# TABLE OF CONTENTS

EXECUTIVE SUMMARY .................................................................................................................. ii

ACKNOWLEDGMENTS .................................................................................................................. v

INTRODUCTION ............................................................................................................................ 1

Chapter 1 – THREATS AND GENERAL SOLUTIONS ................................................................ 5
  Section 1 – Electrocution ............................................................................................................. 5
  Section 2 – Pesticides ............................................................................................................... 9
  Section 3 – Industrial and other contaminants ................................................................. 20
  Section 4 – Collisions with human-created structures ...................................................... 29
  Section 5 – Human persecution and disturbance ............................................................. 33
  Section 6 – Habitat loss and degradation ........................................................................... 38

Chapter 2 – PRIORITIZING THREATS AND SPECIES ....................................................... 43
  Section 1 – Priority factors .................................................................................................... 43
  Section 2 – Approaches to prioritizing species and threats ............................................. 45
  Section 3 – Current efforts by other organizations .......................................................... 51

Chapter 3 – HAWKWATCH INTERNATIONAL CONSERVATION STRATEGY .............. 55
  Section 1 – HWI Conservation Program goal and objectives .......................................... 55
  Section 2 – Issues and actions ............................................................................................ 55
  Section 3 – Supporting actions .......................................................................................... 59

TABLES ........................................................................................................................................... 61

LITERATURE CITED ..................................................................................................................... 73

PERSONAL COMMUNICATIONS ............................................................................................... 81
EXECUTIVE SUMMARY

HawkWatch International (HWI) has a substantial history as a raptor research, monitoring, and education organization. HWI has now begun a new conservation program that will strive to reduce human-related population limitations in raptors. HWI will achieve this goal through a strategic suite of actions (Chapter 3) that are derived from the literature reviews and prioritization schemes presented in this document (Chapters 1 and 2, respectively).

There are six general types of threats facing raptor populations that we review in this document: electrocution, pesticide poisoning, industrial contaminant poisoning, collisions, disturbance and persecution, and habitat loss/degradation.

Electrocution of raptors on overhead power lines appears to be very widespread. Large, open country raptors are at the greatest risk (e.g., Golden Eagle, Ferruginous Hawk), yet some urban raptors that are highly social are also at risk (Harris’ Hawk). There is little regional data available describing rates of electrocution, so it is difficult to estimate the impact of electrocution on populations. Solutions include a variety of retrofitting options, elevated perches, and designs for new, raptor safe poles.

Pesticide poisoning has been a major factor in raptor conservation issues worldwide. Though some pesticides that caused raptor declines in the past are no longer used in the U.S., many are still in use elsewhere. A variety of insecticides still in use in the U.S. are known to have harmed raptors. Pesticides need not kill raptors outright to cause population impacts; many have serious reproductive, physiological, and prey-base effects that are often difficult to document. Bird- and insect-eating raptors are at the greatest risk because their prey are either pesticide targets or can transmit pesticides to raptors quickly and in large doses. Fish- and mammal-eating raptors are also at risk to persistent chlorine-based pesticides and rodenticides, respectively. Again, the magnitude of this problem is hard to gauge, but evidence is amassing implicating a “priority” list of pesticides that need to be restricted. Solutions to this problem include reducing the amount of pesticides used, changing the types available, altering when pesticides are applied, and integrated techniques for managing pests.

Industrial contaminants (which include heavy metals and industrial chemicals) have had major impacts on raptor populations. Likely the most significant are lead (Pb) and polychlorinated-biphenyls (PCBs). Lead has killed many raptors, having the most acute population impacts in carrion-eating raptors such as California Condors and Bald Eagles. PCBs have had varying impacts on aquatic raptors such as Bald Eagles and Osprey. These problems may have declined in severity with the restriction of lead shot for hunting waterfowl and the cessation of additional PCB production in the U.S., but lead bullets are still used for most non-waterfowl hunting in the U.S. In addition, many industrial contaminants are long-lived and still in use in other nations, including lead ammunition and fishing weights. Some contaminants are produced consistently as unwanted manufacturing by-products and thus are still a serious hazard. Solutions to raptor poisoning by industrial contaminants include reducing production of certain toxic materials, better containment and cleanup of impacted sites, and hunter/fisher education.

Raptors can suffer collisions with a variety of human-created objects such as house windows, auto windshields, power lines, and wind turbines. Roadside-foraging raptors are at risk of hitting autos (e.g., kestrels and many buteos), and Golden Eagles have tended to strike wind turbines more than other species (though this depends strongly on turbine placement and design). Little information is available quantifying collision rates, but it is apparently
widespread. Solutions include more thoughtful placement of structures and roads, and moving bird feeders away from home windows.

Humans can impact raptor populations through behaviors that disturb nesting birds or by willingly persecuting raptors. Persecution generally results from misconceptions about raptor-human interactions, many of which suggest that raptors harm a particular resource that humans wish to protect. Outdoor recreation has increased in recent years and humans are frequently approaching raptor nest locations, causing stress or even abandonment. Again, little information exists on rates of disturbance and persecution impact, but education and adequate protective measures for known raptor areas could help reduce impacts.

Habitat loss is the most significant avian conservation issue today. Raptors generally nest in low densities and need large areas for successful breeding. Deforestation, drainage of wetlands, urban expansion, and exotic plant invasions are all affecting raptor populations. Raptors with the smallest ranges, the longest life spans, and the narrowest habitat requirements are at the greatest risk. Some raptors currently at risk from habitat loss include the Spotted Owl and Florida Snail Kite. Solutions are mainly restoring damaged habitat and preventing further loss. Achieving these two actions can involve land purchasing, conservation easements, manipulation of disturbance regimes (e.g., controlled burning), manipulating water movements, altering resource extraction efforts, connecting fragmented landscapes, and revegetation efforts.

We attempt to sort out the many types of threats and relative degrees of vulnerability of each raptor species in western North America using a scoring matrix. In this matrix, each species and threat pair was assigned a score of 1, 2, or 3 (with 3 indicating the greatest degree of threat or concern), allowing us to sum and sort threats and species by rank, from highest to lowest. We hope to refine this prioritization scheme further with new information and ideas about the scoring. We also discussed a variety of other approaches, including the Partners in Flight (PIF) approach. The PIF process is a very significant development in avian conservation, but it may need to incorporate additional raptor-specific information. In addition, we describe the ongoing raptor conservation programs of other organizations to help clarify what threats are most in need of additional action.

Finally, we present a summary of HWI’s Raptor Conservation Strategy. The strategy was formulated by HWI’s science and conservation committees and was derived in large part from the information and prioritization ideas presented in the first two chapters of this document. These committees reviewed summary information, including a list of potential conservation actions, the species and threats prioritization scheme, HWI’s resources and strengths, ongoing programs operated by other organizations, and achievability of each action. The strategy specifies an array of research needs, cooperative projects, and educational objectives that will help guide HWI towards its ultimate goal: to protect raptors and the habitats upon which they depend. Specifically, HWI has identified the following high-priority threats to raptors: powerline electrocution, toxic contamination, persecution and disturbance from humans, and habitat loss and degradation. HWI’s Conservation Strategy will positively address these threats to raptors through the following actions:

A. **Powerline Electrocution** – While no systematic data reporting system exists that can provide an estimate of the total number of raptor deaths occurring by electrocution each year, the little regional data that are available demonstrate that the problem is large. To reduce electrocutions, HWI will organize citizen-based powerline surveys to record mortalities, pioneer model cooperative programs with power companies to retrofit problem poles, and research regulatory options to promote raptor-safe poles and designs.
B. Toxic Contamination – HWI will address the following toxic threats:

1. *Poisoning from lead shot and sinkers used in hunting and fishing.* Lead contamination from sporting activities is still a threat to raptors. Areas of action for HWI are to (a) compile and disseminate the latest information to convince sportsmen to use non-lead alternatives; and (b) inventory current regulations about the use of lead shot/sinkers and explore regulatory solutions to reduce their use.

2. *Pesticides.* HWI will identify those pesticides that have the greatest impacts on raptors and focus on their reduction/elimination by promoting alternatives, educating consumers, and working with growers, manufacturers, and other organizations.

C. Human Persecution And Recreational Disturbance – HWI already addresses this threat, in part, through nesting surveys in northern Utah that assess human disturbance, rural classroom programs to nurture appreciation of raptors, and, beginning in 2001, monitoring the impacts of heli-skiing operations on Golden Eagles in Utah’s Wasatch Mountains. Other research and education opportunities pertaining to persecution and disturbance will be pursued.

D. Habitat Loss and Degradation - HWI habitat conservation efforts will include:

1. Active involvement in Partners in Flight (PIF), a regional and nationwide avian conservation effort, to provide a level of raptor expertise that is currently lacking, and serving as a liaison between PIF and the raptor research/conservation community.

2. Providing HWI scientific expertise to other conservation organizations working on policy/habitat issues affecting raptors.

3. Working with land trusts to protect important areas where raptors concentrate in high numbers and/or diversity.

4. Developing a raptor habitat characteristics database to be used by agencies and conservation groups assessing potential impacts of land management decisions on raptors.

HWI will support these actions through multifaceted education and media campaigns, networking efforts with other conservation organizations, and commenting on pertinent agency management documents.
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INTRODUCTION

BACKGROUND

HawkWatch International (HWI) is a non-profit, membership organization whose mission is “to protect hawks, eagles, other birds of prey and their environments through research, education and conservation.” HWI was founded in 1986 in Albuquerque, New Mexico and currently is based in Salt Lake City, Utah.

HWI operates a long-term population monitoring program that is based primarily on standardized counts of migrating raptors. A network of multiple sites throughout western North America provides data on regional and continental scale raptor populations for certain species. The count sites are generally located along mountain ridges or coastlines, both of which are topographic features that concentrate migrating raptors into narrow stretches. At these sites, large numbers of raptors can be observed passing by on their spring or fall migrations. Official observers are stationed at these sites and tally the observed migrants. Over time, these counts can reveal natural and human-induced variation in population size. HWI’s monitoring program is truly a conservation effort because it produces data on population change. This information is disseminated widely to land managers and the general public. Understanding population dynamics by using tools such as migration counts is an important part of being able to protect raptor populations.

HWI also offers education programs that are designed to increase awareness of threats to raptors as well as create a heightened sense of appreciation for wildlife. Programs are offered to schools and universities, social and civic organizations, and businesses. One of HWI’s best educational offerings is a visit to one of the field sites, which are open to the public and provide unparalleled wildlife viewing. At the sites, visitors can also observe the research projects and interact with counters, banders, and on-site educators.

Although HWI has conducted its conservation efforts largely through its monitoring and education programs, HWI staff have pursued and contributed to other conservation efforts as well. These efforts include: writing letters of opposition regarding development of a shooting range in the Florida Keys near the HWI migration monitoring site; working with conservation and planning groups to oppose building of the Legacy Highway in Davis County, Utah; submitting comments on various environmental impact statements, including the management plan for Northern Goshawks on Utah's National Forests and the permit for a heli-skiing operation in Utah's Wasatch Mountains; and co-signing letters of support written by other conservation groups for various legislation or regulations that are in line with HWI's mission. Although these efforts were pursued with the hopes of protecting raptors and their habitats, they were never conducted in a comprehensive and strategic manner.

PROGRAM GOAL

HWI education and monitoring programs can increase awareness of conservation issues among the public, and through time may prompt individuals to adopt lower-impact lifestyles or make political decisions that favor environmental and wildlife protection. In addition, data collected at migration sites have been used to affect agency management and research decisions and policy. At this stage in its history, however, HWI will begin a new program that more directly benefits raptors. The goal of this new program is to contribute to the protection of raptor
populations and their habitat. HWI will work on three objectives to achieve this goal. These are to 1) identify, 2) quantify, and 3) reduce human-related population limitations for raptors.

THE AIM OF THIS DOCUMENT

This document stems from our initial efforts to achieve the first two objectives in preparation for the third objective. For simplicity, we refer to human-related activities and changes to the environment that cause population limitation in raptors as “threats.” The document begins by attempting to identify threats to raptors (objective 1), continues by offering possible methods of gauging the relative importance of the various threats (objective 2), and finishes by providing a list of potential solutions that could help reduce these threats. Ultimately, this document is intended to provide the background necessary for HWI to create a suite of potential actions that will lead to meaningful conservation results (objective 3). The document will be dynamic and updated to reflect new information.

Figure 1. Western North America with a depiction of the major western raptor migration flyways and the locations of HWI long-term monitoring sites.
SPECIES ADDRESSED

HWI has historically focused on diurnal migratory raptors because they are the most easily monitored at migration count sites. The conservation program, in contrast, is concerned with protecting all raptors, including owls and non-migratory diurnal raptors (Table 1).

GEOGRAPHIC CONSIDERATIONS

By virtue of its location and the location of the majority of its monitoring sites, HWI’s conservation program will operate primarily in western North America and in other regions in which HWI has major projects (i.e., Florida Keys and coastal Texas). We define this priority area in two biologically relevant ways. First, HWI’s primary geographic scope roughly coincides with the three currently described prominent raptor migration flyways in western North America. These are the Pacific Coast, Intermountain, and Rocky Mountain flyways (Figure 1). These flyways delineate the year-round movements of many western raptors and thus provide a framework for visualizing the geographic areas important to western raptors. Second, HWI’s primary geographic scope coincides with several of the Bird Conservation Regions (BCR) created by the North American Bird Conservation Initiative (NABCI, Figure 2). These regions define biologically cohesive (but not necessarily uniform) areas throughout most of North America that are not abridged by national or state boundaries. The following BCRs are consistent with HWI’s view of western North America (numerical identification code corresponds to map, Figure 2): Northwest Interior Forest (4), Northwest Pacific Rainforest (5), Great Basin (9), Northern Rockies (10), Sierra Nevada (15), Southern Rockies/Colorado Plateau (16), Shortgrass Prairie (18), Coastal California (32), Sonoran and Mojave Deserts (33), Sierra Madre Occidental (34), and Chihuahuan Desert (35).

CRITERIA FOR IDENTIFYING STRATEGIC ACTIONS

After identifying the threats and potential solutions, HWI will create a suite of strategic actions based on whether they meet the following four criteria:

1. Does the action address a threat that appears to be significant? In an ideal world, we would have unbiased data that clearly indicates which threats are having the greatest impacts to raptor populations. These data do not exist. Instead, we have developed a prioritization scheme that will at least provide a first-approximation of the importance of the varying threats.

2. Is the action currently being taken by another organization? HWI will not embark on projects that are redundant or address issues that are being adequately covered by others.

3. Will the limited number of staff and financial resources HWI has available be adequate to truly make an impact on the problem? Given an important conservation opportunity, HWI will strive to find the funds and/or partners, greater than those it has now, necessary to address it. At the outset, however, HWI will select projects in part based on its ability to successfully manage and complete them given current resources. In addition to simply having the resources to undertake a project, HWI will ask whether the specific action seems cost-effective.

4. Will the action occur close enough to HWI’s current areas of operation to make it logistically feasible? HWI is a volunteer and member-supported organization, and the volunteer base tends
to be centered in areas adjacent to long-term field sites. It is important for HWI to include volunteers and members in its conservation efforts. This approach improves public interest, enhances knowledge of the issues and solutions, and provides rewarding opportunities to help conserve raptor populations. Thus, HWI will most frequently work in areas where its volunteers are close enough to participate. In fact, any project that is volunteer-intensive may by necessity be centered in these areas.

Figure 2. North American Bird Conservation Regions (map from NABCI website). Regions of interest to HWI include Northwest Interior Forest (4), Northwest Pacific Rainforest (5), Great Basin (9), Northern Rockies (10), Sierra Nevada (15), Southern Rockies/Colorado Plateau (16), Shortgrass Prairie (18), Coastal California (32), Sonoran and Mojave Deserts (33), Sierra Madre Occidental (34), Chihuahuan Desert (35).
Chapter 1

THREATS AND GENERAL SOLUTIONS

Section 1

ELECTROCUTION

HOW IT HAPPENS

Electrocution occurs when a bird perches on a power pole and completes an electric circuit by simultaneously touching two conductors or a conductor and a grounded line (Bevanger 1994). The configuration of conductors and grounds are a primary factor in creating a risk of electrocution for raptors interacting with power poles. Medium-voltage distribution lines (1-69kV according to APLIC [1996]) are the primary problem. The spacing of conductors (clearance) is specified by the National Electric Safety Code. Lower voltages require smaller clearances. Therefore lines around 12.5kV are frequently involved (Rick Harness, pers. comm.). These lines can be dangerous because they typically have configurations that place multiple conductors and grounds close together. The spacing between lines varies, but in many instances it is small enough to be bridged by medium-sized to large birds. A common “electrocution trap” has three top-mounted lines on a crossbeam (fig. 3 in Bevanger 1994, Harness 1997). Raptors alight on the crossbeam and bring their wings down on either side, touching the lines. Another common electrocution trap is the transformer pole (fig. 4 in Bevanger 1994). These poles typically have an array of wires, including some that run along the crossbeam, and even small birds are at risk of completing circuits. Also, transformers have uninsulated jumper wires and exposed bushings (Rick Harness, pers. comm.).

Feathers are much more conductive when wet (Olendorff et al. 1981, APLIC 1996). This feature creates enhanced risk to lower voltage circuits because greater amounts of electricity can pass through the bird. Whereas creating skin-to-skin or skin-to-beak contacts is usually required under dry conditions, electrocution can occur through feather-to-feather contacts when wet, and potentially also through arcing (i.e., when electricity jumps to the bird, Mark Vekasy, pers. comm.). In addition, it was previously thought that touching only one conductor would not cause electrocution. Recently it was discovered that well-soaked poles can ground out single hot lines if a bird bridges a line and the pole (Bob Lehman, pers. comm.). Hence, some electrocutions can occur during storms even on poles that pose little risk during dry periods. Under the right conditions, all distribution poles can electrocute birds.

WHAT SPECIES ARE AT RISK

There appear to be two biological risk factors associated with the probability of electrocution in raptors. The first factor is body size (Bevanger 1994), and in particular, wing span. Large birds are more likely to bridge the gaps in wire spacing when they perch on poles. Small birds are less likely to bridge this gap and are also more likely to perch on the wire itself, away from poles (pers. obs.). The second risk factor is behavioral preference. Some raptors utilize power poles as roost sites, nesting platforms, and hunting perches (Bevanger 1994). In areas with few trees, raptors can be drawn to the power poles for these uses. Open country
Raptors tend to be at greater risk than forest-dwelling raptors because the latter are usually not dependent on the structure provided by power poles (APLIC 1996). However, some raptor species will use power poles in urban or forested areas and are also at risk.

Raptors of nearly every species occurring widely in the western U.S. have been reported killed by electrocution. Species that are electrocuted at the highest rates include Golden Eagles and Red-tailed Hawks (APLIC 1996, Harness 1997). Immature Golden Eagles appear to be most susceptible bird because of their inexperience (tendency to be less graceful when landing on power poles) and behavior (tendency to perch-hunt more often than adults, APLIC 1996). Other species that are electrocuted frequently include Bald Eagles, Great-horned Owls, Ferruginous Hawks, and Harris’ Hawks (Dawson and Mannan 1995).

CURRENT STATE OF THREAT

By all accounts, the problem of electrocution is large. Unfortunately, nobody knows much more than this and many electrocutions go undetected (Williams 2000). While several utilities maintain databases on raptor mortalities, the data are collected only as electrocutions are encountered through routine maintenance instead of through targeted surveys. Because of this, we cannot provide an estimate of the total number of deaths by electrocution occurring each year. There are currently local efforts in the southwest to create a regional reporting system (Bill Howe, USFWS, pers. comm.), but these are not yet in place. A national system was created in the 1970's by the USFWS but it was canceled only a couple of years later for unknown reasons (Williams 2000). There are a few locations where USFWS law enforcement or biologists are conducting surveys. For example, in Utah, a USFWS agent has records on 128 electrocutions over a 1.5-year span in Utah, 35 of which were eagles (Williams 2000). The National Eagle Repository for Native Americans collected approximately 115 electrocuted eagles during the 5-month period from October 1997 to February 1998 (Thomas 1998). The USFWS reported over 2000 raptor deaths from 1978 to 1998 in CO, NE, KS, WY, SD, and ND (Thomas 1998). Harness (1997) reported data on 1450 documented raptor mortalities in the western U.S. from 1986 through 1996. Recently, systematic surveys in the Mission valley of Montana from 1997-1999 revealed that Rough-legged Hawks and Red-tailed Hawks are still being electrocuted (Olson 1999). There are many other reports of local findings that are available (APLIC 1996). Still, few adequate inventories are being conducted, and scavenging and decomposition likely cause surveys to underestimate the mortality rates.

Much of the data on electrocutions comes from chance encounters and pole visits due to a power outage caused by an electrocution. What is clear is that there are many thousands of miles of dangerous power lines spread across the nation that could be killing raptors. Many of these poles are located in areas occupied by wintering Golden Eagles, Bald Eagles, Ferruginous Hawks, and Red-tailed Hawks. With over 116 million distribution poles in the U.S. (Williams 2000), most accessible to large raptors, the current threat to raptors appears massive.

It is unknown whether any raptor populations have declined in the U.S. because of electrocution deaths. In Europe, both the Eagle Owl and the Spanish Imperial Eagle (Ferrer et al. 1991, Ferrer and Hiraldo 1992) are thought to have suffered population declines because of electrocutions. Otherwise, it tends to be assumed that electrocutions are having population effects on raptors (e.g., Bevanger 1994). However, the issue of whether electrocutions are additive or compensatory for natural rates or mortality is still open.

Even in circumstances where it is unclear that the level of mortality due to electrocution is directly causing population declines, there is still reason to be concerned. Raptors typically
show reversed sexual size dimorphism, where the female is larger than the male. Because size is related to the probability of being electrocuted, females are at greater risk than males of being electrocuted. Ferrer and Hiraldo (1992) have demonstrated sex-biased mortality in Spanish Imperial Eagles, as well as in Peregrine Falcons, Northern Goshawks, and Golden Eagles. Sex-biased electrocution was also documented in Harris’ Hawks (Dawson and Mannan 1995). This mortality bias suggests that electrocutions are impacting the effective population size of some raptors, possibly causing negative demographic changes that could indirectly cause population declines.

Sometimes the placement of power lines in open country is viewed as the construction of new “habitat” for raptors. This view suggests that power lines could be beneficial to raptor populations (Steenhof et al. 1993). APLIC (1996) reviewed three studies that documented successful nesting of several raptor species on power-line structures. The nesting species included Golden Eagles, Red-tailed Hawks, Osprey, and Ferruginous Hawks. Mostly, these nests were placed on transmission lines (carrying greater than 69 kV) and are thus associated with a different class of structures than those that typically cause electrocutions. It is not always clear that these pairs had relocated to the power lines after they were built or if the increases represented actual increases in population size after the limiting factor of nesting substrate was reduced. There are two reasons to view this supposed benefit with caution. First, artificially increasing predator levels in communities that may have naturally supported fewer predators could have unintended impacts such as changes in prey and/or plant communities. Second, young birds that are raised on power-line nests are often electrocuted as fledglings (Dawson and Mannan 1995). Furthermore, these birds may be attracted to power lines in the future for nesting, which could cause increased risk of electrocution for these birds later in life.

In some cases power lines offer an undeniable benefit to raptors. A recent expansion of Osprey into New Mexico was facilitated by the presence of power lines running along the edges of artificial lakes (Dale Stahlecker pers. comm.). These birds were apparently originating from an expanding population in southern Colorado. The newcomers nested on the power poles, later aided by the erection of nest platforms by the local electric cooperative. Now, however, alternative nesting platforms have been erected to lure birds away from the lines and ensure that young birds have as little a tendency as possible to continue nesting on the lines. Hence, the power lines assisted colonization of these areas by dispersing birds, but are still dangerous and additional efforts are required to keep them nesting away from the lines.

In the future, the threat of electrocution could actually become worse because of the half-century or so life span of wooden power poles (APLIC 1996). Metal poles, which are cheaper, stronger, and resistant to animal and weather damage may become more common as they are used to replace old wooden poles (Harness 1998, Williams 2000). Metal poles, however, are more dangerous than wooden poles because the poles themselves are conductive. In Europe, where metal poles are commonplace, many different-sized raptors are at risk of electrocution. Even small raptors such as kestrels may easily be electrocuted on metal poles because of the ease at which circuits are completed (Janss and Ferrer 1999). A new suite of protection devices are being developed to protect birds from electrocution on steel power poles (Janss and Ferrer 1999). Installing non-conductive crossbeams made from wood or fiberglass, combined with insulative caps on some structures is one solution (Harness 1998).
SOLUTIONS

Short-term and long-term solutions to the problem of raptor electrocutions have been identified. The basic short-term solution is to retrofit power poles to make them “raptor-safe”. Methods of modifying wooden poles to make them raptor-safe have been developed and refined since the 1970’s (Bevanger 1994, APLIC 1996). These methods include ways of discouraging the use of poles (perch guards and scare techniques), preventing contact with hot lines (increasing distances between wires, insulators, elevated perches, and perch guards), removing the risk altogether (running lines underground), and reducing the risk by locating lines in areas with few raptors. Though there is evidence that the recommended modifications help to reduce raptor electrocution, more research needs to be conducted to determine the effectiveness of modifications (Harness and Garrett 1999). Despite these options, it is nearly impossible to fully eliminate the risk of electrocution without putting the line underground. In addition, recommended procedures can lead to increased raptor mortality. For example, discouraging birds from using preferred perching poles by installing triangles may encourage the use of more dangerous poles (Rick Harness pers. comm.). Because of possibilities such as this, at least one expert believes that it is better to make poles safe to use than to discourage their use.

Despite nearly three decades of voluntary action on the part of utility companies, which have retrofitted thousands of poles over the last two decades, most poles remain dangerous. It appears that industry momentum was greatest in the 1970’s but subsided somewhat during the 1980’s and 1990’s (Lehman 1999). Several developments in the 1990’s may have especially deflected utility company attention away from the problem of electrocution. First, deregulation has occupied the attentions of utilities as they brace for major change in the economic environment in which they operate. Second, the historical problem of raptor electrocutions causing power outages has been reduced because of technical improvements in energy distribution (Lehman 1999). Recent events seem to have rekindled industry interest in proactive prevention, in particular the successful conviction of a utility company that had inadequately addressed the electrocution problem and allowed continued raptor mortalities on their lines.

USFWS staff would prefer to stay out of court (Laura Roman, USFWS, pers. comm.), and by and large this preference is achieved because utilities do voluntary retrofit poles that are known to have killed raptors. However, a recent conviction of Moon Lake Electric Association has sent a message that the USFWS will not allow utilities to ignore the problem (Melcher and Suazo 1999, Williams 2000). Though voluntary involvement by utilities is the most productive way of reducing the problem, resistant companies may more realistically face fines and/or jail time now that this legal precedent has been set. Still, some believe that the threat of legal action may not be enough to motivate utilities to voluntarily retrofit poles; public pressure may be necessary as well (Williams 2000).

The only long-term solution to the electrocution problem is to ensure that all new construction and replacement of aging power lines incorporates raptor-safe design. Even if utility companies are rejuvenated in their efforts to reduce mortalities through pole modifications, the gains will be short-term, since every wooden power pole currently in existence in the U.S. will likely be replaced within the next century. Failure to ensure long-term commitment to using raptor-safe poles will extend the electrocution problem well into the future. Currently, utilities do not face a uniform legal obligation to make new lines raptor safe (Rick Harness, pers. comm.). New lines constructed on federal lands must install raptor-safe poles as a permitting requirement. Also, the Rural Utilities Service cooperatives (a branch of the USDA) are required to install raptor-safe poles for all new lines as a prerequisite for borrowing money
from the government. However, investor-owned and municipality utilities are not required to follow any guidelines, APLIC or other, when installing new lines on private land. Hence, there may be a need for additional motivation created by public concern and/or legal action to help reduce this source of mortality in the long run. The development of new power structures provides easy and cost-effective opportunities to protect birds, as safety features can be built into the structures from design phase to installation (at relatively low cost or even no cost). For long-term protection of raptors, this aspect is essential. In the meantime, there remain thousands of problem poles that will continue to kill raptors until discovered and corrected.

Section 2

PESTICIDES

The term pesticide refers to any substance that is used to control biological pests. Pesticides are classified by the type of organism they target: insecticide (insects), herbicide (plants), fungicide (fungi), rodenticide (rodents), and avicide (birds). Though many types of pesticides are potentially harmful to humans, it is primarily the insecticides that have caused noticeable harm to birds. The most widespread types of insecticides in use today are the organophosphorous compounds (OPs) and carbamates. Beginning in the 1970s, a gradual phase out began of the once widespread organochlorine compounds (OCs, also called chlorinated hydrocarbons), some of which are still in use today outside of North America but not as much as in the past. Many of these compounds are toxic to a wide array of organisms, including birds. Anticoagulant rodenticides also pose a threat to birds, especially raptors. At least 60 different pesticides are known to have killed migratory birds, but the lack of systematic surveys or a national information database suggests that kills caused by additional pesticides may have been overlooked (Lyon 1999).

OUTLINE OF TERMINOLOGY

Pesticide terminology seems to be somewhat varied in its usage. For this reason, Kelley Tucker at the American Bird Conservancy (ABC) has tried to garner consensus on the use of terms and asked me to incorporate this usage into our document. What follows is a brief outline of this terminology.

BIOLOGICAL TERMS

Routes of exposure – how birds get poisoned
  Ingestion – consuming pesticides or contaminated food
  Inhalation – breathing in aerosols, dusts, or gases
  Dermal contact – touching sprayed plant material (i.e., brushing up against or perching on), walking through contaminated soil or bathing in contaminated water

Direct effects – impacts to the bird
  Secondary poisoning effects – impacts to predators that consume poisoned prey (here a universal problem of differentiating between vertebrate and invertebrate predators persist, secondary poisoning still refers only to carnivorous predators)
  Lethal – kills the bird outright
Sublethal – doesn’t kill the bird
Weakening – disposes birds to other mortality factors
Reproductive – inhibits breeding
Endocrine disrupting – alters important hormone levels
Behavioral – causes improper care of offspring

Indirect effects – harms something important to birds
Food effects – reduces prey base
Habitat effects – diminishes habitat availability

LEGAL TERMS

Labeled use – use consistent with EPA registration
Mislabeled use – unintentionally using a product in unregistered ways
Illegal use – intentional use of a product in unregistered ways
Restricted-use Product – pesticides with a specific legal use, license required
General-use – pesticides that can be used by general public, no license needed
Cancellation – removing the registration of a product
Ban – there is no such thing, DDT’s registration was cancelled, it was not banned
Deny – not allowing the registration of a product

ORGANOCHLORINE PESTICIDES

Description.—The first OCs were synthesized before 1900 but the 1940s saw the first large-scale use of OCs as pesticides. The OCs were favored in the post-war years partly because of their environmental stability (Furness 1993). Examples include DDT, DDD, chlordane, aldrin, endosulfan, and others.

Sublethal effects.—The use of OC pesticides in North America and Europe has had serious long-term impacts on some bird populations because of sublethal (endocrine disrupting) effects (Henny et al. 1999). The OCs tend to accumulate in the environment with each application because of their chemical stability. The OCs are lipid-soluble and therefore tend to be sequestered into fatty tissues of animals and move up the food chain to top predators, reaching higher concentrations with each trophic level (biomagnification). The stable metabolite of the widely-used DDT, DDE, decreases avian estrogen levels. This change impairs the ability to store and then redistribute calcium, leading to the production of thin-shelled eggs (Newton 1979). Birds that were exposed to high levels of DDT laid thin-shelled eggs, which they crushed during incubation, leading to lower reproductive success and population declines (Newton 1979). These declines reversed once restrictions on DDT and other OCs were put into place in the 1970s (Henny et al. 1999, Newton and Wyllie 1992). Though it has not been shown for raptors, embryonic exposure to DDT residues can cause feminization of male California and Western Gull embryos (Fry and Toone 1981). These effects can lead to female-female pairing, infertile eggs, and decreased productivity.

Lethal effects.—In the early years of use, OCs were praised for their low toxicity to vertebrates and high toxicity to insects (Furness 1993). OCs can kill birds (and other vertebrates) if environmental concentrations are high enough, but more frequently birds are exposed to sublethal doses. Chlordane (and the other cyclodiene) is highly toxic to birds, and because of its
persistence it is still killing birds today (see later, Stansley and Roscoe 1999). Dieldrin, rather than DDT, may have been responsible for some of the raptor declines in the U.K. and the U.S. due to acute poisoning (Elliott and Martin 1994 and references therein). Because periods of great energy expenditure can cause the rapid utilization of fat reserves, accumulated OCs can be released rapidly from fat stores into the blood stream. This spike in exposure can kill a bird even though it was not exposed to a lethal dose directly from the environment (Van Velzen et al. 1972).

**What species are at risk.**—Fish-eating and bird-eating raptors were hit the hardest by the reproductive effects of DDT and other OCs. Osprey experienced population declines in the northeastern U.S. probably as a result of OC pesticide use (Wiemery et al. 1987). Among the accipiters, OC burdens were highest in Sharp-shinned Hawks, intermediate in Cooper’s Hawks, and lowest in Northern Goshawks (Elliott and Martin 1994). For Cooper’s Hawks, pairs that took more birds than others had higher levels of DDE in their eggs (Snyder et al. 1973). Levels of contaminants appeared to relate to the proportion of migratory songbirds in the diet and tendency to migrate to the tropics (Elliott and Martin 1994). Though DDE residues have declined in some Peregrine Falcons sampled on spring migration (Henny et al. 1996), raptors that migrate from North America to Central and South America may still be at risk of poisoning by OCs that are no longer in use in North America but are used elsewhere (Elliott and Martin 1994, Noble and Elliott 1990, Peakall et al. 1990, Henny 1998). Such winter time exposure is in part blamed for the slow recovery of Peregrine Falcons in the eastern part of Canada (Peakall et al. 1990), and northern Peregrine Falcons may have been exposed to OCs primarily on their wintering grounds (Henny et al. 1982). Juvenile Sharp-shinned Hawks migrating in spring through the Great Lakes region were found to carry higher OC residues than when they migrated south the previous fall (Elliott and Shutt 1993). Though owls appear to be physiologically as sensitive to pesticides as diurnal raptors, they were affected less strongly by the OCs than were other birds because it seems that they were exposed less to these chemicals (Blus 1996).

**ORGANOPHOSPHORUS AND CARBAMATE PESTICIDES**

**Description.**—The OPs include monocrotophos, dicrotophos, famphur, fenthion, malathion, chorypyrifos, terbufos, and many others. The carbamates include carbofuran, aldicarb, carbaryl, and others. The OPs and carbamates are structurally similar and so act in the same way, but carbamates lack the central phosphorus atom characteristic of OPs. Their use as pesticides increased as OCs were beginning to be phased out, especially in the 1960s and 1970s (Henny et al. 1999).

**Sublethal effects.**—Because OPs and carbamates are often rapidly degraded in tissues (see references in Henny et al. 1985), birds can recover from sublethal exposures (Solomon and Robel 1980). Sublethal doses of OP insecticides on nesting birds can cause reduced growth rates, fledgling mass, and brain cholinesterase (ChE) activity, but in European Starlings these effects appear to be reversible if they do not result in immediate death (Stromborg et al. 1998). Sublethal exposure of carbamates to Bobwhite Quail did not cause noticeable changes in body weight or energetic characteristics of treated birds, and within 2 days of treatment brain ChE activity was normal (Solomon and Robel 1980). These results and those of others (cited in Solomon and Robel 1980) suggest that sublethal effects of these insecticides are reversible. However, sublethal exposure of parents can lead to reduced chick provisioning rates with
resultant decreases in productivity (Grue et al. 1982). Also, OPs appear to affect birds’ orientation ability, inhibiting their ability to migrate in the correct direction and potentially leading to increased mortality during migration (Vyas et al. 1995).

**Lethal effects.**—OPs and carbamates are intended to have lethal effects. They kill by inhibiting the functioning of cholinesterase enzymes (ChE, Chambers 1992), primarily acetylcholinesterase (AChE). This enzyme is vital to the proper functioning of the nervous system. Acetylcholine (ACh) is the molecule that stimulates muscle movement when triggered by nerve impulses. After the movement, AChE hydrolizes the ACh causing movement to stop. The OP and carbamate pesticides, however, mimic the structure of ACh and are hydrolized instead of the ACh. The pesticide therefore ties up enzyme molecules and does not release them rapidly enough to prevent the build-up of ACh. As ACh accumulates, uncontrolled movements begin, leading to convulsions and paralysis of breathing, and ultimately death. This biochemical process appears to be common to all vertebrates and invertebrates, yet OPs are in general more toxic to birds than to mammals, fish, and amphibians (Wallace 1992).

**Indirect effects.**—OPs and carbamates used in areas where birds forage may reduce populations of prey species. Chemicals applied to farm fields can reduce important prey numbers in the edge habitats where many species forage (Rands 1985). In England, the Grey Partridge experienced population declines because of reduced insect productivity in farmland edges (Rands 1985). A similar scenario could be imagined for American Kestrels or other raptors that utilize habitats in agricultural landscapes; this may have already occurred for Burrowing Owls in Canada (Fox et al. 1989, cited in Blus 1996).

**What species are at risk.**—Almost all raptor species are susceptible to the effects of OP and carbamate poisoning (Henny et al. 1999). Mineau et al. (1999) provided a summary of raptor mortalities due to OP and carbamate pesticides from 1985-1995 in the U.S., Canada, and U.K. After reviewing 520 incidents (amounting to 998 individual deaths), they described several key risk factors that make some raptor species more susceptible than others to OP and carbamate poisoning. These include “insectivory and vermivory; opportunistic taking of debilitated prey; scavenging, especially if the gastrointestinal tracts are consumed; presence in agricultural areas; perceived status as pest species; and flocking or other gregarious behavior at some part of their life cycle.” Of the 25 species generally occurring in HWI’s geographic area of primary concern, 16 were reported as being poisoned by pesticides in this report (U.S. cases). Of these, four species made up the bulk of labeled use mortalities: Red-tailed Hawks, Bald Eagles, Swainson’s Hawks, and Mississippi Kites (from highest to lowest frequency). These species exhibit several of the risk factors identified above. Curiously, American Kestrels, which are insectivorous and present in agricultural areas, were recorded poisoned only four times (out of a total sample of 736 in the U.S.). However, small non-flocking birds tend to be found less often, suggesting the risk to American Kestrels may be underestimated by the data used in Mineau et al.’s (1999) survey. Avian predators that frequent urban environments such as golf courses can be in danger of OP and carbamate secondary poisoning because of the use of such insecticides on golf course turf where prey species such as American Robins, European Starlings, and other birds are likely to be exposed (Brewer et al. 1993). Burrowing Owls appear to be at serious risk from the use of carbofuran near nesting sites in grassland and agricultural areas (Blus 1996). The use of carbofuran has been implicated in the declines of Burrowing Owl populations in Canada (Fox et
al. 1989, cited in Blus 1996), but the causal mechanism (reduction in prey, increased mortality, or reduced productivity due to physiological effects) has not yet been determined (Blus 1996).

In addition to raptor mortalities caused by legal uses of pesticides, there are those that are caused by illegal (either intentional or accidental) application of pesticides. Three species made up the bulk of abuse cases in Mineau et al.’s (1999) study on OP and carbamate caused raptor deaths: Golden Eagle, Bald Eagle, and Red-tailed Hawk (from highest to lowest frequency). For the Golden Eagle, all 125 cases were classified as abuse, suggesting a high rate of intentional poisoning or possibly just a high rate of scavenging on improper target species. Significantly, nearly half of the cases Mineau et al. (1999) reported were abuse cases, suggesting that an important component of reducing OP and carbamate pesticide poisoning in raptors is to reduce the illegal use of these compounds. However, eagles and abuse cases are more likely to be reported than legal use mortalities, so these results may overplay the relative importance of abuse cases (Henny et al. 1999).

**ANTICOAGULANT RODENTICIDES**

*Description.*—Anticoagulants are typically used as baits in urban and agricultural areas to reduce rat and vole numbers (Kaukeinen 1993). Examples include warfarin, brodifacoum, diphacinone, and others.

*Lethal effects.*—Anticoagulant rodenticides kill by interfering with the action of Vitamin K, which is vital to blood clotting in vertebrates (Stone et al. 1999). The poisons usually cause internal hemorrhaging, but importantly, they make target organisms sensitive to uncontrolled bleeding when injured. Minimum exposure levels are required for rodenticides to work, and in some cases birds exposed to sublethal levels of anticoagulants can return to normal after a period of time (Newton et al. 1990). Some anticoagulants take several days to work (e.g., brodifacoum) even with lethal doses, allowing rodents to forage, accumulate greater body burdens, and be exposed to raptor predation before dying (Kelley Tucker, pers. comm.). When depredated, they can deliver significant doses to the predator. Still, raptors are often poisoned only enough to bleed to death from a broken feather or minor cut rather than die directly from toxicosis (Kelly Tucker, pers. comm.).

*What species are at risk.*—Raptors that eat small mammals in urban and agricultural areas are at risk of being poisoned by anticoagulant rodenticides. Relatively little research has been conducted on the effects of these chemicals as compared with the ChE-inhibiting pesticides. One study found that Red-tailed Hawks and Great-horned Owls made up the bulk of raptor mortalities from secondary poisoning (Stone et al. 1999). This study also reported smaller numbers of poisoned Screech Owls, and an individual Barn Owl, Snowy Owl, Golden Eagle, Bald Eagle, and Peregrine Falcon. Another study demonstrated the deaths of Eastern Screech-Owls in Virginia orchards that preyed upon brodifacoum-contaminated voles (Merson et al. 1984).

**ROUTES OF EXPOSURE TO RAPTORS**

Pesticides are applied to the environment as dusts, liquid sprays, scattered granules, baits, and gases. Non-target organisms, including raptors, can be exposed to pesticides in one of three ways: ingestion, inhalation, or dermal contact. Ingestion includes consuming contaminated prey or drinking contaminated water, and even preening feathers that have been exposed from the air
or from plants. Inhalation occurs when an animal is present in an area with recently sprayed
gaseous or liquid formulations (from aerosols). Dermal exposure occurs when a raptor comes
into contact with the pesticide such as by direct hits from aerial applications (Fry et al. 1998,
cited in Henny et al. 1999), bathing in contaminated pools (Mineau et al. 1999), and from
contacting any object covered in the substance (e.g., brushing against plants, walking across
soils, perching on branches; Kelley Tucker, pers. comm., Mineau et al. 1999).

Secondary poisoning is sometimes defined as that which results from ingesting poisoned
vertebrate prey (Henny et al. 1999). Because of this usage, it is useful to separate secondary
poisoning due to consumption of vertebrates from secondary poisoning due to consumption of
invertebrates. Exposure through the consumption of insects is very common. Typically, an
agricultural field is treated with an AChE-inhibiting pesticide to control insects. The insects
begin to convulse and die if the doses are high enough. The dying insects attract insectivorous
birds by their erratic movements, and the birds consume the insects along with the pesticide.
This type of exposure led to the deaths of Swainson’s Hawks in Argentina in the mid-90's from
the OP monocrotophos (Woodbridge et al. 1995, Goldstein et al. 1996). The Swainson’s Hawks
were wintering in large concentrations in agricultural areas where monocrotophos (and to a
lesser extent fenthion) were used to control grasshoppers. Upon application, many hawks were
attracted to the fields of dying insects, foraged on the insects, and received a lethal dose of
pesticide. These incidents killed up to 20,000 hawks and attracted worldwide attention. Many
smaller-scale and less publicized cases of poisoning have been documented in the U.S. and
elsewhere (Mineau et al. 1999).

The same type of secondary poisoning can occur when the pesticides are applied to kill
vertebrates. Anticoagulant rodenticides often leave rodents in urban areas alive long enough to
be preyed upon by raptors (Merson et al. 1984). Raptors can accumulate enough poison to cause
internal hemorrhaging, or merely enough to bleed to death given an injury (Stone et al. 1999).
The use of fenthion in Africa to control quelea has led to secondary poisoning of many raptors
that foraged on the dying birds (Keith and Bruggers 1998). Waterfowl may accidentally ingest
granular pesticides by sifting sediments (Elliott et al. 1996) or consuming tadpoles (Kelley
Tucker, pers. comm.), putting predators such as Bald Eagles at risk of secondary poisoning.

Secondary poisoning of raptors can also occur through the consumption of contaminated
non-target birds. Songbirds that mistake granular formulations of pesticides as seeds or that
forage on insects dying from pesticide exposure can in turn be preyed upon by raptors (Henny et
al. 1999, Balcomb 1983). Sometimes pesticides reach raptors through highly unexpected
channels. For example, Black-billed Magpies will ingest cow hair (Henny et al. 1985). If the
cows have been treated topically with an OP pesticide to control warble fly larvae (typically
famphur), then the magpies can die from secondary poisoning. Red-tailed Hawks have been
found preying upon these poisoned magpies and have accumulated fatal pesticide levels, and
Great-horned Owls have been found poisoned from scavenging poisoned Red-tailed Hawks
(Henny et al. 1985).

LEGAL USE, MISUSE, AND ILLEGAL USE OF PESTICIDES

Pesticides can be classified as a general-use or restricted-use product (RUP). The former
refers to over-the-counter use by the public without any legal restrictions on the target pest.
RUPs have specific uses that are registered by the EPA and can only be applied by licensed
applicators. Any use that is not described on the pesticide container’s label is illegal.
Unfortunately, pesticides are sometimes used in unregistered ways, both intentionally and
unintentionally (Henny et al. 1999). Pesticides that are restricted to certain uses have been so categorized because there is the potential for impacts on humans (Williams 1997).

WHAT SPECIES ARE AT RISK

It can be difficult to determine what raptor species are at the greatest risk to pesticide poisoning. Most information regarding toxicity has been collected from toxicity trials where lethal doses are determined for a particular compound-species combination. This information is often lacking for more than a few species per compound, and risk determined by toxicity trials does not always translate accurately to field settings where exposure occurs (Blus and Henny 1997).

SOME INSECTICIDES TO WATCH OUT FOR

Mineau et al. (1999) concluded that of the many OP and carbamate pesticides in use around the world today, four are responsible for most of the raptor poisoning deaths: famphur, fenthion, carbofuran, and monocrotophos. The first three of these are leading killers of raptors in the U.S., but there are at least 17 other OP and carbamate pesticides that are known to have caused raptor deaths in the U.S. (Mineau et al. 1999). Documenting sublethal effects of pesticides that are currently in use has proven difficult, so the “most-unwanted” pesticides are those that tend to kill birds outright as opposed to causing subtle long-term effects. The following list reviews several pesticides that are known to be dangerous to raptors but does not include pesticides that may be of concern primarily because of their widespread use, such as malathion.

Brodifacoum.—As seen above, this anticoagulant rodenticide is a potential owl and hawk killer in many urban and agricultural areas. This compound is general-use and is thus widely available. Though it is believed by supporters of the use of this chemical that poisoned rodents go into their burrows to die, others suspect that poisoning causes excessive thirst, prompting poisoned rodents to seek out water where they are susceptible to predation (Kelley Tucker, pers. comm., referring to a conversation with Ward Stone). There are efforts by the American Bird Conservancy to make this pesticide a restricted-use compound.

Carbofuran.—This carbamate insecticide is likely responsible for more bird deaths in the U.S. per year than any other pesticide (Kelley Tucker, pers. comm.). Carbofuran use in granular formulations has now been cancelled in Canada and restricted in the U.S. because it has caused many bird kills even in low concentrations (Mineau 1999). Liquid formulations (still very toxic) are still available for use on a wide variety of crops including corn, alfalfa, soybeans, and rice (Lyon 2000). Both granular and liquid formulations are still widely used in Latin America (Mineau 1999). In 1996, 5.6 million pounds of carbofuran were shipped from the U.S. to other nations (FASE 1998). Carbofuran is often the pesticide of choice for illegally killing birds through carcass lacing (Kelley Tucker, pers. comm., referring to a conversation with Don Patterson).

Chlorfenapyr.—This insecticide represents a relatively new type of compound on the pesticide market. It is classified as a pyrrole and works by inhibiting enzymes that produce ATP (Williams 1999). Chlorfenapyr thus has the potential to disrupt cellular function in all forms of life. Chlorfenapyr is currently used in Latin America and recently has been under review for use
in the U.S. From most accounts this compound is as toxic to birds as many of the worst OP compounds and is also very persistent (Mineau 1999), two characteristics that make it a potentially disastrous addition to the natural environment. There has been some effort to prevent the registration of this compound, and recently EPA issued a statement of intent to deny registration of chlorfenapyr on cotton. In response to this issuance, American Cyanamid formally withdrew their registration request, leaving open the possibility of filing an additional registration request (Kelley Tucker, pers. comm.).

**Ethyl Parathion**.—This OP insecticide has been used extensively on a variety of crops and was then restricted to use on nine grain and seed crops. Its use is most extensive in the upper Midwest where it has been implicated in a wide array of documented human and wildlife impacts. Ethyl parathion has a relatively long half-life for an OP insecticide, in addition, its degradate is more toxic and more easily absorbed. Raptors have experienced secondary poisoning by this insecticide, but ethyl parathion has had the most impact on waterfowl. Recent efforts coordinated by ABC resulted in the gradual cancellation of ethyl parathion’s registration for all uses of in the U.S.

**Famphur**.—This OP insecticide is still used in the U.S. as a topical livestock treatment for Warble fly larvae despite documented mortalities of migratory birds, including several raptor species. In 1983, regulation of this insecticide was transferred to the U.S. Food and Drug Administration (Lyon 2000), and the implications of this action are unclear to me at this time.

**Fenthion**.—This OP was once used extensively in Rid-a-Bird™ perches in the U.S., which led to poisoning of many urban birds and subsequent secondary poisoning of some raptors (Mineau et al. 1999). Voluntary cancellation of this use should have been complete by the end of 1999 (Henny et al. 1999). Use of fenthion for mosquito control in Florida continues, and the product is still available as a pour-on, spot application, or ear-tag for livestock ectoparasite control. Fenthion is still widely used in Africa as an avicide against Red-billed Quelea, a use that has caused secondary poisoning in dozens of raptor species (Keith and Bruggers 1998). ABC requested cancellation of all uses of fenthion in the U.S. in October 1999.

**Monocrotophos**.—This pesticide is no longer registered for use in the U.S. but is widely used outside of North America (Mineau 1999). Mineau (1999) suggested “that almost any use of [monocrotophos] has the potential to give rise to extensive bird mortality.” As early as the 1970s this compound was killing raptors. Hundreds of birds of prey were killed in Israel by secondary poisoning from a mislabeled use of monocrotophos (Mendelssohn and Paz 1977). Raptor poisoning occurred by feeding on contaminated voles. Monocrotophos is not labeled for vole control, though that information had not been presented in the Hebrew translation on the label. According to Mineau et al. 1999, monocrotophos is still in use in this manner in Israel today but is still not labeled for such use. All U.S. uses were canceled in 1991 (Lyon 2000). Importantly, Argentina cancelled all uses of monocrotophos in May 1999, and the phase-out should be completed by March 2000. Australia began phasing out monocrotophos in December 1999. ABC continues to pursue complete cancellation of the use of this pesticide in the western hemisphere. Starting in April 2000, DOW agrosciences is reportedly phasing out all production of monocrotophos (Kelley Tucker, pers. comm.).
Strychnine.—This pesticide has been implicated in deaths of Red-tailed Hawks (Franson et al. 1996). Though there appears to be continued illegal use of strychnine such as with carcasses lacing, strychnine is only labeled for underground rodent control (Lyon 2000).

CURRENT STATE OF THREAT

The problem of pesticide poisoning is complex. Beginning with the vast numbers of pesticides in use worldwide (with differing toxicities and persistence times) and extending to the often species-specific susceptibility of birds to the substances, the problem’s magnitude is hard to accurately describe. However, in 1997 one researcher estimated that at least 672 million birds are affected each year by pesticides in agricultural areas alone (Pimentel et al. 1992). In addition, exposure to combinations of pesticides can alter birds’ sensitivity to pesticides (Blus and Henny 1997). As with most human impacts on wildlife, little nationwide or even regional information is available on the magnitude of the threat.

What is clear is that there are many pesticides in use today that can harm birds, some of which do stand out (see above). Some of the worst killers are no longer in use in the U.S. (e.g., monocrotophos and dieldrin), though others are (e.g., carbofuran). Most are still used in countries where North American raptors winter, yet information regarding uses in Central and South America is limited. However, it is clear that U.S.-based companies are exporting many of these products. In 1996, more than 95 million pounds of cancelled, restricted, or unregistered pesticides were shipped from the U.S. (FASE 1998).

There are approximately 900 registered pesticides in the U.S. (Aspelin and Grube 1999). The U.S. used one-fifth of the total world pesticide use in 1997, with agricultural applications making up roughly three-fourths of that. Herbicides made up the bulk, with at least 15 of the 25 most heavily used compounds in the U.S. being herbicides. The compounds most typically associated with bird mortalities are insecticides, of which only 2 (chlorpyrifos and terbufos, both OPs) made the 25 most-used chemicals list. This ranking may be a little misleading, however, as the least-used chemical on this list had 5-6 million pounds of active ingredient distributed in 1997, giving plenty of room for lesser-used chemicals to be applied in quantities sufficient to injure birds.

According to Williams (1997), the EPA, which regulates pesticides, places little emphasis on the effects of pesticides on wildlife. In general the EPA acts as if their only concern is human health despite laws that direct them to consider the impacts on wildlife (Williams 1997). As an example, the EPA cancelled the use of DDT because it was found extensively contaminating humans, not because of its impacts on bird populations, despite what is commonly believed by many raptor lovers (Williams 1997). The implication of this fact is that if not for the impacts on humans, DDT would still be in use in the U.S. today. The first and only pesticide to have registration denied or cancelled by EPA for purely wildlife impact reasons is chlorfenapyr this past year (Kelley Tucker, pers. comm.).

Some cancelled pesticides are still killing raptors. Stansley and Roscoe (1999) recently reported the deaths of over 400 birds of several species, including Cooper’s Hawks, in New Jersey. These birds died from lethal secondary poisoning by chlordane, an OC cyclodiene cancelled in the U.S. since the 1980’s (though another source indicates that its use continued as a termiticide until recently, Lyon [2000]). It was theorized that resistant insects continued to pick up chlordane from the soil, allowing continued biomagnification in the insects and transfer of lethal doses to predators. Okoniewski and Novesky (1993) also reported avian mortalities
(including seven species of raptors) from residual chlordane on turf in the eastern U.S. Such cases emphasize the insidious dangers of persistent pesticides.

Wood et al. (1996) examined Sharp-shinned Hawks from the eastern U.S. and found residues of several OC compounds detectable in blood, brain, and liver samples. These birds belong to populations that primarily winter in the U.S. (Struve and Goodrich 1992, cited in Wood et al. 1996), suggesting continued threats from chemicals that have been out of use for decades, such as DDT, dieldrin, and aldrin (Wood et al. 1996). Despite these residues, Wood et al. (1996) suggest that it is unlikely that recent declines in eastern Sharp-shinned Hawk populations are resulting from OC contamination. Noble and Elliott (1990) found that OC residues had generally decreased from the late 1960s to the late 1980s. They found some individuals with residues that exceeded critical levels and concluded that continued monitoring may be warranted, especially for birds that spend winters in Central and South America. Bald Eagles on the coast of British Columbia appear to still be exposed to detectable levels of DDT through their prey as a result of the compounds environmental persistence as well as from its transport from Asia and Central/South America (Elliott et al. 1996b). Osprey in the eastern U.S. appeared to experience reduced OC pesticide burdens from the 1970s to the 1980s, but at least in the 1980s, Ospreys were still carrying noticeable burdens (Wiemeyer et al. 1987).

Pesticides are detectable in many stream environments nationwide in levels that are deemed dangerous to aquatic life (Larson et al. 1999). Though some waterfowl and gamebirds show undetectable levels, several OCs are still detectable in birds from many areas in Canada (Braune et al. 1999). These levels are interpreted as posing no health risk to humans but it is unclear whether they pose a risk to raptors foraging in areas with the highest contaminant levels. DDE is still detectable in Osprey eggs in the northwestern U.S. but these levels do not appear to be causing decreases in hatching success (Elliott et al. 1999).

Aplomado Falcons in south Texas may be exposed to residual DDE in some prey species, notably Common Grackles (Mora et al. 1997). Other common prey species, however, such as Mourning Doves and Eastern Meadowlarks showed low levels of DDE and undetectable levels of several other OCs. The potential effect of OP and carbamate pesticides on Aplomado Falcon recovery in this heavily agricultural area has not been evaluated.

The future holds both promise for solutions and the potential for greater problems. With the increasing global human population, most agricultural areas will likely face increasing pressure to produce more food. Countries that are food exporters will not likely switch large-scale agriculture over to fully organic techniques. Hence, there will probably always be pesticides in use, regardless of their impacts on wildlife, and many of the new generation of pesticides can be expected to be just as lethal as the older compounds (Mineau 1999). On the other hand, small-scale organic operations and the development of effective integrated pest management techniques may help curtail the use of some pesticides in some places. The power of the consumer here is critical, as the demand for organic foods by people who can afford it may help to reduce pesticide use even more.

Future pesticide uses may be under more scrutiny, thanks to the 1996 Food Quality Protection Act (USEPA website). This legislation amends the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) to require periodic review of all registered-use products to ensure that they still adhere to the health-based requirements set out in FIFRA. This may facilitate the process of getting dangerous and widely used products cancelled as more information becomes available. The current spate of reregistrations is a result of this legislation.
SOLUTIONS

The only complete solution to the problem of pesticide poisoning of raptors is to eliminate the use of these compounds. After all, these compounds are specifically designed to kill things, and therefore any use of pesticides can potentially lead to the death of non-target organisms. Because of the world’s growing demand for food and shrinking amount of arable land, however, the complete elimination of these compounds is highly unlikely. Given these factors, all the following solutions address some way of reducing the hazard of the pesticides that are used.

First, cancel the registrations of the most deadly compounds. Though some of the pesticides most harmful to birds have been cancelled or restricted in the U.S., others still pose problems and new dangerous products are pending review. The use of several chemicals cancelled in North America continues in Central and South America, a condition that could greatly endanger migratory raptors that winter outside of North America.

Second, cancel the most persistent compounds. Persistence is one of the most dangerous characteristics of a pesticide. Indeed, the only substantial long-term pesticide-induced declines in raptor populations were in part due to the persistent nature of the compounds involved. Persistent compounds tend to accumulate greater concentrations with use and pose problems long after use ends.

Third, limit the use of corn- and silica-based granular formulations. Granular formulations appear to be especially harmful to birds because they are mistaken for seeds or grit (Henny et al. 1999). Hence many granivorous birds consume these formulations and are poisoned. This route of exposure makes secondary poisoning of raptors very likely, as nearly all raptors opportunistically prey on weakened prey when the chance arrives (Newton 1979). Liquid formulations appear to pose less of a threat in this regard, however, granular formulations were developed to reduce exposure of humans to sprays and gases. Therefore non-bird-attracting formulations should be continued.

Fourth, push for greater enforcement and education regarding proper usage of the compounds that are available. Mineau et al. (1999) documented a startling number of mislabeled applications that caused raptor mortalities. Blus and Henny (1997) note that mislabeled uses are generally not considered during the registration process, leading to unanticipated and potentially severe problems with the use of a particular pesticide. The limiting factor in enforcement appears to be that there are few USFWS or other wildlife enforcement officers working to locate kills and problem areas. Additional staff will be necessary to achieve this goal.

Fifth, encourage the implementation of Integrated Pest Management (IPM). IPM generally involves some use of pesticides when necessary but relies on a suite of physical and biological approaches to reducing crop pest damage. When needed, pesticides can be applied at strategic times using the minimum amounts needed to minimize deaths of non-target organisms. Greater awareness of which pesticides can be used with minimal impacts under these circumstances should be achieved. When feasible, growing crops without the use of pesticides is certainly desirable. Though organically grown foods generally cost considerably more than conventionally grown foods, consumer demand appears to be encouraging many farmers to switch to organic techniques, at least on a small scale. As organic and IPM techniques become more popular, one might expect an increase in knowledge that will help the agriculture industry reduce the use of chemicals even on larger scales, while still providing adequate food for a rapidly growing global population.
Many of the most dangerous pesticides (in terms of toxicity to birds) have been cancelled or restricted in the U.S. but are still used in other countries. Compounds such as monocrotophos, carbofuran, and most of the OCs probably should be under severe use restrictions worldwide. Two UN agencies, UNEP (United Nations Environment Programme) and FAO (Food and Agriculture Organization), have developed the Prior Informed Consent procedure (USEPA, http://www.epa.gov/oppfead1/international/pic.htm). This system is intended to provide information to pesticide users in developing nations to assist them in making informed decisions regarding the use of certain chemicals. The lack of such information was implicated in the monocrotophos killings of Swainson’s Hawks in Argentina in the mid-1990s (see above, Line 1996). The effectiveness of this new system in helping to reduce the use of bird-killing compounds is still unknown, however, and cooperative efforts to help reduce the use of these compounds in important wintering areas in Central and South America may yet be needed.

Section 3

INDUSTRIAL AND OTHER CONTAMINANTS

This section deals with the poisoning of raptors by toxic chemicals and heavy metals concentrated in the environment by human activity. Some of the substances listed herein have been in use by humans for centuries (e.g., lead, mercury, and arsenic), and others were developed in the 20th century. The amounts of these substances in use exploded during the last fifty years or so, creating severe local contamination as well as widespread global contamination, even in areas not inhabited by humans. Raptors are generally exposed to these contaminants through their prey, but direct exposure from water is also an issue for some species.

In general, the contaminants outlined here are still being produced and released into the environment. The problems seem nearly intractable, and I have found only a few ideas for solutions at this time. Bioremediation procedures (especially of contaminated soils and sediments) are perhaps the most promising at this point, but investigating these would involve writing an entire module in itself. The only obvious solution to any problem listed here is to stop using, producing, and emitting these substances. This goal seems a long way off for most contaminants.

ARSENIC

General.—Arsenic is a naturally abundant element that is beneficial or essential at low levels but toxic at higher level (Eisler 1988). Arsenic is used in the production of some pesticides and is released into the environment from smelters, coal-burning electric plants, arsenical herbicides, and mine tailings (Eisler 1988).

This element can bioaccumulate but apparently does not biomagnify (Eisler 1988). Arsenic poisoning in birds can cause death through internal hemorrhaging and sublethal effects, including physical debilitation and decreased alertness (Eisler 1988). However, birds appear to be able to tolerate sublethal exposure fairly well and excrete it (Eisler 1988). Arsenic has been related to depressions in food supply for some raptors, including Tengmalm’s Owls in Sweden (Hörnfeldt and Nyholm 1996). Arsenic is known to impair reproductive performance in waterfowl, but has also been found to counteract the negative effects of selenium toxicosis (Hoffman et al. 1992).
What species are at risk.—Because arsenic is released into the environment primarily as herbicides (Eisler 1988), raptors that frequent agricultural areas are presumably at the greatest risk of exposure. This might include American Kestrels, Red-tailed Hawks, Great-horned and Barred Owls, and Swainson’s Hawks.

Current state of threat.—Raptors are known to be able to accumulate greater burdens of arsenic from their prey in areas where environmental levels are high (Erry et al. 1999). Arsenic is still used in many agricultural and other industries, but I have not found any information to suggest that the current state of raptor poisoning by arsenic is substantial.

Solutions.—Reduce the environmental input, most effectively through decreased use of arsenical herbicides and decreased coal-burning for electricity.

Cyanide

General.—Cyanide is used most frequently in the mining of precious metals from low-grade ores (Henny 1999), though it is also used in antipredator devices, pesticides, electroplating, and plastics manufacturing (Eisler 1991). Gold mining operations have proven notoriously dangerous to wildlife. After use, the chemical is left in solution in ponds and in tailings piles. Migrating birds descend to the ponds and land on the surface, getting exposure through the skin or through inhalation. Other birds drink the water from the edge (Henny 1998).

Cyanide is an extremely toxic compound and operates as an asphyxiant (Eisler 1991). It can be absorbed through the skin, inhaled, or ingested, and regardless of exposure it inhibits enzymes in the lungs from binding oxygen (Eisler 1991). Sublethal doses of cyanide can be metabolized and excreted without causing long-term harm (Eisler 1991). Because of this, cyanide does not appear to bioaccumulate or biomagnify, but can persist in the environment for some time (Eisler 1991).

What species are at risk.—Raptors and other meat-eating birds appear to be physiologically relatively sensitive to the effects of cyanide poisoning (Eisler 1991). Because of the location of most of the cyanide leaching mining operations, raptors that occur in mountainous regions of the western U.S. are at the greatest risk, especially those that might be attracted to waterfowl or other animals that use the tailings ponds. This might include Golden Eagles and several of the buteo species. Because of the use of cyanide in M-44 coyote killers, any raptors in ranchlands where coyotes are targeted could be at risk, but limited evidence of this type of mortality is available.

Current state of threat.—The number of gold mines in the western U.S. increased rapidly through the 1980s along with a rapid increase in the rate of associated bird mortality (Henny 1999). By the early 1990s, many mine companies were covering their ponds with netting and chemically treating others to reduce concentrations of cyanide (Henny 1999). Some problems still persist because cyanide leachates are contaminating puddles and other water bodies, but it is apparently reduced (Henny 1999). Sodium cyanide is still used in M-44 coyote killers by Wildlife Services (formerly Animal Damage Control). These devices have been known to kill a wide variety of non-target organisms, including raptors (Eisler 1991), but the numbers appear to be minimal (three individual raptors out of 22,162 total non-target kills from 1991 through 1998,
Solutions.—Eliminating cyanide heap-leach mining techniques is the only clear way of preventing cyanide from continuing to be a hazard to wildlife and water bodies. However, covering leach ponds to prevent wildlife access has been a reasonably effective solution for reducing wildlife mortality (Henny 1998), yet it has not solved the problems of cyanide contamination of water bodies.

LEAD

General.—Excess lead in the environment results primarily from fishing weights and spent gun shot (Henny et al. 1991, Scheuhammer and Norris 1996, Henny 1999), though past uses such as in pipes, paints, gasoline, and solder also were sources of lead pollution (Scheuhammer and Norris 1996). Raptors may scavenge or kill a wide variety of birds and mammals that can be exposed regularly to lead, leading to a risk of secondary poisoning (Scheuhammer and Norris 1996, Wayland and Bollinger 1999). Lead poisoning in waterfowl has been widely documented (see references in Kramer and Redig 1997, Wayland and Bollinger 1999). Ducks, swans, and other waterfowl may ingest spent shot, lead bullet fragments, and/or lead sinkers from the sediment while feeding (Kramer and Redig 1997, Henny 1999). Mourning Doves, American Woodcock, and other upland game birds can ingest lead-contaminated invertebrates or lead shot from the soil, mistaking it for food or grit (Kendall et al. 1996, Scheuhammer et al. 1999). Fish may also accumulate concentrations of lead by absorption (Henny et al. 1991). Waterfowl, deer, and other game that have been shot but not killed may eventually be eaten by raptors as well (Scheuhammer and Norris 1996).

Ingested lead remains in the proventriculus or gizzard where it is eroded and absorbed into the blood stream (Furness 1993, Kramer and Redig 1997). Raptors, as meat eaters, have very acidic stomachs, allowing rapid absorption of lead into the blood (Hoffman et al. 1981, cited in Pain et al. 1995). Lead poisoning, if acute, can cause death within a few days (Scheuhammer and Norris 1996). Lead poisoning can also have sublethal effects, including immune suppression, reproductive impairment, and tissue damage (Scheuhammer and Norris 1996). Many sublethal effects can lead to death via reduced physical performance, increasing the risks of collision, electrocution, and depressed hunting success (Kendall et al. 1996, Scheuhammer and Norris 1996, Kramer and Redig 1997). Lead does not biomagnify as do some other environmental contaminants (Henny et al. 1991). Lead, and other heavy metals, can also cause reductions in prey base, leading in turn to reduced breeding performance of raptors (Hörnfeldt and Nyholm 1996).

What species are at risk.—Any raptor species that forages on game animals is at risk of lead poisoning (Pain et al. 1995). Golden and Bald Eagles are at very high risk of lead poisoning because they scavenge and are likely to locate and feed on animals that have been shot, have lead embedded in their tissue, and later died (Pain et al. 1995). Bald Eagles, because they feed on waterfowl extensively during the winter, are potentially at the greatest risk of lead poisoning because of the pervasive nature of lead poisoning in waterfowl (Braune et al. 1999, Wayland and Bollinger 1999). Despite the banning of lead shot for hunting waterfowl, these two species are still experiencing lead poisoning possibly due to persistence of lead in the environment or lead shot that is still used for hunting animals other than waterfowl such as deer and small mammals.
(Craig and Craig 1995, Kramer and Redig 1997). As waterfowl are important prey items for Peregrine Falcons, they may be at risk as well (Pain et al. 1995), especially on the wintering grounds where the use of lead shot apparently persists. Raptors that forage on upland game birds and passerines in heavily hunted areas, or near shooting ranges, may also be at risk of lead poisoning (Kendall et al. 1996, Vyas et al. 2000). California Condors are at risk of lead poisoning as these animals are strictly scavengers and typically scavenge large animals that in some cases have been killed with lead shot (Janssen et al. 1986, cited in Kramer and Redig 1997). Condors are additionally at risk because they tend to regurgitate indigestible material, and thus lead fragments, less frequently than eagles (Graham 2000). Part of the condor population decline this century was attributed to extensive lead poisoning (Graham 2000). Though Osprey have been documented foraging on fish contaminated with lead from upstream mining operations, they do not always suffer reproductive or other harm from the exposure (Henny et al. 1991).

Current state of threat.—Lead shot for waterfowl hunting was cancelled in the U.S. in 1991, and within the last three years in Canada. From 1996-8, lead shot for hunting upland game birds was phased out on most National Wildlife Refuges, though a few refuges in Alaska still allow it (John Kauffeld, USFWS, pers. comm.). Lead is still the primary material for shot and bullets used for other hunting, including deer and elk, upland game birds, prairie dogs, and other small mammals (John Kauffeld, USFWS, pers. comm.). It appears that cases of lead poisoning in raptors tends to increase during the fall and winter, during hunting season, when increased lead input into the environment occurs (Wayland and Bollinger 1999). Efforts to ban all uses of lead are underway but resistance is strong because one of the main alternatives, steel, performs poorly and can cause damage to guns (Graham 2000). However, many of the ballistic problems of early steel shot have been overcome by improvements in shell construction and packing (Scheuhammer and Norris 1996). Tin-tungsten alloys have recently been developed that will be more expensive but apparently outperform lead (Graham 2000). The expense of non-toxic shot is minimal, as one estimate placed the increased cost at less than 1% of a hunter’s total annual expenditure (Scheuhammer and Norris 1996). Even when lead is finally off the market here in North America, problems will likely persist because lead tends to persist in the environment (Henny 1999). Studies are still finding high concentrations of lead in waterfowl (Braune et al. 1999). The USFWS is currently attempting to restrict the use of lead fishing weights on some areas of most National Wildlife Refuges.

Solutions.—Clearly an important goal in reducing the problem of lead poisoning in birds and other wildlife is to eliminate all forms of lead ammunition and lead fishing sinkers. None of these uses is essential to society and suitable replacements are available. A stubborn resistance to change bolstered by arguments of expense is currently the only barrier to stopping the continued input of metallic lead into the environment for recreational purposes.

Mercury

General.—Mercury has no known biological function (Eisler 1987). This element has increased in the environment because of a long history of human uses in industry and seed dressings in agriculture (Eisler 1987, Henny 1999). Mercury is also used to recover gold and silver in mining operations (Henny 1999). Extensive use has caused widespread contamination of soils, sediments, and aquatic environments (Eisler 1987). Mercury occurs in many different
forms, yet less toxic forms can easily be transformed in the environment into the most toxic forms, such as methylmercury (Eisler 1987).

Mercury can bioaccumulate and biomagnify and cause both sublethal and lethal effects in raptors (Eisler 1987). Mercury exposure can reduce hatchability of eggs (see references in Henny 1999), and was associated with reduced brood size in British Peregrine Falcons (Newton et al. 1988).

**What species are at risk.**—Mercury appears to move throughout the environment in oceanic and atmospheric currents, yet contamination in wildlife still correlates geographically with the most contaminated areas (Eisler 1987). Aquatic environments tend to have the greatest accumulations, and fish and bird-eating hawks in these areas are most at risk of mercury poisoning (i.e., Peregrine Falcons and Bald Eagles, Eisler 1987). Reintroduced Aplomado Falcons in south Texas carried noticeable but small mercury burdens (Mora et al. 1997). Low levels of mercury were found in Sharp-shinned Hawks in the eastern U.S. (Wood et al. 1996). Mercury appears to concentrate somewhat on coastlines causing heightened risk for birds that forage on seabirds, such as occurs with coastal Golden Eagles in the U.K. (Newton and Galbraith 1991).

**Current state of threat.**—The use of mercury in mining operations poses significant potential problems to many systems in South America if the results of similar mining activity in the U.S. earlier in this century are any indicator (Henny 1999). Carson Lake in Nevada is still contaminated by mercury from mining operations over 100 years after the activity (Henny 1999). However, elemental mercury for use on crops was voluntarily cancelled in the mid-1980s (Lyon 2000), but apparently had been used as a seed dressing for centuries (Newton 1979).

**Solutions.**—Again, reduce human uses of mercury. Since anthropogenic activity is mainly responsible for high levels in most environments, reduced use is clearly an important goal. However, reducing/containing the output of point sources of mercury may also help to reduce environmental contamination.

**POLYCHLORINATED BIPHENYLS (PCBs)**

**General.**—PCBs are industrial chemicals used as dielectrics in transformers, lubricants for cutting and machinery, plasticizers in paints, resins, and paper, and other industrial purposes (Eisler and Belisle 1996). Production of PCBs was cancelled in the U.S. in 1977 but approximately 65% of the total world historic production is still in use in electrical equipment (Eisler and Belisle 1996). PCBs have traveled to and contaminated many parts of the globe through atmospheric and oceanic transport (Eisler and Belisle 1996). During the height of their use it was unclear of the potential biological harm and they were regularly released into the environment through spills, volatization, disposal, and through application in paints (Ramamoorthy and Ramamoorthy 1997). PCB levels as contaminants in birds seem to correlate with areas that are contaminated, as seen with Osprey in the Northwest U.S. (Elliott et al. 2000).

There are many different PCB congeners; all are lipophilic and thus bioaccumulate and biomagnify through food chains (Eisler and Belisle 1996). This tendency, however, varies with species and structure of the particular PCB congener (Elliott et al. 1996a). The impact of the various PCBs is highly variable, as the degree of toxicity relates to structure and the species exposed (Eisler and Belisle 1996). They tend to correlate with organochlorine pesticides as
contaminants in birds, but their contribution to egg-shell thinning and other reproductive effects is still not entirely clear (Furness 1993). Newton (1979) argued that DDT was the main compound responsible for eggshell thinning, and Elliott and Martin (1994) found that PCBs did not explain any variance in eggshell thickness in accipiters despite its correlation with DDE residues. Furness (1993) points out that not all studies are uniform in implicating PCBs or DDT in eggshell thinning. It may be that PCBs mainly enhance the effect of OC pesticides as endocrine disrupters (Lincer 1994, cited in Henny 1999). In addition to causing eggshell thinning, PCBs have been implicated in avian deformities and embryonic deaths of birds (see references in Henny 1999).

What species are at risk.—Aquatic birds are probably at the greatest risk of contamination from PCBs. Into the 1990s, concentrations of PCBs have still been found in Osprey, Bald Eagles, Golden Eagles, Peregrine Falcons, Merlins, Sharp-shinned Hawks, and Cooper’s Hawks (Noble and Elliott 1990, Elliott and Martin 1994, Elliott and Norstrom 1998, Elliott et al. 1999). Golden Eagles that live near coastlines were found to have accumulated greater burdens of PCBs than eagles occurring inland (Newton et al. 1989). PCB’s have spread widely by way of atmospheric and oceanic cycling, so many coastal wildlife communities across the globe are exposed to these compounds (Boersma and Parrish 1998).

Current state of threat.—These very persistent compounds were taken out of production in the U.S. in 1977 (Ramamoorthy and Ramamoorthy 1997). Nonetheless, a recent survey of contaminants in game birds in Canada found widespread but low levels of PCBs, with the highest levels of PCBs occurring in fish-eating birds (Braune et al. 1999). Eagles and Osprey seem to be contaminated still, though many other raptors appear not to be contaminated enough to cause problems. Bald Eagle productivity in coastal B.C. did not seem to correlate with PCB concentrations in the nesting region (Elliott and Norstrom 1998). Because much of the PCBs produced over the years are still in use, we can expect a continued risk of additional contamination.

Solutions.—Since a large amount of PCBs are still in use in electric distribution line transformers, there is still a strong potential for accidental spills to cause problems with wildlife. One important step in reducing such contamination is to actively retrofit PCB-based transformers with non-toxic units and carefully dispose of or destroy the PCBs. Otherwise, environmental PCB is too widespread for any effective solutions. Natural degradation of many PCBs will take decades if not longer but this may be the only option.

POLYCHLORINATED DIBENZO-P-DIOXINS (PCDDs) AND POLYCHLORINATED DIBENZOFURANS (PCDFs)

General.—These compounds are produced as by-products of the manufacture of many OC pesticides, of the chlorine bleaching processes in paper mills, of municipal incineration, and of wood chip production (Eisler 1986, Elliott et al. 1996b, Ramamoorthy and Ramamoorthy 1997). PCDD/Fs range widely in persistence (Eisler 1986). Exposure to these compounds seems to correlate with point sources of the contaminants, such as near paper mills (Elliott et al. 1996b). The most toxic of the bunch is 2,3,7,8-TCDD, which has been identified as possibly the most toxic synthetic substance ever tested in the lab (Eisler 1986).

PCDD/Fs are soluble in lipids and, depending on structure, can bioaccumulate much the same way as PCBs and OC pesticides, though less evidence exists for their ability to biomagnify
Some of these compounds can cause loss of body mass in birds, which apparently can lead to increased mobilization of many contaminants that were stored in mobilized lipids (Elliott et al. 1996b). This can cause lethal and sublethal effects of poisoning from another contaminant as well. These compounds can have chronic effects on immune and endocrine systems (Elliott et al. 1996b). They can also have embryonic effects such as malformations, edema, reduced hatchability, and reduced liver enzyme activity (Elliott et al. 1996a).

**What species are at risk.**—These compounds have become widespread contaminants in aquatic ecosystems, thus fish-eating birds are at relatively high risk of contamination (Jones et al. 1993). Several studies have documented PCDD/F contaminants in eggs, chicks, and adults of Osprey and Bald Eagle (Elliott et al. 1996, Elliott and Norstrom 1998, Elliott et al. 1999), but I have yet to locate any studies documenting contamination in other raptor species. Bald Eagle eggs contain higher amounts of these chemicals in areas near pollution sources, and at least in the early 1990’s, despite efforts to reduce effluents from mills, such birds were still experiencing subtle physiological effects (Elliott et al. 1996a). Bald Eagles appear to be only mildly affected by residual concentrations in coastal B.C. and more dependent on local prey abundance for successful reproduction (Elliott and Norstrom 1998).

**Current state of threat.**—Improvements in manufacturing technology and requirements by the USEPA have led to reduced contamination of pesticide and other products with PCDD/Fs (Eisler 1986). Nevertheless, these compounds are still being produced, most heavily in the paper bleaching industries. Also, their persistence makes them a potential problem in heavily contaminated areas. Surface residues may break down in UV light but deeper soil residues may persist for decades. I have yet to find information on the amount of these compounds accidentally produced in Central and South America during the production of OC pesticides, leaving open the possibility that PCDD/Fs are still being put into the environment in areas where many raptors winter.

**Solutions.**—Reduce the production of these compounds by improving manufacturing techniques of other compounds (many of which should probably not be in production anyway) in areas where this is still a problem. This includes paper mills, where chlorine bleaching should likely be eliminated altogether, especially since there are non-toxic alternatives. In highly contaminated areas, there is little that can be done about remediation at the current time, especially in aquatic environments.

**Selenium**

**General.**—Selenium is a naturally occurring element. Agricultural irrigation practices in several arid western valleys in the U.S. have led to selenium enrichment of wetland habitats (Presser et al. 1994). Irrigation water passes through soils and leaches out selenium (Presser et al. 1994). In some places excess irrigation water is collected, diverted to evaporation ponds and eventually to wetland areas where selenium concentrations increase to harmful levels (Presser et al. 1994). Another source of selenium is coal-fired power plants, which release the element in fly ash (King et al. 1994).

As with many environmental contaminants, raptors are exposed to selenium through contaminated prey, and selenium is known to bioaccumulate (Ohlendorf 1989, cited in...
Fairbrother et al. 1994). Toxicity appears to be species-specific (Wiemeyer and Hoffman 1994, Santolo et al. 1999). Elevated dietary selenium have been shown to cause decreases in fertility in American Kestrels (Santolo et al. 1999) and liver stress and decreased productivity in birds in Eastern Screech Owls (Wiemeyer and Hoffman 1994). Selenium poisoning has also been linked with embryonic deformations and mortality in several types of waterbirds (Ohlendorf et al. 1989) and reduced hatching size and immune system effects in American Avocets (Fairbrother et al. 1994).

What species are at risk.—Aquatic birds are generally the most susceptible to the effects of selenium poisoning because of physiological sensitivity (Ohlendorf 1999). Another reason for this susceptibility is that selenium tends to accumulate in wetland areas, placing wetland birds at the greatest risk of exposure. Therefore, raptors that forage in these areas are among the most likely to experience secondary selenium poisoning. This would include species such as Bald Eagles, Northern Harriers, Peregrine Falcons, and kites. Northern Harriers and American Kestrels have bioaccumulated levels of selenium in Kesterson Reservoir, a wetland location that was transformed into a terrestrial habitat in an experimental effort to reduce selenium exposure to aquatic birds (Santolo and Yamamoto 1999). The observed levels in these birds sometimes exceeded known toxicity levels (Santolo and Yamamoto 1999); otherwise exposure to selenium in strictly terrestrial raptors appears not to have been well documented.

Current state of threat.—The problem of selenium accumulation in wetlands and the subsequent bioaccumulation and poisoning of wetland birds was only discovered in the mid-1980s (Presser et al. 1994). After that initial discovery, the USDOI conducted a survey across the western U.S. to determine the scope of the problem. These results are reported in Presser et al. (1994). There are extensive wetland areas in California, Utah, Wyoming, Montana, and Nevada where wetland birds are experiencing serious selenium toxicosis, with six other western sites having potential for ecological problems. Thus, the selenium problem is widespread and likely to worsen as selenium concentrations continue to increase at these sites. However, little work has been done to document secondary poisoning of raptors that forage in these areas.

Solutions.—Kesterson Reservoir, where the problem of selenium accumulation was first discovered, has now been transformed into a terrestrial habitat (Santolo and Yamamoto 1999). Other clean terrestrial habitats were transformed into wetland habitats to compensate for the loss (Gary Santolo, pers. comm.). The intent of this habitat type change was to stop the high rates of embryonic deformation and breeding failures of wetland birds caused by selenium toxicosis, and this effort has been very successful (Gary Santolo, pers. comm.). It appears that the site is still contaminated and that selenium exposure in terrestrial birds is occurring (Santolo and Yamamoto 1999). However, terrestrial birds are less susceptible to acute toxicosis and the selenium-exposed terrestrial birds at the remediated site are not showing the kinds of severe symptoms shown by the wetland birds (Gary Santolo, pers. comm.).

Bradford et al. (1991) evaluated some solutions to the contamination hazard in the evaporation ponds and determined that reducing bird presence was of primary importance. They suggested that removing vegetation and wind breaks as well as hazing birds and deepening ponds were the best solutions. However, this may not help to reduce exposure to birds at the wetland drainage endpoint, where it is important for birds to maintain viable populations. There currently are no known effective methods of removing selenium from contaminated wetland areas (Gary
Santolo, pers. comm.). Therefore, solving the selenium toxicosis problem in many areas around the west will be difficult. Only in places where clean terrestrial habitats can be transformed into wetland habitats can transforming contaminated wetlands help to reduce the problem to birds. Otherwise, it may be far more effective to limit the amount of irrigation occurring in arid valleys with naturally occurring levels of selenium.

Changing the nature of the irrigation system itself by re-engineering the flow of water could also potentially reduce the leaching of selenium from the soils.

**WHITE PHOSPHORUS (P₄)**

*General.—* This substance is used by the military in several devices because it readily produces thick, white smoke when exposed to air (Sparling et al. 1999). Because of this trait it is used as a smoke obscuring and included in shells to mark the locations of artillery strikes (Sparling et al. 1999). However, if P₄ is fired as an obscuring over wetland habitats and falls into water, it remains inert and stable for long periods of time (Sparling et al. 1997). In contaminated wetlands, the fired pellets can be mistaken for food and are consumed by a variety of wetland birds, especially ducks and swans (Sparling et al. 1999).

When ingested this substance can affect blood plasma chemistry, cause lethargy and convulsions, promote kidney and liver damage, and lead to death (Sparling et al. 1999). Secondary poisoning of raptors has been documented for Bald Eagles and Golden Eagles that foraged on weakened waterfowl (Sparling et al. 1999), and experimental evidence that raptors can die or experience other effects from secondary poisoning has been obtained with American Kestrels (Sparling and Federoff 1997).

*What species are at risk.—* The primary non-target mortalities from P₄ are waterfowl and swans (Sparling et al. 1999). Waterfowl that die from P₄ exposure can harbor intact P₄ in their tissues and digestive tracts for up to a week, suggesting that secondary poisoning to some scavenger is a strong possibility (Sparling and Federoff 1997). Hence, raptors that typically forage on waterfowl or that might scavenge waterfowl that died from P₄ are at the greatest risk, particularly Golden and Bald Eagles. Sparling and Federoff (1997) suggested that a single ingestion of P₄ pellets from the gizzard of a contaminated duck could kill an eagle.

*Current state of threat.—* P₄ is apparently used extensively in military training operations. Exactly how much is put into the environment I have not been able to determine, but the military may be able to give us an idea. Any effort by the military to reduce P₄ use is also unknown to me at this time. At least at Fort Richardson in Alaska, the U.S. Army is attempting to reduce P₄ contamination by drying out some of the wetlands, which should allow the P₄ to dry out and then smoke off (Sparling et al. 1999). Of course, this type of remediation may seriously damage the wetland habitats.

*Solutions.—* This substance will apparently remain stable in wetland areas until exposed to air and allowed to smoke off. Accordingly, the only known solution is to temporarily drain a wetland, allowing the P₄ to dry. This solution has obvious drawbacks as it may cause unwanted disruption of the ecological dynamics of the wetlands.
Section 4

COLLISIONS WITH HUMAN-CREATED STRUCTURES

Avian mortality due to collisions with human-created structures was arguably not significant until the 20th century, though kills of flocks of migrating songbirds had been recorded at lighthouses for centuries (TowerKill.Com website). Avian collisions with telegraph lines were observed in the 19th century (APLIC 1994). During this century, tall (especially glass-lined) buildings, radio and television towers, power lines, windpower plants, and automobile traffic have all increased dramatically in numbers, posing an increasing threat to birds (Bevanger 1994). It is expected by some that the impact of these kills will continue to grow with the proliferation of more towers and structures each year (TowerKill.Com website). In the early 1970s it was estimated that 32% of the human-caused bird mortality each year in the contiguous U.S. (roughly 63 million birds) was attributable to collisions (Banks 1979). I have yet to find estimates for more recent years, but the problem has undoubtedly grown.

Raptors typically collide with automobiles, building windows, and windmill blades (Newton et al. 1999), and some reports of collisions with overhead power lines are available (Bevanger 1994). Tower kills are most dangerous for nocturnal migrant songbirds. In fact, over 99% of birds killed in 28 years at a tower in Tennessee were neotropical migrant songbirds, with raptors making up a negligible portion of the total kill (TowerKill.Com website, citing Nehring 1998). Other tower kill monitoring studies have reported similar results. Hence, we do not consider raptor collisions with towers any further.

AUTOMOBILES

How it happens.—Collisions with automobiles are easily visualized. A raptor flies low across the road just as a vehicle passes by and smacks the window or the grill. Such types of mortality have been documented widely in Europe and North America, and frequently there are “hot-spots” where many birds get killed (e.g., Loos and Kerlinger 1993). These hotspots seem to occur where a significant concentration of birds intersects a highway with high-speed traffic. Significant concentrations of raptors can be associated with certain habitats such as wetlands, peninsulas, shorelines, or ridge tops.

What species are at risk.—Because low-flying birds are much harder to see at night, owls tend to be particularly susceptible to auto collisions. Northern Saw-whet Owls and Eastern Screech Owls made up the bulk of casualties in a study conducted on highways in New Jersey (Loos and Kerlinger 1993), though some diurnal raptors were found as well. Barn Owls are also commonly hit by automobiles (Newton et al. 1991, personal observation). Diurnal raptors that frequent and hunt along roadside habitats, such as kestrels, are at relatively greater risk of auto collisions (Newton et al. 1999).

Current state of threat.—The U.S. highway system stretches over 13 million kilometers (8 million miles) of all types of road (Trombulak and Frissell 2000). Though occasional local surveys have been conducted, we have not found systematic surveys provide collision rates that could allow us to estimate the annual mortality in any given area. Increases in road coverage, automobile use, and highway speeds may all contribute to greater risks of raptor collisions with automobiles in the future (Forman 2000). Newton et al. (1991, 1999) reported that the frequency
of auto collisions for Barn Owls and Kestrels has increased over the last couple of decades in Britain.

**Solutions.**—Reducing the number of automobile collisions will require either rerouting roads through areas where raptors occur in lower numbers and/or reducing the traffic speeds. The only practical solution to this problem, given the enormous dependence of our society on automobile travel, is to identify collision hotspots and rally to have these areas posted with warnings for wildlife activity and to have the posted speeds reduced. Given pressure to build new roads, efforts to site planned roads in low-risk areas should be made. Surveys for concentrations of migrating, wintering, or breeding raptors should be conducted, especially for high-risk groups such as owls.

**POWER LINES**

*How it happens.*—Collisions with power lines seem to be a function of several things. First, flight characteristics such as rapid flight, low maneuverability, and flocking tend to be associated with high collision risk (APLIC 1994). Aspects of the power lines themselves are also important, such as line construction and location of the power lines (Bevanger 1994). Collisions seem more likely in low-light scenarios (e.g., at dawn or dusk), during foul weather, and in locations where migrating raptors concentrate or where raptors concentrate around an abundant prey resource (Bevanger 1994). Similar to wind turbine collisions, raptor collisions with power lines seem to result from hunting near the lines, when the bird is paying attention to prey and not the lines (Bevanger 1994).

*What species are at risk.*—Collisions with power lines appear to be a problem mainly for non-raptors. For example, of 126 dead raptors collected along roadsides and power lines in Montana in the late 1990s, only 1 died from a collision, and with a fence post (Olson 2000). Bevanger (1994) indicated that soaring raptors, as are many of the raptors associated with power lines, tend to be at less risk of colliding with power lines than species that fly very quickly (e.g., waterfowl). However, aerial pursuit raptors such as Peregrine Falcons may be at risk of collision with power lines (Bevanger 1994). Raptors with very large wings and low flight maneuverability, such as California Condors, also may be at risk (APLIC 1994).

*Current state of threat.*—This threat will obviously grow with the continued growth of above-ground power distribution systems. However, the problem is likely a small one for raptors (APLIC 1994), so even with an expansion of power lines it may still not become a serious problem in the future.

*Solutions.*—One important solution to the power line collision problem is to locate power lines in safe areas. For example, power lines should not be placed between roosting and foraging areas for birds such as waterfowl (APLIC 1994, Bevanger 1994). Also, running power lines parallel to predominant wind directions, flight lanes, and close to trees or cliffs can help reduce collisions (Bevanger 1994). Some technical alterations that may reduce bird collisions are closer spacing of phase conductors (a solution that would increase the risk of raptor electrocutions), the elimination of continuous ground wires (which are thinner and harder to see), and the organization of lines in a horizontal arrangement instead of a vertical one (Bevanger 1994). Making wires more visible is also an option, by painting and coating, marking with various
devices, installing acoustical warning devices or scaring devices such as bird silhouettes (APLIC 1994, Bevanger 1994). Still, it appears that underground cabling is the best alternative despite the expense and difficulty associated with repair (Bevanger 1994).

**WINDMILL BLADES**

*How it happens.*—Any raptor frequenting the area around a wind power generation site runs the risk of colliding with the windmill blades or the tower guy wires. It appears that raptors can generally see the blades and that most collisions occur when the raptor is distracted by hunting efforts (Mark Fuller, pers. comm.). Hence, prey concentrations are a major component leading to collisions at wind farms. For example, the wind farm at Altamont Pass is located in an area with a significant concentration of ground squirrels, which attract Golden Eagles and other raptors (Grainger Hunt, pers. comm.). Golden Eagle hunting behavior also contributes to their risk of collision. These birds sometimes employ contour hunting, where they cruise low through the hills looking for prey. Eagles will quickly fly over or around hills, sometimes coming up suddenly upon a turbine and running into the blades (Grainger Hunt, pers. comm.). Approximately 40% of eagle deaths in the Altamont Pass area result from collisions with windmill blades. An additional 10-15% of the mortality results from electrocution by lines connecting generators (Grainger Hunt, pers. comm.).

*What species are at risk.*—One of the main factors contributing to the risk of raptor collisions with windmill rotors is the attractiveness of the wind farm site to raptors. Windmills are placed in areas with substantial and consistent winds. These factors can attract raptors, which use winds to aid in migratory and hunting flight (Kerlinger 1989). Also, wind farms typically are kept free from ground vegetation, attracting many soaring raptors that naturally forage in grassland areas. Apparently, the base of the windmill towers themselves can provide prime rodent cover (e.g., for pocket gophers), increasing the attractiveness of the areas immediately around the windmill to raptors (Karin Sinclair, pers. comm.). Several species of raptors can be associated with these habitats and prey types, including Golden Eagles, American Kestrels, and many *Buteo* species.

*Current state of threat.*—The U.S. wind industry produces roughly 3.5 billion kilowatt-hours of electricity annually, which is enough to meet the annual electricity needs of 1 million people (National Wind Technology Website). Some estimates suggest that the U.S. has enough windy locations to eventually provide 1.5 times as much electricity as is currently used today through windmills (Elliott and Schwartz 1993). Though it seems unlikely that the U.S. will ever garner 100% of its electricity needs from wind power, it is apparent that wind farms will continue to proliferate. The wind power industry is growing at 35% per year, the fastest among any generation type (McBride 1999). Energy Secretary Bill Richardson reportedly hopes to increase wind generation to 5% of the total U.S. output by 2020 (McBride 1999). There are currently no federally determined requirements for windmill design, though in some cases there are requirements for new plants to conduct environmental impact statements prior to construction (Mark Fuller, pers. comm.), particularly if federal land is used as part of the site (Jim Maloney, pers. comm.).

The Foote Creek Rim site in Wyoming opened in 1999 and has attempted to reduce potential problems with raptors through tower design and location (Eugene Water and Electric Board website). They went through a significant process to survey the site and microsite towers
(i.e., small scale adjustment in tower locations) in the safest locations possible. It appears that such attention to the particulars of the site and the turbine design may lower the bird-collision rates associated with wind power generation (Jim Maloney, pers. comm.), but additional monitoring is necessary to confirm these initial observations. Future sites may not cause the severe impacts associated with the Altamont pass site if developed carefully.

_Solutions._—Perhaps the most important solution to collisions at wind farms is to locate the facility in areas of low raptor usage (Mark Fuller, pers. comm. – in fact, everyone says this). The other key technique is to alter the windmill design to limit collisions with the birds that do use the site (Tucker 1996). Efforts to identify patterns that can be painted onto the rotors that may help raptors see turbines more readily have yielded positive results in the laboratory, but no effort to determine the effectiveness of such measures has been attempted in the field (Mark Fuller, pers. comm.). Painting turbine blades with ultraviolet reflecting paint may help make the blades more visible to raptors (Jim Maloney, pers. comm.). Other options include building towers that discourage perching (Jim Maloney, pers. comm.) and using longer and slower rotors that are more visible and less likely to hit a passing bird (McBride 1999). However, the ends of long rotors may still move quite quickly, and raising the towers to accommodate the longer blades may intercept flight altitudes of raptors more often. Additional measures to be considered at current sites are to reduce prey populations, especially at places like Altamont Pass where great numbers of ground squirrels are present (Grainger Hunt, pers. comm.).

WINDOWS

_How it happens._—Birds may mistakenly fly into a reflective glass window because they cannot distinguish it from open air. Raptor window collisions usually occur at homes and buildings frequented by a variety of songbirds. Urban landscapes sometimes have flocks of birds present near heavily glassed and mirrored buildings. Such locations are very dangerous to all birds. Many songbirds are killed each year by colliding with glass windows (personal observation). It is the presence of songbirds foraging near windows, especially if there is a bird feeder, berry trees, or other attractive food source, which attracts raptors close enough to be in danger. Collisions can happen as a result of a raptor pursuing a prey flying near the window, fleeing from another raptor, aggressively attacking what it appears to be another bird, or just by the window intercepting an apparently convenient flyway.

_What species are at risk._—Perhaps the raptor most at risk of collisions with windows is the Sharp-shinned Hawk. These birds are commonly attracted to backyard bird feeders, especially during the winter, and make regular visits to hunt the songbirds. Other bird eaters such as Cooper’s Hawks, Merlins, and Northern Goshawks may also be found visiting backyard feeders and may be at risk. With the recent growth of Peregrine Falcon populations in cities, these raptors may become more at risk of collisions with building windows, especially juveniles and fledglings (Cade and Bird 1990).

Habitat associations and behaviors make it apparent that some risks of collision are more dangerous for some species than others. For example, in a 30-year study of raptor mortality in Britain, 35% of Eurasian Kestrels deaths were caused by collisions, mostly with cars, while 65% of Eurasian Sparrowhawk deaths were caused by collisions, mostly with home windows. The difference was interpreted as resulting from differential habitat associations (Newton et al. 1999).
Current state of threat.—The rapid growth of the human population in the western U.S. and the accompanied growth in housing is certainly increasing the opportunity for window collisions. Add to this increase an increase in the popularity of bird-watching and the proliferation of bird feeders, this problem is likely growing and will likely continue to grow. Newton et al. (1999) report increases in the frequency of window collisions for Sparrowhawks in Britain. However, I have not found any published data on the frequency of such events and/or the geographic areas where it occurs most frequently in the U.S.

Solutions.—Bringing this problem to the attention of bird lovers may be a big part of solving the problem. People can place their bird feeders in safer locations, limiting the chance of a raptor striking a window. Some suggestions I have heard are to put the feeders closer to windows, thereby reducing the speeds at which birds hit the windows if they do hit. Somewhat more intuitive is the idea of moving the bird feeders away from the windows so that bird activity is as far from danger as possible. Placing streamers, screens, and plants in front of windows may also help prevent bird from mistaking the windows for open air.

COMPARISON STUDIES

Much of the information available on the magnitude of the collision threat comes from retrospective studies on raptors brought into rehabilitation centers or collected by other interested agencies. Many of these studies report results that are biased by the method of sample collection, with a tendency towards finding birds hit by cars or injured near human habitation (Franson et al. 1996). Nonetheless, from these studies we can learn that collisions are a common and widespread form of mortality in raptors. A recent study of dead raptors in California found that just over half of the birds examined (409 individuals of 17 species) had injuries consistent with death by collision (Morishita et al. 1998). Unfortunately, these data were not broken down by species or by collision substrate. A retrospective study conducted in Iowa during the mid 1980s implicated collisions in roughly 30% of injured raptors brought in for treatment to a rehabilitation center (Fix and Barrows 1990). Approximately 25% of Osprey necropsied in the eastern U.S. from 1975-1982 died from trauma injuries; however, these data were not presented in terms of the type of collision or whether the traumas were human-caused (Wiemeyer et al. 1987). A variety of traumas (including collisions with unknown structures) were responsible for the deaths of roughly 26% of Great-horned Owl (Franson and Little 1996) and 18% of Red-tailed Hawks collected over a wide area of the U.S. from 1975-1993 (Franson et al. 1996).

Section 5

HUMAN PERSECUTION AND DISTURBANCE

Mortality from illegal pesticide use is covered in Module 2, “Pesticides.” Here we will focus on shooting and trapping, as well as the effect of human intrusions on nesting sites.

Reasons for and history of persecution and intrusion

Resource protection.—Some raptors will prey upon game animals (e.g., pheasants, quail) and farm/range animals (e.g., chickens, lambs, and fighting cocks) (Kenward 1999). Such depredation led to widespread shooting and some trapping of raptors by the 19\textsuperscript{th} century. Most
of this effort was aimed at protecting game birds, especially in Europe (Newton 1979). Many national and state governments maintained bounty programs on raptors up into the 20th century for precisely this reason (Newton 1979). By 1916, five raptor species had been extirpated from Britain through the efforts of “game-keepers,” individuals who were employed to shoot raptors (Newton 1979). In North America, raptor shooting apparently never became as common as in Europe (Newton 1979), but historical raptor names such as the “Chicken Hawk” allude to attitudes that raptors were, and still are by some, viewed as pest animals.

**Sport.**—Another reason for shooting appears to be sport hunting. Sport hunting of hawks was wildly popular from 1910 through around 1930 at several hawk migration concentration points in the eastern U.S. (Broun 1949). The most famous of these was in the Blue Mountains of Pennsylvania, part of the Kittatinny Ridge where Hawk Mountain Sanctuary is now located. Though no official tally is available, easily tens of thousands of migrating raptors were shot over the years by hundreds of “sportsmen” who traveled to the site for this purpose. Some weekend days saw more than 200 hunters shooting hundreds of raptors each day (Broun 1949). It appears that the shooting really got going after the end of World War I, as the economy improved enough for people to afford the literally boxes and cases of shells required to make the most of an outing to the ridge (Harwood 1973). This slaughter came to an end with the purchase of the area in 1934 as a wildlife refuge by outraged private citizens (Broun 1949), though it likely continued at other sites for some time thereafter. Today, illegal sport hunting seems to occur most often along roadsides, where raptors make easy targets to anyone with a rifle and a car (Newton 1979, Olson 2000).

**Illegal trade.**—A third reason for shooting hawks is for the illegal trade in raptor parts, particularly feathers. In 1996, nine Native Americans were arrested on charges of killing and trading in raptor parts in the southwestern U.S. (The Arizona Daily Star, Tucson, November 22, 1996, B4). It was unclear how many birds these individuals had killed for the bird trade market, but it appeared that the market was extensive, and dead eagles could sell for up to $1000.

**Non-target killing.**—In North America, raptors are often killed unintentionally as a consequence of efforts to kill other animals. This is most often the case for individuals attempting to control coyotes on ranchlands with poisoned carcasses or leg hold traps baited by carrion. Wildlife Services, formerly Animal Damage Control, is a federal agency within APHIS (Animal and Plant Health Inspection Service). This agency operates an extensive problem-animal elimination program in the United States. They use a variety of methods to control coyotes. Such devices as the M-44, which is a cyanide-ejecting device planted in the ground to kill coyotes, only rarely kills raptors (see Chapter 3).

**Recreational disturbance.**—Humans are visiting natural areas where raptors breed, roost, and winter with increasing frequency. Visitation generally occurs for various recreational activities, including hiking, biking, running, climbing, river running, and riding motorbikes, four-wheelers, sport utility vehicles, and snowmobiles. Given the expanding population in the west and the increasingly popular view of the West’s natural areas as a playground (see any recent issue of High Country News), it is likely that people come close enough to be detected by and cause stress to breeding raptors on a regular basis.
The effect of human presence on breeding raptors appears to vary depending on the timing, the type and intensity, and existing amount of disturbance (Steidl and Anthony 2000). A variety of studies have found reductions in productivity as a result of human disturbances (see review in Steidl and Anthony 2000), yet disturbance may also cause more subtle behavioral effects that could affect fitness or productivity in less obvious ways (Steidl and Anthony 2000). Humans can flush incubating or brooding adults, which exposes young to predators and excess heat or cold. If frequent, failed nests can result. Changes in parental behavior can also affect the feeding rates of both adults and chicks, potentially leading to energetic consequences (Steidl and Anthony 2000).

Humans can disturb wintering raptors as well. Just the presence of hikers passing through an area can influence the choice of roosting and hunting habitat for some raptors, as indicated by a recent study of raptors wintering in riparian areas in Colorado (Fletcher et al. 1999). In other situations, raptors appear able to tolerate or habituate to the presence of humans (e.g., Brown et al. 1999, Wood 1999).

**Aircraft disturbance.**—Another form of intrusion is the noise and presence of aircraft and at military installations, weaponry. Loud bursts of sound from explosions, sonic booms, and fly-overs can potentially disrupt the behavior of raptors, causing a change in roosting and hunting site selection or lowered reproductive success. However, the impact is not always detectable. One study found only minor behavioral effects of fly-overs that varied by type of aircraft and the distance to the nest (Grubb and Bowerman 1997), and another study found no impact of low-level jets on behavior of breeding Osprey (Trimper et al. 1998).

**WHAT SPECIES ARE AT RISK**

**Persecution.**—Large raptors that tend to perch on power lines are probably the most at risk to sport hunting, as it is this behavior that creates the hunting opportunity in the first place. Raptors that will attack birds in semi-urban landscapes, such as Red-tailed Hawks, Great-horned Owls, and Northern Goshawks, are probably the most at risk to shooting by poultry farmers. Eagles and buteos are generally the most sought after on the illegal feather trade market, hence these species are the most likely to be shot for this reason. Carrion eaters, especially those with a strong sense of smell like vultures, may be most at risk to M-44s because the target is attracted by an odorous wick that the target must pull to fire off the device.

**Disturbance.**—The species most likely to be directly impacted by intrusion are cliff-nesting raptors and raptors that are associated with other limited habitats that are also attractive to humans, such as rivers, riparian areas, and shorelines. Birds in these areas are in a sense competing for a resource with humans. Golden Eagles, Peregrine Falcons, and Prairie Falcons usually use cliffs for nesting. Climbers will go to cliffs to climb, and therefore the chance of an interaction exists. The effect of climbers can vary, but in some cases long climbs can keep humans in a raptor territory for hours or even an entire day. Ospreys need to be near water and they often nest in trees or power poles right next to the water’s edge. River runners and beachgoers will also frequent these places and may come quite close to nests. In contrast, humans entering forested areas may travel for days before coming close to a raptor nest. Some raptors in urban and agricultural areas may become less sensitive to human intrusion.
CURRENT STATE OF THREAT

Persecution.—The raptor-shooting problem seemed to be under control until recently, when it was discovered that the problem, in at least some areas, was merely overlooked (Olson 2000). In the Mission Valley of Montana, many wintering raptors had been found dead below power lines and presumed electrocuted. After systematic surveys, collection, and necropsy of raptors for two winters, it was discovered that around 84% of these birds were actually shot (Olson 2000). Hence, shooting may be widespread, prevalent, and largely overlooked. In addition, shooting for purposes of illegal trade is by nature overlooked, it only becomes apparent when someone is found out. It may therefore be extremely difficult to determine the extent of this problem.

Despite the elimination of bounty schemes, some people still believe that raptors are a main source of damage to farm or game animal resources. Indeed, many of the Rough-legged Hawks found dead in Montana, during the 1997-98 and 1998-99 winter seasons, were shot by an individual concerned for the pheasant population. This person was an avid pheasant hunter but was not aware that Rough-legged Hawks rarely, if ever, prey upon pheasants (Chad Olson, pers. comm.). Oddly enough, it appears that there are states in the U.S. in which cock fighting is still legal, including New Mexico, and raptor predation on fighting cocks is discouraged by trapping and shooting. In the U.K., however, raptors can seriously impact game bird populations in moorlands and have as a result been shot extensively over the years (Kenward 1999).

Based on band recoveries, it appears that the greatest amount of raptor shooting today in the western hemisphere is occurring in Central and South America (Ewins and Houston 1992, HWI unpublished data). Ospreys banded in Canada and recovered throughout the southeastern United States, the Carribean, and Central America were found shot 39% of the time (Ewin and Houston 1992). Of these, 69% came from Central and South America up through the late 1980s, and 22% from North America, but only up through 1979. These results suggest that shooting is diminishing as a mortality cause in North America but probably continues to be a factor in Central and South America. Band recovery data from the 30s through the 70s also suggest a significant decline in shooting mortalities of raptors in the U.S. but not in Latin America (Robbins 1986).

Sometimes, cases of wanton raptor killing still surface and the perpetrators can be brought to trial. In 1995, the first felony conviction of a man who had shot and trapped 14 Bald and Golden Eagles in Wyoming was achieved. It is unclear what this person’s motivation for the killing was. Such events show that raptors are still targets for shooting and trapping, despite improved public appreciation for the birds.

Wildlife Services (WS) plans to become involved in removing problem Golden Eagles again (Richard Wadleigh, pers. comm.). Golden Eagles apparently have non-trivial effects on sheep herds, especially in states like Wyoming. The hope of WS is to remove problem eagles and transfer them to USFWS-permitted and certified Native American tribes for religious use. According to WS studies, such actions would benefit the sheep industry and the raptors because it would help to reduce the amount of eagle kills caused by ranchers who have to take it upon themselves to solve the problem. WS estimates that 30 to 50 eagles would be removed from ranchlands and transferred to tribes each year.

Some information on current U.S. public attitudes towards raptors can be gleaned from a recent survey of opinions on predator control aimed at protecting bird reproduction (Messmer et al. 1999). Though the survey was not designed to measure the public’s acceptance of raptor persecution, it did show that the public values hawks and owls as important ecological players,
more so than they valued medium-sized mammalian predators. This result is a far cry from the early part of the century when raptors were widely loathed as vermin (Broun 1949).

Many species of game birds can be maintained at harvesting rates of 20 to 50% of post-breeding population levels (Newton 1998). However, these values presuppose an active management and enhancement program for mainly r-selected (high growth rates and short lifespan) species, characteristics that are generally not shared with raptors. To what extent persecution can be tolerated by raptor populations is currently unknown.

Disturbance.—I know of no data at this time that can help us determine the actual rate of intrusions on raptors, but it is likely that in the West the intrusion rate is increasing rapidly. Anecdotal information suggests that more and more places are being used for recreation, especially using off-road vehicles and motorbikes.

Solutions

Raptors are protected by the Migratory Bird Treaty Act. Eagles are protected by the Bald and Golden Eagle Protection Act. These laws prohibit virtually all of the persecution and disturbance threats considered in this section. At this point in time, the only raptors protected by the Endangered Species Act that are likely to be shot in western North America still are the Bald Eagle (threatened) and the Aplomado Falco (endangered). Despite such protections, prosecution of shooting events is difficult because the events are most commonly detected long afterwards. Sometimes shot birds are found and identified as such, but the shooter is typically long gone. On rare occasions a person is observed shooting a raptor, but even this does not guarantee a successful prosecution (Dale Stahlecker, pers. comm.). Most disturbance events, however, will go undetected by law enforcement.

The only real solution to human persecution is to remove the motivation to harm raptors. In many cases the motivation stems from an inaccurate or culturally determined view of raptors as vermin. Education may help reduce this perception. In other cases, actual depradation may spur people to shoot raptors. Education may not help the perception of the persecutor, but it may help to increase awareness of alternatives that can reduce depradation without harming raptors. Kenward (1999) reviews some of the ways livestock and game birds can be protected without harming raptors, which includes better landscaping, physical and chemical deterrents, compensation to growers or managers, and relocating raptors, and goes on to suggest conditions under which shooting may be effectively used to control raptor predation.

Reducing human disturbance may be difficult because having access to natural areas is important to nearly everyone, including conservationists – and Hawkwatchers! Given this reality, the only option is to restrict access in vulnerable areas, especially to the most disruptive activities. Perhaps the USPS model of creating sacrifice zones can give people places to conduct their activities, while leaving most of the other areas unvisited, would help reduce the extent of the problem.
Section 6

HABITAT LOSS AND DEGRADATION

Habitat is that place, defined by its abiotic and biotic components, where an organism lives. Raptor populations are ultimately limited by their habitat (Newton 1998). For raptors, habitats provide nesting substrates (e.g., cavities, crooks in trees, ledges), hunting locations (e.g., perches), protection, and food. All of these components may limit a population independently, regardless of the state of the other components. For this reason, protecting raptor habitats may require more than maintaining the mere presence of a forest or a marsh. These areas need to be properly managed to ensure that a prey base and certain structural components are preserved.

Habitats are lost or degraded in a variety of manners that can be classified in two main ways. First, many habitats are impacted by society’s efforts to liberate natural resources for use. Nearly all forms of resource extraction harm habitats in some way. Some natural resources are the habitat itself (e.g., timber) yet other resources require the disruption or removal of habitat to get to the resource (e.g., petroleum, minerals, peat). Of significance is the manner in which habitats are treated after some resource extraction activity. Some methods of extraction and reclamation lead to severely degraded habitats that are insufficient for maintaining the full biological complexity and ecological processes initially present. Such practices can also impair or delay future resource extraction. Second, habitats are changed to support human activities such as agriculture, housing development, or other urban expansion. These habitat changes are often permanent.

Habitat patches are not all equal even if all occupied by the same organisms. Some populations occur across a landscape in metapopulations, which are collections of spatially disjunct sub-populations that are connected through dispersal. Characteristically, subpopulations vary in several attributes, including site-specific demography (births and deaths), habitat patch size, distance from other patches, and rates of immigration and emigration. Subpopulations may also vary in their productivity, where certain sites produce excess young (sources) that disperse to sites with low productivity (sinks) (Pulliam 1988). This pattern allows the maintenance of a larger population than would be possible without dispersal. It is typically difficult to determine which sub-populations represent sources and which represent sinks, in fact, source populations can potentially be smaller than the sink populations, making it difficult to distinguish between large populations and productive ones (Pulliam 1988). Habitat protection for any species that exists in a metapopulation pattern must focus on the protection of source populations. In fact, the addition of sink habitats in an effort to bolster populations can lead to reduced population size by increasing the proportion of area with poor productivity (Pulliam and Danielson 1991). However, sites can vary through time in relative productivity (i.e., status as a source or a sink), and thus the maintenance of a suite of subpopulations can still be very important to the survival of a population (Newton 1998).

CURRENT STATE OF THREAT

It is difficult to say how much raptor habitat is being “lost” currently. The complexity of land ownership, human demographics, changing resource patterns, and restoration efforts combine to make an incalculable state of affairs. However, we can look at some basic information on habitat loss and bird endangerment and attempt to prioritize areas for habitat preservation.
Habitat loss and alteration is a major force causing declines in bird populations worldwide. Eleven percent (or 1,111 species) of the world’s avifauna (roughly 10,000 species) has been identified as threatened by Birdlife International (Collar et al. 1994). More than 50% of these species are at risk because of habitat loss and/or alteration, but the actual value may be higher because an additional 23% of species are classified as threatened due to restricted ranges and small population sizes (i.e., species that are inherently susceptible to habitat loss). A majority (65%) of the threatened species occupy forests, with scrub (9.3%), wetlands (8.8%), and grasslands (6.3%) making up most of the remainder. The USA ranks as the nation with the ninth highest number of threatened bird species (46), mainly because entire assemblages of species are threatened in Hawaii. Many Latin American countries are in the top 25 for number of threatened species, implying that many wintering habitats for North American neotropical migrants (which includes some raptors) may also be threatened.

Of the four raptors listed in the U.S. as federally endangered or threatened (Spotted Owl, Aplomado Falcon, Snail Kite, Ferruginous Pygmy-owl), three are declining primarily due to loss of habitat. In the case of Spotted Owls, old-growth and mature conifer forests are lost to logging. In the case of Snail Kites, everglade habitats are lost or altered due to water diversions and development. Ferruginous Pygmy-owls are losing habitat to the rapid urbanization of desert riparian areas in southern Arizona. Many of the non-raptorial birds listed as endangered or threatened are also facing habitat reductions (e.g., California Gnatcatcher). A recent series of proposals to list the Northern Goshawk in parts of its range, albeit unsuccessful, were based on habitat loss due to logging of old-growth and mature forests.

Fortunately, many raptor populations are widespread and occur in a variety of structurally characteristic but otherwise variable locations. For example, Northern Goshawks occur throughout the northern hemisphere in a wide variety of forest types (e.g., aspen, ponderosa pine, mixed-conifer, and deciduous), but nearly always in forests that have adequate populations of medium to large-sized prey, open understories for hunting, and suitable nesting substrates (i.e., typically a more mature forest). However, raptors generally occur at low densities (typical of predators) and because relatively large areas of habitat are needed to maintain a population.

In addition, many North American raptors are migratory and thus have annual cycles of habitat use that effectively increase the area of habitat needed to sustain the population. Breeding habitats are important for productivity, and migratory corridors and wintering habitats are important for birds to survive from one breeding season to the next. In certain species, migratory bottlenecks are evident. Many raptors migrate along mountain ridges to utilize the atmospheric lift associated with mountain topography. They also depend upon roosting sites and prey available in these corridors. Many raptors converge in their migrations along coastal areas. The most notable area is the Gulf of Mexico from southern Texas through Veracruz, Mexico. Entire populations of some raptors funnel through the state of Veracruz in the fall (e.g., Fuller et al. 1998), making the habitats used in this area of extreme significance to their survival. Protecting this habitat (i.e., roosting sites and prey base) is of obvious importance.

Wintering habitats are also potentially limiting. Wintering areas for many migratory raptors are smaller in extent than the breeding ranges (National Geographic Society 1999). Raptors can face food shortages (both absolute and created by competition) during the winter that may affect survival. Importantly, winter habitats are important for sustaining the energetic and nutritional condition of birds prior to undertaking spring migration and breeding. Thus, if winter habitats are of insufficient quality or extent, populations may experience increased winter or migration-season mortality as well as reduced reproductive output the following summer.
Therefore, the entire suite of habitats used annually by a population of birds is important for maintaining healthy populations.

**THE ISSUE OF SCALE**

Raptors generally occur at low densities, and, in North America at least, populations occur across large spatial scales. Except for certain species in some locations, the only accurate way of describing a population is on a landscape scale. However, the study of landscape ecology has revealed that individual organisms perceive habitat at multiple scales (Freemark et al. 1995). Protecting habitats of specific species will therefore entail the protection of a host of habitat parameters consistent with the appropriate scale. These scales may include nest site, territory, habitat patch, landscape, and physiographic region (Villard et al. 1998). For migratory raptors, protecting habitats on a continental scale may also be necessary.

**SOLUTIONS**

*Protect land.*—Several conservation organizations specialize in purchasing land for the purpose of protecting habitat. Notable among these is The Nature Conservancy, yet many smaller land trust organizations have popped up around the west in recent years (Nijhuis 2000). Often, these groups arrange for voluntary conservation easements to be placed on plots of land. Easements stipulate a legally binding range of acceptable future uses of the plot of land. The goal of an easement is to usually to prevent urban or other development while keeping the land in some form of low-intensity agriculture (e.g., grazing). Rarely (ever?) do these groups purchase land or arrange easements for the primary purpose of protecting raptors, but the cumulative impact of protected habitat, especially those sections adjoining large stretches of habitat, benefits raptors.

Globally, protecting habitat for conservation occurs mainly in regions with high diversity and endemism, such as tropical areas in the Americas, southeast Asia, and Africa (Collar et al. 1994). These are areas where the protection of small amounts of habitat can help sustain the populations of many different species. Compared to global prioritization approaches, conservation of North American raptors will look quite different. Most of the raptors in North America cover wide geographic ranges, and species diversity and turnover across the landscape are much lower. Small areas of protected habitat can potentially maintain some raptors (e.g., those currently threatened or those that occur within our geographic focus area as a peripheral species such as the Gray Hawk) but may be of little overall conservation impact for most species. Nonetheless, there are some places where raptors concentrate enough in numbers and diversity that the protection of small areas may be of great importance (e.g., Snake River Birds of Prey Area).

*Improve management.*—One way to promote sound habitat management is to comment on draft federal agency land management plans. Many National Forests and Wildlife Refuges are currently retooling their management plans (typically a 10 or 15-year plan). The agencies solicit public comments on their plans, including sometimes entirely new options to include in the process. In fact, HWI commented on the Northern Goshawk plan for Utah forests (more info coming later).

Litigation can be used to promote improved habitat management in some cases. There have been cases where a governmental land agency such as the USFS was delinquent in implementing the habitat management guidelines set for a particular species. Such was the case
for the Mexican Spotted Owl in the Southwest. The Center for Biological Diversity has had an ongoing legal battle with the USFS to force the latter to implement its own habitat management guidelines for the owl.

Volunteer habitat work on special areas has become an increasingly common tool for habitat protection. Defenders of Wildlife and the National Audubon Society both have programs to create public support and involvement in the national wildlife refuge system. The NAS operates the Audubon Refuge Keepers (ARK) program, which creates groups that act as advocates of the refuge, helping to maintain and raise awareness of the importance of refuges and the entire refuge system.

Several bird conservation groups, including the National Audubon Society and the American Bird Conservancy are involved in the designation of Important Bird Areas (IBAs). These areas have been designated because of some critical concentration of breeding, migrating, or wintering birds.

Raptors are top-level predators and thus rely on intact suites of vegetation components and prey types. In the past, many large expanses of habitats were managed for single goals such as timber extraction or grazing. More recent developments in land management philosophy have led to the idea of ecosystem management, where managers attempt to maintain a variety of ecosystem components. Such components include ecosystem processes such as natural disturbances (e.g., fire and flooding), predator-prey dynamics, and multiple human uses. In some cases, the processes needed to help maintain a healthy ecosystem need to be recreated by managers, such as wildfires. In some habitats (e.g., pine savannas and prairies), cool ground fires help to prevent the build-up of excess vegetation and stimulate the growth of beneficial ground vegetation. In forests, they also foster the growth of larger stands and more productive understory communities, all of which can benefit forest raptors.

Some groups have begun to work on promoting ecosystem integrity through cooperative efforts to unify management in a specific ecosystem (e.g., the Greater Yellowstone Coalition, the Northwest Forest Plan, the Interior Columbia Basin Ecosystem Management Project). Because of the need for large areas of habitat to support raptor populations, efforts to preserve remnant but relatively intact and unique ecosystems could be one of the best ways to prevent substantial impact to raptor populations. In addition, The Wildlands Project (www.twp.org) also coordinates large-scale biodiversity preservation and wildlands protection strategic plans, using the cooperative effort of several to many local and national organizations. Many of these efforts are just getting underway. Projects that may be of significance to certain priority raptors might represent good collaborative opportunities for HWI.

Reduce resource need.—It could be argued that many societies (especially our own) use too many natural resources and could get by using much less. We could both reduce the demand for certain products as well as improve the efficiency with which we use what cannot be reduced. If we reduced the need for wood products, fewer trees would need to be cut, leaving intact wildlife habitat and ecological processes. Clearly, recycling paper and choosing to purchase only recycled paper is a simple way to reduce that need. Substituting other materials may also help greatly, such as alternative paper fibers (e.g., kenaf, corn stalks) or recycled plastic lumber for decking, fencing, and other construction uses. Many other examples could be provided. The challenge is to infuse a philosophy of treating resources as valuable and reusable into society at large. A massive low-impact lifestyle educational campaign is needed to help redefine how we view natural resources.
Improve urban development planning.—Urban sprawl has become somewhat of the “devil within us” for western environmentalists. As much as the phenomenon is defiled, many individuals who choose to build new houses on the outskirts of town or up in the foothills near the National Forest proclaim themselves to be environmentalists. As we know there probably is no stopping urban sprawl, but a better informed zoning board or planning process could at least help to reduce the impact of urban sprawl. Some urban sprawl might be reduced if city revitalization plans can be developed. Fallow plots within town could become new home sites if people perceived that living in town actually would not reduce their quality of life. It may take revitalizing the local economies, reducing crime, and improving transportation options to convince people to stay in town.

An important role for the FWS is guiding the development of Habitat Conservation Plans (HCPs). HCPs are voluntary agreements between private land-owners and the FWS (or the National Marine Fisheries Service) to enable development while maintaining habitat for endangered animals that occur on the developed land. The land owners develop ideas for protecting the endangered species, and if the federal agency guiding the process determines that the protection plan will allow the proposed development to go forward without harming the species, then the agency will issue an incidental take permit. This permit allows for take (e.g., harm, kill, molest) of individuals of the endangered species if it unintentionally occurs as part of the development process, without the possibility of criminal penalties. In addition, provided it is properly implemented and adhered to, the plan comes with assurances from the federal agency that no additional restrictions will be created for a species already covered in the plan. HCPs may protect populations of endangered raptors, but it is important to note that there are only a few endangered raptors in the continental U.S. right now. Still, many raptors may benefit from the general protection of habitats that HCPs provide, and it appears that sometimes non-listed raptors may factor into the creation of some HCPs as well. However, it seems that the presence of common raptors on private land is not necessarily reason enough to enact an HCP.
Chapter 2

PRIORITIZING THREATS AND SPECIES

Section 1

PRIORITY FACTORS

INHERENT VULNERABILITY OF SPECIES

Growth and decline of populations, and the eventual extinction of species, is a natural phenomenon. HWI’s objectives revolve around human-caused population limitations, but the degree to which these limitations impact species will depend on both the severity of the limitation and the relative sensitivity of a species to that limitation. Hence, some consideration of the inherent vulnerability of a species is warranted.

Evidence for the conservation importance of this characteristic comes from the history of raptor persecution in Great Britain during the last couple of centuries (Newton 1998). Several species of raptors were extirpated from Britain, mainly those with small ranges, large body size, and slow breeding rates (e.g., White-tailed Eagles and Common Buzzards). In contrast, the three species least affected by persecution (Merlin, Sparrowhawk, and Eurasian Kestrel) were smaller, with wider ranges, and had greater reproductive rates. Inherent vulnerability is dependent on natural biological characteristics, including a variety of individual and population level traits:

Range.—In general, species with small ranges are more vulnerable to declines than those with large ranges. Local populations can go extinct for a species regardless of range size. Species with large ranges, however, are likely to persist because some areas may not be affected by the decline and remaining populations can therefore supplement the declining one. Species with smaller ranges are relatively closer to total extinction when local populations decline.

Density.—Species with low breeding density are more vulnerable to declines than those with high density. This is at least partly due to the Allee effect, when individuals have reduced opportunity to locate potential mates because there are so few of them, leading to a reduction in productivity below what might be expected for the given population size.

Habitat breadth.—Species with narrow habitat breadths (i.e., specific habitat requirements) are more vulnerable to declines than those with wide habitat breadths. In general, species that can successfully breed and survive in a variety of habitats may adapt to changing conditions, even those caused by humans, more easily than those needing specialized habitat types (unless the change increases availability of a specific need).

Body size.—Range size, longevity, and age at first breeding tend to be positively related to body size. Hence, larger birds tend to have larger home ranges, which causes populations to have lower breeding season densities (see above). Larger birds tend to live longer, and the mortality of adult birds therefore has a major impact on the reproductive potential of a population. Finally, larger birds tend to take longer to reach breeding age, increasing the time it takes for young birds to replace lost breeding adults. Body size also relates negatively to
reproductive output, both in number of eggs produced per attempt and the frequency of attempts, causing slower rebound and recovery from declines. There are many exceptions to these correlations. For example, range size is also dependent upon prey availability. The salient point, however, is that certain life history characteristics, partly related to body size, can make the impacts of human-related mortality and reduced reproduction more difficult for a population to absorb. Typically, it is the larger species that are most susceptible to population level impacts.

Reproductive strategy.—Classically, there are two basic strategies of reproduction in animals, and the tendency to fall in one class or the other has an impact on a species’ population dynamics and resistance to human impacts. Some animals are classified as *k*-strategists and have few offspring with relatively high survival probabilities. These are typically species that live close to the carrying capacity of a habitat, referred to as *k*, and have slow population growth rates. They are often viewed as relatively vulnerable to human impacts because they are slower to rebound (few offspring per unit time) after some type of decline. Other species are *r*-strategists because they have high reproductive rates with relatively low survival probabilities for each offspring (the *r* refers to the intrinsic growth rate of a population). This strategy allows for rapid population increase given habitat openings. *R*-strategists can often rebound from declines rapidly, and this allows them to quickly occupy new habitats. Many hunted avian species are *r*-strategists (e.g., some ducks).

Island versus mainland populations.—Island populations are and have historically been the most vulnerable to extinction (Newton 1998). The only population of raptors known to have gone extinct due to human factors was the Guadalupe Caracara, which once lived on Guadalupe Island off the coast of Mexico (Newton 1998). Britain lost more raptor populations due to persecution than Western Europe, and several island raptors are among the most endangered birds in the world (Mauritius Kestrel, Philippine Eagle, Hawaiian Hawk). In North America, the only raptor that fits this profile is perhaps the Queen Charlotte Goshawk, which inhabits forested islands in Alaska and Canada.

**OTHER CONSIDERATIONS WHEN ASSESSING PRIORITIES**

Annual cycles.—The annual cycle of raptors creates temporal patterns of vulnerability to human impacts. For migratory species, seasonal movements can lead to variable habitat availability, with resulting impacts on competition and mortality. Also, if seasonal movements cause birds to face location-specific patterns of exposure to human hazards, then reducing those impacts could require greater understanding of where and when impacts are actually operating.

The annual cycle also encompasses seasonal patterns of reproduction and mortality. Reproduction occurs from late winter through summer in the northern hemisphere. Hence, any efforts to improve raptor productivity should occur before the breeding season when individuals are preparing to breed. Mortality can occur throughout the year, however, and rates may vary greatly throughout the annual cycle (Newton et al. 1991, 1999). For example, the post-breeding period may have high mortality rates for juveniles, and migration periods may have especially high mortality rates for some long-distance migrants. It is likely that the most important time of year to reduce human impacts on raptors is during the time when natural mortality is low. For example, efforts to reduce mortality after most natural mortality has occurred (i.e., during spring migration or summer) may have a higher probability of protecting breeding stock. In contrast,
protecting raptors during periods and in locations where they are likely to die anyway may have 
minimal population level impacts.

_Density-dependence and the interaction of mortality and reproduction._—Population 
regulation is a complicated phenomenon, where changes in reproduction or mortality can in turn 
affect the other. For example, increased winter survival can lead to occupancy of suboptimal 
habitats for breeding and result in lower productivity for some survivors. These types of 
counteracting effects can alter the intended consequences of conservation strategies if the most 
limiting factor has not been adequately defined. For example, if Golden Eagles are limited by a 
maximum reproductive rate due to nest site or food limitations, increasing overwinter survival by 
removing electrocution risk may not lead to a larger eagle population (at least in the short term). 
This is because additional surviving individuals will have no opportunities to breed, except 
following the death of individuals occupying suitable territories.

**HUMAN-CAUSED POPULATION LIMITATIONS**

These issues were discussed at length in Chapter 1. They are an important component of 
assigning priority to species and will be discussed more in Section 2.

**Section 2**

**APPROACHES TO PRIORITIZING SPECIES AND THREATS**

In this section we consider the hazards to individual birds and threats to habitats in 
western North America and attempt to construct a list of those issues critical to the maintenance 
of raptor populations. Essentially, there needs to be a way to prioritize the species in terms of 
conservation concern and the severity of population limitation that various threats represent. 
Though we will focus on continental and regional patterns of prioritization, we can start with a 
global perspective for all birds. Worldwide, habitat loss is the single greatest threat to bird 
populations, especially in tropical forested areas (Collar et al. 1994). This threat results from the 
rapid increase in human populations worldwide and our expansions into wildland areas for 
habitation and agriculture. Habitat loss is a paramount issue in the status of 52% of threatened 
species, followed by natural small range and population size (23%), hunting and persecution 
(8%), introduced species (6%), natural causes exacerbated by other influences (3%), trade and 
egg collecting (3%), other, which includes pesticide and other poisonings, (3%), and unknown 
(3%) (Collar et al. 1994).

**RABINOWITZ SCHEME**

This scheme is one way of prioritizing species based on three components of their 
inherent vulnerability. Rabinowitz (1981, cited in Newton 1998) described four levels of 
vulnerability based on three population characteristics: range size, habitat width, and density. 
These levels are as follows; italics indicate a high-vulnerability characteristic:

1. Large range, wide habitat, high density (low)
2. Large range, wide habitat, _low density_ (medium)
3. Large range, _narrow habitat_, high density (medium)
4. Small range, wide habitat, high density (medium)
5. Large range, narrow habitat, low density (medium-high)
6. Small range, narrow habitat, high density (medium-high)
7. Small range, wide habitat, low density (medium-high)
8. Small range, narrow habitat, low density (high)

Though these classifications refer to the initial characteristics of a species, human activities can bump a species into a more “inherently” vulnerable category. For example, habitat loss may cause range declines for a species with an initially wide distribution. Humans are not likely to change the habitat breadth of a species, but they may alter conditions to the point that a species can no longer occupy some types of habitats. Excessive mortality from shooting or other impacts could cause a population to experience reduced density.

There are problems with this scheme and its use for raptors, no doubt resulting from the scheme’s development with plants in mind (Rabinowitz 1981). One problem is that the simplistic dichotomies between, for example, large and small range, do not adequately capture the variation within raptors. Clearly, American Kestrels have a large range, but so do Western Screech-owls, even though their range is only half that of the Kestrel. Another problem is that nearly all raptors have low densities. Raptors are sometimes patchily distributed or have localized breeding colonies in an otherwise low-density population. Thus, it is hard to distinguish clearly a high and low-density raptor. Nonetheless, such schemes are useful for identifying species that might require relatively greater monitoring or conservation attention because of inherent, biological considerations.

PARTNERS IN FLIGHT SPECIES PRIORITIZATION SCHEME

Partners in Flight (PIF) is a group of government agencies, non-governmental organizations, and concerned individuals working together to plan for the effective conservation of land birds in North America (Carter et al. 2000). PIF working groups have been established for each state and province in the U.S. and Canada, and these groups collectively prepare a conservation plan for that state. The plans summarize priority species for each habitat type in that state. They also discuss threats and management solutions to habitat problems that will help maintain or increase populations of priority species. Plans are intended to provide guidelines for land managers and a framework for future research and monitoring on priority species.

How it works.—The species prioritization approach taken by PIF uses a suite of scores representing a comprehensive view of each species’ range, threats, and trends. Scores are assigned to each of seven categories, including breeding distribution, nonbreeding distribution, relative abundance, threats to breeding, threats to nonbreeding, population trend, and area importance. The first three categories regarding distribution and abundance reflect a population level view of inherent vulnerability. The threats categories emphasize habitat issues. The population trend category is primarily based on Breeding Bird Survey data, augmented with other sources. Area importance varies locally, and thus a species’ score could vary by location. For each category, a species is assigned a score from 1 to 5, corresponding to low through high priority. For example, a score of 1 for the relative abundance category indicates a very abundant bird (relative to others) and a score of 5 indicates a very rare bird. Also, a score of 1 for population trend indicates an increasing trend and a score of 5 indicates a decreasing trend. Scores are summed for all seven categories, giving a minimum score of 7 and a maximum score.
of 35. For each habitat type in a given state, species are ranked by score. Associated habitat, research, and monitoring needs are also included. Scores were created for each state, and they were then compiled for species breeding in each physiographic region in the western U.S. (available at the Colorado Bird Observatory’s website (www.cbobirds.org, 2000.3).

How we used this information.—The scores from each physiographic region were used to come up with a region-wide view of raptor species priorities according to PIF. Scores were compiled for every raptor species listed in each physiographic region as a breeder. Some species were listed in only one or two regions (e.g., Aplomado Falcon). Scores were averaged across the regions in which they occurred to give a general ranking for the species across the western U.S. States in which species were not scored were not included in the average (i.e., no blanks were averaged). Species were then sorted in order of highest to lowest rank (Table 2).

Results.—This approach indicated that during the breeding season, the Spotted Owl (average score = 24), Whiskered Screech-Owl (23), Elf Owl (23), Aplomado Falcon (22), Ferruginous Hawk (22), and Flammulated Owl (22) were the species of greatest concern (Table 3). In the three physiographic regions that were examined (Colorado Plateau, Northern Sierra Nevada, and Basin and Range) the highest-ranking raptor placed in the top five priority species overall but non-raptors were generally the highest-ranking birds.

Problems with this approach.—One problem with the PIF approach is that the population trend information mostly comes from the Breeding Bird Survey. This annual roadside survey method is biased towards highly detectable species that occur along roadsides. Raptors are often poorly represented by this survey, and thus the results for this category may be of limited value. However, the PIF plan also incorporates other trend information for raptors, such as migration counts, which are likely better population indicators for some species. However, the total score is only partly made up of trend information and thus is not overly weighted towards this aspect.

Beissinger et al. (2000) reviewed the PIF approach and found that the mix of quantitative and qualitative scoring mechanisms could create biases that would affect the outcome of the prioritization scheme. To date, these biases have not been addressed. In addition, these authors found that the threats to breeding and threats to nonbreeding categories needed further revision, as they are strongly oriented towards historic habitat loss patterns and generally overlook future losses or other population threats. Historically, many raptor extirpations, extinctions, and declines have been caused by non-habitat threats. It seems likely that, as a group, raptors may be more vulnerable to these threats than the songbirds the PIF scheme was designed to prioritize. Because of this, the PIF outcomes may not characterize raptor priorities as well as for some other groups.

Another limitation of current PIF scores is that they are geographically tied to breeding seasons. For example, the Rough-legged Hawk has not been given a score through this U.S.-based process because it does not breed in the lower 48 states. This species winters in the U.S., however, and PIF coordinators are currently compiling scores for wintering locations. This process will enhance each region’s ability to identify priority wintering species.

THREATS-BASED PRIORITIZATION SCHEME

Natural mortality is high for most raptor species, especially during the first year of life (Newton 1979). Because of this, it is possible that human-induced mortality merely offsets
natural mortality in many cases, especially during the first few months after young birds fledge. In fact, some hunting practices in Europe are believed to have not had long-term population effects on target raptor species because of their focus on young birds (Newton 1998). However, additional mortality factors added on top of hunting could potentially have an impact. Human-caused mortality can begin to exceed natural rates if it becomes too severe or occurs at the wrong time of the year. For this reason, gauging the extent and variety of causes of raptor mortality can help identify species that may be experiencing above-normal mortality rates due to human causes. A species that is vulnerable to a wide variety of mortality factors may be closer to the point where human-caused mortality will have population effects. We have attempted to determine the extent and types of human-caused mortality and other individual-level impacts facing western raptors, and to rank these species by the number of impacts they experience. The scheme includes threats to individual birds, both those that cause mortality and some that can cause sublethal effects to the individual. No habitat-based threats are included in this scheme because the goal here is to address some of the threats that are not addressed by the PIF plan.

How it works.—We developed a ranking system based on a general sense of the magnitude of non-habitat threats facing raptors (Chapter 2). The threats are grouped into ten types that operate independently (Table 3). For example, anticoagulant rodenticides operate in a different way than organophosphate pesticides, in terms of both their physiological effects and manner of application. Even though our stated geographic focus includes all of western North America, at this time we have only considered threats to raptors that occur in the western U.S.

Each species was assigned a score for each threat of 1, 2, or 3 corresponding to low, medium, or high rate of impact (Table 3). Scores are intended to reflect both the geographic extent of a problem and its frequency of occurrence. Scores were assigned independent of scores for other species. The scoring regime is conservative because a score of 1 is given if current information is insufficient to evaluate a threat for a given species. As information becomes available, we are more likely to raise scores than lower them.

A score was also assigned to each species based on a factor called “area responsibility” (similar to the PIF regime, Table 3). This factor represents the relative importance of the western U.S. to a species’ overall breeding range and is important given HWI’s stated regional focus (see Introduction). Scores were assigned as 1, 2, or 3 corresponding to low, medium, and high importance of the western U.S. to that species’ total range. Species for which the majority of the breeding range comprises the western U.S. received a score of 3. There are three ways that birds were assigned a score of 2. First, species received a 2 if they are widespread breeders in the western U.S. but have significant portions of their range in other areas. Second, species received a 2 if they are widespread in Mexico and occur in the U.S. only in western states (e.g., Harris’ Hawk and Zone-tailed Hawk). Third, species received a 2 if the western U.S. represents an important wintering area for a species that otherwise breeds further north (e.g., Rough-legged Hawk). Species for which western states occupy only a fraction of the total range, or for whom the majority of the range is in eastern states, received a 1.

For each species, the total score was added across all threats, giving a general ranking of the magnitude and variety of human threats to individuals of that species. Once the rankings were created, species were then sorted by area responsibility into three groups. Within each area responsibility group, species were then sorted from highest to lowest by their total threats score. Finally, scores were summed for each threat type and sorted from highest to lowest.
Results.—This approach produced a hierarchical prioritization, first of birds that western states have an obligation to conserve and then of birds at risk of direct impact from humans. The current scoring effort indicates that 8 species have a high area responsibility, 15 species have a medium area responsibility, and 21 species have a low area responsibility (Table 3). In the high responsibility group, Golden Eagles and Ferruginous Hawks are the two species at greatest risk to human hazards. In the medium area responsibility group, Swainson’s Hawk and Harris’ Hawk are the two most at-risk species. In the low area responsibility group, Bald Eagle and Osprey are the two most at-risk species. Bald and Golden Eagles had the highest hazards ranking of any species. We also found that electrocution has the greatest impact to the greatest number of species, and window collisions had the least impact to raptors in general (Table 3).

There are notable differences between these results and the results from the PIF scheme (Table 2). The only two species that are on the top-ten priority species list for both schemes are Swainson’s Hawk and Ferruginous Hawk. The six highest-ranking species on the hazards scheme are not on the top-ten list for PIF, and the top-ranking PIF priority (Spotted Owl) received the minimum possible hazards score. These differences emphasize the importance of distinguishing and considering both habitat threats to species as well as hazards to individual birds.

Problems with this approach.—There are several problems with this approach. First, the scores were assigned using a subjective weighting of information from the literature, personal observations, and personal communications with other researchers. No objective, comparative data are available to rank these threats for any species (in this regard similar to some facets of the PIF scoring approach). However, some attempt must be made even if it does not represent an ideal procedure. Second, the scheme may be fairly sensitive to errors. If some scores have been assigned incorrectly, then the priority species may not have been properly identified. A change of even one point for a threat could change the priority level of that species. Third, threats that occur outside of the U.S. during the nonbreeding season, particularly in Mexico and Latin America, may be of real concern. For example, most bird-eating and fish-eating raptors that migrate to Latin America are likely at greater risk of poisoning by organochlorine pesticides than has been indicated on the table at this point. Perhaps each of these species (e.g., Peregrine Falcon) should have an additional point added to their scores. Or, each threat could be divided into winter and summer impacts.

INTEGRATING THE PIF AND THE HAZARDS APPROACHES

The PIF approach takes into consideration many of the variables that are relevant to determining conservation priorities in birds, including habitat threats, population indices, and inherent vulnerability due to range and density. However, many raptors are more susceptible to human-caused threats than the birds (mostly songbirds) the PIF scheme was designed to prioritize. If the PIF scheme were augmented to include a more explicit consideration of non-habitat threats, then the relevance of the PIF scheme to raptors could be increased.

One way of augmenting the PIF scheme is to add an additional five-point variable, just for raptors, that represents the magnitude of the non-habitat threats. We took the results of the hazards scheme (Table 3) and converted them to a five-point scale using the following conversions: hazards score 10 and 11 = 1, 12 and 13 = 2, 14 and 15 = 3, 16 and 17 = 4, and 18, 19, and 20 = 5. We then added these scores to the PIF total score (Table 4). This approach yielded a prioritization scheme, with values from 8 to 40, which considers non-habitat threats on
par with habitat threats and the other PIF variables, and thus is consistent with PIF’s intention to
counter all the possible variables that factor into the conservation priority of a species. In this
approach, the addition of threats to the mix tempers, but does not overwhelm, the results of the
PIF approach.

Alternatively, the HWI threats approach could be expanded to include habitats as a threat.
We collapsed the threats in Table 3 to create five general non-habitat threats (Table 5). We then
added a sixth threat for habitat loss and degradation. However, we do not at this time have a
good sense about how to rank habitat threats, so we used the PIF prioritization results (Table 2)
as a surrogate for the magnitude of the habitat threat. We converted the PIF results to a three-
point scale using the following conversions: PIF score 13 –16 = 1, 17 – 20 = 2, and 21 – 24 = 3.
We then summed across all threats for each species (Table 5). This approach yielded a
prioritization scheme that considers all general categories of threats as potentially equal, and
allows the sorting of the six threats from highest to lowest impact based on its combined impact
to all species. Although we sorted species by area responsibility, this approach does not provide
the comprehensive consideration of all the variables used by PIF. In this approach, the addition
of the PIF scores tempers, but does not overwhelm, the results of the hazards approach. It should
be kept in mind though that the PIF results may not be a completely valid surrogate for habitat
threats because the scores also represent other factors (see above).

PRIORITIZING HABITATS

Raptors occupy most all types of natural habitats as well as some human created habitats.
Many habitats are decreasing in area, while others are increasing. It is not possible to protect all
habitats, so some form of prioritization is necessary to protect the habitats that, if reduced in size,
will have the greatest impact on raptor populations. To this end, we suggest several approaches
that might allow us to prioritize habitats based on how critical it is to protect them.

*Prioritize by species ranking in the PIF system.*—We can use the species rankings
created by Partners in Flight (Table 2) to identify those habitats most in need of protection. This
is somewhat circular, as habitat threats are part of the basis for the species ranking. What we get
from this approach is a list of habitats that need to be protected to help preserve the populations
of the highest-ranking (i.e., of greatest conservation concern) raptors (Table 6).

*Sort habitats by abundance and loss rate.*—In this approach, we would gather
information on the abundance of a habitat and its annual rate of loss in a given area. Then we
could plot all habitats on a graph, with the x-axis representing abundance and the y-axis
representing annual loss rate (Figure 3). Habitats that rank low in abundance and high in loss
rate (in the upper left portion of the graph) will fall out as those in greatest need for protection.
Habitats that rank high in abundance and low in loss rate (in the lower right portion of the graph)
will fall out as a low priority. This approach is species-free and is not biased by any perceived
need for focusing on a particular species’ habitat. This type of diagram may need to be created
for each Bird Conservation Region (BCR) that HWI ranks as a high priority, as both the relative
abundance and loss rates vary regionally. Actual values of loss rate and relative abundance
might be derived from PIF documents, government documents, or GAP analysis projects.
Figure 3. Conceptual view of a format to determine the most critically at-risk habitats in a particular area. The closer a habitat is to the top left corner of the graph the greater is its priority. Any habitat that floats to the top of the graph will also rank as a habitat of concern. Current plotted locations of each habitat type are guesstimates.

Focus on hotspots.—Focus on particular concentrations of raptors such as in wintering areas (e.g., wildlife refuges such as Bosque del Apache, prairie dog towns like at Ejido San Pedro, Mexico, and other special areas such as Willard Canyon), migration bottlenecks (e.g., Veracruz floodplains), or important breeding sites (e.g., Gila River, Tongass NF). Focus efforts on protecting these areas. If non-sink breeding habitats or other locations that could create seasonal limitations on a raptor population can be found, then with relative ease this limiting factor could be addressed through habitat protection and restoration (as compared with trying to protect larger portions of the range). This type of approach may not be suitable for defining overall priorities but would be a valuable component of any effort to protect high-priority habitats.

Section 3

CURRENT EFFORTS BY OTHER ORGANIZATIONS

One step toward defining HWI’s conservation niche is to determine the nature and extent of the conservation work conducted by other organizations. This information will allow HWI to find suitable collaborators and to find areas where its work will fill important gaps. What follows is a basic description of the attention being given to the threats we have defined in Chapter 2. We have generally included only descriptions of an organization’s efforts if they are actively working to diminish these threats. For habitats, however, there are no “raptor habitat” groups, so I have included a variety of organizations doing different things to generally protect habitats.
ELECTROCUTION

_Tucson Audubon Society._—TAS is working with Tucson Electric Power to create a monitoring program for Harris’ Hawk electrocutions in Tucson. They have been involved in discussions with USFWS, University of Arizona, Arizona Game and Fish, and others, to structure ways of monitoring and reducing the electrocution rate. There is a consultant who coordinates a hotline, a database for electrocution information, and training sessions for TEP linemen. Apparently they have had some success and are hoping to initiate an area-wide survey soon that will determine whether improvements have really been made.

_Center for Biological Diversity._—CBD is trying to force Tucson Electric Power to do more to prevent Harris’ Hawk electrocutions. Electrocutions continue despite the cooperative efforts of Tucson Audubon Society, TEP, and others. CBD is therefore circulating petitions, threatening litigation, and generally creating heat for TEP. They have also set up an electrocution hotline and demanded a series of actions that TEP should take, including hiring a full-time biologist and proactively retrofitting all distribution poles near Harris’ Hawk nests.

_San Bernardino Valley Audubon Society._—This group is working on an electrocution problem in southern California. I am still waiting to hear back from them on the details of their activities.

_Bureau of Land Management._—The USGS employs a biologist who, among other things, has worked to create a better understanding of the problem of raptor electrocutions. Bob Lehman continues to write about electrocutions in journals and talk about it at meetings. He is also conducting surveys on the Snake River Birds of Prey Area to quantify the problem there.

_Fish and Wildlife Service._—The USFWS employs several agents who are able to do at least some on the ground surveys to help locate problem areas and poles and, ultimately, force action by the utilities that own the problem poles. It was the work of these agents that led to the court ruling against Moon Lake Electric Power company to retrofit problem poles and do more proactive prevention work on their distribution grid.

PESTICIDES

_American Bird Conservancy._—The ABC employs the only full-time advocate/biologist in the U.S. working to minimize avian pesticide interactions. ABC is working to get registrations for the worst pesticides cancelled or prevented. They are also working to reduce the use of certain pesticides throughout the western hemisphere, especially highly toxic organophosphates such as carbofuran and monocrotophos. They also promote the adoption of Integrated Pest Management and are pushing for a more thorough risk assessment of pesticide usage.

_International POP Elimination Network._—IPEN is a worldwide network of hundreds of non-governmental organizations hoping to achieve a complete elimination of the use and manufacture of persistent organic pollutants. Many of the POPs under scrutiny are organochlorine pesticides, but they also include many industrial chemicals. INEP has created a platform statement on POPs and has acquired endorsements from hundreds of environmental groups. Currently they are supporting and pushing the efforts of a United Nations working group negotiating a global treaty on the elimination of POPs.

52
**World Wildlife Fund.**—WWF has developed at least one partnership with an agricultural trade organization to develop and implement Integrated Pest Management tools for large-scale agriculture. They have apparently had good results with the Wisconsin Potato and Vegetable Growers Association, reducing the use of pesticides and maintaining production and profits for the farms involved.

**INDUSTRIAL AND OTHER CONTAMINANTS**

*Environmental Defense Fund.*—EDF works to facilitate reductions in pollution of a variety of sorts by collecting and disseminating information regarding human health impacts. Though wildlife toxicology is not a focus of their work, wildlife will benefit by any gains made through such efforts.

*International POP Elimination Network.*—See above under pesticides.

*World Wildlife Fund.*—WWF’s Global Toxics Initiative (GTI) is a program aimed at ending “the production, release and use of chemicals that are endocrine disruptors, bioaccumulative or persistent within one generation - by no later than 2020.” Activities include congressional lobbying, convening scientific review panels to assess the impacts of toxic substances, public education, and promoting alternative, non-toxic products. They appear to be very active in INEP.

**COLLISIONS**

*National Wind Coordinating Committee.*—The NWCC is a collaborative group of industry, government, and environmental representatives (oddly, no actual raptor groups are on the roster) working towards the “development of an environmentally, economically, and politically sustainable commercial market for wind energy.” This group has produced the landmark guidance procedures for documenting and monitoring avian interactions at wind power facilities, which should lead to a more complete understanding of impacts to bird populations and, potentially, the minimization of the problem.

*National Renewable Energy Laboratory/Santa Cruz Predatory Bird Research Group.*—The SCPBRG, funded through the NREL, is conducting an intensive population study of Golden Eagles in the Diablo Mountains of California, home of the Altamont Pass Wind Resource Area. This study has revealed much information about mortality rates, population effects, and potential solutions to the avian collision problem at wind farms in general. The study is ongoing.

**PERSECUTION**

*Most raptor groups.*—Aside from HWI, many western migration-oriented and other raptor groups (e.g., Golden Gate Raptor Observatory, Hawks Aloft, Idaho Bird Observatory, and many others) conduct education programs designed to increase the appreciation of raptors by the general public. This work may ultimately reduce the proportion of the population either inclined to view raptors as vermin or unaware of the laws protecting raptors.
HABITAT LOSS AND DEGRADATION

*American Bird Conservancy.*—ABC operates collaborative and supportive efforts to enhance the habitat protection efforts of people in Latin American and Caribbean countries. These efforts are usually prioritized towards habitats harboring highly endangered birds.

*Forest Stewardship Council.*—The FSC operates an international certification program that promotes responsible forestry. They have a number of accredited certification bodies that regularly inspect and certify forests and forest products according to standards of economic, social, and environmental sustainability. This program will likely increase the amount of forested acreage worldwide that will continue to support wildlife populations despite continued and increasing demand for forest products.

*The Nature Conservancy.*—TNC purchases land, arranges the transfer of land, and secures conservation easements on tracts of land vital to the protection of sensitive species, habitats, or ecosystems. Raptors are generally benefited by the creation and maintenance of these preserves, especially for those raptors that are rare or dependent on rare habitats (e.g., Gray Hawk).

*Land Trust Alliance.*—Not a land protection entity itself, the alliance is made up of hundreds of local land trusts across the nation (nearly 250 across the West). Land trusts often protect small fragments of open space in rapidly developing areas but are in some cases moving towards prioritizing important wildlife areas. As with The Nature Conservancy properties, land under easements will help prevent the loss of additional raptor habitat. However, many such easements will exist in a fragmented landscape that does not provide optimal conditions for wildlife.

*Sierra Club.*—The Sierra Club has several campaigns aimed at protecting habitat of key ecosystems and ending commercial logging on federal lands. Their work is aimed at congress to facilitate the passage of acts that will benefit habitat protections.

*The Wilderness Society.*—TWS has designated the ten most endangered ecosystems in North America, based on what appears to be the combination of overall importance to wildlife and the magnitude of the threats to that ecosystem. These include: Arctic NWR, Okefenokee NWR, Klamath Basin NWRs, Cabeza Prieta NWR, Owyhee Canyonlands, Grand Staircase-Escalante NM, Whitney Estate, Boundary Waters Canoe Wilderness, Snoqualmie Pass, and the California Mojave Desert.

*The Wildlands Project.*—TWP views the protection and restoration of large tracts of wilderness as the only good long-term method for preserving biodiversity. They are creating blueprints for large-scale site-specific land conservation projects with the help of a host of regional constituents that focus on their area. The goal is to recreate functioning ecosystems that are not dependent on human intervention and that support all or most of the historic biodiversity and ecological processes. At this stage, TWP’s efforts are limited to conservation proposals and organizing regional involvement rather than actual land acquisition.
Chapter 3

HAWKWATCH INTERNATIONAL CONSERVATION STRATEGY

Although there are several successful avian and other habitat conservation efforts underway in North America, few specifically focus on raptors (notable programs include recovery and reintroduction efforts for specific raptor species). While general habitat conservation efforts benefit raptors, many raptors suffer extensively from non-habitat threats such as powerline electrocution, pesticides, persecution, and disturbance from humans. In fact, most raptor declines and extinctions through history have resulted from factors acting either independently or in conjunction with habitat factors, notably persecution and pesticide poisoning. Clearly, raptor conservation efforts need to take both a threats-oriented and habitat-oriented approach.

HWI CONSERVATION PROGRAM GOAL AND OBJECTIVES

The goal of HWI’s conservation program is to contribute to the protection of raptor populations and their habitat by achieving the following objectives: (1) reduce human-related population limitations (“threats”) to raptors, and (2) assist on-going avian and habitat conservation efforts so that they benefit raptors. HWI will address the threats discussed below using the accompanying actions. HWI will more fully define and implement these actions as opportunities and funding become available, and based on evolving information and the relative success of initial efforts.

ISSUES AND ACTIONS

ELECTROCUTION

Outside of habitat threats and degradation, electrocution was the threat that, throughout our conservation planning process, garnered both the most interest and solicited the most actions consistent with our stated selection criteria. Three major areas of action through which HWI can reduce electrocutions are as follows:

1. Citizen-based powerline surveys. For the most part, extensive regional data on electrocution-caused raptor mortalities do not exist. While several utilities maintain databases on raptor mortalities, the data are collected only as electrocutions are encountered through routine maintenance instead of through targeted surveys. HWI could conduct power lines surveys to identify problem areas and establish regional mortality estimates. This could be accomplished by hiring coordinators and volunteers from our membership and other organizations (Audubon and other conservation groups). Surveys could be focused on high-density raptor areas or conducted on a statewide basis using a randomized sampling design.

2. Cooperative efforts with power companies. The preferred option in conducting any kind of survey effort would be to work cooperatively with power utilities. This could be a
mechanism for funding the work, directing our efforts toward problem areas, facilitating faster retrofitting of problem poles, and modeling successful programs for other companies and regions. Another cooperative component would be to participate in APLIC (Avian Powerline Interaction Committee) and other relevant cooperative groups.

3. Regulatory agenda to promote raptor-safe poles/designs/regulations. There is no national legislation requiring all new power line structures to be raptor-safe. Existing regulations regarding raptor electrocution prevention apply only to power lines placed on federal land or to lines built using federal funds. Standardized and updated regulations could make a large contribution toward reducing raptor electrocutions. HWI will evaluate the existing regime of powerline regulations more carefully, and explore the possibility of mounting a state- or national-level campaign to require raptor-safe poles more comprehensively.

TOXIC CONTAMINATION

The widespread use of pesticides and release of industrial contaminants in our environment has had toxic effects on humans and wildlife. At least 60 different pesticides are known to have killed migratory birds. In addition, the accelerated rate of industrial activity in the 20th century has created many local and widespread global contamination problems due to the release of heavy metals and other industrial compounds and by-products into the environment. Because raptors are ubiquitous and occupy the tops of their food chains, they are susceptible to the toxic effects of many of these compounds through both direct and indirect pathways.

**Lead.**—Lead (Pb) shot and sinkers used in hunting and fishing, respectively, still pose a threat to raptors. Areas of action through which HWI can impact this issue are as follows:

1. Compilation, synthesis, and dissemination of the latest data and literature concerning Pb shot/sinkers. Sportsmen will need to be convinced of the importance of changing their equipment because some alternatives cost more and/or may not perform as well. This audience will need to be targeted through various media such as sporting publications, conventions, and organizations.

2. Legislative/regulatory agenda to partially or fully ban use of Pb shot/sinkers. Regulatory solutions could have a wider impact than any educational outreach efforts, valuable as they might be, provided changes were enacted. However, since no outcomes are guaranteed, these two options should go hand-and-hand. More legal research is needed in this area, as well, such as compiling data on the extent of current regulations pertaining to use of lead shot/sinkers, and exploring regulatory solutions.

**Pesticides.**—The quantity of pesticides in use today in the U.S. and worldwide is staggering and decreasing their usage generally would be an overwhelming task for HWI. However, considering the effects pesticides have had on raptors, it is imperative that HWI address their usage in a more focused manner.

To seek this balance, HWI will identify those pesticides that have the greatest impacts on raptors and focus on their reduction/elimination. HWI will pursue efforts to promote alternatives to these pesticides and, where available, alternatives to the products dependent on these
pesticides. HWI will strive to work with pesticide users (e.g., growers), other organizations, and pesticide producers to achieve these objectives. Similar programs may be in place that HWI can become part of and work to expand into areas of HWI’s geographic focus.

*Partner in ecotoxicology research.*—HWI’s network of five raptor banding sites provides an excellent opportunity for researchers to analyze toxic loads carried by migrant raptors. HWI should inform the ecotoxicology community of the potential to partner on research projects using our banding project network to collect samples (e.g., blood and feathers).

**PERSECUTION AND RECREATIONAL DISTURBANCE**

Increasing human populations, misconceptions about raptor behavior, and recreational pressures in raptor habitats all can impact raptor populations. HWI has identified the following actions to address these issues, all of which are on-going or currently being planned.

1. **Application of HWI Northwest Utah Nesting Survey (NUNS) results.** Based on pilot efforts in 1998-2000, results from HWI’s NUNS project indicate that recreational usage of public lands in the project area impacted nest success. HWI will notify public land managers of these findings, suggest corrective management actions, and look for similar impacts in future NUNS efforts.

2. **Rural education.** HWI already sends classroom educators to rural areas where people live side-by-side with raptors to impart an appreciation of raptors’ intrinsic values and the ecological roles they fill. These educators also stress the impacts of human activities on raptors and their habitats. Nurturing appreciation for raptors in these rural areas has an important long-term impact on changing misperceptions about raptors and reducing raptor persecution. HWI will probably incorporate a community education component into NUNS in 2001.

3. **Investigate research opportunities into recreation impacts on raptor behavior.** HWI is currently negotiating initiation of a five-year study in 2001 to monitor the effects of heli-skiing operations on Golden Eagle nest usage and success in Utah’s Wasatch Mountains. Other research opportunities pertaining to persecution and disturbance will be pursued.

**HABITAT LOSS AND DEGRADATION**

Consistent with conservation biology theory, habitat loss and degradation constitutes a significant threat to raptor populations. A stated goal of HWI’s overall conservation strategy is to protect raptors and their habitats. Moreover, by preventing raptor habitat loss and degradation, HWI will help raptors as well as many other species that share the same habitats.

1. **Involvement with Partners in Flight.** Partners in Flight (PIF) is a group of government agencies, non-governmental organizations (NGOs), and concerned individuals working together to plan for the effective conservation of landbirds in North America. PIF working groups have been established to address the entirety of the U.S. (either by state or physiographic region) and a few Canadian provinces. These groups prepare a conservation plan that details avian conservation needs for their area, based in part upon a priority avian species pool (derived from a species prioritization process) and the habitat needs of those species. In turn, many agencies,
NGOs, and funders are now prioritizing funding and implementation of avian conservation efforts based on the identified habitat needs of that species pool. Thus, the output from the PIF species prioritization process is now driving conservation priorities for a wide range of avian habitats in North America. There are three ways HWI could contribute to the PIF process to benefit raptors.

a. **Refine scoring of PIF species prioritization parameters to more accurately address the needs of raptors.** The PIF species prioritization process involves assessing the magnitude of seven features of vulnerability for each species in North America. However, recent advances in thinking about raptor biology have not been consistently incorporated into the PIF prioritization process. The array of threats faced by raptors is unique, and not always accurately incorporated into PIF threats scores. Refinement and rescoring may be needed for three of the seven variables in the system (population trend, threats to breeding, and threats to nonbreeding). The PIF process is heavily geared towards the effects of habitat loss and change. Though some raptors have had non-habitat threats considered when scores were assigned (e.g., Swainson’s Hawks and pesticides in Argentina), the PIF process has not systematically addressed the full array of threats facing raptors. HWI could derive a process, based on its research and input from other experts in the raptor community, to assist PIF planners in making more accurate assessments of threats to raptors.

The population trend information is primarily derived from BBS data. These data are generally viewed as inadequate for determining population trends of raptors because, with some exceptions, they undersample raptors. Migration counts should be considered, as well, both from HWI and non-HWI raptor count sites.

b. **Serve as a liaison between PIF and the raptor research/conservation community.** HWI’s co-leadership role in developing the North American Raptor Monitoring Strategy (NARMS – a collaborative effort between agencies, academia, and NGOs to devise a continental-scale approach to monitoring raptor populations) coupled with an interest in improving PIF makes HWI an obvious candidate to serve as a liaison between these two projects. Though NARMS is focused on monitoring, it is the principal cooperative raptor planning effort now occurring in North America. HWI can serve both the raptor and PIF communities by keeping these two efforts apprised of each other’s progress and acting on any opportunities to “crosswalk” them. HWI is also actively involved in the Hawk Migration Association of North America and the Raptor Research Foundation.

c. **Be involved in the PIF process for selected Bird Conservation Regions (BCRs) in the PIF Western Working Group.** Now that a draft PIF plan exists for many areas, BCRs are being formed to lead regional efforts and ensure that plans have common priorities across common bird regions (e.g. Great Basin). As BCR efforts move forward and area plans are refined, involvement at the BCR level will allow for HWI to monitor the effects of its recommended refinements for scoring PIF parameters for raptors. Initially, HWI will limit its involvement to two BCRs, the Great Basin and
Northern Rockies (and the Western Working Group, where much BCR planning takes place), so as to not dilute our resources. We have chosen these BCRs because HWI’s four longest-term field projects monitor raptor migration from these regions.

2. Support other NGOs working on policy/habitat issues affecting raptors. HWI can serve an important role in the conservation community by providing our scientific expertise on matters that other organizations may be working on related to habitats used by raptors (e.g. evaluation of NEPA documents, efforts to protect rare or diminishing habitat types). HWI’s objective in these efforts would be to make sure that these organizations have access to the best scientific information that HWI can provide, considering HWI resource constraints, so that their efforts, when overlapping with HWI’s mission, are enhanced and more effective and efficient by our involvement.

3. Work with land trusts. Several conservation organizations specialize in purchasing land or conservation easements for the purpose of protecting habitat or open space. The goal of an easement is to usually to prevent urban or other development. Rarely do these groups purchase land or arrange easements for the primary purpose of protecting raptors, but the cumulative impact of protected habitat, especially those sections adjoining large stretches of habitat, benefits raptors. While most of the raptors in North America cover wide geographic ranges, there are some places where raptors concentrate enough in numbers and diversity that the protection of small areas may be of great importance (e.g., Snake River Birds of Prey Area in Idaho). HWI can bring such important places to the attention of land trusts.

4. Develop a raptor habitat characteristics database. HWI will assemble a database of raptor habitat characteristics by species to be used by agencies and conservation groups assessing potential impacts of land management decisions on raptors.

SUPPORTING ACTIONS

CONSERVATION EDUCATION

All of the above strategies should be accompanied with a multifaceted education campaign. First, the Conservation Scientist will need to develop education modules in conjunction with the Outreach Coordinator to be used by HWI’s classroom education interns and on-site educators. Second, issue-specific education and public relations strategies should be developed regarding each action to make the public, HWI members, funders, allies, knowing and unknowing threat perpetrators (e.g. power companies, ranchers, hunters, fishers), agencies and public officials aware of our efforts.

HWI’s conservation research identified many societal behaviors that impact raptors and our environment that are not mentioned above. Many of these behaviors result from and can be affected by citizen consumption patterns and decisions. As time permits, it would be appropriate to write popular press articles describing these behaviors, their implications, and alternative consumer choices.
NETWORK WITH OTHER GROUPS/SIGN-ON LETTER

HWI can lend its name to the efforts of other groups working on similar threats through networking, sign-on letters, coalition efforts.

REVIEW OF PERTINENT AGENCY DOCUMENTS

HWI will comment on certain public policy issues, such as passage of certain legislation/regulations/management actions, that are related to the threats mentioned above.

REFINEMENT OF HWI THREATS PRIORITIZATION SCHEME

*Background and Priorities for HawkWatch International’s Conservation Program* (2000, 90 p., available upon request) describes a method for prioritizing raptor conservation efforts based on both species and threat, and this work has contributed to our identification of the above threats and strategies. HWI will continue to refine this method for ranking threats through peer review and publication. In the meantime, HWI will begin to develop its conservation program based on its Conservation Strategy and the results of its latest threats prioritization method. HWI will modify our priorities, if necessary, as new information becomes available. Since no method is currently available that defines conservation priorities for raptors based on both threats and species, refinement and publication of the HWI prioritization method will likely influence the general direction of raptor conservation efforts of many entities.
TABLES

Table 1. Family, common name, and scientific name of raptors in western North America.

<table>
<thead>
<tr>
<th>Family</th>
<th>Common name</th>
<th>Scientific name</th>
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<tbody>
<tr>
<td>Accipitridae</td>
<td>Osprey</td>
<td>Pandion haliaetus</td>
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<td></td>
<td>White-tailed Kite</td>
<td>Elanus leucurus</td>
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<td></td>
<td>Mississippi Kite</td>
<td>Ictinia mississippiensis</td>
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<td>Bald Eagle</td>
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<td>Golden Eagle</td>
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<td>Tytonidae</td>
<td>Barn Owl</td>
<td>Tyto alba</td>
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Table 2. PIF scores for most physiographic regions in the western U.S., compiled from the Colorado Bird Observatory website (www.cbobirds.org, accessed March 2000, last update October 1999).

<table>
<thead>
<tr>
<th>Physiographic region →</th>
<th>Species</th>
<th>Southern Pacific Rainforests</th>
<th>Sierra Nevada</th>
<th>Colorado Plateau</th>
<th>Mohave Desert</th>
<th>Basin and Range</th>
<th>Wyoming Basin</th>
<th>Central Rocky Mountains</th>
<th>Columbia Plateau</th>
<th>Southern Rocky Mountains</th>
<th>Utah Mountains</th>
<th>Mogollon Rim</th>
<th>Northern Sierra Nevada</th>
<th>Chihuahuan Desert</th>
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<td>Whiskered Screech-Owl</td>
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Table 3. Scores for various non-habitat threats to western raptors. 1 = low impact and 3 = high impact (see text for further explanation). The data are sorted by area priority (second column), by total score (last column), and also by threat priority (across the bottom). Scores are assigned based on a subjective assessment of the impact for each threat for each species, with a score of 1 as default when little is known about that particular species/threat combination. Scores last updated 6/10/2000.

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|               | 62 | 59 | 59 | 58 | 58 | 58 | 52 | 49 | 48 | 48 |
Table 4. Total hazards score (from Table 4), conversion of that score to a five-point scale, averaged PIF score (from Table 3), and the augmented PIF score (original PIF plus hazards five-point scale) for each species for which both scores were available. Species are sorted from highest to lowest priority.

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<td>1.00</td>
<td>6.00</td>
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<tr>
<td>Long-eared Owl</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1.00</td>
<td>1.00</td>
<td>6.00</td>
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<td>Red-shouldered Hawk</td>
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<td>1</td>
<td>1</td>
<td>1.00</td>
<td>1.00</td>
<td>6.00</td>
</tr>
</tbody>
</table>

70 51 51 49.33 43.67 43.5

67
Table 6. The ten highest priority raptors determined by Partners in Flight. Average scores given are calculated from the scores assigned to most of the physiographic regions in which that raptor occurs (Table 3). Habitat abbreviations are as follows: MC = mixed conifer, PP = ponderosa pine forest, PO = pine oak forest, DG = desert grassland, PJ = pinyon juniper woodland, SB = shrubland, SD = salt desert scrubland, AG = agricultural landscapes, RW = riparian woodland, FM = freshwater marsh. Main threats to breeding habitats and other aspects of concern for this species are derived from PIF plans and general information from this document.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average PIF Score</th>
<th>Habitats used</th>
<th>Main threats to breeding habitats</th>
<th>Other aspects of concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spotted Owl</td>
<td>24</td>
<td>MC, PP</td>
<td>Logging, catastrophic fire</td>
<td>Fragmentation and disturbance</td>
</tr>
<tr>
<td>Whiskered Screech-owl</td>
<td>23</td>
<td>PO</td>
<td>Urbanization</td>
<td>Restricted range and habitat</td>
</tr>
<tr>
<td>Elf Owl</td>
<td>23</td>
<td>PO</td>
<td>Urbanization, logging</td>
<td>Restricted range and habitat</td>
</tr>
<tr>
<td>Aplomado Falcon</td>
<td>22</td>
<td>DG</td>
<td>Conversion to agricultural lands</td>
<td>Restricted range and habitat</td>
</tr>
<tr>
<td>Ferruginous Hawk</td>
<td>22</td>
<td>DG, PJ, SD</td>
<td>Exotic invasions, urbanization, agricultural conversion</td>
<td>Reduced prey base (i.e., prairie dogs)</td>
</tr>
<tr>
<td>Flammulated Owl</td>
<td>22</td>
<td>PP, MC</td>
<td>Logging, catastrophic fire</td>
<td>Loss of wintering habitat, altered migration corridor habitat</td>
</tr>
<tr>
<td>Prairie Falcon</td>
<td>21</td>
<td>SB, SD, DG, PJ,</td>
<td>Exotic invasions</td>
<td>Falconry, disturbance</td>
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<tr>
<td>Swainson’s Hawk</td>
<td>21</td>
<td>AG, DG</td>
<td>Agricultural conversion, urbanization</td>
<td>Exposure to pesticides on wintering grounds, pesticide-induced reduction in prey base on breeding grounds</td>
</tr>
<tr>
<td>Common Black-Hawk</td>
<td>21</td>
<td>RW</td>
<td>Water diversion, catastrophic fire, exotic invasions</td>
<td>Restricted range and habitat</td>
</tr>
<tr>
<td>Short-eared Owl</td>
<td>20</td>
<td>FM</td>
<td>Draining for agriculture, urbanization</td>
<td>Restricted habitat</td>
</tr>
</tbody>
</table>
Table 7. Summary view of potential actions that HWI could take to address threats to raptor populations. Potential collaborative partners indicated in parentheses.

<table>
<thead>
<tr>
<th>Threat</th>
<th>Conservation research</th>
<th>Conservation education</th>
<th>Supporting other organizations</th>
<th>Regulatory involvement</th>
<th>On-the-ground involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrocution</td>
<td>Survey power-lines for problem areas (utility cos)</td>
<td>Newsletter articles</td>
<td>New brochures/workbook</td>
<td>Promote national legislation on raptor-safe pole designs</td>
<td>Partner-based retrofitting (utility cos)</td>
</tr>
<tr>
<td></td>
<td>Determine preferred-pole characteristics (utility cos)</td>
<td>TV spots</td>
<td>Encourage citizen/members to voice concern</td>
<td>Promote adoption of raptor-safe standards by U.S. based aid-givers (USAID)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model impacts of mortality and sex-biased mortality on population maintenance</td>
<td></td>
<td></td>
<td>Litigate against utilities that ignore the electrocution problem+</td>
<td></td>
</tr>
<tr>
<td>Threat</td>
<td>Conservation research</td>
<td>Conservation education</td>
<td>Supporting other organizations</td>
<td>Regulatory involvement</td>
<td>On-the-ground involvement</td>
</tr>
<tr>
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<td>----------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Summarize info on particular crop/pesticide combos that harm raptors</td>
<td>Newsletter articles</td>
<td>Review registration of pesticides and advocate cancellation of the worst pesticides (ABC)</td>
<td>Advocate stronger criminal penalties for pesticide abuses</td>
<td>Promote alternatives and IPM (ABC, IPEN)</td>
</tr>
<tr>
<td></td>
<td>Research pesticide impacts on migrating birds in hotspots e.g., Veracruz</td>
<td>Promote consumption of organics and at-home organic gardening</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Determine contaminant levels in raptors at monitoring sites</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluate effectiveness of raptor-based pest controls e.g., Barn Owls (fruit-growers associations)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threat</td>
<td>Conservation research</td>
<td>Conservation education</td>
<td>Supporting other organizations</td>
<td>Regulatory involvement</td>
<td>On-the-ground involvement</td>
</tr>
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<td>----------------------------------------------------------------------------------------</td>
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<td>----------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Industrial contaminants</td>
<td>Determine contaminant levels in raptors at monitoring sites</td>
<td>Newsletter articles</td>
<td></td>
<td>Evaluate impacts of emissions, Se-leaching, chlorine bleaching of paper, trash-burning, cyanide heap-leaching gold mining, PCB-based transformers, and lead shot; then focus on regs./laws to address the most harmful activity(ies)</td>
<td></td>
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<tr>
<td></td>
<td>Determine contaminant levels in birds found electrocuted or hit by vehicles</td>
<td>Promote use of products made using non-toxic processes e.g., non-chlorine bleached paper, non-toxic shot</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Discourage trash-burning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collisions</td>
<td>Locate auto collision hotspots</td>
<td>Newsletter articles</td>
<td>Support efforts to site new wind farms with low impact (NWCC, utility cos)</td>
<td>Litigate against transportation agencies that fail to consider raptor collisions when constructing new roads</td>
<td>Coordinate with state transportation agencies to locate new roads in safe areas (UDOT)</td>
</tr>
<tr>
<td></td>
<td>Conduct pre- and post-construction surveys at wind plants</td>
<td>Promote safer placement of home bird feeders (NAS, ABC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persecution and disturbance</td>
<td>Survey for shot raptors along roadsides</td>
<td>Newsletter articles</td>
<td></td>
<td>Advocate positions on eagle relocation and other relevant actions by Wildlife Services (aka ADC)</td>
<td>Promote placement of new power lines further from roads (utility cos)</td>
</tr>
<tr>
<td></td>
<td>Study impacts of recreation activities on breeding raptors</td>
<td>Programs in rural areas (4-H, FFA, growers associations, gun clubs)</td>
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<td></td>
<td>Promote protective measures e.g., sheep dogs, chicken enclosures</td>
</tr>
<tr>
<td>Threat</td>
<td>Conservation research</td>
<td>Conservation education</td>
<td>Supporting other organizations</td>
<td>Regulatory involvement</td>
<td>On-the-ground involvement</td>
</tr>
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</tr>
<tr>
<td>Habitat loss</td>
<td>Review research on rates of habitat loss and degradation</td>
<td>Newsletter articles</td>
<td>Encourage wildlife-based prioritization in land-trust groups</td>
<td>Make comments on agency mngt. plans or proposed rulings, including roadless area protection, wilderness desig., purchase of in-holdings, and prescriptive actions.</td>
<td>Be involved with PIF in order to ensure that raptors are adequately addressed</td>
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<td></td>
<td>Study raptor productivity in native and exotic plant-dominated habitats</td>
<td>Promote low-consumption activities/lifestyles e.g., live in town, ride the bus, recycle and buy recycled</td>
<td>Support efforts to protect rare or rapidly diminishing habitat types</td>
<td>Support ecosystem management directions among land managers (USFS, BLM)</td>
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<td></td>
<td>Determine habitat use and threats for raptors that leave the U.S. during the winter</td>
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<tr>
<td></td>
<td>Study prioritization procedures and approaches</td>
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Lyon, L. 1999. Table of pesticides that have caused documented die-offs of migratory birds ... USFWS, unpublished document.

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Olson, C.V. 2000 (unpublished manuscript). Human-related causes of raptor mortality in western Montana: things are not always as they seem.


PERSONAL COMMUNICATIONS

Keith Bildstein, Hawk Mountain Sanctuary, Kempton, PA, May 11, 2000
Allen Fish, Golden Gate Raptor Observatory, San Francisco, CA, May 12, 2000
Mark Fuller, USGS—BRD, Snake River Birds of Prey Area, Boise, Idaho, April 17, 2000
Rick Harness, Engineering Data Management, Fort Collins, CO, February 11, 2000
Bill Howe, USFWS, Albuquerque, NM, January 27, 2000
Grainger Hunt, Predatory Bird Research Group, Livermore, California, April 19, 2000
Greg Kaltenecker, Idaho Bird Observatory, Boise, ID, May 12, 2000
John Kauffeld, USFWS, VA, March 6, 2000
Bob Lehman, USGS-BRD, Snake River Bird of Prey Area, Boise, ID, January 20, 2000
Jim Maloney, Eugene Water and Electric Board, Eugene, Oregon, April 19, 2000
Chad Olson, University of Montana, Missoula, MT, March 8, 2000
Annie-Marie Sanchez, PNM, Albuquerque, NM, January 26, 2000
Gary Santolo, CH2M Hill, Sacramento, CA, February 29, 2000
Karin Sinclair, National Renewable Energy Laboratory, Golden, Colorado, April 19, 2000
Dale Stahlecker, Eagle Environmental, Inc., Santa Fe, NM
Richard Wadleigh, Wildlife Services, CO, April 21, 2000
Nancy Zierenberg, Wildlife Damage Review, AZ, March 31, 2000