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**Abstract:** Sandhill crane (*Grus canadensis*) collisions with power lines were studied in southcentral Nebraska in 1986 and 1987. Approximately 596 km of power lines were surveyed for dead cranes in 1986, and 210 km of power lines in 1987. A total of 135 dead cranes were located. Cranes collided 4 times more with transmission lines than distribution lines, although distribution lines were twice as abundant. We believe cranes collided with the static wires on the transmission lines. Juveniles and Canadian sandhill cranes (G.c. rowani) had a higher probability of colliding with power lines than other age groups and subspecies.

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Power line collisions by birds have been well documented (Malcom 1982; Faanes 1984; Brown et al. 1984), but such mortality likely represents only a small portion of actual incidents (Cornwell & Hochbaum 1971; Krapu 1974). Predators, scavengers and humans often remove injured or dead birds (Scott et al. 1972; Krapu 1974; Tacha et al. 1979; Brown et al. 1984; Faanes 1984), making it difficult to evaluate fully the numbers of birds that die from collisions.

Moreover, the problem of estimating wire-associated bird mortality is intensified because many birds striking lines are injured but are able to fly or walk out of the area and eventually die (Anderson 1978; Malcolm 1982; Brown et al. 1984). Anderson (1978) reported that 59% of the birds found in his study were crippled by power line collisions, and Malcolm (1982) found some line collision casualties (waterfowl) up to 3.4 km from the set of power lines he was studying.

Many variables affect the probability of birds colliding with power lines, including bird's age (Krapu 1974; Brown et al. 1984), size (Faanes 1984), numbers of birds present (Anderson 1978), power line height (Tacha et al. 1979; Brown et al. 1984), power line type (Scott et al. 1972; Faanes 1984), and adverse weather (Walkinshaw 1956; Higgins & Johnson 1972; Krapu 1974; Anderson 1978; Tacha et al. 1979; Malcolm 1982; Brown et al. 1984; Faanes 1984).

Power line collisions by whooping cranes (*Grus americana*) have been cited as the major known cause of post-fledgling deaths (J. Lewis pers. comm.). Since 1965, 16 whooping cranes have collided with power lines and subsequently died or been injured to the extent they could not be released back into the wild.

The objective of this study was to determine what variables were responsible for increasing the probability of a whooping crane's chance to collide with a power line. Sandhill cranes, because of their similarity in behavior and morphology to whooping cranes, were used as the surrogate research species in this study.

## STUDY AREA

The Platte River in southcentral Nebraska was selected as the study area because of the large concentrations of staging sandhill cranes there in March and April. From 80 to 100% (500,000) of the midcontinental population of sandhill cranes use the Platte and North Platte rivers each spring during their northward migration (Kroonmeyer 1979; Krapu 1981). The study was conducted between the towns of Overton and Grand Island in southcentral Nebraska.

## METHODS

Power lines were classified by powerpole construction and categorized 1 through 21 (21 powerpole types existed in the study area).

Power lines can be grouped into 2 subsets; transmission lines and distribution lines. Transmission lines carry large amounts of electricity (kilovolt capacities) from power plants and substations. Distribution lines have a lesser kilovolt capacity and carry electricity from transmission lines to individual communities and houses. In our study area,

average distribution lines were approximately 7 m in height and supported poles 100 m apart. Distribution lines had from 1 to 7 wires (1 neutral and 2-6 phase wires) and were typically all the same diameter and within 2 m of other wires. Transmission lines averaged 11 m in height and support poles were 220 m apart. Transmission lines typically had 3 conductor wires and 2 static wires. Conductor wires conduct the electricity, and static wires, which are 4-15 m above the conductor wires, shield the conductor wires from lightning strikes. Static wires are one-half the diameter of conductor wires.

During the first week (March 3-10) of the study in 1986, all power lines within 1. 6 km and on either side of the river were plotted on United States Geologic Survey (USGS) topographic maps (scale 1:24,000) and searched by pickup truck or on foot for dead sandhill cranes. Dead cranes were assigned an I.D. number, locations were plotted on the USGS topographic maps, photographs were taken of wings to later determine the bird's age (Nesbitt 1987), and a mortality form was completed on which cause of death (broken bones or external injuries), various anatomical measurements (length of culmen, wing cord, tarsometatarsus, tibiotarsus, and middle toe) to determine subspecies by use of Discriminant Analysis (Nie et al. 1975), approximate time since death, location with respect to power poles, perpendicular distance to wires, type of power lines, height of wires, habitat type, direction and distance to river, and UTM coordinates were recorded. The hallux on each foot was clipped to identify carcasses as having been processed, then left in place to determine the rate of removal by scavengers and/or people.

From 11 March through 25 March 1986, counts of flying cranes were conducted to establish concentrations on different segments of the river. Twenty-four power line segments (1.6 km in length) were selected and sampled during this 2 week period, 12 south of the river and 12 north. Criteria for selecting the sampling areas included were power lines 1. 6 km in length, parallel to the river, and within 1. 6 km of the river.

Each area was sampled twice, once in the evening beginning 1 h before sunset, while the cranes were flying from secondary roosts to river roosts, and once the following morning, beginning at first light while cranes were leaving river roosts for secondary roosts.

Prior to the evening surveys, the power line segments being sampled that evening were searched for dead cranes. After the morning flight survey the following mornings the same group of power lines were rechecked.

For the remaining 2 weeks of the study (26 March to 8 April 1986), all power lines in the study area were searched for dead cranes twice a week, evenings then the following mornings.

During spring 1987, 10 power line segments which had had a high percentage of crane collisions in the spring of 1986 were selected to attempt to observe collisions. Each site was monitored twice a week (once at evening and then the following morning) for 4 consecutive weeks. This sampling design enabled us to interpret the relative number of sandhill cranes using an area versus the number found dead below power lines, and collect more exact data on variables responsible for collisions. These power lines were searched for dead sandhill cranes and for flyovers in a similar manner as in 1986.

## RESULTS

### Power Line Types and Distribution

Twenty-one power line types ( 596 . 5 km) were checked for dead sandhill cranes in 1986 (Table 1), and 7 types (210.3 km) were searched in 1987. The most abundant types for both years were #3 (320.5 km), #9 (45.9 km) and #10 ( 154 . 9 km) . Distribution lines were 2 . 3 times and 1. 4 times more abundant than transmission lines in the samples in 1986 and 1987, respectively.

### Flight Surveys

In 1986 and 1987, we recorded 277,489 crane flyovers during 140 sampling periods. In 1986, no cranes were observed colliding with power lines during flight surveys, although 1 was observed striking a static wire on a transmission line while we were searching for dead cranes ( Table 2 ) . In 1987, 7 sandhill cranes were observed colliding with static wires on transmission lines during the flight surveys, 6 of which were able to recover and continue flying. The seventh had collided with a static wire, fell to the ground, then after 2 minutes rose and walked 400 m to a barbed wire fence, where it paced back and forth for at least 10 minutes. We presumed the crane eventually either walked or flew out of the area. Weather during these 7 collisions ranged from breeze to windy conditions, clear to cloudy skies, and dry to rainy.

In 1987, about 15 observations were made of cranes obviously maneuvering to avoid transmis-

sion lines. Typically they ascended gradually from a secondary roost, approaching the conductor wires, then, when within an estimated 5 m of the wires, apparently became aware of the static wires and either turned around to gain altitude or vigorously flapped (lowered their abdomen and legs) to clear the static wires. The latter avoidance behavior is a primary reason why many dead or injured sandhill cranes had broken, lacerated or severed legs.

### Mortality

Sixty and 75 dead sandhill cranes were located below power lines in 1986 and 1987, respectively (Table 1). Because scavengers fed on some, anatomical measurements were made on only 85 carcasses. Forty-eight percent were lesser (*G.c. canadensis*), 35% Canadian and 9% greater (*G.c. tabida*) sandhill cranes (Table 3). Lewis (1979) determined subspecies composition of lesser and Canadian sandhill cranes along the Platte River during spring migration. Our data were dissimilar [$X^2 = 9.8425$, $p = 0.0023$, $V = 1$ (Zar 1985)] to his; we observed fewer lesser sandhill cranes and more Canadian sandhill cranes than expected.

Of the 85 carcasses aged by wing molt characteristics, 18 were juveniles, 55 were subadults (1-4 years old) and 12 were adults (Table 3). Reinecke and Krapu ( 1986 ) reported 11. 8% of the sandhill crane population in areas of the Platte River during migration were juveniles and 88 . 2% were subadults and adults. Our data were dissimilar [$X^2 = 6.375$, $p = 0.0124$, $V = 1$ (Zar 1985) ], finding more juvenile crane carcasses and fewer subadults and adults than expected from the population composition.

Cranes collided 4 times more with transmission lines than distribution lines (110 vs 25, respectively), although distribution lines were, twice as abundant (Table 1). Cranes tended to collide more near the center of the power line span (between powerpoles) (Fig. 1), suggesting they were avoiding the poles and colliding during daylight hours (nighttime collisions would have been more uniformly distributed).

### Weather

Weather during 1986 was very different than in 1987. Mean temperature in 1986 during all flight surveys was 4.06°C, cloud cover averaged 75%, and wind speed averaged 6.22 km/hr from the southwest; no severe storms occurred. The number of dead cranes located that spring may be an index of crane mortality during mild springs.

In 1987, weather was very diverse. March 1-7 was mild and dry, with average maximum daytime temperatures near 19°C and nighttime temperatures near 2°C with no precipitation. Between 8-21 March precipitation increased and temperatures decreased; 12 . 01 cm of rain fell and average maximum daytime temperature was 9°C. Many of the Platte River sandbars were submerged. Numerous cranes were observed roosting in the crop and grassland fields where large shallow ponds existed because of the heavy rainfall.

During 22-31 March temperatures further decreased, averaging 0°C. Central Nebraska was hit by 2 springtime blizzards during that time, leaving 48 . 26 cm of snow in the Kearney area. On 23 March, an afternoon storm began with strong gusty winds and heavy rain which turned into snow as the afternoon progressed. By nightfall, heavy snow fall had reduced visibility to 0. 5 km. The second storm arrived the night of 27 March, and by dawn 28 March, 6 cm of snow was on the ground and visibility was 0 . 25 km. Snow continued to fall for another 24 hours. Northerly winds during these 2 storms reached 80 kmph. Although cranes were not seen during the blizzards, some were noted immediately before and after feeding in exposed cornfields. The large numbers of cranes we observed the prior week feeding in these cornfields were not present immediately before or after the storms. The majority probably remained at roosts during the blizzards.

## DISCUSSION

Although we observed only one-third the power lines in 1987 as in 1986, we located more crane carcasses that latter year, suggesting weather conditions in 1987 increased crane collision mortality. The increase in numbers of carcasses found after the 1987 storms may be because cranes had to search more for exposed cornfields and areas to roost during high winds. Wind speed and direction seemed to be the most important weather factor contributing to power line strikes. A bird with a tail wind approached power lines faster and had less time to react.

Other studies have also documented increased mortality rates with adverse weather. Tacha et al . ( 1979 ) found 51 dead cranes below power lines after fog developed between the cranes' feeding fields and their roost. Brown et al. (1984) noted a

sharp decrease in power line mortality of cranes from season to season when weather was favorable versus adverse.

Sandhill cranes have a higher probability of colliding with transmission lines compared to distribution lines, probably due to 4 basic reasons, individually or collectively. First, transmission lines are generally 2 to 25 m higher than distribution lines. Second, neutral wires on distribution lines are the same diameter as the phase wires, while static wires on transmission lines are about one-half the diameter of conductor wires. Third, neutral wires on distribution lines are usually ~1 m from the phase wires, but on transmission lines the static wires are 2-10 m above the conductor wires. Fourth, support poles for distribution lines are approximately 100 m apart while poles for transmission lines are 200 m to 430 m apart.

Nighttime mortality of birds flying into power lines has been documented by Malcolm (1982 ), Siegfried & Fitzpatrick (1972) and Scott et al . (1972). But nighttime collisions in our study was minimal. Otherwise, we would have expected a more uniform distribution of crane carcasses between support poles.

Juveniles collided at nearly twice the rate that they occurred in the population. Other researchers also found juvenile sandhill cranes, whooping cranes and waterfowl more susceptible than adults. Brown et al. (1984) believed juvenile sandhill cranes in the San Luis Valley, Colorado, were more likely to collide with power lines because of lack of flying experience and unfamiliarity with the area. Of 14 whooping cranes of known age that have collided with power lines since 1956, 8 were juveniles, 3 were subadults, and 3 were adults (J. Lewis, pers. comm. ) . Krapu (1974) concluded that immature waterfowl may be more susceptible to certain types of wire-related losses than adults.

Crane mortality was further subspecies specific in our study area. Lesser sandhill cranes collided less with power lines than Canadian sandhill cranes in proportion to their frequencies in the population. Wirth Associates (1980, in Faanes 1984) and others believe that the larger and less maneuverable the bird, the more vulnerable it is to power line collisions. Canadian sandhill cranes are larger than lessers.

Our 7 observations of sandhill cranes colliding with power lines revealed 2 other important points about sandhill such collisions. First, most cranes apparently are able to fly after colliding with a line, suggesting that the occurrence of sandhill crane (and perhaps whooping crane) collisions is much higher than suspected indicated by the number of carcasses found. Second, distribution lines, in one respect, are more dangerous than transmission lines. Although we did not observe any cranes colliding with distribution lines, it appeared in many instances, when carcasses were located, that they had been electrocuted. After a strike, apparently instead of falling and/or regaining its balance, its wings or wing and rectices made contact with 2 wires (neutral and phase). This is not possible with transmission lines since the wires are separated by 3-15 m.

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**Table 1. Power line types, lengths and associated sandhill crane mortality on the Platte River study area in 1986 and 1987.**

| Power line type (Ward et al. 1986) | Distribution (D) or transmission (T) line | Total lengths (km) | | Number of dead sandhill cranes | |
|---|---|---|---|---|---|
| | | 1986 | 1987 | 1986 | 1987 |
| 1 | D | 126.7 | 12.4 | 0 | 0 |
| 2 | D | 8.3 | 0 | 0 | 0 |
| 3 | D | 215.6 | 104.9 | 0 | 0 |
| 4 | D | 1.2 | 0 | 0 | 0 |
| 6 | D | 14.1 | 0 | 1 | 0 |
| 7 | T | 15.0 | 15.6 | 8 | 5 |
| 8 | T | 7.0 | 9.2 | 9 | 18 |
| 9 | T | 20.3 | 25.6 | 18 | 30 |
| 10 | T | 118.7 | 36.2 | 11 | 11 |
| 11 | D | 30.3 | 3.1 | 0 | 0 |
| 12 | D | 3.0 | 0 | 0 | 0 |
| 13 | D | 8.0 | 0 | 0 | 0 |
| 14 | D | 0.3 | 3.3 | 0 | 0 |
| 16 | T | 7.4 | 0 | 0 | 0 |
| 17 | T | 1.8 | 0 | 0 | 0 |
| 18 | T | 2.6 | 0 | 0 | 0 |
| 19 | T | 4.6 | 0 | 0 | 0 |
| 20 | T | 3.2 | 0 | 0 | 0 |
| 21 | D | 2.6 | 0 | 1 | 0 |
| 22 | D | 2.6 | 0 | 0 | 0 |
| 23 | D | 3.2 | 0 | 0 | 0 |
| Subtotal | D | 415.9 | 123.7 | 14 | 11 |
| Subtotal | T | 180.9 | 86.6 | 46 | 64 |
| TOTALS | D and T | 596.5 | 210.3 | 60 | 75 |

**Table 2. Weather statistics at the time of seven observed sandhill crane collision with power lines.**

| Date | Line type | Wind Speed *(kmph) | Wind Direction | Temp (íC) | Precip. | Cloud cover | Outcome |
|---|---|---|---|---|---|---|---|
| 3/30/86 | 10 | 03 | W | 13 | 0 | 0 | Flew away |
| 3/04/87 | 9 | 16 | W | 20 | 0 | 30 | Flew away |
| 3/07/87 | 8 | 24 | S | 24 | 0 | 10 | Flew away |
| 3/18/87 | 8 | 24 | N | 4 | Drizzle | 100 | Flew away |
| 3/18/87 | 8 | 24 | N | 4 | Drizzle | 100 | Flew away |
| 3/18/87 | 8 | 24 | N | 4 | Drizzle | 100 | Flew away |
| 3/23/87 | 8 | 24 | N | 2 | Snow | 100 | Walked away |

*Wind speed approximations

**Table 3. Subspecies and age classes of 85 dead sandhill cranes found beneath power lines in 1986 and 1987.**

| Subspecies | Juvenile | Age Class Subadult | Adult | Total |
|---|---|---|---|---|
| *G. c. canadensis* | 8 | 27 | 6 | 41 |
| *G. c. rowani* | 8 | 17 | 5 | 30 |
| *G. c. tabida* | 2 | 6 | 0 | 8 |
| Undetermined | 0 | 5 | 1 | 6 |
| Total | 18 | 55 | 12 | 85 |

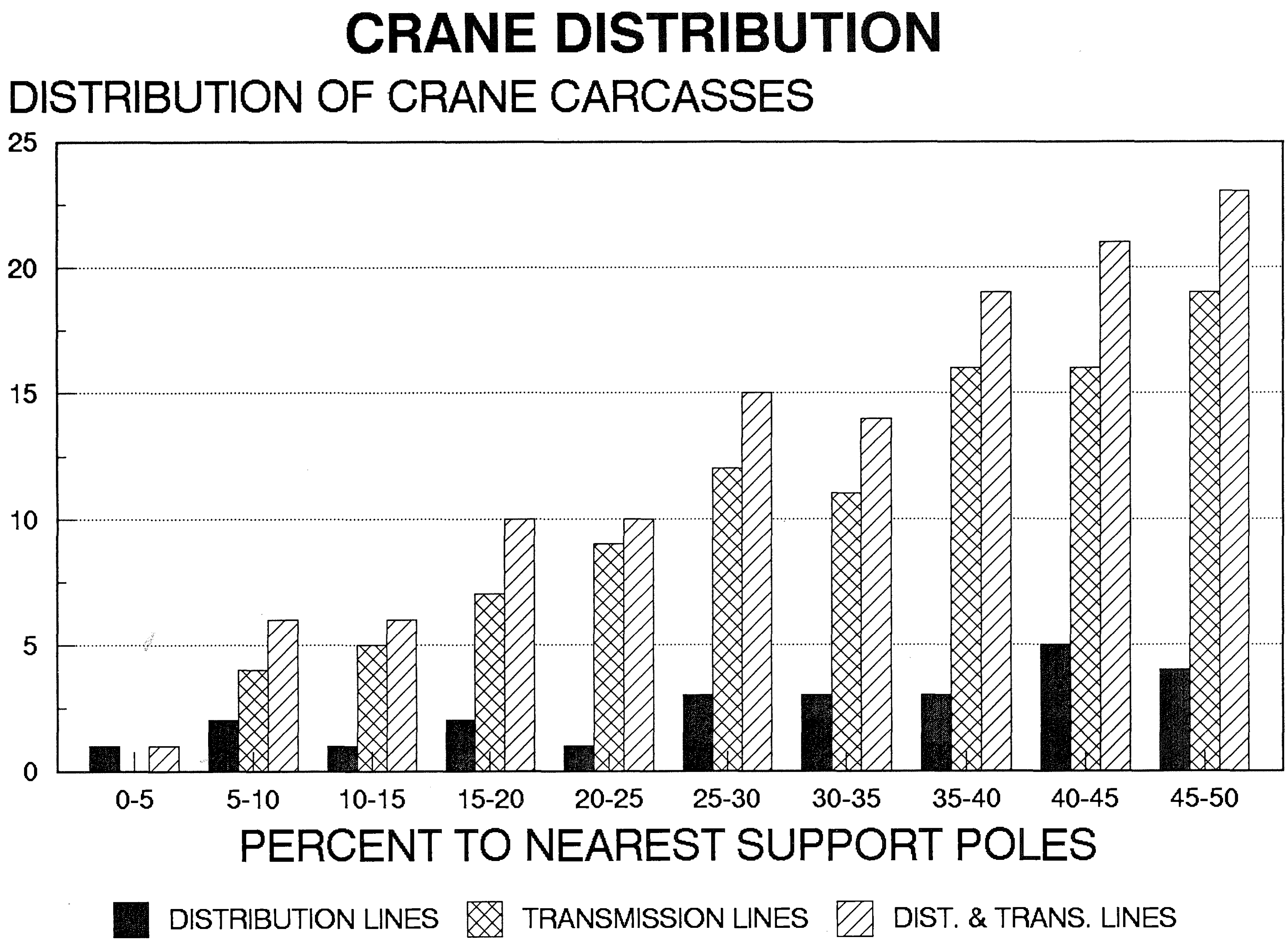


*Figure 1. Distribution of crane carcasses found below all power lines in relation to distances to support poles (1986 and 1987 data combined)*