DWR-1298

PROCEEDINGS

1985 CRANE WORKSHOP

WORKSHOP CO-CHAIRMEN

DR. JAMES C. LEWIS
U.S. Fish and Wildlife
Service

JOHN G. VANDERWALKER
Platte River Whooping Crane
Habitat Maintenance Trust

EDITOR

DR. JAMES C. LEWIS

COPY AND LAYOUT EDITORS

JERRY W. ZIEWITZ DR. JAMES C. LEWIS

PUBLICATION SPONSORED BY
PLATTE RIVER WHOOPING CRANE HABITAT
MAINTENANCE TRUST AND U.S. FISH AND
WILDLIFE SERVICE.
1987

AVAILABLE FROM PLATTE RIVER
WHOOPING CRANE MAINTENANCE TRUST
2550 N. DIERS AVE. SUITE H
GRAND ISLAND, NE 68803

$6.00 POSTPAID

PREFACE

This Proceedings includes 45 of the 53 papers presented at the 1985 Crane Workshop held 26-28 March in Grand Island, Nebraska. Published here along with the 45 papers mentioned previously are 6 papers submitted for the Proceedings but not presented at the Workshop. The 1985 Workshop was the 4th in a series of such workshops held in the United States; the previous meetings were in Baraboo, Wisconsin, in 1975; Rockport, Texas, in 1978; and Grand Teton National Park, Wyoming, in 1981. The series of workshops and proceedings have been designed to improve communication and interaction among individuals researching or managing cranes in North America, to stimulate further research, to help identify research and management needs, and to provide ease of access to a large amount of crane literature. The 1975 Proceedings is out of print. The 1978 Proceedings (259 pages, 36 articles) is available from National Audubon Society, 4150 Darley Street, Suite 5, Boulder, CO 80303 for $6.00. The 1981 Proceedings (296 pages, 38 articles) is available from National Audubon Society, Attn. Alexander Sprunt IV, 115 Indian Mound Trail, Tavernier, Florida. 33070 for $25.00 a copy.

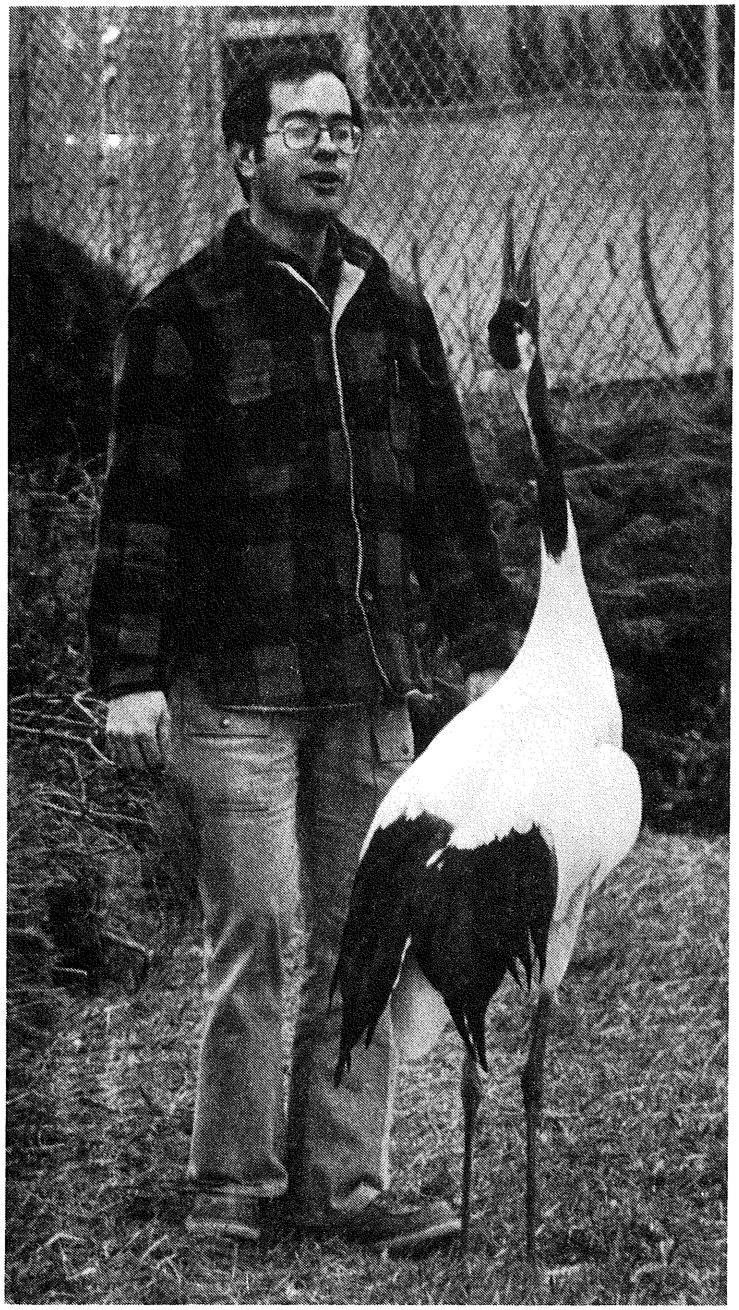
Another recent crane publication, Crane Research Around The World (48 articles, 260 pages, 55 photos) is available from International Crane Foundation, Route 1, Box 230C, Shady Lane Rd., Baraboo, WI 53913 for $17 in the United States or $20 if the mailing is to other nations.

The editors of the 1985 Proceedings thank the U.S. Fish and Wildlife Service and Platte River Whooping Crane Habitat Maintenance Trust for funding this publication. We especially thank Donna Narber and Teresa Block for typing.

On Thursday, December 4, 1986, Aransas National Wildlife Refuge manager Frank Johnson died in his sleep of a heart attack. The popular and well-known 54-year-old Johnson held the position of refuge manager at Aransas since 1973. Frank had been with the U. S. Fish and Wildlife Service since his graduation from Mississippi State University in 1954. He served as refuge manager at Wapanocca and Cape Romain refuges, then completed Departmental training and served in the Atlanta Regional Office for 6 years as a planner and acting assistant supervisor.

In his 13 years as manager at Aransas, Frank did much to further the recovery of whooping cranes. His amiable manner helped make thousands of whooping crane enthusiasts feel at home when they visited Aransas. Frank assisted in hosting the 1978 Crane Workshop and is co-author of a paper in this Proceedings.

Dr. James C. Lewis



Dr. Ronald T. Sauey (1948-1987) was a co-founder and a director of the International Crane Foundation. Active in research and conservation since 1972, Ron passed away January 7, 1987, after suffering a cerebral hemorrhage on Christmas Day. He will always be remembered for his comprehensive studies of the Siberian Cranes in India, which are eloquently described in his 1985 Ph.D. dissertation, The Range, Status, and Winter Ecology of the Siberian Crane, Grus leucogeranus. He received his doctorate degree from Cornell University, in Ithaca, New York. Ron was loved and repsected by many. His untimely death leaves a void that affects his many friends worldwide and the advance of the study and preservation of cranes.

George Archibald

TABLE OF CONTENTS

PAGE

PAGE

PAGE

MORTALITY OF CRANES AND WATERFOWL FROM POWERLINE COLLISIONS IN THE SAN LUIS VALLEY, COLORADO

WENDY M. BROWN, Idaho Cooperative Wildlife Research Unit, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, ID 83843.

RODERICK C. DREWIEN, Idaho Cooperative Wildlife Research Unit, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, ID 83843.

ELWOOD G. BIZEAU, Idaho Cooperative Wildlife Research Unit, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, ID 83843.

Abstract: Crane and waterfowl mortality from collisions with powerlines in the San Luis Valley, Colorado, was investigated during two spring and two fall periods of 1983-84. Powerline segments were searched for dead birds and cranes were observed as they flew over the lines. Factors contributing to the incidence of powerline strikes were analyzed. Sandhill cranes (*Grus canadensis tabida*), and particularly whooping cranes (*G. americana*), were more vulnerable to wire strikes than waterfowl. Juvenile cranes struck powerlines more frequently than adults ($p=0.001$). The incidence of collisions was influenced by the proximity of powerlines to roosting and feeding sites and by adverse weather conditions (fog, precipitation, and wind) which affected visibility and flight control ($p=0.001$). Evaluation of experimental modification of a 115 kv transmission line indicated that static wire removal substantially reduced strikes; however, in a limited study, static wire enlargement was not shown to reduce strikes. We recommend locating new powerlines at least 2.0 km from traditional roost and feeding sites, and investigating techniques of color marking static wires to increase visibility and minimize collisions at perennial problem locations.

1985 CRANE WORKSHOP PROCEEDINGS

The San Luis Valley in south-central Colorado is the major spring and fall migration stop for the Rocky Mountain populations of greater sandhill cranes and cross-fostered whooping cranes (Drewien and Bizeau 1974, 1978, Kauffeld 1981). These populations currently number 17,000-20,000 sandhill cranes and 30-35 whooping cranes. Cranes use the valley for 3-4 months annually, primarily from October through mid-November and mid-February through mid-April. The valley also provides important habitat for 8,000-10,000 Canada geese (*Branta canadensis*) and over 25,000 other waterfowl (M. Suthers, pers. comm.).

Barley, wheat, and potato farming are the primary land uses in the valley, and additional lands are converted annually to agriculture. Recently, several large power transmission lines and numerous distribution lines have been constructed to service the expansion of overhead sprinkler irrigation. Many power lines cross traditional crane and waterfowl concentration areas.

It is well established that powerline collisions are a source of avian mortality (Walkinshaw 1956, Cornwell and Hochbaum 1971, Drewien 1973, Krapu 1974, Stout and Cornwell 1976, Anderson 1978, Tacha et al. 1978, Malcom 1982, Brown et al. 1984). The potential effect of collision mortality on populations of rare and endangered species has been noted by Lee (1978), Thompson (1978), and Faanes (1983, Assessment of powerline siting in relation to bird strikes in the Northern Great Plains, Unpubl. Rept., Northern Prairie Wildl. Res. Cent., Jamestown, North Dakota. 90 pp). Since 1956, six powerline collisions resulting in injury or death of whooping cranes have been documented in the Wood Buffalo-Aransas population (J. Lewis 1985, Whooping crane mortality/injuries. Unpubl. Table. U. S. Fish and Wildlife Service, Albuquerque, N. M.). A minimum of eight cross-fostered whooping cranes in the Rocky Mountain population have struck powerlines since 1977. Seven of these were killed or incapacitated accounting for 39% of all known losses of fledged birds to date (unpubl. data, Id. Coop. Wildl. Res. Unit). Six of these line strikes occurred in the San Luis Valley.

This study was initiated to assess crane and waterfowl mortality from powerline collisions in the San Luis Valley, to evaluate factors which contribute to collisions, and to provide insight on how to reduce that mortality.

We thank G. Halvorson, U. S. Fish and Wildlife Service, Albuquerque, for obtaining funds and assisting with project initiation for fall 1983 studies. D. Walker substantially contributed to data collection and summary during fall 1983, and D. Kingery generally donated her time walking powerlines throughout the study. We especially appreciate the assistance, facilities, and equipment made available by M. Nail and staff of Alamosa-Monte Vista National Wildlife Refuge. We are grateful to San Luis Valley Rural Electric Cooperative, Inc., Public Service Company of Colorado, and Colorado Ute Electric Association, Inc. for their cooperation in modifying a transmission line and providing technical information. K. Reese assisted with statistical analysis, and helpful reviews of the manuscript were provided by S. Derrickson, and C. Rice. E. Myers typed the manuscript.

METHODS

Mortality Surveys

Powerline collision (strike) mortality data were collected during two spring (February-April) and two fall (October-November) periods 1983-84. Selected segments of electric transmission (69 and 155 kv) and distribution (7.2-24 kv) lines were thoroughly searched one or more times each season (Fig. 1). Weekly searches of 14 transects along 10 different powerlines were conducted during fall 1983. Supplemental information on strike mortality was provided by Alamosa-Monte Vista National Wildlife Refuge personnel.

The area searched under all lines included an adjoining strip approximately 30 m on each side of support poles. One or two observers walked a zig-zag pattern, or when terrain offered good visibility, an all terrain cycle or truck was used.

All dead birds, or parts thereof, found within the search area were considered strikes, including feather spots indicating a bird had hit the ground and left the area. For subsequent identification, all avian carcasses were marked with red enamel paint and numbered strips of orange flagging tape. Species, age, sex, type of injuries, carcass condition, and date of death were recorded when possible. Strike locations were plotted on maps and the surrounding habitat, approximate distance from roost and feeding sites, and recent weather conditions were noted.

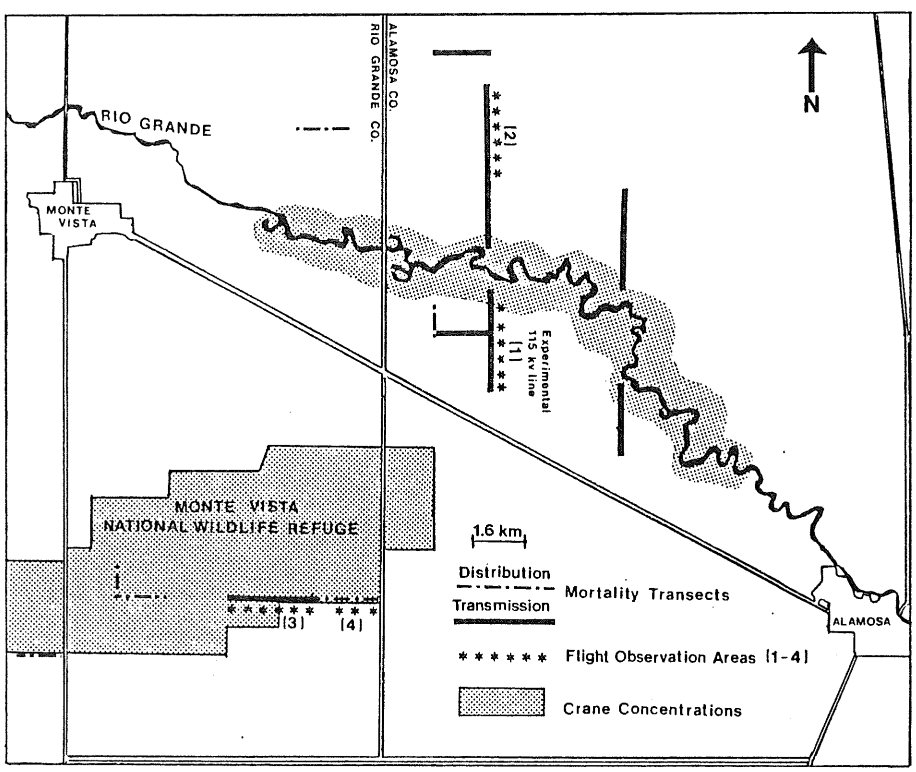


Fig. 1. Locations of major powerline transects for bird mortality surveys (two spring and two fall periods 1983-84) and bird flight observation areas (fall 1983) in the San Luis Valley, Colorado.

Experimental Modification of a 115 kv Transmission Line

A 3.2 km segment of 115 kv transmission line (Fig. 1) was experimentally modified and monitored through a cooperative effort by Colorado Ute Electric Association, Inc. (CUEA), the U. S. Fish and Wildlife Service (FWS), and Edison Electric Institute (EEI). We began intensive surveys of this line in March 1983, after a whooping crane with impact injuries was found nearby.

In an effort to reduce crane strikes, the static wire was experimentally removed in August 1983. The static wire is the nonconducting, topmost wire on a powerline used to minimize power outages from lightening strikes. It is normally smaller than the conductor, and appears to be the wire most often struck by birds in flight (Thompson 1978, Faanes 1983 loc. cit.).

In October, CUEA and FWS initiated thrice-weekly searches of the experimental segment for dead birds, and their effort continued throughout fall 1983 and spring 1984 (H. G. Laire. 1984, San Luis Valley - Waverly 115 kv transmission line - 1983, Unpubl. Rept., Colorado Ute Electric Association, Montrose). Their mortality data for these two periods are included in this paper.

In September 1984, cooperators with EEI experimentally replaced two spans (ca. 560 m) of static wire with standard 0.95-cm diameter wire, and two spans with 2.54-cm diameter self-damping wire to determine if the larger wire would be more visible to flying birds and thereby reduce collision frequency. The remaining nine spans were left without static wire. Using remote cameras, EEI contractors filmed crane flights over six experimental spans (T. Nelson, pers. comm.). We continued searches of the entire segment for dead birds.

Bird Flight Observations

Bird flight observations were made at four locations from 8 October-12 November 1983 (Fig. 1). Area 1 comprised a segment of the experimental 115 kv transmission line without static wire. It was situated immediately adjacent to and between heavily-used roost and feeding sites. Area 2 transected cropland feeding areas north of the Rio Grande River and represented a segment of the experimental transmission line with static wire intact. Areas 3 and 4 represented typical segments of 69 kv transmission and 7.2 kv distribution lines, respectively. Both separated a nearby roost on Monte Vista Refuge from feeding sites 3 km or more away.

Observations were made from vehicles, primarily at sunrise and sunset when large numbers of birds were moving to and from roosts. We attempted to gain supplemental observations when large groups of birds were flushed (wild flush) and during adverse weather.

During all observations the species, flock size, reaction distance, altitude above line, flight direction, and weather conditions were recorded for each flight. A flight was defined as a flock of birds, moving together without any break in the unit.

Data Analysis

Daily weather data were compiled from National Weather Service records in Alamosa. Wind speed, fog, and precipitation were considered potentially important to strikes due to their adverse effects on flight maneuverability and visibility. For the purposes of our analysis, weather for each day of the study period was classified as fair or foul. A foul weather day was one having fog, rain, snow, or wind exceeding an average of 32 km/hr for a 3 hour period.

The relationship between weather and bird strikes was determined using a Chi-square contingency table (Zar 1974). The proportion of fresh bird strikes found on foul weather days was compared to the proportion of foul weather days in the survey period. Chi-square analysis was also used to compare the proportion of juvenile sandhill crane strikes found with the proportion of juveniles in the population.

RESULTS

Mortality Surveys

During spring and fall 1983-84, 115 dead birds were found. Sandhill cranes were the most frequent mortalities (67.8%), followed by ducks (17.4%), Canada geese (7.0%), and whooping cranes (2.6%). Five other species (5.2%) were recorded (Table 1).

Table 1. Powerline strike mortality in the San Luis Valley, Colorado during spring and fall crane use periods 1983-84.

Season and line type	No. lines surveyed	Distance (km)	Species: Whooping crane	Sandhill crane	Canada geese	Ducks[a]	Other[b]	Total birds
Spring 1983								
Transmission	2	8.8	1	18	4	5	1	29
Distribution	2	2.4	0	5	1	4	1	11
Fall 1983								
Transmission	4	16.2	0	9	1	1	0	11
Distribution	6	6.0	0	3	0	0	0	3
Spring 1984								
Transmission	3	5.1	1	7	0	3	1	12
Distribution	12	4.8	1	15	0	0	2	18
Fall 1984								
Transmission	1	3.2	0	13	1	4	0	18
Distribution	2	3.2	0	8	1	3	1	13
Total			3	78	8	20	6	115

[a] Eleven mallards (Anas platyrynchos), 2 blue-winged teal (Anas discors), 1 green-winged teal (Anas crecca), 1 ruddy duck (Oxyura jamaicensis), and 5 unidentified.
[b] Two American coots (Fulcia americana), 1 great blue heron (Ardea herodias), 1 lesser yellowlegs (Tringa flavipes), 1 northern harrier (Circus cyaneus), and 1 horned lark (Eremophila alpestris).

In proportion to their abundance, whooping cranes were the most frequent casualties. The number of whooping cranes sighted in the San Luis Valley during 1983-84 ranged from 13-29. In addition to the three powerline kills documented during this period, two whooping cranes struck powerlines and survived. One was apparently unhurt; another sustained a fractured wing near Grand Junction, Colorado, was subsequently captured, its wing amputated, and transferred to Patuxent Wildlife Research Center in Maryland in May 1984. All but one of these five birds were juveniles.

Juvenile sandhill cranes collided with power lines far more frequently than adults (Chi-square = 72.98, 1 d. f., $p<0.001$). Age was determined for 43 crane strikes; 21 (48.8%) were juveniles. The mean percent juveniles in the San Luis Valley during 1983-84 was 9.9%.

Seventy birds (60.9%) were found under transmission lines and 45 (39.1%) under distribution lines. Relatively short sections of a few transmission lines accounted for most strikes; distribution line strikes were generally isolated incidents scattered throughout the valley.

Powerline distance from roost and feeding areas appeared critical to the incidence of strikes. Bird strikes were not found where the distance exceeded 1.6 km, whereas, 101 (87.8%) occurred where a line bordered or bisected a major use area and birds were taking off and landing in the immediate vicinity.

Experimental 115 kv Transmission Line

Fifty-four birds (36 cranes) were found under the 13 spans of experimental transmission line in four seasons. The highest number (25) was found in spring 1983. After removal of the static wire, strikes declined substantially during fall 1983 and spring 1984. When four spans of static wire were replaced in fall 1984, bird strikes increased to 18 (Fig. 2). Most strikes (12) occurred where either standard or experimental wire was present. The number of strikes/span of standard and experimental static wire were two and four, respectively. Only six strikes were found under the nine spans without a static wire (0.7 strikes/span).

Effect of Weather

Dates and existing weather conditions were identified for 29 crane strikes. Twenty strikes (69.0%) occurred on days with high winds, fog, or precipitation. By contrast, only 73 of 196 (37.2%) total survey days had foul weather. A highly significant proportion of collisions occurred during foul weather (Chi-square = 12.48, 1 d. f., p<0.001).

There was also a strong relationship between the proportion of foul weather days in each seasonal survey period and the number of strikes found per kilometer of powerline monitored (Fig. 3). Strikes kilometer of line ranged from 3.0-4.8 during spring 1983 and spring and fall 1984 surveys; foul weather occurred on 38-50% of the days during these periods. In contrast, we found only 0.6 strikes/kilometer of line during the exceptionally mild weather (15% foul weather days) of fall 1983 surveys.

Bird Flight Observations

We observed 1,694 crane flights over powerlines. Flocks of 1-4 and 5-20 birds occurred with about equal frequency, comprising 92.5% of all observations. Larger flocks usually occurred when birds were disturbed. Flocks of 21-50 made up 6.9%; flocks >50 comprised only 0.6%.

Most cranes (71%) reacted to powerlines by flaring and adjusting their altitude at some distance away, usually at 25-100 m. Altitude above the top wire was >6 m for 61.9% of all flights. Only two cranes were observed flying under the conductor wire; none between the conductor and static wire. No collisions were observed.

Reaction distance and altitude appeared directly related to distance from flight origin and destination. For example, despite removal of the static wire, Area 1 had the highest proportion of birds reacting at <25 m (44.9%) and the highest proportion crossing at 1-3 m above the line (Table 2). Area 1 is situated between immediately adjacent roost and feeding sites, and birds fly <0.8 km before crossing this transmission line. Altitude is normally low for short flight distances and cranes require considerable adjustment to clear the top wire (about 18 m high).

Reaction distance and altitude were greater at Area 2, despite presence of the static wire which increased height of the powerline to 22 m. Roost and feeding sites at this segment of line are separated by >2 km. Area 4, a small distribution line separating roost and feeding sites by >3.5 km had the fewest birds (11.1%) reacting at <25 m; most showed no reaction. Additionally, 77.9% of flights cleared the top wire by >6 m.

It was apparent that cranes' maneuverability and control are impaired by high winds; several near-collisons were observed. Cameramen for EEI also noted the detrimental effect of wind (EEI Crane Study, Unpubl. Rept.). Meaningful observations during fog and precipitation were difficult to obtain, because these conditions limited visibility for observers as well as birds.

Wild flushes were observed on two different occasions at Area 1. Both incidents resulted when a large group of cranes was disturbed by a farmer entering his adjacent field. Fifty-two flights involving a total of over 700 individuals were recorded; 37 flights (71.2%) reacted at <25 m; 4 (7.7%) of these reacted at <5 m, and 30 flights (55.7%) cleared the top wire by only 1-6 m. A third wild flush, during which four cranes struck the powerline, was filmed by EEI cameramen at Area 1.

DISCUSSION

Mortality Surveys and Flight Observations

Our surveys provide an index rather than a true measure of powerline mortality in the valley. Because of the large number of powerlines, it was impossible to monitor every potential problem site. Further, unrecorded crippling loss probably adds significantly to strike mortality. Anderson (1978) and Faanes (1983 loc. cit.) estimated their searches accounted for only 58% and 26% of mortality, respectively.

Our results indicate that cranes are more vulnerable to wire strikes than waterfowl, and whooping cranes more vulnerable than sandhills. This is undoubtedly related to the large size and low maneuverability of cranes, particularly whooping cranes. Thompson (1978) noted that large birds in flocks are especially susceptible to collisons. However, some bias towards large species is probably inherent in mortality searches, because smaller birds are more readily removed by scavengers or simply overlooked.

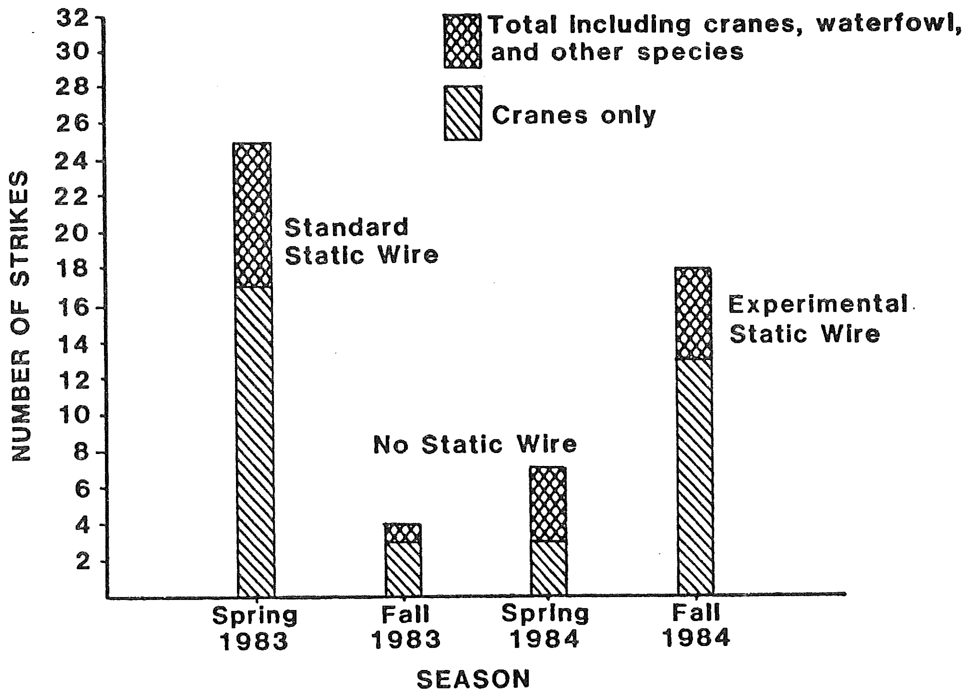


Fig 2. Number of bird strikes found beneath 13 spans of a 115 kv transmission line with experimental static wire modification during spring and fall crane concentration periods in the San Luis Valley, Colorado 1983-84.

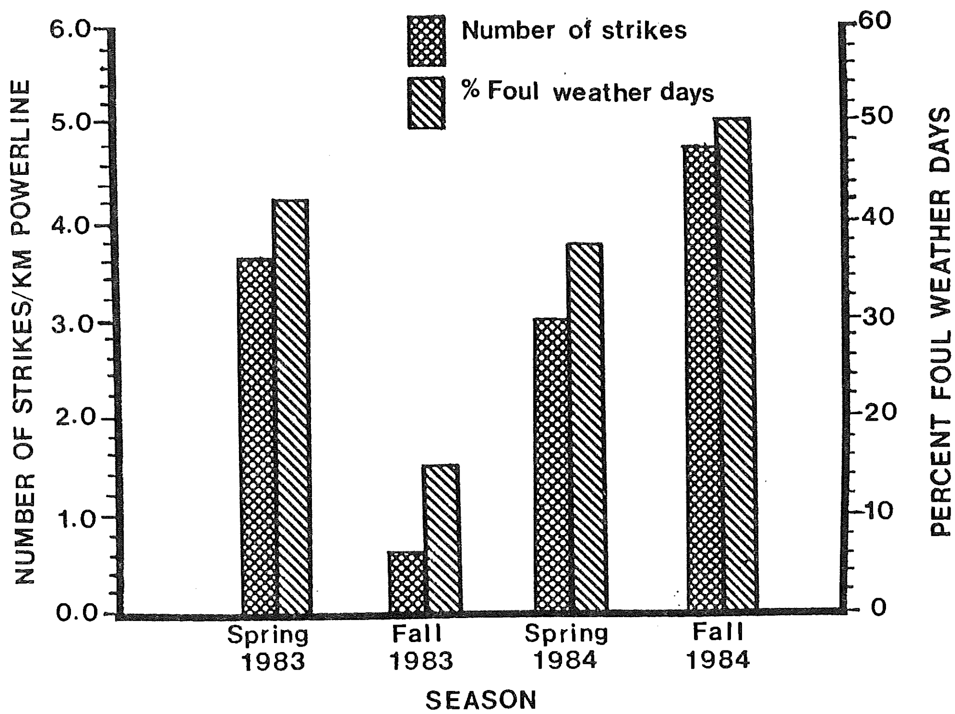


Fig. 3. Number of bird strikes found per kilometer of powerline and percent foul weather days during spring and fall crane concentration periods in the San Luis Valley, Colorado 1983-84.

Table 2. Reaction distance and altitude above line exhibited by cranes at four powerline study sites.

Observation area and powerline characteristics	No. flights observed	Reaction distance (m) and percent of observations				Distance (m) above line and percent of observations				
		<5	5-25	25-100	>100 or no reaction	Under	<1	1-3	3-6	>6
1 115 kv without static wire	463	0.9	44.9	41.7	12.5	0.2	0.0	6.5	39.3	54.0
2 115 kv with static wire	311	0.3	28.3	43.4	28.0	0.0	0.0	4.5	37.6	57.9
3 69 kv	353	0.0	27.2	46.2	26.6	0.0	0.0	2.6	42.2	55.2
4 7.2 kv distribution	515	0.1	11.1	41.0	47.8	0.2	0.0	3.1	18.8	77.9

Our results indicate that juvenile cranes strike powerlines more frequently than adults ($p<0.001$). Young birds lack flight experience and are no doubt less agile; they also lack familiarity with the area and its obstacles. Most researchers agree that these factors influence strike mortality (Thompson 1978). The proportion of juveniles in the cross-fostered whooping crane flock ranged from 35.7-59.4% during 1983-84 surveys, a factor which probably contributed to the high mortality of this species.

Although the magnitude of mortality from powerlines is unlikely to affect thriving populations of sandhill cranes and waterfowl in the valley, the impact on endangered species may be biologically significant (Lee 1978, Thompson 1978, Faanes 1983 loc. cit.). In the circumstance of cross-fostered whooping cranes, high juvenile mortality from powerline collisions impedes the buildup of a mature bird population necessary for intraspecies interaction and pair-bond formation.

Strikes occurred at both transmission and distribution lines, but were concentrated where transmission lines bordered heavy use areas. In equivalent locations, transmission lines are probably more hazardous than distribution lines because of their greater height.

Proximity of powerlines to roost and feeding sites appears most critical. No strikes were found >1.6 km from a roost or feeding site; most strikes occurred where at least one of these two habitats was adjacent to the line. Bird flight observations demonstrated that reaction distance and altitude are most reduced where a powerline separates two closely adjacent use-areas. The frequency of collisions increases because bird concentrations are high in such areas and frequent low-level flights are made across the line. Faanes (1983 loc. cit.) also found that interspersion of habitats at powerlines was important to the magnitude of mortality.

Inclement weather was a primary factor influencing the frequency of crane strikes at problem locations. The overall relationship between foul weather and strikes was highly significant ($p<0.001$) However, our sample size was insufficient to partition the individual effects of high winds, fog, or precipitation for statistical analysis.

The apparent increased vulnerability of cranes to wire collisions during inclement weather or poor visibility has been previously noted by Walkinshaw (1956), Wheeler (1966), Nesbitt and Gilbert (1976), and Tacha et al. (1978). Measures to increase visibility of problem lines are especially needed in the San Luis Valley, because adverse weather is common during crane-use periods. Increased strike mortality during inclement weather has been reported for other species by Scott et al. (1972) and Lee (1978), however, researchers were unable to establish a definitive relationship between fog and increased mortality of gulls and waterfowl in an Oregon powerline study (James, B. W., and B. A. Haak. 1979. Factors affecting avian flight behavior and collision mortality at transmission lines. Unpubl. Rept., Bonneville Power Admin., Portland).

Observations also indicated that strikes are likely to occur when birds are flushed near powerlines. Feeding sites in the valley are primarily agricultural fields with easy access by county roads, affording ample opportunity for human disturbance.

Experimental Transmission Line

Because of its location between adjacent, heavily used roost and feeding sites, the experimental line (Fig. 1) presents the greatest hazard of any powerline studied. However, results indicate that static wire removal significantly reduced mortality. Strikes declined markedly after the static wire was removed from the experimental segment (13 spans) in fall 1983, and increased only slightly during the adverse weather of spring 1984. When four spans of static wire were replaced in fall 1984, the number of strikes in the experimental segment increased substantially. Furthermore, 67% of strikes in the experimental segment occurred under spans where static wire (standard and enlarged) was present, whereas, these spans constitued only 31% of the total experimental area. Similarly, a study in Oregon reported 35% and 69% reduction in avian mortality after static wire removal at two sites (Beaurlaurier, D. L. 1981. Mitigation of bird collisions with transmission lines. Unpubl. Rept., Bonneville Power Admin., Portland). Faanes (1983 loc. cit.) estimated static wire removal could reduce strikes by 80% at one site in North Dakota.

Although larger samples are needed for statistical evaluation, preliminary results obtained in fall 1984 suggest that the enlarged static wire was much less effective than static wire removal in preventing collisions. Because of the small sample size, it is impossible to analyze the difference in the number of strikes found beneath standard and enlarged static wire (4 and 8 birds, respectively), however, the results certainly suggest that the enlarged static wire represented no improvement.

These preliminary findings do not support the hypothesis posed by Thompson (1978) and Faanes (1983 loc. cit.) that increasing the size of static wire should reduce mortality. It may be that larger size alone does not sufficiently increase visibility under variable light conditions. The dark, non-specular wire used in this study shows up well against overcast skies, but is less visible on sunny days because it fails to reflect light (Thompson 1978).

Color-marking the static wire may have more potential. Beaulaurier (1981 loc. cit.) summarized the results of 17 studies and found that marking powerlines with colored devices such as orange aviation marker balls, black and white ribbons, and luminous tape reduced avian mortality by an average of 45%. Similarly, installation of various yellow marking devices reduced powerline mortality of red-crowned cranes (G. japonensis) by about 43% in Japan (from 60% of total deaths to 34%, Yamaguchi, M. 1984, Letter to Chief, Endangered Species, Region 2. U. S. Fish and Wildlife Service).

RECOMMENDATIONS

Construction of new transmission lines within 2 km of traditional roost or feeding sites should be avoided. Under no circumstances should new transmission or distribution lines divide adjacent, heavily-used roost and feeding sites. New distribution lines needed in critical crane-use areas might be buried underground; this is technically feasible and in some situations less expensive than overhead construction (Thompson 1978).

Line modification or other measures to reduce mortality are needed where powerlines are already present in critical areas. Habitat modification to discourage crane use of hazardous areas seems unlikely on private lands. However, education of the local public regarding the danger of frightening birds near powerlines might reduce strikes caused by wild flushes. Static wire removal has been demonstrated to reduce mortality in this and other studies and should be employed when possible. However, because static wire removal increases the probability of lightening-caused power outages, other means of static wire modification should be explored. Comparative studies of the enlarged static wire with technically and economically feasible color marking devices are needed so that effective modification can be made at specific, critical areas where strikes perennially occur.

LITERATURE CITED

Anderson, W. L. 1978. Waterfowl collisions with power lines at a coal-fired power plant. Wildl. Soc. Bull. 6:77-83.

Brown, W. M., R. C. Drewien, and D. L. Walker. 1984. Crane flight behavior and mortality associated with power lines in the San Luis Valley, Colorado. For., Wildl., and Range Exper. Sta., Univ. Idaho, Moscow. 16 pp.

Cornwell, G., and H. A. Hochbaum. 1971. Collisions with wires--a source of anatid mortality.

Wilson Bull. 83:305-306.

Drewien, R. C. 1973. Ecology of Rocky Mountain greater sandhill cranes. Ph.D. dissertation, Univ. Idaho, Moscow. 152 pp.

_____, and E. G. Bizeau. 1974. Status and distribution of greater sandhill cranes in the Rocky Mountains. J. Wildl. Manage. 38:720-742.

_____, and _____. 1978. Cross-fostering whooping cranes to sandhill crane foster parents. Pages 201-222 in S. A. Temple, ed. Endangered birds: management techniques for preserving threatened species. Univ. Wisconsin, Madison.

Kauffeld, J. S. 1981. Management of migratory crane habitat on Alamosa and Monte Vista National Wildlife Refuges. Pages 117-121 in J. C. Lewis, ed. Proceedings 1981 crane workshop. Natl. Audubon Soc., Tavernier, Florida.

Krapu, G. L. 1974. Avian mortality from collisions with overhead wires in North Dakota. Prairie Nat. 6:1-6.

Lee, J. M. 1978. Effects of transmission lines on bird flights: studies of Bonneville Power Administration Lines. Pages 93-116 in M. L. Avery, ed. Impacts of transmission lines on birds in flight. U. S. Fish and Wildl. Serv., Washington, D. C.

Malcom, J. M. 1982. Bird collisions with a power transmission line and their relation to botulism at a Montana wetland. Wildl. Soc. Bull. 10:297-304.

Nesbitt, S. A., and D. T. Gilbert. 1976. Power line and fence hazards to birds. Fla. Nat. 29:23.

Scott, R. E., L. J. Roberts, and C. J. Cadbury. 1972. Bird deaths from powerlines at Dungeness. British Birds 65:273-286.

Stout, J., and Cornwell, G. W. 1976. Nonhunting mortality of fledged North American waterfowl. J. Wildl. Manage. 40:681-693.

Tacha, T. C., D. C. Martin, and C. G. Endicott. 1978. Mortality of sandhill cranes associated with utility highlines in Texas. Pages 175-176 in J. C. Lewis, ed. Proceedings 1978 crane workshop. Natl. Audubon Soc., New York.

Thompson, L. S. 1978. Mitigation through engineering and habitat modification. Pages 51-92 in M. L. Avery, ed. Impacts of transmission lines on birds in flight. U. S. Fish and Wildl. Serv., Washington. D. C.

Walkinshaw, L. H. 1956. Sandhill cranes killed by flying into a powerline. Wilson Bull. 68:325-326.

Wheeler, R. H. 1966. Sandhill cranes casualties in the blizzard of March 2, 1966. Nebr. Bird Rev. 34:69-70.

Zar, J. H. 1974. Biostatistical analysis. Prentice-Hall, Inc. Englewood Cliffs, New Jersey 620 pp.