Suggested Practices for Avian Protection On Power Lines:

The State of the Art in 2006

PIER FINAL PROJECT REPORT CEC-500-2006-022

EDISON ELECTRIC INSTITUTE

Avian Power Line Interaction Committee

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Prepared by:

Avian Power Line Interaction Committee

EDISON ELECTRIC INSTITUTE

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PURPOSE AND USE OF THE PUBLICATION

In the early 1970s, an investigation of reported shootings and poisonings of eagles in Wyoming and other western states led to evidence that eagles were also being electrocuted on power lines. Since then, the utility industry, wildlife resource agencies, conservation groups, and manufacturers of avian protection products have worked together to understand the causes of raptor electrocution and to develop and implement solutions to the problem. Those efforts have improved our understanding of the biological factors that attract raptors and other birds to power lines, and the circumstances that lead to avian electrocutions.

This publication, *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006*, summarizes the history and success of over three decades of work. It springs from three previous editions of *Suggested Practices for Raptor Protection on Power Lines*, and has been expanded and updated to assist those concerned with complying with federal laws, protecting and enhancing avian populations, and maintaining the reliability of electric power networks.

THE ISSUE

Discoveries of large numbers of electrocuted raptors in the early 1970s prompted utilities and government agencies to initiate efforts to identify the causes of and develop solutions to this problem. Literature from the 1980s and 1990s continued to document electrocutions of raptors throughout the world. Now, reports of electrocutions of birds other than raptors are appearing in the literature and the impacts of avian interactions on power reliability are becoming more evident.

REGULATIONS AND COMPLIANCE

Three federal laws in the United States protect almost all native avian species and prohibit "taking," or killing, them. The Migratory Bird Treat Act protects over 800 species of native, North American migratory birds. The Bald and Golden Eagle Protection Act provides additional protection to both bald and golden eagles. The Endangered Species Act applies to species that are federally listed as threatened or endangered. Utilities should work with the U.S. Fish and Wildlife Service and their state resource agency(ies) to identify permits and procedures that may be required for nest management, carcass salvage, or other bird management purposes.

BIOLOGICAL ASPECTS OF AVIAN ELECTROCUTION

Bird electrocutions on power lines result from three interacting elements: biology, environment, and engineering. The biological and environmental components that influence electrocution risk include body size, habitat, prey, behavior, age, season, and weather.

Of the 31 species of diurnal raptors and 19 species of owls that regularly breed in North America, 29 have been reported as electrocution victims. Electrocutions have also been reported in over 30 non-raptor North American species, including crows, ravens, magpies, jays, storks, herons, pelicans, gulls, woodpeckers, sparrows, kingbirds, thrushes, starlings, pigeons, and others.

SUGGESTED PRACTICES: POWER LINE DESIGN AND AVIAN SAFETY

Avian electrocutions typically occur on power lines with voltages less than 60 kilovolts (kV). Electrocution can occur when a bird simultaneously contacts electrical equipment either phase-to-phase or phase-to-ground. The separation between energized and/or grounded parts influences the electrocution risk of a structure. Electrocution can occur where horizontal separation is less than the wrist-to-wrist (flesh-to-flesh) distance of a bird's wingspan or where vertical separation is less than a bird's length from head-to-foot (flesh-to-flesh). In this document, 150 cm

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(60 in) of horizontal separation and 100 cm (40 in) of vertical separation are recommended for eagles. Utilities may choose to adopt these recommendations or modify their design standards based on the species and conditions at issue.

Single-phase, two-phase, or three-phase configurations constructed of wood, concrete, metal, fiberglass, or other materials can pose avian electrocution risks if avian-safe separation is lacking. In particular, structures with transformers or other exposed, energized equipment account for a disproportionate number of avian electrocutions.

Both avian-safe new construction and retrofitted existing structures should be used to reduce avian electrocution risk. The principles of *isolation* and *insulation* should be considered when designing or retrofitting structures. *Isolation* refers to providing adequate separation to accommodate avian use of structures and should be employed where new construction warrants avian-safe design. *Insulation* refers to covering exposed energized or grounded parts to prevent avian contacts. Although equipment that is covered with specifically-designed avian protection materials can prevent bird mortality, it should not be considered insulation for human protection.

PERCHING, ROOSTING, AND NESTING OF BIRDS ON POWER LINE STRUCTURES

In habitats where natural nest substrates are scarce, utility structures can provide nesting sites for raptors and other birds. Likewise, many birds use power poles and lines for perching, roosting, or hunting.

Bird nests on utility structures can reduce power reliability. Nest management, including the design and installation of platforms on or near power structures, can enhance nesting while minimizing the risk of electrocution, equipment damage, and loss of service. Utilities are encouraged to collect data on bird-related outages to quantify the impacts of birds on power systems, and to develop measures for preventing bird mortalities and their associated outages.

DEVELOPING AN AVIAN PROTECTION PLAN

In 2005, the Avian Power Line Interaction Committee and the U.S. Fish and Wildlife Service announced their jointly developed Avian Protection Plan Guidelines (Guidelines) that are intended to help utilities craft their own avian protection plans (APPs) for managing avian/power line issues. An APP should provide the framework necessary for implementing a program to reduce bird mortalities, document utility actions, and improve service reliability. It may include the following elements: corporate policy, training, permit compliance, construction design standards, nest management, avian reporting system, risk assessment methodology, mortality reduction measures, avian enhancement options, quality control, public awareness, and key resources. The Guidelines present a comprehensive overview of these elements. Although each utility's APP will be different, the overall goal of reducing avian mortality is the same. An APP should be a "living document" that is modified over time to improve its effectiveness.

FOREWORD

Avian interactions with power lines—including electrocutions, collisions, and nest construction—have been documented since the early 1900s when electric utilities began constructing power lines in rural areas. However, it was not until the early 1970s that biologists, engineers, resource agencies, and conservationists began to identify the extent of the problem and address it. Those early researchers and authors are to be commended for tackling a contentious issue and building a foundation of credibility and cooperation that continues today.

The U.S. Fish and Wildlife Service (USFWS) and the Avian Power Line Interaction Committee (APLIC) have a long history of working together on avian/power line issues. These efforts began in 1983 with an ad-hoc group that addressed whooping crane collisions with power lines in the Rocky Mountains. They continued with the release of Avian Protection Plan Guidelines (Guidelines) in April 2005, and have now produced this 2006 edition of *Suggested Practices*.

In 1975, the first edition of *Suggested Practices for Raptor Protection on Power Lines* had 2½ pages of text and 15 exhibit drawings. It summarized, "…studies conducted in the western United States document electrocution losses of egrets, herons, crows, ravens, wild turkeys and raptors, with 90% of the electrocution victims being golden eagles." The document concluded, "this loss of eagles is significant, but pesticide contamination, loss of habitat and illegal shooting remain the most threatening problems to raptors in general." The theme of reducing raptor electrocutions on power lines with an emphasis on "eagle-safe" designs was followed through the 1975, 1981 and 1996 editions.

Electric utilities have recognized that the interactions of migratory birds with electrical facilities may create operational risks, health and safety concerns, and avian injuries or mortalities. The USFWS understands these issues and is also responsible for conserving and protecting North American trust resources[1] under laws and regulations that include the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, and Endangered Species Act. In the 2006 edition of *Suggested Practices*, APLIC and the USFWS have expanded the focus of avian/power line issues from raptors to include other protected

Signing of Avian Protection Plan Guidelines, April 2005. Pictured left to right: top – Jim Burruss (PacifiCorp), John Holt (National Rural Electric Cooperative Association), Quin Shea (Edison Electric Institute); bottom – Jim Lindsay (Florida Power and Light), Paul Schmidt (U.S. Fish and Wildlife Service).

[1] Trust resources are wildlife, such as migratory birds, that are held in the public trust and managed and protected by federal and state agencies.

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migratory birds such as waterbirds, songbirds, and ravens and crows (corvids).

With this edition of *Suggested Practices* and the voluntary Guidelines, utilities have a "tool box" of the latest technology and science for tailoring an Avian Protection Plan (APP) that meets specific utility needs while conserving migratory birds. The 2006 edition of *Suggested Practices* represents a significant update from the 1996 edition.

APLIC and the USFWS hope you will use this edition of *Suggested Practices* along with the Guidelines to help utilities improve system reliability, implement APPs, and conserve migratory birds.

Paul Schmidt
USFWS, Assistant Director
Migratory Bird Programs

Jim Burruss
APLIC, Immediate Past Chairman

Jim Lindsay
APLIC, Chairman

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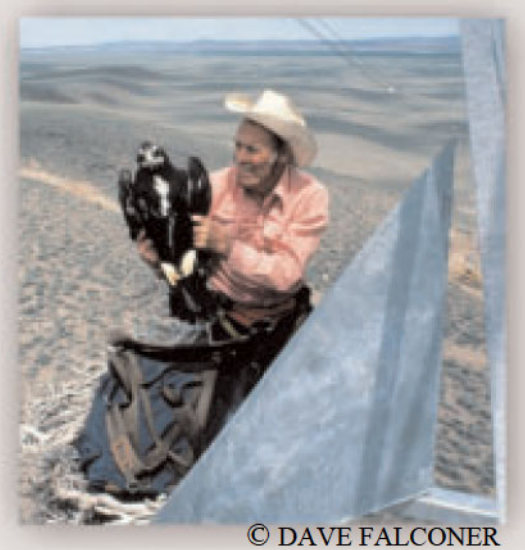
THIS PUBLICATION IS DEDICATED TO THE MEMORY OF

Morley Nelson

(1917 – 2005)



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"A man born with the heart and soul of an eagle"

Morley Nelson devoted his life to promoting raptor conservation and educating the public about their importance. He accomplished this through his personal zeal for working with raptors and his cinematography skills. Morley's achievements include: award-winning films on raptors, the establishment of the Snake River Birds of Prey National Conservation Area, raptor rehabilitation, public lectures that helped educate Americans about the importance of raptors, and research that formed the foundation of recommendations made to the electric utility industry for reducing raptor electrocutions.

A master falconer, Nelson raised public awareness about birds of prey through dozens of movies and TV specials starring his eagles, hawks and falcons—including seven films for Disney. His love of raptors began when he was a boy growing up on a farm in North Dakota. Moving to Boise after serving in World War II, he began his raptor conservation efforts along with rehabilitating and training birds.

Morley's raptor/power line research became the focus for cooperation among conservation groups, resource agencies and electric utility companies. His legacy of pooling knowledge and resources for raptor conservation is reflected in this document.

To foster the memory of Morley, APLIC will periodically present its *Morley Nelson Award* to an individual who makes significant contributions to raptor conservation. The individual must demonstrate a long-term commitment to natural resources, a consistent history of investigating or managing the natural resource issues faced by the electric utility industry, and success in developing innovative solutions.

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CHAPTER 1

Introduction

IN THIS CHAPTER

This book presents engineers, biologists, utility planners, and the public with a comprehensive resource for addressing avian electrocutions at electric power facilities.[2] It outlines the importance of the issue, describes methods for avoiding or mitigating electrocution problems, and highlights management options and cooperative partnerships.

PURPOSE AND SCOPE

In the early 1970s, an investigation of reported shootings and poisonings of eagles in Wyoming and other western states led to evidence that eagles were also being electrocuted on power lines (Olendorff et al. 1981). Since then, the utility industry, wildlife resource agencies, conservation groups, and manufacturers of avian protection products have worked together to understand the causes of raptor electrocutions and to develop ways of preventing them. Those efforts have improved our understanding of the biological reasons why raptors and other birds can be attracted to power lines, and the power line configurations that lead to avian electrocutions.

This publication, *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006*, summarizes the history and achievements of over three decades of work. It succeeds three previous editions and has been expanded and updated to assist those concerned with complying with federal laws, protecting and enhancing avian populations, and maintaining the reliability of electric power networks.

Early attempts to understand the engineering aspects of raptor electrocution led to the first edition of *Suggested Practices* (Miller et al. 1975). The 1975 edition was followed by the 1981 edition (Olendorff et al. 1981), which explored the biological and electrical aspects of electrocution, provided guidance for reducing bird mortalities, and contained a comprehensive annotated bibliography. The 1996 edition (APLIC 1996) expanded and refined recommendations for power line structure designs and modifications for protecting raptors, included updated research

[2] This book focuses on avian electrocutions, not collisions. Readers seeking information about the collision of birds with power lines may consult *Mitigating Bird Collisions with Power Lines: The State of the Art in 1994* (Avian Power Line Interaction Committee [APLIC] 1994) or the current edition of this manual.

results, and illustrated the effectiveness of cooperative efforts.

Although raptors remain a focal point of electrocution issues, utilities have found that many other birds also interact with electrical structures, and can reduce power reliability. Accordingly, this 2006 edition of *Suggested Practices* expands upon prior editions by addressing additional avian species. This edition also reflects utility efforts to improve configuration designs and to evaluate the effectiveness of various retrofitting options. The 2006 edition includes the following additions or updates:

- A new chapter on regulations and permits related to migratory birds,
- Biological perspectives and information on electrocution risks for non-raptor avian species, including wading birds, corvids,[3] and songbirds,
- Consideration of the National Electric Safety Code (NESC) relative to suggested practices,
- An overview of electrocution risks and mitigation measures associated with steel and concrete poles,
- Updated recommendations for post-mounted configurations,
- A discussion of perch discouragers and their proper use,
- An overview of new avian protection devices as well as their uses and installation[4],
- A review of bird-related outages,
- An updated bibliography and literature review (Appendix A),
- An appendix containing the voluntary Avian Protection Plan Guidelines (Guidelines) developed by APLIC and the United States Fish and Wildlife Service (USFWS) in 2005, as well as suggestions for developing and implementing an Avian Protection Plan (APP).

ORGANIZATION OF THIS DOCUMENT

This book is intended for use by electric utilities, resource agencies and scientists worldwide. International literature is included, but it is primarily focused on North America. A brief synopsis of each chapter is listed below.

Chapter 2: The Issue
Defines the avian electrocution problem, traces its history, and reviews the latest research on avian electrocutions and their prevention.

Chapter 3: Regulations and Compliance
Reviews the major federal laws related to migratory birds and identifies potential permit requirements.

Chapter 4: Biological Aspects of Avian Electrocution
Describes the range of avian/power line interactions and discusses the biological and environmental factors that influence avian electrocution risk.

Chapter 5: Suggested Practices: Power Line Design and Avian Safety
Presents the reader with the background necessary to understand avian electrocutions from an engineering perspective, i.e., the design and construction of power facilities. Suggests ways to retrofit existing facilities and design new facilities to prevent or minimize avian electrocution risk.

[3] The corvid family includes crows, ravens, magpies, and jays.

[4] See the APLIC website (www.aplic.org) for a current list of avian protection product manufacturers.

Chapter 6: Perching, Roosting, and Nesting of Birds on Power Line Structures
Explores the benefits of power lines to raptors and other birds and proposes strategies for relocating nests or providing alternative nesting sites that minimize electrocution risk while maintaining safe and reliable electrical service. Discusses the use of devices intended to discourage perching versus modifying structures to be avian-safe. Provides an overview of bird-related outages and their impacts on reliability and operating costs.

Chapter 7: Developing an Avian Protection Plan
Presents the elements of an APP and provides guidance for APP implementation.

For literature citations from the text and additional useful references, see the Appendix A Literature Cited and Bibliography section. Appendix B contains a history of early agency actions that addressed the electrocution issue; Appendix C Avian Protection Plan Guidelines; Appendix D a glossary; and Appendix E a list of acronyms.

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CHAPTER 2

The Issue

IN THIS CHAPTER

This chapter defines the avian electrocution issue, traces its history, reviews the literature, introduces the latest research, and discusses approaches to solving the problem. Particular emphasis is placed on studies completed since the previous edition of *Suggested Practices* (1996). This chapter also includes an overview of the avian electrocution issue in other countries.

Raptors (birds of prey) are ecologically important and sensitive to toxic substances, habitat alteration and destruction, and persecution by humans. Inadvertent harm to raptors can occur where humans and raptors interact. The biological importance and environmental sensitivity of raptors have led to substantial academic and public interest in these birds and to the problem of electrocution. This has resulted in better protection and management for raptors and their habitats.

The electrocution issue began with raptors because their size, hunting strategy, and nesting preferences make them particularly vulnerable. However, decades of research have found that other species also incorporate utility structures into their lifecycles. The interactions caused by perching, roosting, loafing, and nesting birds can result in electrocutions or power outages, each of which is receiving more attention from utilities, wildlife resource agencies, and the public.

In the United States, the federal government provides protection for migratory birds through several laws (see Chapter 3). Prominent among these are the Bald and Golden Eagle Protection Act (BGEPA) (16 U.S.C. 668–668C), the Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703–712), and the Endangered Species Act (ESA) (16 U.S.C. 1531–1543). *Taking*[5] a bird protected by these laws can result in fines and/or imprisonment. Because electrocutions of protected birds on power lines are considered *takes* under the law, many utilities have acted

[5] In 50 CFR 10.12, *take* means "to pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to pursue, hunt, shoot, wound, kill, trap, capture or collect."

voluntarily and a few under duress to reduce electrocution mortality.

Another major impetus for action is the impact on the electric power network. Bird-caused outages reduce power reliability and increase power delivery costs (See Bird-Related Outages, Chapter 6). Some outages may impact only a few customers temporarily, yet they can still affect a utility's service reliability and customer guarantees. Larger outages can have dramatic consequences. For example, in 2004, several bird-related incidents resulted in power outages at the Los Angeles International Airport, which caused flight delays and threatened airport security. Wildlife-related outages in California alone are estimated to cost from millions to billions of dollars each year (Hunting 2002; Singer 2002; Energy and Environmental Economics, Inc. 2005). In a culture that depends upon electronic devices, power outages can cause inconveniences to residential customers, mortal risks to those who need electricity for heat or life-support systems, and major production losses for industrial and commercial customers.

The impact of electrocution on raptor populations, and avian populations in general, is poorly understood. Newton (1979:212) summarized the difficulties of addressing population impacts on raptors:

> *The importance of different mortality causes is also poorly understood, partly because it is hard to find a sample that is representative of the whole population, and partly because of the operation of pre-disposing causes. Starvation, predation and disease are all recorded as causing deaths of raptors, as are various accidents and collisions, electrocution, shooting, trapping and poisoning. The [banding] recoveries and post-mortem analyses which provide most information are inevitably biased towards deaths that occur from human action or around human habitation.*

Both direct and indirect mortality factors must be considered when studying raptor population dynamics. In addition to electrocution, Postivit and Postivit (1987) identified eight other human activities that affect birds of prey: (1) persecution,[6] (2) pesticide use and pollution, (3) agricultural development, (4) logging, (5) dam construction and water management, (6) energy and mineral development, (7) urbanization, and (8) recreation. Kochert and Steenhof (2002) identified the greatest threats to golden eagles *(Aquila chrysaetos)* in the United States and Canada as the adverse impacts of human activity, including collisions, electrocutions, shooting, and poisoning from lead or agricultural pesticides. Other human-related sources of mortality that impact birds in general include window and motor vehicle collisions, predation by domestic and feral cats, and collisions with power lines, communication towers, and wind generation facilities (National Wind Coordinating Committee [NWCC] 2001). Estimates of avian mortality due to these causes run in the millions annually, far greater than the estimated number of birds killed by electrocution (Figure 2.1).[7] Habitat destruction is thought to cause greater reductions in bird and other wildlife populations than any other factor, and is still the most serious long-term threat (Newton 1979; Wilcove et al. 1998; USFWS 2002).

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[6] The term *persecution* was used by Postivit and Postivit (1987) to mean shooting. Persecution could also include poisoning and direct trapping.

[7] Figure 2.1 was generated using estimates of avian mortality from NWCC 2001, Curry and Kerlinger LLC: What Kills Birds? (http://www.currykerlinger.com/birds.htm), and the U.S. Fish and Wildlife Service: Migratory Bird Mortality (http://www.fws.gov/birds/). Avian mortality rates associated with electrocution are presented for various species in Chapter 4. The numbers provided in Figure 2.1 are gross estimates collected using different techniques and levels of accuracy, therefore this graph is intended only to provide a relative perspective of various sources of avian mortality.

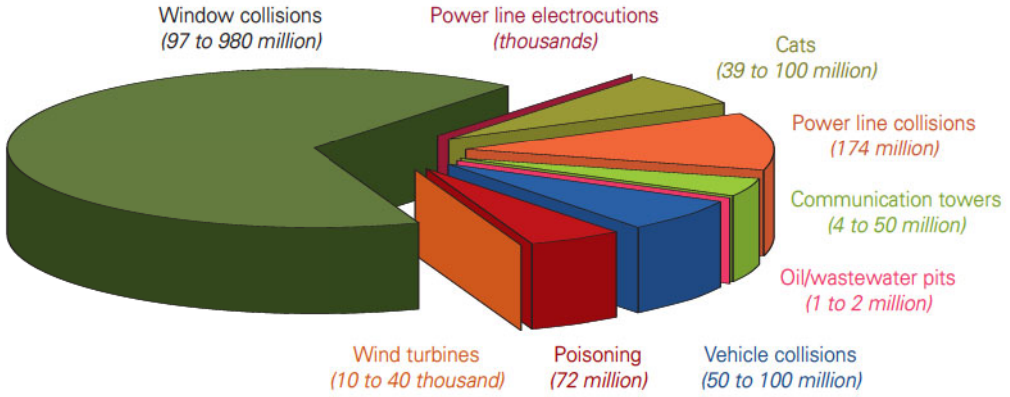

FIGURE 2.1: Comparison of human-caused avian mortality.

Nevertheless, electrocution on power facilities remains a legitimate concern and a source of mortality that can be reduced. Electrocutions can be minimized through a variety of mitigation measures that include applying "avian-safe"[8] designs to new construction, and retrofitting existing lines that pose an electrocution risk. It is in the interest of utility planners, biologists, and engineers to familiarize themselves with the issue and its dimensions, and to plan for and implement measures that identify and rectify existing and potential electrocution problems.

EARLY REPORTS

Before the 1970s, raptor electrocutions had been noted by several researchers (Hallinan 1922; Marshall 1940; Dickinson 1957; Benton and Dickinson 1966; Edwards 1969; Coon et al. 1970), although the extent of the problem was not known. Surveys in Wyoming and Colorado during the 1970s found nearly 1,200 eagle mortalities that were due to poisoning, shooting from aircraft, and electrocution. Although most of these eagles had been shot, others had been electrocuted by contact with lines not designed with eagle protection in mind. In northeastern Colorado, 17 golden eagles, 1 red-tailed hawk *(Buteo jamaicensis)*, and 1 great horned owl *(Bubo virginianus)* were found dead—all probably electrocuted, along 5.6 kilometers (km) (3.5 miles [mi]) of line (Olendorff 1972a). Five golden eagles and 4 bald eagles *(Haliaeetus leucocephalus)* were found dead under a power line in Tooele County, Utah, and another 47 electrocuted eagles were found along a line in Beaver County, Utah (Richardson 1972; Smith and Murphy 1972). Of 60 autopsied golden eagles in Idaho, 55% had been electrocuted (M. Kochert, pers. comm. in Snow 1973). In June of 1974, 37 golden eagles and 1 short-eared owl *(Asio flammeus)* were found dead under a line southwest of Delta, Utah (Benson 1977, 1981). In a review of bald eagle mortality data from 1960 to 1974, 4% of the eagle deaths were attributed to electrocution (total sample size not given) (Meyer 1980). Similar electrocution problems were also noted in

[8] The term *raptor-safe* has been used in previous editions of *Suggested Practices* to identify power poles that are designed or retrofitted to prevent raptor electrocutions. Because this edition of *Suggested Practices* encompasses many avian species, the term *avian-safe* is used.

New Mexico (Denver Post 1974), Oregon (White 1974), Nevada (U.S. Fish and Wildlife Service 1975a), Louisiana (Pendleton 1978), and Idaho (Peacock 1980).

Much of the information from the early 1970s was summarized by Boeker and Nickerson (1975). This 1971 summary documented 37 golden eagle deaths along a power line of just 88 poles in Moffat County, Colorado. Carcasses and skeletons of 416 raptors were found along 24 different 8 km (5 mi) sections of power lines in six western states (Benson 1981). In Utah, U.S. Fish and Wildlife Service (USFWS) employees found the remains of 594 raptors (some dead up to five years) under 36 different distribution lines (spanning approximately 400 km [250 mi]). Of these carcasses, 64 were fresh enough to determine the cause of death: 87.5% had been electrocuted (R. Joseph, pers. comm. in Avian Power Line Interaction Committee [APLIC] 1996).

SUGGESTED PRACTICES: 1975, 1981, AND 1996

The eagle deaths documented in the western United States during the 1970s raised serious concern about raptors and electric power facilities. Industry, government, and conservation organizations began to work together to identify and solve the problem of raptor electrocution.[9] Agencies involved included the Rural Electrification Administration (REA; now the Rural Utilities Service [RUS]), U.S. Forest Service (USFS), Bureau of Land Management (BLM), USFWS, National Park Service (NPS), and Bureau of Indian Affairs (BIA). The USFWS began searching for lethal lines, while the REA began developing line modification methods to minimize eagle electrocutions. The National Audubon Society and the Edison Electric Institute (EEI) initiated workshops, sought utility participation, raised funds, and began to develop ways to address the problem. In 1972, the REA published a bulletin describing causes of raptor electrocution resulting from certain grounding practices and conductor spacing. This bulletin (61-10) was revised in 1975 and again in 1979 to incorporate research conducted since each earlier edition, including revised inter-phase clearances (Figure 2.2) (U.S. REA 1979).[10] In the 1970s, the USFWS also initiated a raptor mortality data bank to track electrocutions.

As data were gathered on the magnitude of raptor electrocution numbers during the early 1970s, regional meetings were held to familiarize industry and agency personnel with the problem. Several electric companies, most notably Idaho Power Company, had retained Morley Nelson[11] of Boise, Idaho, to begin testing the safety of new power line designs and to propose modifications of existing lines. These tests were instrumental in forming the basis for the first definitive work on the subject: *Suggested Practices for Raptor Protection on Power Lines* (Miller et al. 1975). This publication was widely circulated and used by both industry and government (Damon 1975; EEI 1975). For example, the BLM and other agencies began requiring "raptor-safe" construction as a condition of rights-of-way permits on federal land and explicitly stipulated that such actions be consistent with *Suggested Practices* (Olendorff and Kochert 1977).

Field tests of the recommendations contained in the 1975 edition of *Suggested Practices* led to a need for further documentation and evaluation, as some of the recommended dimensions were found inadequate. For

[9] Appendix B presents a history of individual and agency contributions.

[10] REA Bulletin 61-10 was the precursor to the *Suggested Practices* series.

[11] Morley was a cinematographer and pioneer in North American falconry. He filmed trained eagles, hawks, and falcons to study and demonstrate their behavior on a variety of utility pole configurations.

instance, the suggested 61 centimeters (cm) (24 inches [in]) height of the overhead perch was too high, and needed to be reduced to 41 cm (16 in) to keep birds from landing beneath the perch. New cover-up materials and conductor support schemes were also developed. In the 1981 edition of *Suggested Practices* (Olendorff et al. 1981), earlier recommendations were corrected and updated, and a complete literature review and annotated bibliography were provided. This edition of *Suggested Practices* was adopted (incorporated by reference at 7 CFR 1724.52(a)) by the REA as their standard for raptor protection. *Suggested Practices* continues to be used by the RUS as a resource for mitigating problems in areas where birds are a concern.

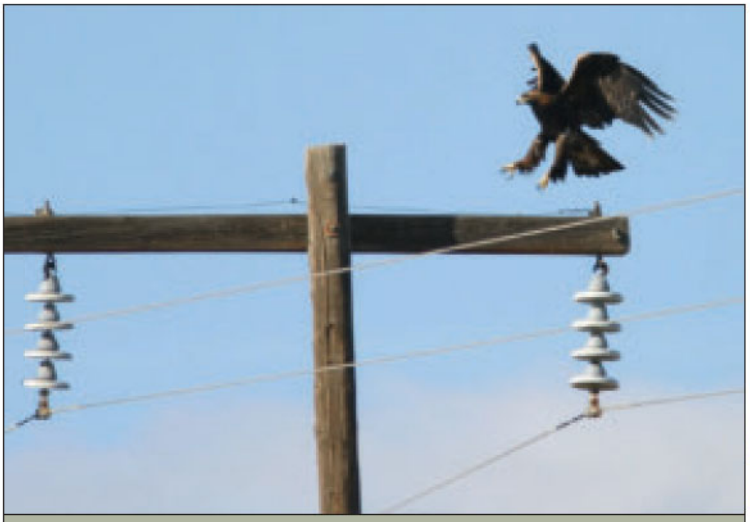

FIGURE 2.2: Golden eagle landing on avian-safe pole. Early research on avian electrocutions and pole modifications focused largely on golden eagles.

By the mid-1990s, continued progress was being made in reducing raptor electrocution risks. Many utilities had adopted or participated in raptor enhancement or protection programs (Blue 1996). However, despite these efforts, electrocutions continued in North America and concerns remained over electrocution problems internationally (Lehman 2001). The 1996 edition of *Suggested Practices* refined recommendations from the previous editions, updated the literature review, offered suggestions for cooperative actions among agencies and utilities, and began to identify avian electrocution issues outside of North America.

In the past decade, great strides have been made in preventing avian electrocutions. Many utilities consider avian safety in new construction and continue to retrofit existing poles that pose electrocution risks. There is a growing variety of products and materials manufactured for avian protection (see www.aplic.org). Increased awareness within utilities has improved electrocution reporting and corrective actions. In 2005, APLIC-member utilities were surveyed to obtain information on utility programs, electrocution rates, bird-related outages, and progresses made in avian protection efforts. Of survey respondents (n=13), most utilities had either an avian protection plan (69%) or policy (77%) (APLIC 2005). Survey respondents were asked to compare their utility's current avian protection efforts to those of 10 and 20 years ago. All utilities surveyed currently retrofit poles for avian protection, however, two decades ago only 31% retrofitted poles for birds. Likewise, the amount of money spent on avian protection efforts has increased substantially. Twenty years ago, half of the utilities surveyed did not have a budget for avian protection; whereas currently all utilities surveyed spend money on avian protection. In addition to expanding their avian protection efforts, many utilities noted that they have

experienced improved relationships with resource agencies. Communication with agencies was considered to be fair by the majority of utilities (45%) 20 years ago, while 58% considered communication good 10 years ago, and 58% reported that they currently have excellent communication with wildlife resource agencies.

ELECTROCUTION ISSUES TO DATE

ELECTROCUTION ISSUES AND PROGRESS IN NORTH AMERICA

Recent literature indicates that electrocution continues to be a cause of mortality for various raptors in North America—particularly eagles and some hawks and owls. Because of increased awareness, non-raptor electrocutions are also being documented. The small number of comprehensive field surveys, however, limits the extent of our knowledge of electrocution mortality. Differences in the scope of electrocution studies and the type of data collected make it difficult to compare historic and current information. Additionally, little data exist that quantify the risk of electrocutions relative to other sources of avian mortality. Assessments that use data subsets or incidental reports for extrapolating results based on an estimated number of poles are inaccurate because electrocution risk is not uniformly distributed. Though quite difficult, systematic surveys over large areas can provide more accurate electrocution rate estimates.

Several recent studies have quantified avian electrocution rates. In a survey of over 70,000 poles in Utah and Wyoming in 2001 and 2002, 547 avian mortalities were found —32% of which were common ravens *(Corvus corax)*, 21% buteos, 19% eagles, 6% passerines/small birds, 4% owls, 2% falcons, 2% waterbirds, and 14% unidentified (Liguori and Burruss 2003). In a survey of 3,120 poles in Colorado, 68 carcasses were discovered, including eagles (53%), hawks (23%), and corvids (7%) (Harness 2001). In a study of 4,090 poles in Montana, golden eagle electrocutions were documented at 4.4% of poles, 20 of which had electrocuted more than one eagle (Schomburg 2003). In Chihuahua, Mexico, studies in 2000 and 2001 documented an average annual electrocution rate of 1 bird per 6.5 concrete poles in non-urban areas (Cartron et al. 2005). In northern California and southern Oregon, confirmed and suspected avian electrocutions were documented at 0.9% of poles surveyed (n=11,869) in 2004 and 2005 (PacifiCorp, unpubl. data). Of these mortalities, 48% were buteos, 27% owls, 11% eagles, 5% corvids, 5% unidentified raptors, 2% vultures, 1% harriers, and 1% herons.

Studies that have documented electrocutions through incident reports without systematic pole surveys provide conservative estimates of electrocution rates. Harness and Wilson (2001) documented 1,428 raptor electrocutions in a review of mortality records from utilities in the rural western United States from 1986 to 1996. From 1988 to 2003, 210 raptor electrocutions were documented in Nebraska (USFWS/Nebraska, unpubl. data). In Montana, 32 golden eagle mortalities were confirmed from 1980 to 1985 (O'Neil 1988). From 1978 to 2004, nearly 800 electrocutions were reported by Alaska utilities to the USFWS (USFWS/Alaska, unpubl. data). Prior to 2000, most electrocutions reported in this database were of bald eagles, which accounted for 83% of reports from 1978 to early 2005. Other birds reported in Alaska include ravens, magpies, crows, owls, gulls, ospreys *(Pandion haliaetus)*, and great blue herons *(Ardea herodias)*.

Bald and golden eagles continue to be a focus of electrocution research in North America, with electrocution accounting for <1% to 25% of eagle deaths in various studies. The U.S. Geological Survey's (USGS)