

Raptor Electrocutions and Outages – A Review of Rural Utility Records spanning 1986-1996

Richard E. Harness and Kenneth R. Wilson

ABSTRACT

Raptor mortality records spanning the years 1986 through 1996 were gathered from 58 electric utilities located in the western United States. These 1,450 records were reviewed to determine the types of utility structures causing outages and placing raptors at risk. The most commonly reported species electrocuted were eagles, with Golden Eagles *Aquila chrysaetos* reported 2.3 times more frequently than Bald Eagles *Haliaeetus leucocephalus*. Juvenile eagles were reported more frequently than adult birds. Eagle mortality was detected at an elevated rate during the late winter. Red-tailed Hawks *Buteo jamaicensis* and Great Horned Owls *Bubo virginianus* were the most commonly reported hawk and owl species. Hawk and owl electrocutions resulting in electric outages were elevated in the late summer. Six hundred and forty-six raptor deaths were tied to specific utility construction units. These data suggest that although transformers are relatively rare on rural overhead distribution systems, they are associated with most rural electric raptor electrocutions. Three-phase transformer banks were associated with a disproportionate number of detected electrocutions. These units are particularly lethal to raptors because of minimal phase-to-phase and phase-to-ground separation between bare energized jumper wires connecting transformers, protective cutouts and surge arresters. Three-phase transformer banks may also be dangerous because they often serve irrigation pumps located in remote areas likely to support numerous raptors.

INTRODUCTION

Distribution powerline raptor electrocutions have been studied extensively since 1971. Numerous methods to modify powerline structures to eliminate the potential for electrocutions and outages have been developed, published, and utilized by the electric industry. Two recent publications, *Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1996* and *Animal-Caused Outages* have provided utilities with numerous construction alternatives to minimize animal electrocutions and outages. Some of the modified overhead distribution line construction units have been adopted as standards by utilities, dramatically reducing raptor electrocutions. However, despite the utility construction improvements some electrocutions persist. These electrocutions often cause outages resulting in damaged equipment, safety problems and loss of service to consumers.

A 1993 Institute of Electrical and Electronics Engineers, Inc. (IEEE) survey stated the majority of their respondents still experience outages caused by squirrels, birds, raccoons and snakes (IEEE Power Engineering Society 1993). Southern Engineering Company (SC&E) recently surveyed 560 electric utilities nationwide to determine where and how outages occur. According to their survey results, animals are the third leading identifiable cause of all power outages, and birds cause more outages than any other animal (Southern Engineering Company 1996). According to the surveyed utilities, raptors and other birds were the number one cause of transmission outages in the Western United States. The respondents also indicated that birds were the most frequently reported cause of substation outages. Detroit Edison (1997) reported 255 animal caused substation outages and 39 bird caused outages between 1987 to 1994. Historically, 186 (27%) of Detroit Edison's 688 substations experienced one or more animal or bird caused outages in the past ten years. Historically, animals are the second greatest cause of all Edison's substation outages and animal outages have been increasing from 1987 to 1994. Although most of these outages were momentary, approximately 25% were sustained, resulting in lost revenue and consumer confidence. Georgia Power Company (1998) reported that animal caused substation outages on their system last an average 50.62 minutes and cost \$15,000 (U.S.) each.

JUSTIFICATION

Reducing electrocutions will result in reduced outages, representing an opportunity to gain a competitive edge by reducing operating and maintenance costs. When utilities have a better understanding of which construction units cause most animal electrocutions, they will also be able to optimize their resources to mitigate the electrocutions. Since United States Federal law protects all birds-of-prey, successful research and development directed at mitigating animal-caused outages would have environmental benefits. The main laws employed by the United States Fish and Wildlife Service (USFWS) to protect raptors from electrocutions and wire strikes are the Migratory Bird Treaty Act (MBTA), Bald and Golden Eagle Protection Act and the Endangered Species Act (ESA). A proactive approach would also address pressures that may inevitably be aimed at electric utilities by environmental groups.

METHODS

Raptor mortality records spanning the years 1986 through 1996 were gathered from 58 electric utilities located in the western United States. The records provided data on 1,450 raptor deaths. These records were reviewed to determine the number of outages and types of utility structures potentially placing raptors at risk. Fifty-eight electric utilities located in the western United States provided 1,366 records. Wildlife rehabilitators and the USFWS provided 38 accounts. Additional records (n = 131) were obtained from Canada, and falconers provided 22 records.

RESULTS

Species Electrocuted

Twenty-six different electrocuted species of North American raptors are reported in the scientific literature (APLIC 1996). Sixteen species were recorded in this study, spanning in size from small American Kestrels *Falco sparverius* to Bald Eagles *Haliaeetus leucocephalus*. Non-raptor electrocuted species included a Sandhill Crane *Grus canadensis*, Great Blue Heron *Ardea herodias* and Common Ravens *Corvus corax*. Wildlife rehabilitators located in Texas and New Mexico reported one Brown Pelican *Pelecanus occidentalis*, and four Franklin's Gull *Larus pipixcan* electrocutions. Powerline collisions were also recorded for a Sandhill Crane and swan (species unknown). Table 1 tabulates the raptor electrocutions using six taxonomic groups; eagle, hawk, falcon, owl, osprey and vulture.

Table 1. Summary of all detected raptor electrocutions from 1986-1996.

<i>Taxonomic Groups</i>	<i>Electrocutions</i>
Eagle Total	748
Hawk Total	278
Falcon Total	14
Owl Total	344
Osprey Total	11
Vulture Total	18
Unidentified Raptors	15
Total	1,428

The most frequently reported raptors were eagles ($n = 748$). Golden Eagles *Aquila chrysaetos* are historically electrocuted more frequently than any other North American bird of prey (APLIC 1996). This study documented 272 Golden Eagle and 118 Bald Eagle electrocutions. Golden Eagle juveniles ($n = 44$) were electrocuted 2 times more frequently than adults ($n = 22$). Bald Eagle juveniles ($n = 15$) were electrocuted 1.6 times more frequently than adults ($n = 9$).

This study also tabulated 278 confirmed hawk electrocutions, mainly represented by buteos. The most frequently electrocuted species were Red-tailed Hawks *Buteo jamaicensis* ($n = 35$). Similarly, the most common hawk species to interact with power facilities in the Salt River Project's Avian Protection Program near Phoenix, Arizona were buteos; Harris' Hawks *Parabuteo unicinctus* and Red-tailed Hawks (Nobel 1995).

Although buteos comprise the largest non-eagle group of electrocutions (APLIC 1996), this study collected 344 owl electrocutions, surpassing the 278 hawk records. Historically, Great Horned Owls *Bubo virginianus* have been the most commonly electrocuted North American nocturnal raptor (Olendorff *et al.* 1981). Great Horned Owls were the most commonly electrocuted raptor on Salt River Project's power facilities located in Phoenix, Arizona (Nobel 1995). Likewise, Great Horned Owls ($n = 86$) were the most commonly reported nocturnal raptor in this study. Great Horned Owls may be more vulnerable, because of their large size and ability to thrive in urban areas with greater concentrations of overhead powerlines.

Seasonal Mortality

One-thousand one-hundred and forty-six of the 1,428 confirmed electrocution records included either a carcass discovery ($n = 735$) or precise electrocution ($n = 411$) date. Eighty-two percent of the precise raptor electrocution dates were tied to power outages.

There were 612 eagle electrocution outage ($n = 96$) and carcass discovery ($n = 516$) dates (Figure 1). Most detected eagle mortality and outages noted in this report occurred January, February, March and April. March carcass detections ($n = 136$) were disparately greater than any other month. Most eagle electrocutions ($n = 516$) were not tied to outages and therefore did not define precise electrocution dates. Therefore, it is possible that many eagles detected in March were actually killed in previous months. The carcasses may have avoided detection until spring thaws when utility crews became more active, especially in remote areas. Winter carcass detections may also be greater because cold temperatures delay the decaying process. Scavenging pressure may also be less in winter.

A late summer increase in the number of electrocuted hawks and owls was noted in this study. There were 210 hawk electrocution outage and carcass discovery dates (Figure 2) and 273 owl electrocution outage and carcass discovery dates (Figure 3). July, August and September had twice as many hawk deaths as any other month. Non-outage hawk mortality, not coinciding with the actual time-of-death, was similarly highest in September. Forty-seven percent of the 182 owl outage electrocutions also occurred in late summer months, peaking in August ($n = 26$). The elevated mortality in this study may similarly have been due to increased numbers of inexperienced fledgling birds since temperate breeding raptors often fledge during the late summer (Newton 1979). In a study of urban Harris' Hawks in Tucson, Arizona, Dawson and Mannan (1995) reported that birds at some nests are particularly susceptible to electrocution during the initial 2 weeks after fledging.

Figure 1. Eagle electrocution monthly mortality 1986-1996

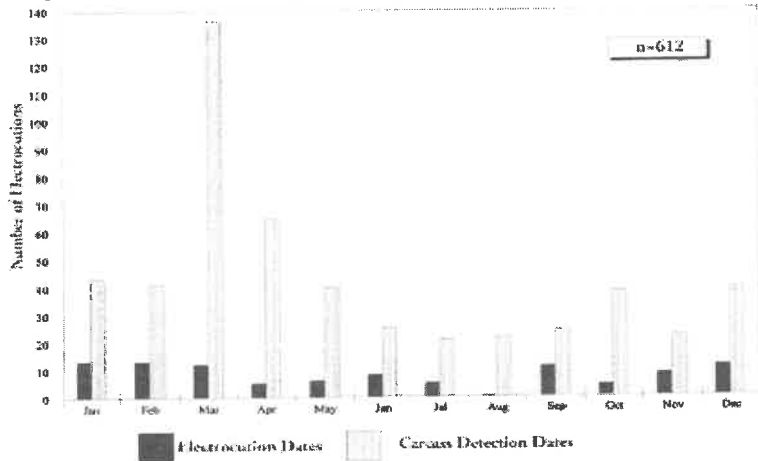


Figure 2. Hawk electrocution monthly mortality

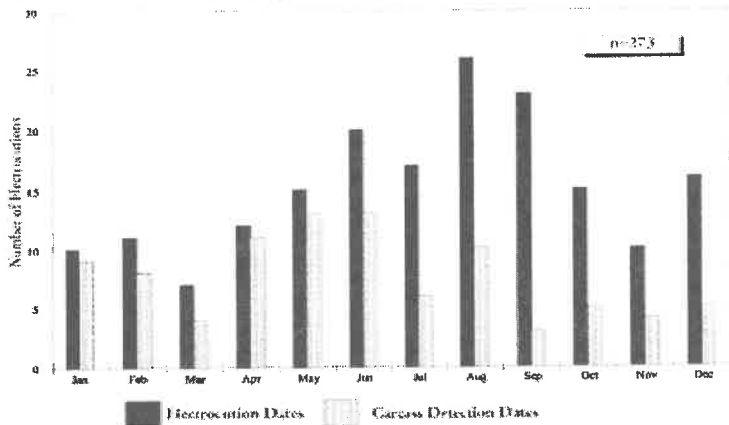
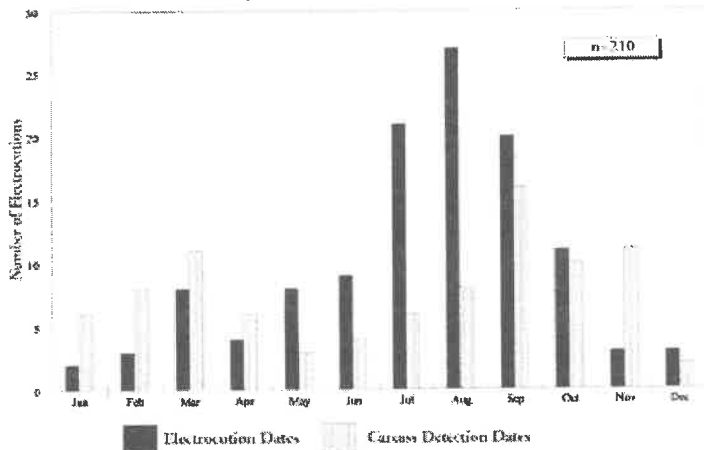


Figure 3. Owl electrocution monthly mortality

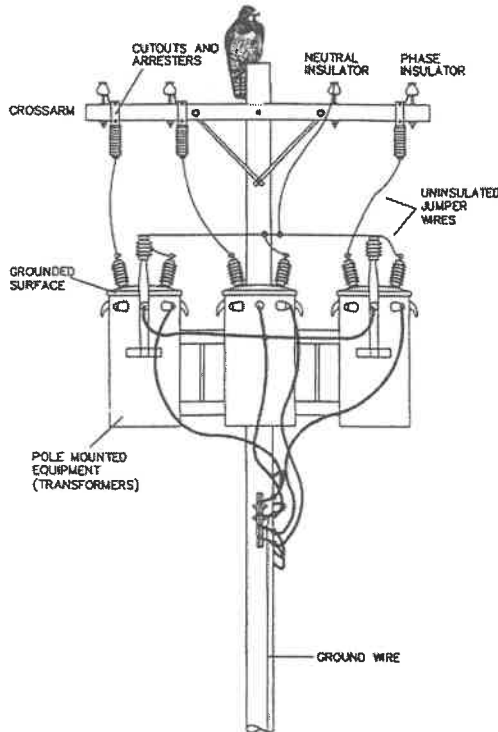


Structure Comparisons

Six hundred and forty-six raptor deaths were tied to specific utility construction units. These data suggest that although transformers are relatively rare on rural overhead distribution systems they are associated with most rural electric raptor electrocutions (Harness 1997). An urban study of Harris' Hawks in Tucson, Arizona also recorded more electrocutions by transformers than any other unit (Dawson & Mannan 1995). Dedon and Colson (1987) reported that Pacific Gas and Electric (PG&E) troublemen indicate that most PG&E electrocutions are also associated with incidental wiring and hardware on pole equipment (e.g. transformers, capacitors, etc.).

Most raptor electrocutions in this study were recorded at three-phase transformer banks (Figure 4). This is significant because three-phase transformer banks ($n = 125$) show comparable mortality rates to single phase transformers ($n = 109$) even though the number of three phase banks in rural areas is much lower. Rural multi-phase transformer banks often serve remote irrigation or oil pumps and may be particularly harmful, because they are often situated near open agricultural fields likely to support numerous raptors. These units are particularly lethal to raptors because of minimal phase-to-phase and phase-to-ground separation between bare energized jumper wires connecting transformers, protective cutouts and surge arresters.

Figure 4. Typical three-phase rural distribution structure with three-phase transformer.



DISCUSSION AND RECOMMENDATIONS

Each year animals cause a significant number of outages on overhead distribution lines. PacifiCorp recently reported an average of 346 annual system outages from 1986 through 1995 caused by large perching birds (PacifiCorp, unpubl. data). Pacific Gas and Electric Company (PG&E) reported that 8 % of all their overhead outages from 1979 through 1983 were also due to birds (Dedon & Colson

1987). Some PG&E districts reported as many as 23 % of their outages were due to birds. Starlings *Sturnus vulgaris* and Blackbirds flocking in late fall and early winter primarily caused these outages.

Unfortunately the total number of outages caused by raptors and other animals is predicted to be large but cannot be estimated with current information. Although some utilities record and report all documented electrocutions, many do not because they are not required to do so. In addition, the few utilities that voluntarily keep records of the cause of all outages often have incomplete reporting. There is also no standardized raptor electrocution reporting form. The forms vary to meet the participating utilities' needs.

The use of automatic reclosers on rural electric powerlines further reduces the potential for detecting electrocutions. Reclosers automatically clear most short duration faults on primary conductors without tripping a fuse. Because the lines reenergize within seconds, outages are avoided and line crews are not required to investigate the service interruption causes. Electronic equipment and computers are sensitive to transient "blinks" due to recloser operations. Therefore, power quality suffers from even these momentary outages.

The data in this report indicate that an emphasis on providing insulated jumpers on all electrical equipment and at tap and deadend locations should reduce outages and provide the greatest amount of protection for all raptor species, including eagles. Fortunately, transformer units can be raptor-proofed without making major structural changes. The amount of exposed energized hardware can be dramatically reduced on new transformer installations by using 600 volt insulated jumper wire and installing insulated bushing covers. Existing transformer units can be retrofitted by either replacing bare wire with 600 volt insulated jumpers or by sliding insulating material over bare jumpers. Several utility manufacturers produce insulating material constructed with an open seam, allowing it to be easily slipped over existing bare conductors. Because the insulating material and bushing covers are relatively inexpensive and easy to install, this option is also economically attractive compared to increasing separation between conductors. Increased phase separation should continue to be used in remote areas with eagle populations.

All utilities should be encouraged to report raptor electrocutions/outages annually on a standardized form. The form should include detailed information on the types of construction units contacted and address the presence or absence of existing raptor-proofing on structures contacted. This knowledge would provide an indication as to what sorts of mitigating measures are working or failing. Recording measurements from the electrocuted raptor would also help determine clearances required to mitigate raptor electrocutions. Wildlife biologists should aid utility personnel with raptor species identification, and necropsies should be performed whenever possible to rule out other causes of mortality. These data should be compiled and shared annually. An observational study designed to monitor distribution line raptor electrocutions would also help determine if information contained in the outage reporting forms is representative of electrocutions detected.

Utilities should also actively look for electrocutions on their systems. Utilities annually inspect a percentage of the wood poles in their service territory to determine if they are deteriorating. Searching for raptor carcasses should be combined with ongoing pole inspection programmes to identify problem areas.

Promising protective methods and devices have recently been developed to mitigate electrocutions and outages. Unfortunately, insufficient data are available to assess their effectiveness. Documentation on existing protective methods and devices is also quite limited and there are minimal data on their relative cost-effectiveness. Research should be conducted to determine the effectiveness of these devices.

ACKNOWLEDGMENTS

Electrical Systems Consultants, Inc funded this study. Jerry Hager was especially helpful with the technical details of this study. Dennis Rankin of the Rural Utilities Service, Monte Garrett of PacifiCorp, and Sam Milodragovich of Montana Power Company were invaluable in their assistance with gathering raptor electrocution data.

I am especially indebted to my committee members, Dr. Ken Wilson, Dr. Pat Kennedy and Dr. Denis Dean for enthusiastically supporting my work while taking the time to learn the difference between "telephone" and "power" poles. Ken Wilson and Dave Smith were indispensable with their statistical advice. I also thank my wife Sue and my two sons, Chris and Dan, for tolerating many side trips on family outings to scout electrocuted raptor carcasses.

REFERENCES

- OLENDORFF, R. R., A.R ANSELL, M.G GARRETT, R.N. LEHMAN & A.D. MILLER 1996.** *Suggested Practices for Raptor Protection on Powerlines: The State of the Art in 1996.* Avian Power Line Interactions Committee (APPLIC). Edison Electric Institute/Raptor Research Foundation. Washington D.C.
- DAWSON, J.W. & R.W. MANNAN 1995.** Electrocution as a mortality factor in an urban population of Harris' hawks. *The Journal of Raptor Research* 29:1-55.
- DEDON, M.F. & E.W. COLSON 1987.** *Bird-caused outages in the PG&E electrical distribution system.* Pacific Gas and Electric Company.
- DETROIT EDISON 1997.** Substation maintenance in 2000 – substation animal intrusion. T&D Management Conference – April 1997, Lansing, Michigan.
- GEORGIA POWER 1998.** Wildlife proofing to prevent animal- caused outages in substations. EPRI Transmission & Substation with Distribution Systems Targets Conference on Wildlife and Pest Control in Transmission Systems – April 1998. Scottsdale, Arizona.
- HARNESS, R.E. 1997.** Raptor Electrocutions caused by rural electric distribution powerlines. M.S. Thesis, Colorado State University, Fort Collins, Colorado.
- IEEE POWER ENGINEERING SOCIETY 1993.** *IEEE guide for animal deterrents for electric power supply substations.* Institute of Electrical and Electronics Engineers, Inc., New York.
- NEWTON, I. 1979.** *Population ecology of raptors.* Buteo Books, Vermillion, South Dakota.
- NOBEL, T.A. 1995.** Salt River Project's Avian Protection Program. *The Journal of Raptor Research* 29: 64.
- OLENDORFF, R.R., A.D. MILLER & R.N. LEHMAN 1981.** Suggested practices for raptor protection on powerlines: the state of the art in 1981. Raptor research report no. 4. Raptor Research Foundation, University of Minnesota, St. Paul, Minnesota.
- SOUTHERN ENGINEERING COMPANY. 1996.** Animal-caused outages. Electric Power Research Institute, National Rural Electric Cooperative Association. Arlington, Virginia.

Richard Harness
Environmental Specialist
EDM International
4001 Automation Way
Fort Collins, Colorado 80525
USA

Dr. Kenneth Wilson
Colorado State University
Department of Fishery and Wildlife Biology
135 Wagar
Fort Collins, CO 80523
USA

