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Raptor electrocution on power lines: current issues and outlook

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Abstract Electrocution on power lines is one of many human-caused mortality factors that affect raptors. Cost-effective and relatively simple raptor-safe standards for power line modification and construction have been available for over 25 years. During the 1970s and early 1980s, electric industry efforts to reduce raptor electrocutions were very coordinated and proactive, but predictions about resolving the problem were overly optimistic. Today, raptors continue to be electrocuted, possibly in large numbers. The electrocution problem has not been resolved, partly because of the sheer number of potentially lethal power poles in use and partly because electrocution risks may be more pervasive and sometimes less conspicuous than once believed. Also, responses to the problem by individual utilities have not been uniform, and deregulation of the electric industry during the 1990s may have deflected attention from electrocution issues. To control raptor electrocutions in the future, the industry must increase information sharing and technology transfer, increase efforts to retrofit lethal power poles, and above all ensure that every new and replacement line constructed incorporates raptor-safe standards at all phases of development. Finally, responsibility for the electrocution problem must be shared. Federal, state, and local governments, academic institutions, the conservation community, and the consumer all can play critical roles in an effort that will, by necessity, extend well into the new century.

Key words electrocution, mortality, power lines, raptors

Electrocution on power lines is one of many human-caused mortality factors that affect raptors. In the United States, wildlife biologists and electrical engineers have worked together for over 25 years to understand causes of raptor electrocution and develop solutions to the problem (Miller et al. 1975, Olendorff et al. 1981, Avian Power Line Interaction Committee [APLIC] 1996). From a strictly technical standpoint, raptor electrocutions are preventable. Nearly all electrocutions in the United States (U.S.) occur on comparatively low-voltage distribution lines supplying individual users and businesses. Raptor electrocution problems on these lines usually can be resolved by relatively simple methods, and individual poles can be modified with little expense.

During the 1970s and early 1980s, efforts by the electric industry to correct hazardous power lines were notable and marked by considerable optimism (Miller et al. 1975, Nelson and Nelson 1976, Phillips 1986). The problem could be controlled over the short term, it was felt, by correcting a proportionately small number of existing poles. Over the long term, construction of new lines to raptor-safe standards would essentially eliminate electrocution hazards. Recent evidence, however, indicates that raptors continue to be electrocuted, possibly in large numbers (Harness and Wilson 2001, Melcher and Suazo 1999, Suazo 2000). Some observers outside the industry feel that utility companies are not doing enough to reduce these numbers (Melcher and Suazo 1999, Williams 2000).

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In contrast, many in the electric industry feel their efforts to reduce electrocution hazards have not been adequately recognized. Industry officials point out that most electrocution research during the last 25 years has been funded or conducted by the electric industry and that the industry has actively promoted use of raptor-safe technology through publications, symposia, and workshops (Colson 1993). Some utilities have well-established programs to deal with electrocution hazards (Garrett 1993). Furthermore, more raptors may be facing electrocution risks today than in the past because power line rights-of-way into raptor habitats have increased (Cringan and Horak 1989) and in some cases raptor populations have increased because of power line construction (Steenhof et al. 1993, Henny and Kaiser 1996). In addition, recent evidence suggests that electrocution risks may be more pervasive and widespread than once believed (Harness and Wilson 2001). The prospect of retrofitting potentially millions of poles while meeting increasing demands for cheap electric power is a real concern of the U.S. electric power industry.

In this paper, I attempt to bring the electrocution issue into perspective. I examine the early history and current scope of the problem, discuss how industry is responding, and address legal issues and research needs. Finally, I outline a set of short- and long-term goals to address the problem.

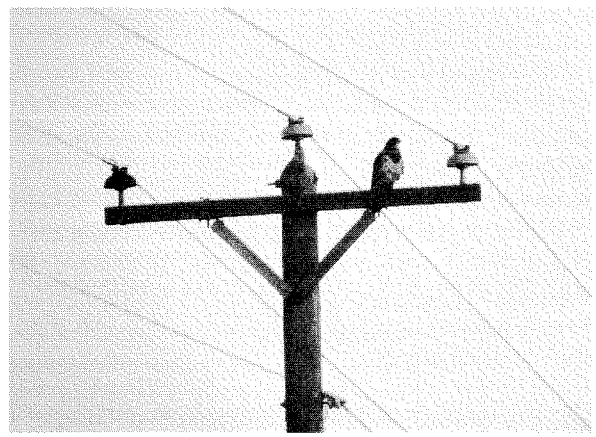
History and scope of the electrocution problem

Early history

In 1971, a federal investigation of shooting and poisoning of eagles by western sheep ranchers led to the discovery of the raptor electrocution problem (Laycock 1973). The investigation culminated in a series of U.S. Senate hearings in which the deaths of over 800 eagles in just one state were documented. The Senate hearings and subsequent court testimonies stimulated wildlife and industry officials and environmental organizations to expand the search for dead birds. This led to the discovery of hundreds of eagles and other raptors dead beneath power lines across the West. Although many had been shot, many others clearly had been electrocuted by contact with the energized components of power poles (Olendorff 1972, Boeker and Nickerson 1975, Benson 1981).

Evidence of large-scale mortality on electric distribution facilities caused immediate and serious concern and mobilized industry, government, and the conservation community. Early in 1972, the Edison Electric Institute (EEI), an association of investor-owned utility companies, took the lead in alerting utilities about the problem and coordinating industry action. An accord was struck among numerous utilities and government agencies to continue searches for lethal lines and to establish a national raptor mortality reporting system, to be maintained by the United States Fish and Wildlife Service (USFWS). It was determined quickly that electrocution problems were associated primarily with distribution lines, which transmit electricity at voltages below 69 kV to residences, businesses, and other individual users (as opposed to transmission lines, typically energized at 115 kV and above; Miller et al. 1975). Before 1971, distribution lines were typically designed with narrow clearances between energized components, clearances that allowed simultaneous contact with conductors and ground wires by wings and body parts of large birds.

Also in 1972, the Idaho Power Company contracted with Morlan W. Nelson, a raptor expert from Boise, Idaho, to test modifications and designs that might reduce electrocution mortality (Nelson and Nelson 1976, 1977; Ansell and Smith 1980). Using trained golden eagles (*Aquila chrysaetos*), Nelson determined that relatively inexpensive methods, such as increasing clearances between conductors and ground wires, gapping ground wires, insulating energized components, and managing perching opportunities on power poles, were available to reduce the most obvious electrocution hazards. These techniques eventually were presented in a

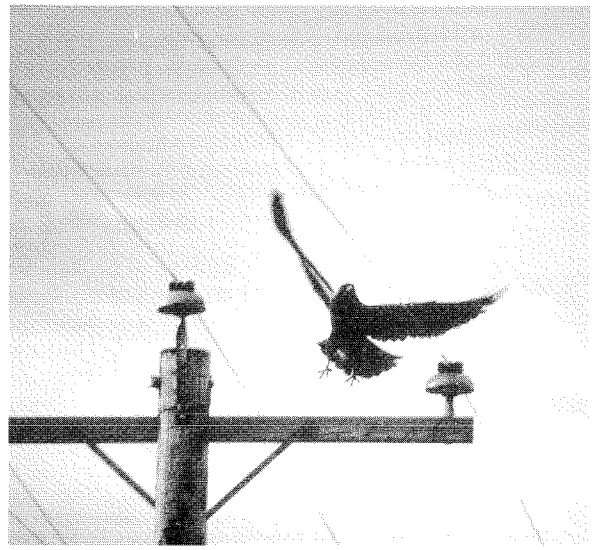


A Swainson's hawk perches on a 3-phase distribution line. Raptors use power poles for hunting, resting, feeding, nesting, and territorial defense. Photo by Mike Kochert.

manual, *Suggested Practices for Raptor Protection on Power Lines* (Miller et al. 1975), which through subsequent editions (Olendorff et al. 1981, APLIC 1996) has remained the industry standard for raptor-safe construction for 25 years.

Throughout the 1970s and early 1980s, progress was made to increase public and industry awareness of the electrocution problem and to correct hazardous poles on the ground. The exact number of poles retrofitted during this period is unknown because no centralized records were kept, but it is safe to say that tens of thousands of poles were modified. Also during this period, raptor protection measures were instituted as part of mandated permitting and licensing requirements by most federal agencies (e.g., Olendorff et al. 1989).

Thus, early responses to the raptor electrocution issue were characterized by strong action and common purpose. To identify causes of electrocution and to find and implement technical solutions, industry quickly assumed a position of leadership. In 1975, the Raptor Research Foundation, an international professional group focused on raptor ecology and conservation, passed a resolution commending the American electric utility industry for its "coordinated and collective efforts on behalf of raptors." By the early 1980s, there was a strong sense within and outside industry that real progress had been made to reduce the number of electrocuted raptors along power lines and that in time the problem would essentially be eliminated.



Many designs of electric industry hardware place conductors and ground wires close enough together that raptors can touch them simultaneously with their wings or other body parts, causing electrocution. Photo by Mike Kochert.

Current scope of the problem

It was a commonly held opinion in the early 1980s that a very small percentage of poles were actually killing raptors. These were the "preferred poles" (Olendorff et al. 1981), those situated in good habitat or near high prey concentrations. After surveying one utility's distribution system, Nelson and Nelson (1976) estimated that 95% of electrocutions could be prevented by correcting just 2% of poles. Although millions of poles had been deployed across the U.S., apparently a more manageable number were likely to attract and electrocute raptors (Williams and Colson 1989). In addition, the industry's strong stand on the issue in the 1970s likely reinforced the impression that a resolution to the problem was within reach. In 1982, the Wildlife Management Institute issued a news release stating that 90% of the raptor electrocution problem had been eliminated (WMI 1982). By the early 1990s, it seemed to some observers that the electrocution problem essentially had been resolved (Gauthereaux 1993). Why, then, has the issue re-emerged on a national scale, and what is the current scope of the problem?

The most obvious answer to the first question is that the optimistic assessments of the 1980s simply were unrealistic. The issue has re-emerged because it was never fully resolved. Answering the second question is more difficult. Unfortunately, the number of raptors electrocuted on power lines each year in the United States has never been estimated. Thus, it is impossible to assess precisely the current scope of the problem, or to compare current electrocution rates with those of the past. There are numerous reasons for this. First, the USFWS's mortality reporting system, established in 1972, was discontinued in 1975. Why it was discontinued is not clear today, but had it been maintained it might have provided an index of electrocution mortality through time. Second, systematic studies of electrocution mortality have always been rare in the U.S. Even in the 1970s, searches for dead birds focused largely on identifying lethal poles and lines for retrofitting, not on estimating electrocution rates (Olendorff et al. 1981). Rate estimates for a particular area require standardized sampling, consideration of biasing factors, and repetitive visits (Bevanger 1999). Today, most data on raptor electrocutions result from observational and retrospective studies based on incidental encounters with

dead birds (e.g., O'Neil 1988) or are contained in the files of individual utility companies (discussion below). Data of this type are biased toward mortalities that are detected easily or occur at the right time and place and are not useful to infer total numbers of birds killed, or to assess actual proportions of deaths among different species or mortality factors. In addition, in retrospective studies, it is impossible to standardize reporting procedures, raising a host of potential problems. It is not always clear, for example, how cause of death was assigned in mortality reports (whether by visual inspection, necropsy, or some other method).

Although rigorous mortality estimates are not available, some recent studies have attempted to define the problem more systematically. Several are noteworthy in part because they represent work done at 3 spatial scales (local, regional, national). Dawson and Mannan (1994) assessed mortality at the local scale in an urban population of Harris' hawks (*Parabuteo unicinctus*) in and near Tucson, Arizona, from 1991 to 1994. Of 200 mortalities evaluated for cause of death, 112 were confirmed electrocutions and an additional 44 were possible electrocutions.

Harness and Wilson (2001) evaluated data collected at the regional scale from sources in 13 western states and Canada from 1986 to 1996. Data was provided by 58 sources, including Rural Utilities Service (RUS) cooperatives, federal and state electric power producers, municipal utilities, investor-owned utilities, wildlife rehabilitators, and falconers. During the 10-year period, 1,450 raptor electrocutions representing 16 species were confirmed. Golden eagles were the most common victims, accounting for 272 of 358 mortalities identified to species.

Finally, at the national level, Franson et al. (1995) summarized mortality data for over 4,300 bald eagles (*Haliaeetus leucocephalus*) and golden eagles necropsied at the National Wildlife Health Center in Madison, Wisconsin, from the early 1960s to the mid 1990s. Electrocution was responsible for 25% of diagnosed golden eagle mortalities (the second leading cause of death after accidental trauma). For the bald eagle, electrocution was the fourth leading cause of death (after accidental trauma, poisoning, and shooting).

As mentioned above, the data reported in these studies may be biased in several respects. Yet, all mortalities reported probably resulted from electrocution (all reports mentioned burns on carcasses or were the result of necropsies); thus, they provide at least the minimum number of birds electrocuted in the areas and periods discussed. Any assessment of these data suggests, conservatively, that hundreds of raptors are electrocuted annually in the U.S. Because the data represent a fraction of potential data sources in the U.S. (in Harness' case, <5% of the utilities operating during the 1990s; EEI 1997), the actual number may be greater by several orders of magnitude.

These and other recent studies also provide insight into the species at risk of electrocution. In the 1970s and 1980s, golden eagles appeared in electrocution records more than any other species (Olendorff et al. 1981, APLIC 1996). This remains a reasonable conclusion today (e.g., Fransen et al. 1995, Harness and Wilson 2001). On the other hand, recent information suggests that electrocution of other species may be underreported. Whaley (1979) was the first to report Harris' hawk electrocutions (8 birds during a 2-year study), but speculated that the problem was more serious than his data indicated. This was confirmed by Dawson and Mannan (1994). Harness and Wilson (2001) also discussed the problem of underreporting for certain species, especially buteos, and APLIC (1996) identified 11 raptor species that appeared in electrocution records after the publication of Olendorff et al. (1981), but not before.

Increases in numbers of species known to be vulnerable represent in part an increased awareness of the problem and perhaps an increase in numbers of birds at risk. Since the 1970s, many utilities have developed procedures to report bird mortalities on their distribution systems; thus more information is now available. Also, massive urban development has occurred in recent decades, especially in the West, resulting in thousands of kilometers of new power line rights-of-way (Cringan and Horak 1989). In some cases, raptor populations have increased because of the perching and nesting opportunities provided by new power lines (Steenhof et al. 1993, Henny and Kaiser 1996), and some populations of formerly endangered species that are electrocuted regularly (e.g., the bald eagle) have increased dramatically in recent years (USFWS 1999).

Recent evidence also suggests that electrocution hazards may be more pervasive and widespread than once thought. In 1981, deaths on transformer poles had been documented but were not seen as a disproportionate cause of electrocution (Olendorff et al. 1981). Yet, Harness and Wilson (2001) argued that transformer electrocutions may be one of the

least recognized electrocution hazards today. They found that 47% of electrocution records that provided pole-top configurations were associated with transformers, yet only 13–24% of available poles had transformer banks. Harness (2000) also discussed the emerging problem of steel poles. Recent construction has emphasized steel because of its strength, durability, and low cost. Unfortunately, steel poles can be extremely lethal to raptors because the structures themselves are conductive. In another development, Hohenberger (1996) documented the electrocution of a peregrine falcon (*Falco peregrinus*) on a 7.6-kV single-phase wooden distribution pole with no ground wire, a configuration that was not known to present an electrocution hazard. The incident occurred in the rain when bird and pole were wet. Apparently, the pole itself provided the ground. It is impossible to say whether this was an isolated incident or a regular occurrence, but it does suggest that nearly any pole may be lethal under certain circumstances.

Finally, electrocution of raptors is a global problem and in some parts of the world has been shown to be a primary cause of population declines. Cape vultures (*Gyps coprotheres*) in South Africa and griffon vultures (*Gyps fulvus*) in Israel have declined due to electrocution and other human-caused factors (Ledger 1980, Lesham 1985). Electrocution is the primary mortality factor for the endangered imperial eagle (*Aquila heliaca*) in Spain (Ferrar et al. 1991, Ferrar and Hiraldo 1991). Unfortunately, electrocution problems tend to be documented and protection programs tend to exist only in developed countries. In the future, electrocution problems will be most severe in developing countries with expanding human populations and the fewest resources to deal with the problem.

Thus, the optimism of the 1970s and early 1980s has given way in the last few years to a more sober assessment of the electrocution problem. By most recent accounts the problem in the United States is a reason for concern, even if its magnitude and effects on populations are unknown. Worldwide, electrocution problems can only be expected to intensify. What, then, can be said of recent industry efforts in the U.S. to resolve electrocution problems?

The industry today

In 1996, the third edition of *Suggested Practices for Raptor Protection on Power Lines* was published by the Avian Power Line Interaction Committee (APLIC 1996), an organization of investor-owned and independent utilities, government agencies, and private conservation groups. APLIC (formed in 1989) promotes industry and public awareness of avian–power line problems and their solutions through research, product testing, and education. APLIC (1996) presents the most thorough treatment of the electrocution problem to date, including an expanded range of solutions to hazardous pole designs identified in earlier editions and corrective measures for some hazardous designs not recognized previously.

The measures outlined in APLIC (1996) are the result of industry efforts throughout the 1980s and 1990s to improve and refine raptor-safe standards. The 1996 edition also stresses the need for greater cooperation within the industry and standardization of policies and procedures in reporting and mitigating raptor electrocutions. Today, several thousand investor-owned, cooperative, municipal, public, and independent utility companies operate in the United States (EEI 1997); yet, reporting or compiling procedures are not mandated by regulatory agencies. Because utilities are not required to report raptor electrocution data, each company has been left to develop, or not develop, its own policies and procedures.

Utilities that have established procedures generally follow 1 of 2 approaches to detect and record mortalities: 1) a systematic approach that fully integrates detection and reporting of raptor electrocutions into company operations, or 2) an opportunistic approach in which electrocutions are recorded and dealt with incidentally (APLIC 1996). In the first case, electrocution problems are dealt with proactively as a matter of policy (Garrett 1993). These companies identify problem poles during routine maintenance activities or service calls associated with power outages. Field personnel are trained to report electrocution incidents and may be required to do so. Typically, bird mortality data are reported on forms provided by the company and are stored in a database. These companies often have established programs for retrofitting hazardous poles and conducting follow-up studies to determine whether corrective actions are effective. The updated measures in APLIC (1996) are based largely on the experiences of these companies.

Many utilities take the second approach. Procedures to detect and report electrocution problems are less standardized and are not incorporated fully into company operations. These companies tend to

rely on incidental reports from field personnel, government agents, or the public to identify hazards. Reporting of bird mortalities probably is not required but may be encouraged. These companies may or may not issue reporting forms and may or may not maintain mortality databases. Retrofitting of hazardous poles generally occurs in the most serious cases, or because of intervention by regulatory agencies.

The fact that many utilities lack well-integrated, proactive programs to identify and correct electrocution problems carries certain consequences. First it means that many, perhaps most, raptor electrocutions go unnoticed. Inspection and maintenance schedules for distribution lines vary from company to company, but few lines are visited by maintenance staff more than a few times a year, unless repairs become necessary (APLIC 1996). This is particularly true in rural areas where most raptor electrocutions occur. This suggests that most dead raptors lying below power poles decompose or are scavenged long before the next visit by linemen. Also, many distribution lines today, especially those in isolated areas, are protected by devices that prevent outages or re-energize the lines after outages occur. Most bird electrocutions on these lines result only in momentary outages that do not require service calls to restore power.

The second consequence of the less-systematic approach is that information sharing often does not occur. It would be useful to know how individual utilities report electrocution problems and the effectiveness of corrective actions. Sharing this kind of information could streamline raptor protection programs considerably and reduce duplication of effort (e.g., Harness and Garrett 1999). Unfortunately, most companies do not publish data on raptor protection efforts.

Another factor, not in the industry's control, has forced major shifts in priorities in recent years and may have deflected attention from electrocution issues. Since March 1995, the Federal Energy Regulatory Commission has published new rules ending years of regulation aimed at increasing efficiency at electric production facilities (Lee and Lin 1998). Today, the transition is toward promotion of competition within the power industry, which has led to cost-cutting and reduction of personnel during the transition period and in turn has resulted in smaller investments in new facilities and equipment. Deregulation may have reduced the industry's ability and willingness to report and mitigate electrocution hazards.

Legal issues

Each time a raptor is electrocuted, the electric utility operating that particular power line violates one or more federal wildlife statutes, including the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, and Endangered Species Act (Suazo 2000). Violation of these statutes can result in fines ranging from $5,000 to $500,000, depending on the statute and whether convictions are criminal or civil. Convictions can result in imprisonment for up to 2 years. Violations of state laws carry their own fines and penalties.

Each of the above laws has "strict liability" provisions (Suazo 2000). This means that prosecutors do not necessarily have to demonstrate knowledge of the law to convict. Yet, prosecution of utility companies for raptor electrocutions has been rare, primarily because utilities have responded quickly to electrocution incidents reported by USFWS law enforcement agents. In such cases, most utilities realize that it is in their best interest to address raptor electrocution issues voluntarily. However, in recent years the USFWS has focused more attention on the problem. In an address to EEI in April 1999, USFWS Director Jamie Clark announced that the agency is committed to a national effort to reduce raptor electrocutions. Clark stressed that the USFWS will work with any utility that demonstrates a commitment to identifying problem areas, promoting awareness of the problem, and designing bird-friendly hardware. Voluntary compliance is the agency's ultimate objective. However, the USFWS is empowered to force compliance through civil and criminal action. This was emphasized in August 1999 when Moon Lake Electric Association, a utility in Utah and Colorado, pled guilty and was fined $50,000 and required to pay $50,000 in restitution for electrocuting at least 12 golden eagles, 4 ferruginous hawks (*Buteo regalis*), and one great horned owl (*Bubo virginianus,* Melcher and Suazo 1999). This was the first criminal prosecution of an electric utility company for violations of the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act and probably will not be the last.

Outlook for the future

Defining the challenge

The challenge of the electrocution issue lies in sheer numbers. Conservatively, hundreds of thousands of kilometers of distribution lines are in

operation in the U.S. today (EEI 1997). Most of these lines were erected before the development of raptor-safe standards; thus, potentially tens of millions of distribution poles throughout the country present electrocution risks to large birds. Furthermore, the number of hazardous poles and pole types currently deployed may be greater than once thought. Other pole types may electrocute raptors at greater rates than was once assumed. New designs are emerging every year, not always with raptor safety in mind. At the same time, the industry faces increasing demands for cheap electric power, increasing competition, and increasing vigilance from wildlife protection agencies.

Objectives for renewed action

It is doubtful that raptor electrocutions can ever be eliminated completely, no matter how much effort and expense are invested (APLIC 1996). A more reasonable goal is to minimize electrocutions so that impacts to raptor populations are reduced to their lowest possible level. Achieving this goal will depend on numerous factors and action on a number of fronts.

Standardized and centralized reporting. We have seen that many utility companies seem to lack well-established procedures to report raptor electrocutions and those that have established procedures and maintain mortality records rarely publish those data or provide summaries to any central location. One reason for this is that industry feels little incentive to do so. There are serious concerns, even among utilities with proactive programs to mitigate raptor electrocutions, that mortality data could be used by the USFWS to levy heavy fines. Additional concerns revolve around the creation of a cumbersome, bureaucratic process that may result in additional costs to the industry and little to no benefit. These are serious issues, and industry and government need to consider ways to clear backlogs of unanalyzed data, ensure more rapid information transfer in the future, and at the same time contend with industry concerns.

Education, information sharing, and technology transfer. Related to the need for standardized and centralized reporting is the need for increased information sharing among utilities. Utilities must share data on electrocution rates, hazardous pole designs, raptor-safe techniques, and follow-up studies through presentation in industry or wildlife journals, workshops, and symposia. Some outreach programs already exist: APLIC has sponsored an annual short course on avian–power line problems since 1996 and has produced several educational videos. The USFWS offers an annual workshop on raptor electrocutions at its National Conservation Training Center. Over the last few years several states have presented their own workshops with industry cooperation. These efforts are to be applauded, but they must be expanded to ensure that industry personnel and government biologists throughout the country are included.

Retrofitting of existing poles. Retrofitting of problem poles on existing lines is the key to reduce raptor electrocutions over the short-term. The scale is daunting, however, because most distribution lines currently in operation in the U.S. were not constructed to raptor-safe standards. It makes no sense to retrofit poles that are not causing electrocutions, and it seems unrealistic to expect that utilities can identify all poles that could kill birds. Tough choices, then, have to be made on how retrofitting programs are to be designed and implemented and who should bear the costs.

Use of raptor-safe technology in new construction. The most important factor that will ensure resolution of the electrocution issue over the long term is the use of raptor-safe technology in new construction. The average life of a wooden distribution pole is 30–60 years (APLIC 1996). Thus, most existing hardware eventually will be replaced. If outdated power lines are replaced with new facilities designed to raptor-safe standards and these standards are applied consistently to all new construction, raptor electrocutions eventually could be minimized. This can be accomplished most effectively by applying raptor-safe standards at early stages of development—i.e., in design and manufacturing stages.

Research. Harness and Wilson (2001) contributed important insights into the scope of the electrocution problem and hazardous pole designs by compiling and analyzing mortality data from selected utilities in the western U.S. Similar efforts to analyze other existing data sets inside and outside the industry should be a top research priority in the future. But basic research should not end here. Well-designed sampling programs along distribution line corridors, especially in high raptor-use areas, are needed to assess current electrocution rates. These studies need to be done on a broad basis to better understand the magnitude of the problem at regional and national levels and to

evaluate the effects of electrocution mortality on populations. Currently, we have no scientific documentation that electrocution mortality is contributing to population declines for any raptor species in North America. However, the information needed to make these assessments is unavailable. Data on age-specific mortality and the breeding status and health of electrocution victims is critical to evaluate whether mortality is additive or compensatory. Because electrocution mortality may affect different species in different ways, better information on risk levels and current status and trend for all raptor species is needed. New approaches to risk assessment and identification of problem areas also must be developed. Application of new technologies and advanced analytic methods, such as population and Geographic Information System (GIS) modeling, could play crucial roles. More follow-up studies of retrofitted lines and new lines built to raptor-safe standards also are needed to determine effectiveness of engineering solutions. In some cases, it may be necessary to test proposed solutions with live birds, as Nelson did in the 1970s. Finally, raptor-safe standards must be developed and incorporated in all new pole designs.

Long-term commitments and new partnerships. Because long-term solutions are needed to resolve the raptor electrocution problem, long-term commitments by the industry and cooperation among all involved will be essential. In the past, partnerships between industry and government were a key element of efforts to reduce raptor electrocutions. In the future, partnerships will be one way to include companies that are uninvolved in mitigation efforts, and will ensure industry-wide treatment of the problem. Partnerships also will promote creativity as new approaches to the electrocution problem are sought.

As in the past, it seems logical for the electric industry to assume the lead in identifying problem areas, devising programs for prioritizing and retrofitting problem poles, involving the manufacturers of electric hardware, and educating industry personnel about the problem. Ultimately, however, these efforts should be collaborative. Government agencies in particular must find ways to assist industry in achieving these goals. The USFWS, for example, can play an important role by assisting smaller utilities that lack environmental or biological staffs in identifying problem areas and, as in the past, promoting education (Suazo 2000).

The entire biological community has the responsibility of informing energy suppliers of the ecological factors that contribute to raptor electrocutions. Results of population and migration studies and research on prey populations that may indicate where electrocutions are occurring or likely to occur should be made available to utilities that will be affected. Ecological research conducted by biology departments throughout academia may have relevance to utilities working to reduce electrocution risks to raptors. Success in dealing with the electrocution issue must be predicated on a blend of disciplines and expertise.

Finally, the consumer must be included in the equation. Consumers have the right and need to know how their actions affect the environment, especially if they are expected to bear the costs of environmental protection. Overall, the American public has demonstrated consistently that it is willing to pay that price, and in a deregulated setting many consumers may choose distributors that have demonstrated their concern for wildlife. An aware public also may find ways to aid the industry and government to end raptor electrocutions. Service in conservation and other volunteer organizations and reporting of electrocution incidents are 2 ways this could occur.

Conclusions

Two basic principles underlie electrocution issues. First, overhead power lines are an inevitable component of raptor habitat. Second, there will continue to be a mandate to protect avian resources from the same public served by the electric industry. Thus, the challenge that faced raptor conservation efforts in 1971 remains today: to increase industry and public awareness of the raptor electrocution problem and its solutions, to retrofit lethal power poles, and to ensure that all new power lines are built to raptor-safe standards. The raptor electrocution problem will take years to resolve, and the electric industry should not face the challenge alone. Governments, academic institutions, private-sector organizations, and the consumer must share the responsibility and costs of solving the electrocution problem. All will have critical roles to play in a cooperative effort that will, by necessity, extend well into this century.

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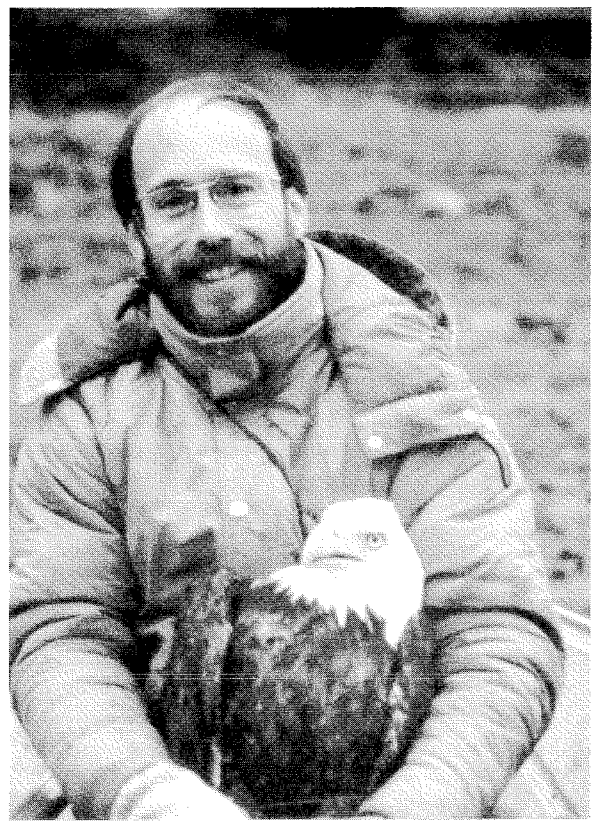

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