usually males.

Migrating cranes usually trickled from the staging area in September and October, but there were exceptions. In the late 1960's and early 1970's, cereal grain production was limited and cranes departed earlier. In 1983, dike repairs were being made along the canals that provided water to roosting sites, not only resulting in those drying, but also excessive disturbance. All roost sites had become mudflats by 10 October. Over 2,100 cranes were using the staging area on the morning of 11 October, but by afternoon, only 446 remained after a mass migration, and none remained after 23 October.

Normally *en masse* migrations did not occur until November. In 1982, cold temperatures, with southerly winds, periods of fog, sleet and snow prevailed 8-12 November. Early on 13 November, northwesterly winds with scattered clouds were recorded, then at 1049 hours winds switched to the northeast and an *en masse* migration ensued. In total, 1,428 cranes were counted in Catlow Valley during a 53 min period, with 98.6% passing over between 1123 and 1155 hours (Table 4). Before this *en masse* exodus, 2,136 cranes were present on the staging areas but by 1200 hours only 179 remained. Such *en masse* November migrations produced large average flock sizes._ In October, average size was 15.6 for 31 flocks (N=483 individuals), while in November average size was 28.2 for 80 flocks (N=2,259 individuals).

Migration in Relation to Weather

Sandhill cranes departed from the staging area with winds from the northwest quadrat 56.3% of the time; winds from the northeast quadrat prevailed during 37.5% of the departures. Only 6.3% of observed departures occurred with wind from the southwest quadrat, while no departures were noted with southeast winds. Most *en masse* departures occurred with winds from the northeast.

Wind direction had less influence on arrivals to the staging area, particularly for birds making the short flight from the pre-staging area north of the refuge. Arrivals occurred 45.5% with northwesterly winds, and 27.3% occurred with northeasterly winds. Twenty-two percent occurred against head winds from the southwest, and 4.5% arrived when winds were from the southeast. Birds arriving from the southwest all arrived with northwesterly, southwesterly or westerly winds.

Sky conditions varied, but 39.4% arrived under clear conditions. Cold temperatures had little influence on movements onto the refuge; 46% arrived when temperatures were below normal, while the remainder arrived with normal or above normal temperatures.

Cranes usually left after a frontal passage accompanied by lower temperatures. In September, 75% migrated when early morning temperatures were 1 to 4°C below normal. Only 1 observation

was made of cranes migrating under overcast conditions; 18.8%left when sky conditions were clear, with the remainder leaving under partly cloudy skies.

Departing cranes crossed Catlow Valley through an 11 km corridor, with wind direction determining which portion of that corridor they used. When winds were from the northwest the eastern half was used, while northeasterly winds resulted in birds migrating along the western half. On 31 October 1981, 5 flocks were observed migrating southward with winds from the west-northwest, but were making little forward progress. On other occasions birds migrated west across Catlow Valley after encountering, unfavorable head winds. This behavior frequently occurred when wind direction was from a northerly quadrat at the departure site, but from a southerly quadrat in Catlow Valley.

Under the northerly wind conditions associated with *en masse* migrations, some cranes made nonstop flights to the California Central Valley. Birds that encountered unfavorable migratory conditions after departure usually landed enroute. "Grounded" cranes have been seen in autumn at Catlow Valley, Warner Valley, Modoc NWR and Big Valley, Modoc County, California, and Fall River Valley, Siskiyou County, California. On 31 October 1970, 11 were observed on a grain field at Cowhead Lake, Modoc County, California. Persistent northeasterly winds had occurred on Malheur NWR between 27 and 30 October, but had changed to the southwest on 31 October. The birds probably left Malheur NWR on 30 October, but encountered unfavorable (i.e. southwesterly) winds along the migration route. In addition, south of Ft. Bidwell, Modoc County, a local rancher reported that 30 to 40 cranes had landed on 23 October, again following a period of southwesterly winds. Snow had fallen on Malheur on 20 October and several cranes were seen unsuccessfully attempting to depart. A few cranes did apparently leave at that time but were successful only in traveling the 160 km distance to Ft. Bidwell. Other "grounded" cranes were noted at Modoc NWR (38 individuals) and Davis Creek, Modoc County, California (8 individuals) on 1 November. With 1 exception, cranes have not departed from the staging area during precipitation or fog, that being 21 individuals that left under snowy conditions on 6 October 1970.

Retromigration

Retromigration was noted on 7 occasions, each incident associated with adverse weather conditions. Two were of birds returning shortly after departing from the staging area, once when 50 left at 1050 hours on 14 October 1970 under clear skies and northeasterly winds. At 1100 hours, 7 returned and 15 returned at 1106. Again on 12 November 1982, cranes departed when winds were calm, but 5 km southward the group encountered 30 kmh^{-1} head winds and landed on a pond 19 km south of the staging area. At 1345 hours, 150 birds left the pond, flew southward briefly, then turned northward, arriving back at the staging area at 1405 hours.

On 30 October 1970, 51 cranes migrated over Jackass Mountain at 1056 hours, but at 1113 hours the entire flock returned to the staging area. Other retromigration observations have been similar; birds migrated into Catlow Valley, encountered head winds and returned to the refuge. An unusual incident occurred in 1977 when cranes migrated *en masse* ahead of an approaching low pressure system on 19 November. By 21 November, 27.5 cm of snow had fallen, and only 1 crane was present on the staging area. All snow had melted by 30 November and 2 cranes were present, but on 3 December, 57 cranes had returned. The last 4 of this group finally migrated on 15 December. Over 1,000 cranes had migrated on 19 November, but apparently a few birds became "grounded" southwest of the refuge and returned with improved weather conditions. No cranes were present north of the staging area at that time and the lateness of the season would eliminate the possibility that these 57 birds were new arrivals to the refuge. Retromigration has otherwise rarely been recorded in southeast Oregon.

Melvin and Temple (1983) reported on a radiotagged juvenile sandhill crane that had migrated from its fledging area and was located on 3 September in North Dakota. On 17 September, it had returned to southern Manitoba. This reverse migration was believed related to hunting pressure in North Dakota.

CONCLUSIONS

Sandhill cranes using Malheur NWR apparently move onto the area from a wide geographical region, the extent of which is presently unknown. Formerly it was believed congregations were from throughout the population's nesting range (Littlefield & Thompson 1979). Recent information, however, suggest cranes nesting in the western and southern portions of their range do not use the refuge. Preliminary information does indicate that

many birds using Malheur in autumn nest in south-central British Columbia, and as long as grain production, favorable roosting and loafing sites, and limited human disturbance exist on the refuge, it will likely continue to be an important autumn use area for the central valley population.

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Table 1. Time, individual numbers and flock numbers of sandhill cranes arriving on Malheur NWR, Oregon.

Hour (PST)	No. of Individuals / Flock No. in Parentheses		Flock $\bar{x}$	Percent Total Flocks	Percent Total Individ.
0700-0800	50	(2)	25.0	1.4	2.6
0800-0900	27	(1)	27.0	0.7	1.4
0900-1000	50	(4)	12.5	2.9	2.6
1000-1100	320	(23)	13.9	16.7	16.9
1100-1200	349	(37)	9.4	26.8	18.4
1200-1300	789	(52)	15.2	37.7	41.6
1300-1400	156	(9)	17.3	6.5	8.2
1400-1500	65	(3)	21.7	2.2	3.4
1500-1600	30	(3)	10.0	2.2	1.6
1600-1700	42	(2)	21.0	1.4	2.2
1700-1800	20	(2)	10.0	1.4	1.1
Total	1,898	(138)	13.8	99.9	100.0

Table 2. Time, individual numbers and flock numbers of sandhill cranes migrating from the Malheur NWR, Oregon staging area.

Hour (PST)	No. of Individuals	Flock No. in Parenthesis	Flock $\bar{x}$	Percent Total Flocks	Percent Total Individ.
0900-1000	192	(7)	27.4	4.7	12.2
1000-1100	1,000	(112)	8.9	75.2	63.7
1100-1200	377	(30)	12.6	20.1	24.0
Total	1,569	(149)	10.5	100.0	99.9

Table 3. Number of birds and flocks from the staging area south to Catlow Valley, Oregon.

Year			S. Blitzen Valley 21 km S. of Departure Area		N. Catlow Valley 35 km SSW of Departure Area	
	Bird No.	Flock No.	Bird No.	Flock No.	Bird No.	Flock No.
1970	685	100	100	6	305	17
1974	139	9	172	4	-	-
1975	67	6	7	1	-	-
1977	-	-	14	1	322	10
1978	149	3	-	-	-	-
1979	-	-	26	1	117	9
1981	-	-	47	9	146	9
1982	203	15	255	14	1,857	66
1983	643	72	21	3	-	-
Total	1,886	205	642	39	2,747	111

Table 4. Sandhill cranes recorded in Catlow Valley, Oregon during an *en masse* migration from Malheur NWR, Oregon on 13 November 1982.

Hour (PST)	Number	Hour (PST)	Number
1123	81	1138	96
1124	89	1140	159
1125	98	1141	113
1127	20	1142	75
1128	28	1147	84
1129	62	1149	20
1130	111	1151	52
1131	10	1154	38
1133	67	1155	15
1134	48	1201	4
1135	142	1215	16
Total			1,428

DISTRIBUTION OF COLOR-MARKED GREATER SANDHILL CRANES BANDED IN UTAH

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Abstract: Twenty-eight greater sandhill cranes (*Grus canadensis tabida*) were banded and color-marked on nesting grounds in northern and central Utah during summers 1986 and 1987. Sixteen were observed 1 or more times between October 1986 and February 1988 on migration, winter and summer areas. Marking studies showed that cranes nesting east and southeast of the Great Salt Lake in northern and central Utah are affiliated with the Rocky Mountain population, with most individuals migrating during the spring and fall through the San Luis Valley, Colorado and wintering in southcentral and southwestern New Mexico, southeastern Arizona and possibly northern Mexico. Future color-marking efforts will be in northwest Utah to determine population affiliation of these cranes.

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Historically, greater sandhill cranes were common summer residents throughout central and northern Utah (Walkinshaw 1949; Drewien & Bizeau 1974; Hayward et al. 1976). Their numbers steadily declined during the late 1800's and early 1900's due to increased human disturbance and subsequent loss of habitat. By the mid-1940's, Behle (1944) no longer considered the species a summer breeding resident, whereas Walkinshaw (1949) estimated only 3 to 5 nesting pairs remained in Utah.

But greater sandhills are reoccupying former ranges and we currently estimate a minimum summer population of about 600 in Utah. The population increase is attributed to protection from unrestricted hunting and protection and enhancement of key habitat throughout their flyway (Drewien & Bizeau 1974).

Sandhill cranes nesting in Utah may belong to 2 distinct populations. Those cranes nesting throughout central and northern Utah, east of the Great Salt Lake, probably are affiliated with the Rocky Mountain population that winters in the Rio Grande Valley and southwestern New Mexico, southeastern Arizona and northcentral Mexico (Drewien & Bizeau 1974; Braun et al. 1975; Lewis 1977; Will 1987). Several color-marked in Rich County, northeastern Utah, in 1969-70, were observed wintering in western New Mexico, the principal winter area for the Rocky Mountain population (Drewien & Bizeau 1974). Cranes nesting in northwestern Utah possibly belong to the Lower Colorado River Valley population that winters in southern California, southwestern Arizona and Baja California (Braun et al. 1975; Drewien et al. 1976; Lewis 1977; Brown 1983). Although staging, migrating and wintering areas of these 2 populations are fairly distinct, boundaries of summer areas in Utah are poorly defined.

Each population has distinct management problems and opportunities. We initiated a marking study to better define nesting distributions and population affiliations in Utah. This paper summarizes reports through February 1988 of cranes banded and color-marked in Utah during summers 1986 and 1987 as part of that effort.

We thank E. Chavez, V. Graham, D. Lockman, B. Luce and N. Stephens for providing sightings of marked cranes. Assistance was also provided by the Bear River Club, Box Elder County Sheriff's Department and personnel of the Utah Division of Wildlife Resources. Financial support was provided by the Utah Division of Wildlife Resources, Wildlife Research Institute, University of Idaho and the U.S. Fish and Wildlife Service.

METHODS

During July and August of 1986-87, flightless young and adults were located in Box Elder, Cache, Davis, Emery, Rich and Weber counties (Fig. 1.). Flightless young and molting adults, located by using spotting scopes from vehicles, were pursued on foot and captured. Two-way portable radios were utilized for communication between the observer and the pursurer. Cranes were weighed and banded with a #9 USFWS metal leg band above the tibio-tarsus joint. Black patagial streamers (TXN226 smooth fabric, Cooley Inc., 50 Eastern Ave., Pawtucket, RI 02860) measuring cm x 22 cm and bearing a painted white alpha-numeric code were attached to each wing using an Allflex livestock eartag button and were similar in design to those used by Rawlings (1985). After release, tagged individuals were observed for a short time to monitor their response to being captured and color-marked.

Approximately 45 hours were spent searching for marked cranes during the 1987 summer in Utah. Marked cranes were also recorded during annual surveys for whooping cranes and sandhill cranes in migration and winter areas in the Rocky Mountain states and in Chihuahua, Mexico.

RESULTS

Capture and Color-marking

Twenty-eight flightless cranes—26 young and 2 adults—were marked on summer areas in 6 counties in northern and central Utah in 1986 (11) and 1987 (17) (Table 1, Fig. 1). One crane marked in 1986 was found dead 5 months later from unknown causes 1 km from the banding site. Consequently, a maximum 27 cranes were alive for future observations. Marked cranes were observed following release until they either disappeared in vegetation or were joined by their parents. The time between release and young rejoining their parents ranged from 5 minutes to 2 hours. No reactions to patagial streamers by adults were observed. One marked young pecked at the ear tag button that held the patagial streamer on the wing of its marked sibling immediately following release of the 2 cranes, after which they walked in the direction from which their parents were calling.

Distribution Outside Summer Areas

Sixteen individual cranes were observed along the spring-fall migration route and on winter areas from October 1986 through February 1988. Nine were observed in the San Luis Valley in southcentral Colorado during fall migrations in 1986 and 1987, between 11 October and 9 November. At least 4 utilized the Monte Vista NWR during their stay; others used private lands near the town of Monte Vista. Two broods containing 2 young each were observed (nos. 14 & 16, 20 & 21). Only 2 birds observed during fall 1986 were resighted in the Valley in spring 1987. In all, 3 marked birds were observed during spring migration—2 near Monte Vista in Rio Grande County and 1 near Sanford and LaJara, Conejos County, Colorado (Table 1). These cranes were observed in the San Luis Valley, Colorado, during spring migration from 27 March to 4 April (Table 1).

Fifteen individuals, including 9 observed during spring-fall migrations in Colorado, were observed on winter areas, 14 in the Rio Grande Valley, New Mexico, 1 at Willcox Playa in southeast Arizona, and 1 near Washington in southwestern Utah (Table 1, Fig. 1). One crane (no. 00) was observed at 2 different winter areas. In November 1986 it was in the Rio Grande Valley, New Mexico, and the following winter at Willcox Playa, Arizona (Table 1, Fig. 1).

A winter record of juvenile no. 13 in southwestern Utah occurred outside traditional winter areas for sandhill cranes, associated with 2 other cranes, possibly its parents, in an area not normally frequented by sandhills (N. Stephens pers. comm.). Only 1 other record of a single crane exists from this area in recent years (12-14 December 1984) according to N. Stephens (pers. comm.). All reports on winter areas were sight records except for bird no. 15, which was shot during a special sandhill crane hunt north of the Bosque del Apache National Wildlife Refuge near San Antonio, New Mexico (Table 1).

Utah cranes were frequently observed in mixed winter flocks containing marked greater sandhill cranes from nesting areas in Idaho and Wyoming. Often, lesser sandhill cranes (G. c. canadensis) and occasionally whooping cranes (G. americana) from the experimental population (Drewien & Bizeau 1978) occurred in the same flocks. For example, on 14 February 1987, crane no. 04 was located at Caballo Reservoir, Sierra County, New Mexico (Table 1) in a flock of 320 greater sandhill cranes, including 2 marked birds from Grays Lake, Idaho, and a whooping crane which 18 days earlier had been wintering near Ascension in northwest Chihuahua, Mexico. Possibly this flock, including the

Utah bird, had recently started the spring migration northward from Mexico.

On 8 February 1988, we observed 2 Utah cranes (nos. 14 & 16) in a flock of 717 cranes at Los Lunas, Valencia County, New Mexico (Table 1, Fig. 1). This flock consisted of 1 whooping crane, 3 marked sandhill cranes from Grays Lake, Idaho; 1 from Big Piney, Sublette County, Wyoming; 1 from the Sweetwater River, Fremont County, Wyoming; and 186 lesser sandhill cranes.

Four Utah cranes were sighted at the Bosque del Apache National Wildlife Refuge, Socorro County, New Mexico, a major winter site for the Rocky Mountain population (Drewien & Bizeau 1974). Utah cranes were reported on winter areas between 27 October and 12 March (Table 1).

Resightings On Summer Areas

Of 10 marked cranes possibly alive from 1986, 5 were resighted in Utah and northwest Colorado during the summer and fall 1987. Four were resighted in Utah between July-September 1987 and were 2, 11, 13, and 64 km from their respective 1986 banding locations. However, a fifth bird was sighted in September 1987 near Hayden in northwestern Colorado (Table 1, Fig. 1) at a fall pre-migration staging area (V. Graham pers. comm.). Hayden is over 400 km east-southeast of Plain City, Utah where this bird was banded, indicating that it did not return to Utah as a yearling, instead may have summered in northwest Colorado or in an ajoining area in Wyoming.

DISCUSSION

Observations of cranes color-marked on nesting and summer areas in northern and central Utah show that they are affiliated with the Rocky Mountain population. One band recovery and all resightings except 1 are within the geographical range frequented by this population. The winter location of a juvenile near Washington, Utah is outside any known winter area frequented by cranes.

Sixteen (59.3%) of 27 color-marked cranes were resighted after departing their respective banding locations, a rate similiar for cranes banded in 1986 (60.0%) and 1987 (58.8%).

Sightings of marked cranes from Utah on migration and winter areas revealed that they occurred in mixed flocks of greater sandhill cranes containing marked birds originating from summer areas in adjoining Idaho and Wyoming. In addition, most winter flocks also included various proportions of the lesser subspecies and occasionally a whooping crane. Some Utah cranes (nos. 03, 04, 06 09, 10, 20, & 21) were only observed on winter areas in the Rio Grande Valley, New Mexico in November or from mid-February to mid-March. During these periods, migrants moving between the San Luis Valley and winter areas farther south pass through the Rio Grande Valley, New Mexico. These sightings suggested that some of these cranes may have wintered in northern Mexico or in other locations in the southwestern United States frequented by the Rocky Mountain population.

No cranes were captured during the first 2 summers of banding in northwestern Utah, an area where cranes associated with the Lower Colorado River Valley population may occur (Brown 1983). Future banding efforts will be directed in this region to clarify population affiliation of these cranes.

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Table 1. Reports through February 1988 of greater sandhill cranes captured and colored-marked on summer areas in northern and central Utah, July-August 1986-87.

CRANE ID. NO.(1) & BANDING LOCATION(2)	LOCATION			
	FALL/SUMMER	FALL MIGRATION	WINTER AREA	SPRING MIGRATION
00 Honeyville, Box Elder	8-17 & 9-16-87 Corinne, UT		11-12-86 Bosque Refuge(3), NM 11-24-86 Socorro, NM 01-02-88 Willcox Playa, AZ	04-04-87 Monte Vista, CO
03 Plain City, Weber	09-04-87 Hayden, CO	10-27-86 Monte Vista, CO	03-06 to 03-12-87 Bosque Refuge(3), NM	03-27-87 Sanford, CO 04-03-87 LaJara, CO
04 West Kaysville, Davis	09-17-87 Corinne, UT		02-14-87 Caballo Res., NM	
06 Honeyville, Box Elder	07-08-87 Salt Cr. WMA(4), UT 08-17 & 09-21-87 Corinne, UT	10-17 to 10-27-86 Monte Vista, CO	11-09-87 Belen, NM	
09 Mendon, Cache			11-11-86 & 02-22-87 Bosque Refuge(3), NM	
10 Salt Cr. WMA(4), Box Elder	07-12-87 Salt Cr. WMA(4), UT	11-09-86 Monte Vista, CO	03-12-87 & 02-22 to 02-29-88 Bosque Refuge(3), NM	03-27-87 Monte Vista, CO
11 & 12(5) Desert Lake WMA(4), Emery			11-23 to 12-01-87 Los Lunas, NM	
13 Mendon, Cache			12-31-87 to 03-04-88 Washington, UT	
14 & 16(5) Corinne, Box Elder		10-12-87 Monte Vista, CO	02-08-88 Los Lunas, NM	
15(6 & 7) Salt Cr. WMA(4), Box Elder		10-11-87 Monte Vista, CO	10-27-87 San Antonio, NM	
20 & 21(5) Honeyville, Box Elder		10-12 to 10-20-87 Monte Vista, CO	11-09-87 Belen, NM	
22 Woodruff, Rich		10-12-87 Monte Vista, CO		
24 Randolph, Rich			12-22-87 Belen, NM	

(1) Number on patagial tag; bird 02 dead near banding site, nos. 01, 05, 07, 08, 17, 18, 19, 23, 25, 26 & 27 not observed.
(2) Nearest city, county.
(3) Bosque Refuge = Bosque del Apache National Wildlife Refuge.
(4) WMA = Waterfowl Management Area.
(5) Siblings marked in brood.
(6) Adult crane.
(7) Shot during sandhill crane hunting season.

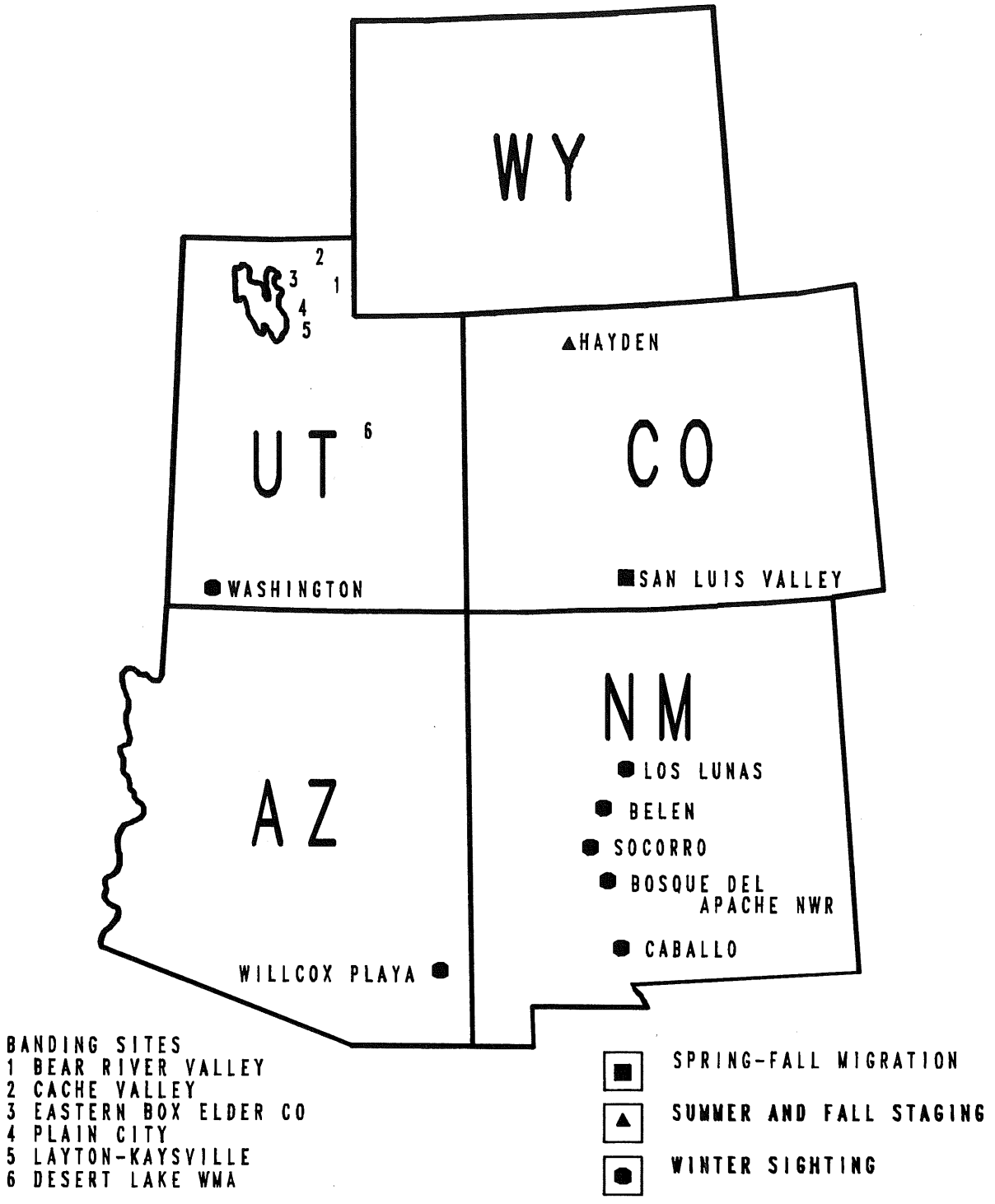

Figure 1. Capture and observation site locations of greater sandhill cranes marked with patagial streamers in Utah, 1986-87.

PRELIMINARY IDENTIFICATION OF WHOOPING CRANE STAGING AREAS IN PRAIRIE CANADA

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Abstract: For 60 years a passive program has been in effect to monitor the migration of whooping cranes (*Grus americana*) through Saskatchewan, and currently the Canadian Wildlife Service coordinates a tri-provincial reporting network and operates a telephone Hot Line to receive reports of sightings of migrating cranes. Analyses of historical data reported through those efforts have identified the chronology of migration, the migration corridor through Canada, and major staging/stopover areas in Saskatchewan. Investigations are continuing to identify specific roost sites, feeding areas and the availability of suitable habitat within the staging/stopover area.

Proc. 1988 N. Am. Crane Workshop

The first whooping crane record from the Prairie Provinces of Canada occurred in 1748 when a skin from a white crane was shipped to England from the Hudson's Bay region of Manitoba (Allen 1952). Confirmed prairie nesting records date from 1871 to 1922 (Allen 1952). F. Bard (pers. comm.) and Roy (1964) indicated probable breeding as late as 1927. Whooping cranes at that time nested within the aspen parklands of Manitoba, Saskatchewan and eastern Alberta (Fig. 1)(Allen 1952). Although whooping cranes do not currently breed in the southern Prairies, nonbreeders occasionally summer in the region (Fig. 2).

Whooping cranes regularly occur in the southern Prairies for 2-3 months each year, when spring and fall they migrate across this area. This paper describes the nature of that use during those times.

STUDY AREA

In Canada, the whooping crane migration route covers a transition from grassland through aspen parkland and into boreal forest. My study area is limited to the southern or agricultural portions of Manitoba, Saskatchewan and Alberta.

METHODS

In 1922, Fred Bradshaw, Saskatchewan's Chief Game Guardian, began collecting reports of migrating Whooping Cranes for the Prairie Provinces, especially Saskatchewan (Bradshaw 1922), and upon joining the Saskatchewan Museum of Natural History (SMNH) in 1928 continued to monitor crane migration (Bard pers. comm.). In 1940, Fred Bard (SMNH) began an active campaign of soliciting sightings, and the museum continued the program until the spring of 1977 when the Canadian Wildlife Service (CWS), Saskatoon, assumed this role (Stephen 1979).

In that effort, volunteers report their observations directly to the CWS, to local offices of provincial wildlife agencies, the Royal Canadian Mounted Police (RCMP) or the SMNH, which, in turn, forward them to the CWS (Stephen 1979; Johns 1987). Data recorded include the number of birds, date, time, location and activity. Sightings are classified as confirmed, probable or unconfirmed per the criteria outlined in the U.S. Whooping Crane Recovery Plan (U. S. Fish & Wildlife Service 1986; Johns 1987). Attempts are made to confirm all sightings.

In 1985, a database was established at CWS, Saskatoon, to provide rapid retrieval of Whooping Crane sightings for the Prairie Provinces. Historical records on file were added to the database in 1986 with the cooperation of the Saskatchewan Natural History Society (Didiuk 1986).

Beginning in 1985, news releases are issued prior to the migration periods, and the following year a 24-hour "Whooping Crane Hot Line" was established to receive reports (Johns 1986).

RESULTS AND DISCUSSION

I analyzed 1,217 sighting records from the period 1956-1987, of which 400 were classified as confirmed, 321 as probable and 496 as unconfirmed (Table 1). Only confirmed sightings are discussed in this paper.

Chronology of Migration

Spring migration through the Prairies begins 10 to 12 days after first departures from Aransas, and spans a 4-6-week period from early April to mid-May (Fig. 3a). Birds which have bred previously are usually the first birds to arrive, while nonbreeders arrive later and linger longer.

Autumn migration occurs from mid-September through late October, although a few cranes may begin migrating in late August and others may linger until early November (Fig. 3b). Since 1977, young whooping cranes have been individually marked with colored leg bands (Kuyt & Goossen 1987), and observations of those indicate that the earliest birds to arrive in the fall (from late August to early September) are yearlings. These birds often migrate separately from other whooping cranes, and in Saskatchewan are usually associated with large flocks of sandhill cranes. Nonbreeders, unsuccessful pairs and family groups begin arriving on the Prairies in mid-September, with numbers peaking the first 2 weeks of October.

Migration Corridor

The spring migration corridor through Canada was first described by Bradshaw (1923) as "... a northwesterly direction from the international boundary ...". Allen (1952) described it as "...into Saskatchewan southeast of Regina. Its course beyond the settled areas is unknown." More recently, sightings from both spring and fall migrations were combined, using axial line analysis (Bellrose 1972, Johnson & Temple 1980), to identify the migration corridor. The "primary" corridor (75% of the sightings) follows a line between southeastern and northwestern Saskatchewan, about 34° west of north (Fig. 4).

Staging/Stopover Areas

Sandhill crane "staging areas", as described by Melvin and Temple (1981), are sites where cranes accumulate during the first segment of their fall migration, usually no more than 1 day's flight from the nesting area and within the first 20% of the migration route. Central Saskatchewan is within the first 20-25% of the migration route. Adults and young may use these staging areas for several weeks, primarily feeding on waste grain in stubble fields (Cooch et al. 1988). Traditional stopover areas are located farther along the migration route, usually between 25 and 75% of the distance between breeding and wintering areas (Melvin & Temple 1981).

Didiuk (1986), using confirmed and probable sightings from the period 1964 through 1985, delineated 18 areas traditionally used by whooping cranes in Saskatchewan, and ranked them based on amount of use and year of last use. I conducted a subsequent analysis of confirmed sightings from 1956 through 1987, which reemphasized the importance of 7 of those areas. Of these 7 intensively used areas, 6 are considered fall staging areas with limited spring use, and 1 (the Meadow Lake area) is a frequent spring stopover with limited fall use (Fig. 5).

Whooping cranes migrate as single birds (24% of the sightings), as pairs (27%) as groups of 3, usually 2 adults and 1 young (23%) and groups of 4 (9%). Larger groups up to 11 birds are occasionally seen on a staging area (Table 2).

Successful breeders, i.e. pairs with young during migration, and nonbreeders concentrate on different areas during the staging period (X^2 = 13.41, $p < 0.01$). In Saskatchewan, Buffer Lake and the Last Mountain-Kutawagan Lakes area are used primarily by nonbreeders. Only 1 (2%) of the 46 groups reported from these areas contained young. Radisson Lake, Midnight Lake and Blaine Lake are used more intensively by breeding birds, with young in 78% of 9 flocks at Radisson Lake, 43% of 14 flocks at Midnight Lake and 36% of 11 flocks in the Blaine Lake area. Witchekan Lake was used by both nonbreeding and breeding segments of the population (young present in 13% of 16 flocks). The spring stopover area, near Meadow Lake, also was used by both successful breeders (young observed in 23% of 22 flocks) and nonbreeders. In areas where several young were recorded, many other sightings of groups of 3 birds were made, probably family groups that had not been recorded as such because young were not specifically mentioned.

The use of a particular site may reflect traditional use within a staging area by specific individual cranes (Kuyt 1984). After the staging period, the cranes make a rapid migration to the wintering area (Kuyt 1984) using traditional and nontraditional stopover areas (Johnson & Temple 1980).

The CWS plans to expand its program to include identification and evaluation of specific roosting and feeding sites within staging areas. Identification of color-banded individuals will provide information on critical staging habitat used by particular individuals or groups of cranes. Once iden-

tified, these traditional use sites will require protection in order to ensure the safety of the whooping crane during migration.

I would like to thank the many people who reported sightings of whooping cranes and the cooperating agencies—Saskatchewan Department of Parks Recreation and Culture, Alberta Fish and Wildlife Division, Manitoba Department of Natural Resources, Saskatchewan Museum of Natural History, Royal Canadian Mounted Police, Saskatchewan Wildlife Federation, Saskatchewan Natural History Society and the U.S. Fish and Wildlife Service, Grand Island. I would also like to thank A.B. Didiuk and B. Miles for plotting locations on maps and entering historical data into the computer, and E.A. Driver, A.W. Diamond, E. Kuyt and J.B. Gollop for comments on the manuscript.

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Table 1. Whooping crane sightings in the Prairie Provinces by season and status, 1956-1987.

	CONFIRMED		PROBABLE		UNCONFIRMED		TOTAL
	Spring	Autumn	Spring	Autumn	Spring	Autumn	
MANITOBA	3	0	7	0	17	3	30
SASKATCHEWAN	90	296	136	163	215	210	1110
ALBERTA	2	9	12	3	26	25	77
Subtotal	95	305	155	166	258	238	
TOTAL	400		321		496		1217

Table 2. Frequency at which various groupings of whooping cranes were observed at Saskatchewan staging areas, 1956-1987.

	NUMBER OF WHOOPING CRANES PER OBSERVATION (FLOCK SIZE)											
STAGING AREA	1	2	3	4	5	6	7	8	9	10	11	MEAN
Last Mountain-Kutawagan Lakes	22[1]	13	0	1	2	1	0	1	0	0	0	1.9
Meadow Lake	3	5	5	5	2	1	0	1	0	0	0	3.3
Witchekan Lake	3	7	5	1	0	0	0	0	0	0	0	2.3
Midnight Lake	0	3	9	0	0	1	0	0	0	1	1	4.0
Buffer Lake	0	4	0	2	0	2	0	1	0	0	0	4.0
Blaine Lake	2	2	3	1	0	2	1	0	0	1	1	4.5
Radisson Lake	0	0	7	1	0	1	0	0	0	0	0	3.4
T0TALS	30	34	29	11	4	8	1	3	0	2	2	3.0
%	24	27	23	8.8	3.2	6.5	0.8	2.4	0	1.6	1.6	

[1] Number of sightings for each flock size.

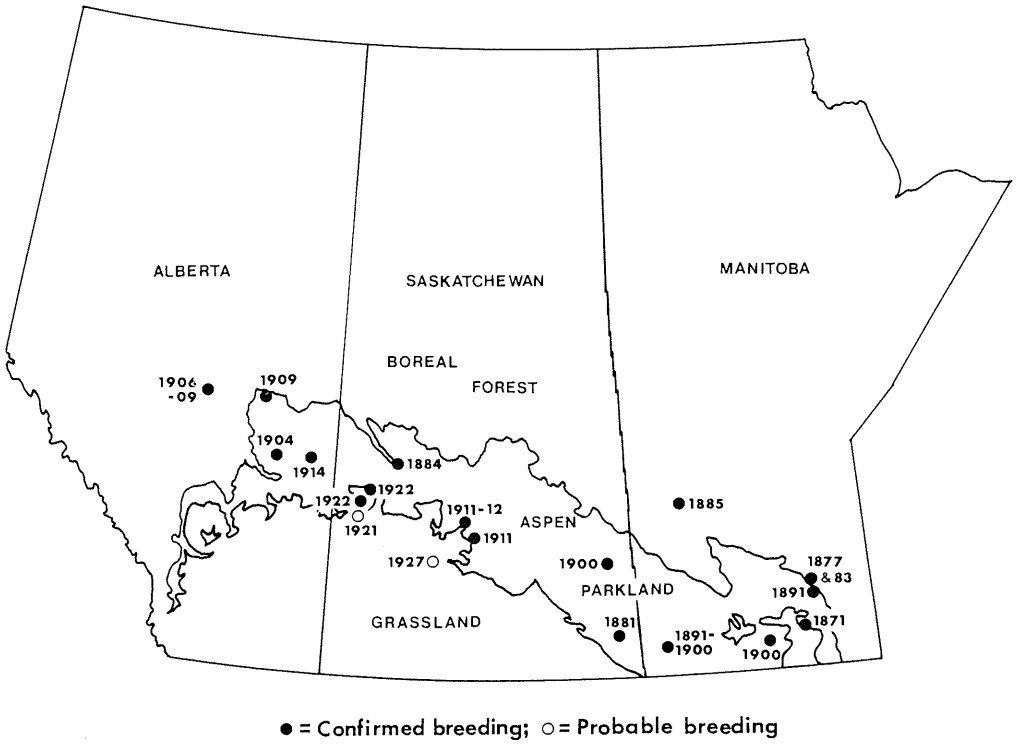


Figure 1. Whooping crane breeding locations, Prarie Provences, 1871-1927.

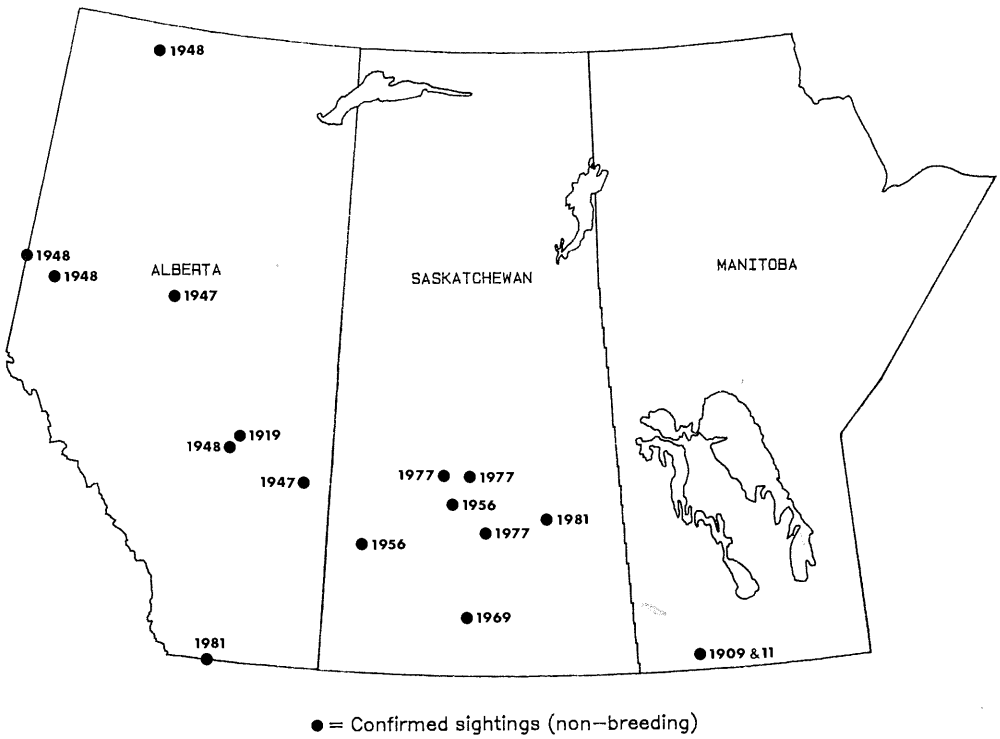
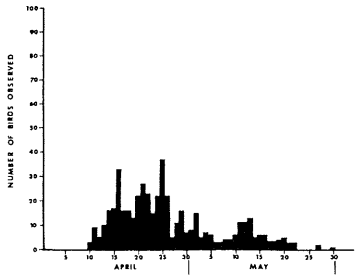


Figure 2. Whooping crane summering locations, Prarie Provinces, 1909-1987.

3a. Spring migration.



3b. Autumn migration.

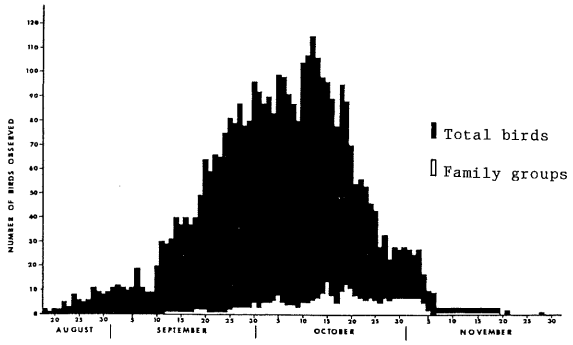
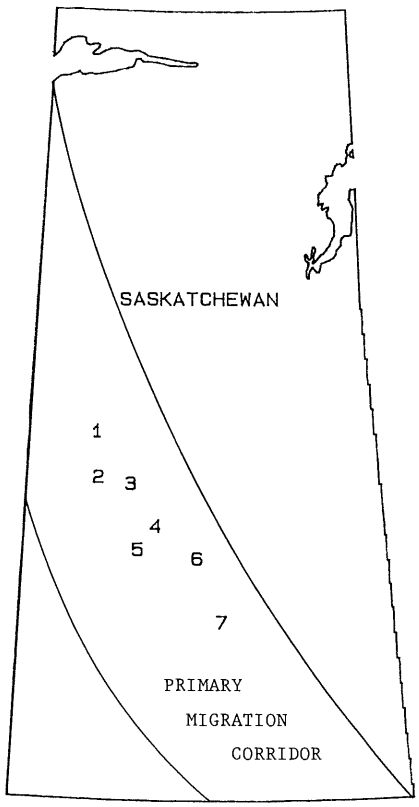


Figure 3. Number of whooping cranes seen on each day during migration through Prairie Provinces, 1956-1987



1 = Meadow Lake; 2 = Midnight Lake; 3 = Witchekan Lake; 4 = Blaine Lake; 5 = Radisson Lake; 6 = Buffer Lake; 7 = Last Mountain – Kutawagan Lakes

Figure 5. Whooping crane staging areas, Saskatchewan.

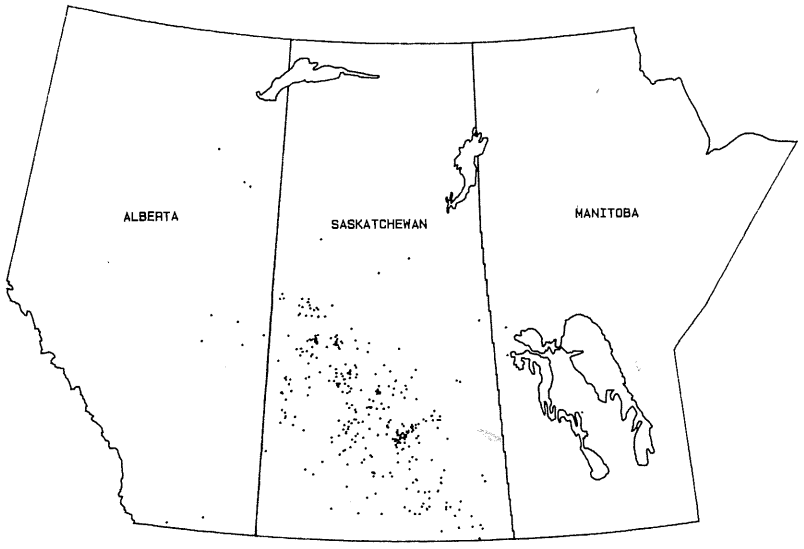


Figure 4. Confirmed whooping crane sightings, Prairie Provinces, 1956-1987.