Status of the California Condor and Efforts to Achieve its Recovery

Prepared by the AOU Committee on Conservation, California Condor Blue Ribbon Panel, A Joint Initiative of The American Ornithologists' Union and Audubon California

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INTRODUCTION

The California Condor (*Gymnogyps californianus*) has long been symbolic of avian conservation in the United States. Its large size, inquisitiveness and association with remote places make it highly charismatic, and its decline to the brink of extinction has aroused a continuing public interest in its plight. By 1982 only 22 condors remained, and the last wild bird was trapped and brought into captivity in 1987, rendering the species extinct in the wild (Snyder and Snyder 2000). At that time, some questioned whether viable populations could ever exist again in the natural environment, and whether limited conservation funds should be expended on what they viewed as a hopeless cause (Pitelka 1981). Nevertheless, since that low point a captive breeding and release program has increased the total population by an order of magnitude, and condors fly free again (Figure 1) in California, Arizona, Utah and Baja California, Mexico. Today, in the summer of 2008, there are more than 300 condors, more than 150 of which are in the wild. The wild birds face severe challenges, however, and survive only through constant human assistance and intervention. The intensive management required to maintain the birds in nature, as well as the ongoing monitoring and captive breeding programs, are tremendously expensive and become more so as the population grows. Thus the program has reached a crossroads, caught between the financial and logistical pressures required to maintain an increasing number of condors in the wild and the environmental problems that preclude establishment of naturally sustainable, free-ranging populations.

Figure 1. Free-flying California Condor in southern California. Photo by Anna Fuentes, courtesy of USFWS.

Recognizing this dilemma, in November 2006 Audubon California requested that the American Ornithologists' Union (AOU) convene an independent panel to evaluate the California Condor recovery program. The National Audubon Society (NAS) and the AOU have a long history of providing leadership and guidance for condor recovery. NAS funded Carl Koford's pioneering studies of condor biology in the 1940s (Koford 1953). A previous panel jointly appointed by NAS and the AOU examined the plight of the condor in the late 1970s, and their report (Ricklefs et al. 1978) laid the groundwork for the current conservation program. NAS was a full partner with the U. S. Fish and Wildlife Service (USFWS) in the early days of the program, from 1980 through 1988. While Ricklefs et al. (1978) recommended that the program "be reviewed periodically by an impartial panel of scientists", the condor program has not been formally and thoroughly reviewed since the previous AOU-NAS review 30 years ago. Audubon California believed that issues that were impeding progress toward recovery needed outside evaluation in order for USFWS, which administers the program, and other policy-makers to make the best decisions about the direction of the program. Such an evaluation would also help funding organizations better invest in the program. USFWS concurred and encouraged the review.

This review falls within the charge of the AOU Committee on Conservation, which is to evaluate science relevant to avian conservation. The AOU therefore agreed to establish a Blue Ribbon Panel as a subcommittee of the Committee on Conservation. Audubon California obtained funding from the National Fish and Wildlife Foundation and the Morgan Family Foundation and other private donors to support the work of the Panel. The Panel's charge is to evaluate and synthesize accumulated knowledge and experience in order to reassess the program's fundamental goals and recommend needed changes (see Appendix 1 for details). Thus it is hoped that this report will provide a vision of the program for the next 10-25 years, much as Ricklefs et al. (1978) did for the past 25 years.

To fulfill this charge we reviewed the condor recovery program from September 2007 through July 2008 by visiting captive breeding facilities in Los Angeles, San Diego, Boise and Portland, visiting release sites in southern California, central California and Arizona, reading the published literature, conducting interviews with program participants in person during site visits and via telephone conference calls, and soliciting written comments from those with whom we were unable to speak personally (Appendix 2). In this document we report our findings.

CONDOR BIOLOGY

The California Condor is by far the largest soaring bird in North America, with a wingspan of 2.8 m and body weight of 8.5 kg (Snyder and Schmitt 2002). The species had a wide distribution in North America prior to the late Pleistocene megafauna extinctions (Emslie 1987; Snyder and Snyder 2000), but by the 17th century was largely restricted to the west coast, from British Columbia to Baja California, and by the middle of the twentieth century the species was confined to southern California (Koford 1953; Wilbur 1978). In modern times, condors inhabited a variety of western landscapes from coasts to deserts to high mountain ranges that included beaches, shrublands, and forests. Modern nesting records are all from California and include rugged cliffs and ancient trees.

Condors feed exclusively on carrion, primarily medium to large-sized mammal carcasses. Prehistoric condors evidently fed on carcasses of (now extinct) megafauna species and marine mammals, and the diet of modern condors includes domestic livestock as well as native terrestrial and marine species (Chamberlain et al. 2005). Condors use their exceptional soaring abilities to cover enormous distances in search of food: Meretsky and Snyder (1992) reported nesting birds traveling up to 180 km in search of food, and foraging ranges of nonbreeding birds of 7000 km^2. Condors are highly gregarious in feeding and most other activities, with the exception of nesting, which occurs in caves in cliffs or natural cavities on nesting territories defended by pairs (Snyder and Schmitt 2002). Theirs is literally a textbook example of a long-lived natural history (Mertz 1971), characterized by high survival rates and exceedingly low reproductive rates with breeding pairs producing, if all goes well, two fledglings in a three-year period (Meretsky et al. 2000). For further details of condor biology, see Koford (1953), Snyder and Snyder (2000) and Snyder and Schmitt (2002).

HISTORY OF THE CONDOR RECOVERY PROGRAM

Condor habitat was first protected nationally in 1967 under the auspices of the U.S. Endangered Species Preservation Act, and the birds were formally listed and protected as endangered with the signing of the U.S. Endangered Species Act in 1972. A Recovery Team was formed in 1973 and it produced the first Recovery Plan for an endangered species in the U.S. in 1975 (USFWS 1975). The program initially followed a noninterventionist course, but based on the continuing decline of the wild population, a pessimistic assessment by Verner (1978) and their own analysis, the AOU-NAS panel recommended an immediate intensive research program which included captive breeding, radio-telemetry and field investigations of the causes of the species' decline (Ricklefs et al.1978). This highly publicized, and to some a highly controversial program was initiated in 1980 by a joint partnership between USFWS and NAS. Despite the intensive fieldwork over the next 6 years the species continued to decline, and by 1986, with only three birds remaining in the wild, the decision was made (based on a recommendation from the Recovery Team) to bring the last birds into captivity (Figure 2). By that time eggs and chicks, and unmated adults, had been removed from the wild to begin a captive breeding program.

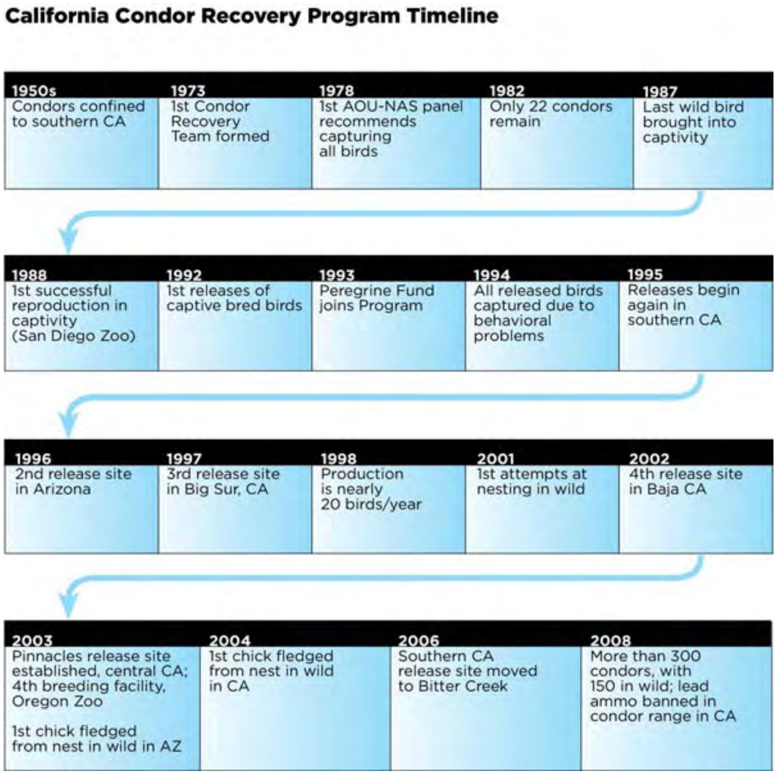

Figure 2. California Condor Recovery Program timeline.

The condors initially were housed at the Los Angeles Zoo and San Diego Wild Animal Park. In 1993 the Peregrine Fund joined the effort as an additional partner and began breeding birds at their Boise, Idaho facility (Figure 2). Successful reproduction in captivity was first achieved in San Diego in 1988 (by two wild-trapped adults), and by the late 1990s, production averaged ~20 offspring per year and all 27 of the birds originally removed from the wild were breeding successfully in captivity (Snyder and Schmitt 2002). The Oregon Zoo in Portland was added as a fourth captive breeding facility in 2003.

The first releases of captive-reared birds occurred in 1992 in southern California, but behavioral problems in the initial cohort of released birds led to a decision to return them all to captivity in 1994. Releases were reinitiated in southern California in 1995 and have continued since. A second release site was established in Arizona in 1996 and a third in central California in the Big Sur area in 1997 (Figure 2). In 2002 a fourth release site was added in Baja California, Mexico and the following year marked the debut of Pinnacles National Monument as a second location from which to release birds in central California. Reintroduced birds first attempted nesting in southern California and Arizona in 2001. The first fledging of a chick by reintroduced birds occurred in Arizona in 2003 (Woods et al. 2007) followed by the first successful fledging in California the next year (Grantham 2007).

THE CONDOR PROGRAM TODAY

The condor recovery program has achieved success beyond what many believed possible when the last few birds were brought into captivity. Numbers have increased steadily (Figure 3) and there are as many birds in the wild now as there were in the 1950s. Managers are routinely releasing reasonably well-behaved, socially appropriate birds raised in captivity. Further additions to the wild population come from chicks fledged from natural nests by breeding pairs that formed on their own after release. In Arizona birds subsist on food they find themselves for much of the year, and in central California they are foraging on natural carcasses of marine mammals, including several whales that have washed ashore. Millions of hectares of nesting and foraging habitat for condors are protected to some degree. A large number of partners are highly committed and contributing substantially to the program and new partners continue to join the program. Recovery of the California Condor, once almost inconceivable, has become imaginable, and the public believes the condor program to be a success.

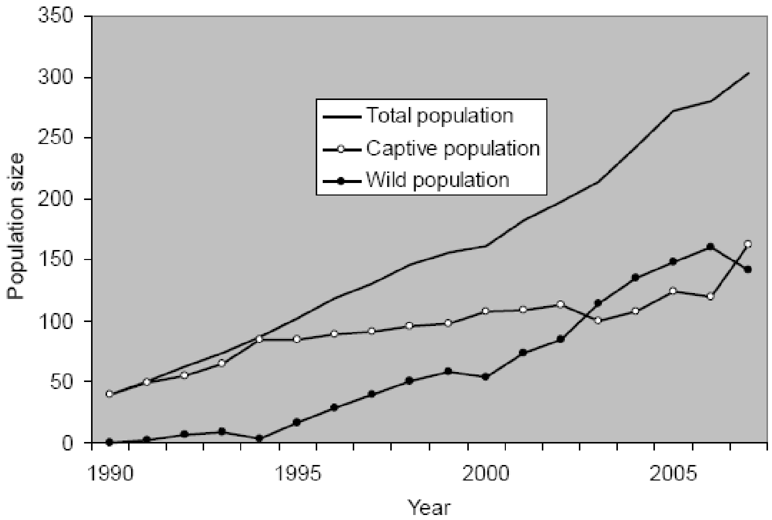

Figure 3. Population size over time for the total, captive and wild portions of the California Condor population. From Wallace et al. (2007a).

But enormous obstacles to recovery still exist, so much so that the possibility that California Condors could once again be extirpated in the wild is as conceivable as recovery. The success that has been achieved to date has come only with enormous investment in intense monitoring and management of adults, subadults and at some locations nestlings. Lead poisoning resulting from ingestion of spent ammunition in carcasses is so severe and chronic a problem at all release sites that the program is unified in the belief that condor recovery cannot be achieved so long as such lead exposure continues. Condors almost certainly would not survive in the wild were they not regularly trapped, tested and treated for lead. Several individuals have been saved from death from lead poisoning multiple times. The wild birds are induced to depend on carcasses provided by humans at feeding stations so that they can easily be trapped and treated for lead poisoning, and to reduce the ingestion of lead that occurs when condors forage on their own. Unfortunately food provisioning has had unintended consequences: without the need to forage widely, condors have ample time for other activities and sometimes the activities and behaviors on which they spend some of this time are inappropriate ones that necessitate returning birds to captivity. Feeding, trapping and chelation treatment reduce deaths from ingestion of lead, but the impacts of sublethal exposure to lead are as yet unknown. Effects on behavior and demography are likely, given the current levels of exposure.

Similarly, nesting success in southern California was nil until intensive management of nests was instituted in 2007. It is likely that fledging success would be reduced to zero again if chicks were not vaccinated for West Nile virus, examined monthly for ingestion of microtrash (i.e., small bits of refuse of human origin including items such as rags, nuts, bolts, washers, plastic, bottle caps, chunks of pipe, spent cartridges, and pieces of copper wire; see Mee et al. 2007a) and treated on site by veterinarians and field biologists. Condors are maintained in the wild only with great effort, so much so that one might argue that they constitute little more than outdoor zoo populations. Partners cannot be expected to expend funds indefinitely to maintain condors in nature, especially when increases in the wild population increase management requirements and annual costs. Population growth is limited not by capacity to produce captive bred birds suitable for release, but by the tradeoffs between demography, management intensity and population size. The program is indeed at a crossroads.

PROGRAM PARTNERS

The California Condor program is one of America's oldest and most complex efforts to recover an endangered species. The large and physiographically imposing geographic range of the species, the need for captive rearing, release, and monitoring expertise, and the uncertain response of free-ranging condors to known and yet-to-be-discovered limiting factors has spawned a complex mix of non-governmental and international, federal, and state governmental organizations cooperating to restore the species at four release sites in two countries (Table 1).

Table 1. Current (2007) annual financial contributions to the condor recovery program by the major partners. Budget figures were provided to the Panel by each partner. Participants either maintain captive rearing facilities, release sites, or both.

Partner	Annual Expenditure	Rearing Facility	Release Site
U.S. Fish and Wildlife Service	$857,000	no	Bitter Creek, Hopper Mountain
Los Angeles Zoo	$573,000	yes	none
San Diego Wild Animal Park	$1,479,000	yes	Baja
The Peregrine Fund	$1,520,000*	yes	Arizona
Ventana Wildlife Society	$244,000	no	Big Sur
Pinnacles National Monument (Park Service)	$500,000	no	Pinnacles
Oregon Zoo	$172,000	yes	none

*Includes $394,000 in earmarked funds through USFWS.

The birds are managed to meet demographic and genetic objectives following a Species Survival Plan (SSP) under the auspices of the American Zoo and Aquarium Association (e.g., Wallace et al. 2007a). Managed as a single population, the birds are exchanged between breeding facilities and a bird raised at any captive facility might be released at any release site. Still, individual breeding facilities are associated with particular release sites due to geographic and programmatic linkages. In Southern California, USFWS has operated release sites at Hopper Mountain and Bitter Creek National Wildlife Refuges, and these sites are linked with the captive breeding operation at the Los Angeles Zoo. Veterinary staff and keepers from the Los Angeles Zoo provide field support at the southern and central California release sites, and birds from these release sites in need of medical attention are brought to the Zoo for treatment. The captive breeding program at the San Diego Wild Animal Park maintains a strong linkage with the southern California release sites as well. In addition the Wild Animal Park operates the Baja California release site in collaboration with the Instituto Nacional De Ecología in Mexico. (The Mexican National Zoo currently has two condors on display and is a likely location for an additional captive breeding program to be associated with this release site in the future.) The Peregrine Fund (TPF) links the captive breeding facility in Boise with the Arizona release site, as it operates both. The Oregon Zoo provides birds to multiple release sites. In central California there is a strong relationship between two partners, the Ventana Wildlife Society and the

National Park Service (NPS), which run the release sites in Big Sur and Pinnacles National Monument, respectively. The birds released at these two sites function as a single flock, and accordingly these two partners have integrated their monitoring and field support activities.

This recovery effort is costly. Pitelka's (1982) projections have proved accurate: tens of millions of dollars have been spent on condor recovery over the past 2-3 decades. Currently, about $5 million is spent per year. USFWS expends $850K annually in directing the program and operating the southern California release sites. The Los Angeles Zoo funds the captive breeding program and field support at these release sites, expending $575K annually (Table 1). The San Diego Wild Animal Park expends $1.5 million of their own funds annually on their contributions to the condor program. Personnel from the San Diego Zoo contribute to these operations as well. USFWS provides TPF with congressionally earmarked funds ($400K in 2007, $633K in 2008) to operate the Boise captive breeding facility and Arizona release site, and TPF contributes another $1.1 million of their own funds annually toward these operations. Ventana Wildlife Society raises $250K annually from non-government sources for its operations in central California, and NPS just received a $500K increase in their permanent base funding that represents their contribution to the condor program. The Oregon Zoo currently spends $175K annually on their captive breeding program, and their contribution will no doubt grow in the coming years as they work toward establishing a new release site in the Pacific Northwest (see below). USFWS devotes modest funding and personnel to condor recovery (Restani and Marzluff 2001), which likely reflects a general lack of political will to fund conservation (Miller et al. 2002; Restani and Marzluff 2002a), competition for scarce dollars throughout the Endangered Species Program and Refuge System, over-regulation of USFWS budgets through the earmarking process (U.S. Government Accounting Office 1988), and the necessity to commit scarce funds and personnel to respond to litigation (Restani and Marzluff 2002b).

Several other partners besides those involved in running the captive breeding programs and release sites mentioned above make important contributions to the condor program. The Santa Barbara Zoo is a new partner with a focus on outreach and studies of breeding ecology of wild birds in southern California. Also in California, a lead awareness campaign is underway in the central and southern parts of the state under the auspices of the Institute for Wildlife Studies. In Arizona, the state wildlife agency is an active partner in the condor program, contributing a full-time condor biologist whose primary responsibility is outreach. Birds released in Arizona range into Utah, and the Utah Division of Wildlife Resources has become involved in the consortium of partners concerned with that population (known as the Southwest Working Group). Currently the California Department of Fish and Game has surprisingly little involvement in the condor program, but that could change with the recent addition of a full-time condor biologist position in the agency.

The business community has shown signs of cooperation in the recovery effort. A private ranch in Baja California contributes to operations at the release site there, and in southern California the Tejon Ranch has recently signed an agreement with several conservation organizations to set aside nearly 100,000 ha of habitat for condors. Some of these lands will need to be purchased by government or private conservation organizations, however. At Big Sur, Pacific Gas and Electric has spent hundreds of thousands of dollars, and may end up spending millions, to reduce condor deaths due to collisions with power lines in this region.

The number of partners involved in the condor program is large and continues to grow (Table 1). Clearly the program is highly dependent on private as well as public partners for funding and operations. Some federal agencies (Bureau of Land Management, U.S. Forest

Service) currently spend very little on condors. These agencies make some contributions in some places (e.g., in California BLM provides a feeding site near Pinnacles, has provided funds for monitoring equipment and is funding the removal of trash for specific areas), but in other instances do not contribute much despite extensive use of their lands by condors (e.g., Forest Service in Arizona and California). These agencies are nevertheless potentially important partners because the lands they administer represent important habitat for condors.

Protection of habitat for nesting and foraging is a critical aspect of the condor program and achievements in this aspect have been considerable. Most of the current condor nesting range is on public land, and in Arizona much of the foraging range is as well (Mee and Snyder 2007). In southern California some historic foraging habitat is no longer suitable, but historic grassland foraging habitat around the base of the San Joaquin Valley remains viable, and since about 1984 large swaths have been protected, including the Bitter Creek National Wildlife Refuge (NWR) (5,867 ha), the private Wind Wolves Preserve (39,000 ha), and the Carrizo Plains National Monument (121,405 ha). The Tejon Ranch conservation agreement protects large swaths of foraging and roosting habitat in an area that is a critical gateway to historic foraging areas in the Sierras (Ricklefs et al. 1978; Mee and Snyder 2007). However, the agreement covers only about 110,000 of the 128,600 acres of designated critical habitat on the Ranch, and the remainder could potentially be developed. Grassland and oak-savannah remain critical foraging habitat for condors, as little foraging takes place in densely forested or chaparral habitat.

BIOLOGICAL ISSUES AND STATE OF THE RELEVANT SCIENCE

The biological challenges of establishing viable populations of a large, wide-ranging species with a low population growth rate are daunting, and serious obstacles to achieving that objective exist. The solutions to these biological issues lie in the relevant science and the research yet to be conducted. We will now evaluate what we perceive to be the major biological issues.

Lead Exposure

Any discussion of the condor program must begin with the issue of lead. A basic tenet of conservation biology is that reintroductions will inevitably fail if the factors that caused the species to decline in the first place have not been addressed (Meretsky et al. 2000). It is now apparent that the reintroduction of condors illustrates this principle, lead exposure being the recurring factor. Habitat loss and direct persecution through shooting and poisoning of carcasses surely were involved in the decline of the condor through the nineteenth and into the twentieth century (Snyder 2007), but there is compelling evidence that elevated mortality due to lead poisoning was a major cause of continuing decline at the time the birds were brought into captivity (Meretsky et al. 2000; Snyder 2007). Although just a few years ago there was debate about the significance and source of lead exposure in reintroduced condors (Beissinger 2002; Riseborough 2002), there is now widespread consensus and overwhelming evidence that poisoning due to ingestion of spent lead ammunition in carcasses and gut piles currently precludes the establishment of viable populations in the wild (Cade 2007).

Because of the life history of the California Condor as a long-lived species with a low reproductive rate, adult mortality rates must be <10% for populations to be self-sustaining (Meretsky et al. 2000). We conclude that condors suffer lead poisoning from ingestion of spent ammunition sufficiently frequently to raise mortality rates well above those required for sustainability. Alternative hypotheses about causes of mortality and sources of lead exposure, which were plausible only a few years ago, now seem desperate rather than credible. Over the past few years, the plight of the condors has brought attention to the lead issue, resulting in a much better understanding of the dynamics of lead exposure and the actions required to solve the problem. Recent studies suggest the lead ammunition issue goes well beyond condors, potentially affecting most other terrestrial scavengers and even human health (see below). Thus condors are functioning as coal mine canaries in the western ecosystems they inhabit, acting as sentinels of environmental problems that have yet to be resolved.

Condor mortalities due to lead poisoning are well documented and instances of lead poisoning have occurred at all release sites. The first condor mortality definitively linked to lead was in 1984. Snyder and Snyder (2000), Fry and Maurer (2003), Woods et al. (2007) and Parish et al. (2007) documented individual mortalities with six known and two suspected lead deaths in Arizona. Stringfield (2007 unpublished report to Condor Recovery Team) has documented 12 known or highly probably lead-caused mortalities in California. Unpublished information from each of the release sites indicates additional recent deaths in all areas, including three deaths (one confirmed lead, two suspected) in Baja. However, many birds that have died since the early 1980s have not been analyzed for lead, and it is not known to what extent lead has contributed to deaths of many of these birds. Altogether, 97 captive reared condors have died across all release programs since releases began in 1992 (Grantham, pers. comm.).

Lead is not an essential element and has no nutrient role in birds or mammals. In birds, acute exposure to lead leads to progressive neurological impairment, initially lethargy and reduced activity, and progressively, loss of appetite, loss of muscular coordination, diarrhea and greenish bile stained feathers around the vent, wing droop, inability to stand, and eventually death. These symptoms may occur within a few days of exposure, or may progress over several weeks. Chronic exposure resulting in blood lead levels of less than 10 ug/dl have been shown to cause subtle but permanent adverse neurological effects in human children (Canfield et al 2003), and it is probable that repeated exposures of condors at similar levels will also cause neurological impairment. No formal behavioral evaluation has been conducted with lead exposed condors to determine whether sublethal effects can be detected in exposed birds.

Exposure to Lead in the Field. Generally condors are exposed through feeding on carcasses or gut piles of animals shot with lead bullets or lead shotgun ammunition. One carcass can contain enough lead to kill many condors due to the “snowstorm” effect (Figure 4) when lead rifle bullets shatter into hundreds of fragments as they enter an animal. Fry and Maurer (2003) calculated the approximate lethal dose of lead to a condor to be 33-65 mg, approximately 0.3-0.6% of the mass of a 9700 mg rifle bullet (150 grains). When a rifle bullet fragments into a lead snowstorm, there may be more than 200 lethal fragments produced that remain within the carcass or viscera left in the field.

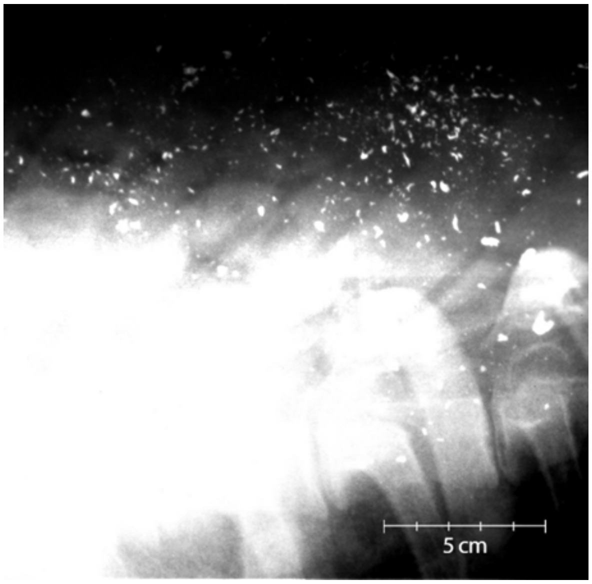

Figure 4. Radiograph of lead fragment "snowstorm". Photo courtesy of the Peregrine Fund.

Bird species other than condors, especially ravens (*Corvus corax*, *C. cryptoleucus*), Turkey Vultures (*Cathartes aura*) and Golden Eagles (*Aquila chrysaetos*), have been used to document the pattern of lead exposure in the environment. The surveillance studies of Weimeyer et al. (1986) and Pattee et al. (1990) documented lead exposures in several species of avian and mammalian scavengers within the condor range in California. A similar study by Craighead and Bedrosian (2008) documented lead exposure in ravens in Wyoming feeding on offal left in the field by elk hunters. Blood measurements in ravens showed significant lead exposure highly correlated with the fall elk hunting season. The California Fish and Game Commission contracted a study in December 2007 with the University of California at Davis Wildlife Health Center to document the extent of lead exposure to avian and mammalian scavengers within condor range and in other selected regions of California to determine whether the lead exposure problem is widespread. Results of this study are due in 2009.

Lead is monitored in condors in the field and confirmed with duplicate samples submitted to clinical reference labs in California and Arizona. Field monitoring is done with portable LeadCare ® machines with rapid readout of blood lead levels with a detection range of 3-65 ug/dl blood. Correlations between LeadCare data and that from clinical laboratories indicates that the field tests underestimate the actual blood lead levels by about 20-30% (Fry and Maurer 2003; Parish et al. 2005; Sorenson et al. 2005). Field crews in Arizona have access to a portable X-ray machine, enabling them to radiograph condors suspected of ingesting lead. We recommend that portable X-ray equipment be provided to all field crews to facilitate lead monitoring until a successful transition to non-lead ammunition is accomplished.

Identification of the sources of lead affecting condors is being undertaken by Donald Smith and his students at the University of California at Santa Cruz, and by John Chesley at the University of Arizona. Both labs are using mass spectroscopy to separate and quantify the natural isotopes of lead, which are found in varying proportions in metallic lead from mines throughout the world (Church et al. 2006; Chesley 2008, unpublished abstract TPF conference). There are four natural isotopes of lead (Atomic weights of 204, 206, 207 and 208) each comprising from 1 to 56% of metallic lead. Lead from a single source often has a distinctive isotope pattern, and lead from different geographical regions is usually distinctive. Metallic lead objects made from a single source can frequently be identified, while lead from recycled sources, such as batteries or electronic parts, has a less distinctive pattern reflecting mixing of different sources.

When a condor ingests lead, the lead is slowly dissolved by stomach acid, enters the blood stream, and is distributed to other tissues, including liver, muscle, kidney, brain, bone and growing feathers. The isotopic pattern of the lead in these tissues reflects the isotope pattern of the lead in the ingested lead object or lead contaminated food. In an effort to identify sources of lead exposure of condors, the labs have been characterizing the lead isotope patterns in blood and feather samples and comparing them to ingested fragments of lead, commercial lead bullets, environmental lead background sources, and published data listing known lead source isotope patterns.

The lead isotopic patterns in blood or feathers have matched lead bullet fragments recovered from carcasses upon which the birds were feeding and isotopes in blood and feathers match lead isotopes of fragments recovered from GI tracts of exposed birds (Church et al. 2006; Chesley 2008, unpublished abstract TPF conference; Parmentier 2008, unpublished abstract TPF conference). These data implicate ammunition as a significant source of lead, but the data are far from complete, and the isotopic composition of some blood samples do not match the isotopic patterns of the few samples of ammunition that have been analyzed by Church et al. (2006) or reported in the literature. Chesley et al. provided convincing evidence at the 2008 Peregrine Fund conference (http://www.peregrinefund.org/lead_conference/PbConf_Proceedings.htm) that lead fragments in carcasses and gut piles match the isotopic patterns of condors feeding on that carrion. The scientists doing the identification have gone to great lengths to document exposures and match them to sources, and the data are convincing. Nonetheless, many individuals have criticized the data at public hearings in California, as all potential sources of lead in the condor range have not been characterized. Many have argued that other sources, including microtrash may be a significant source of lead in addition to lead from spent ammunition. We agree that there are many potential sources of lead in western ecosystems, but are convinced that spent ammunition is the major source of lead exposure for condors in the wild.

Monitoring Lead Exposure. Field blood testing of all condors occurs at least once a year, but generally more often. In California, 469 blood samples taken from free-flying condors in the wild since 2000 have been analyzed for lead, with 386 (82%) testing above 10 ug/dl blood (data supplied by USFWS and Ventana Wildlife Society). Captive reared condors tested at zoos before transfer and release from holding pens have blood lead levels of 4 ug/dl or lower, with a few exceptions when blood lead levels of 7 and 8 ug/dl have been reported. This indicates some condors may have access to unknown lead sources at zoos or holding facilities, such as lead paint, or possible lead in zinc galvanized wire, solder joints or other electrical wiring. These sources of lead in captive facilities need to be discovered and eliminated.

A background or baseline level of 20 ug/dl lead in blood of wild scavengers was proposed by Redig (1984) based on analysis of Bald Eagles (*Haliaeetus leucocephalus*) and other raptors (Redig et al. 1980). Many authors have used this figure subsequently (Weimeyer et al. 1986; Patee et al. 1990; Fry and Maurer 2003). However, this baseline appears to be unrealistically high, and reflective of lead contamination from spent ammunition and other sources, including environmental contamination by leaded gasoline in the 1980s. A more realistic baseline for lead should be the levels measured in captive condors prior to release, which is generally less than 5 ug/dl blood. Fry and Maurer (2003) and Fry (2008, unpublished abstract TPF conference) have used 10 ug/dl as background limit, with values above that interpreted as representing acute or chronic lead exposure.

Lead Exposure and Kinetics of Lead Clearance. Fry and Maurer (2003) calculated the half-life of lead in the blood of condors to be 13.3 +/- 6.5 days from a limited number of pairs of blood samples of birds held in captivity without chelation. Additional analysis has shown a shorter half-life of about 9+/- 6 days with considerable variation among individual birds. This indicates that after an acute exposure event, blood lead levels decrease rapidly, and an acute exposure to as much as 100 ug/dl will fall to about 10 ug/dl within 30-45 days. Since a high proportion of condors are exhibiting elevated blood lead levels when tested at random, and the lead levels drop rapidly back to background levels when birds are not exposed to lead, the data indicate that condors are exposed frequently to lead while feeding in the wild. The data also indicate that if sources of lead exposure are removed condors can recover quickly.

Condors discovered to be exposed in the wild are generally held in captivity and treated to reduce the amount of lead in blood and evaluate whether lead fragments are present in the GI tract. Treatments include purging the gut with oral slurry doses of Psyillium husks to physically push particles through the GI tract, and removing fragments by endoscopic or other surgical procedures. Birds with high blood lead levels, generally above 50 ug/dl but occasionally lower, are treated with chelating agents to chemically bind the lead and remove it from the circulation by excretion from the kidney (Parish et al. 2007; Sorenson and Burnett 2007).

Chelation therapy provides a temporary lowering of lead levels in acutely exposed birds, but blood lead levels may rise again as lead more slowly re-equilibrates back into blood from soft tissues such as liver, kidney, and muscle within weeks, causing a rebound in blood lead levels after chelation. Birds that are chronically exposed will also have lead slowly deposited in bone. The sublethal consequences of this chronic, moderate to high blood lead level is unknown in condors or other birds, but is recognized as a debilitating neurotoxic response in humans.

In Arizona, as of 2007, condors exhibiting high lead levels have been chelated on an emergency basis on 124 occasions (Parish, pers. comm.). There are undoubtedly long-term consequences of repeated sub-lethal lead exposure, and probably consequences of repeated exposure to chelation drugs (primarily calcium EDTA and/or succimer [2, 3-dimercaptosuccinic acid]), as well as the trauma risks of capture and handling. The drastic steps taken in trapping and veterinary intervention on a recurring basis for birds in Arizona, California and Baja California, Mexico (11 wild condors treated for elevated lead levels, Peters, pers. comm.) requires a high investment of time and effort on the part of the field teams, and significantly alters the “wild” status of the birds. An examination of behavior and demography of condors as a function of times chelated and genealogy is a critical research need. Currently there is little understanding of sublethal effects of lead or developmental effects of lead.

The issue of condors being able to feed on their own rather than being sustained by carcasses put out for them at feeding stations is tied to the lead issue. Managers must feed birds to be able to trap them to treat for lead poisoning. In California managers keep birds away from "natural" food to avoid lead exposure, whereas in Arizona they allow natural feeding but then must trap, test and treat birds once or twice each fall and winter when the birds return to the holding pen area after feeding on deer carcasses during the hunting season on the Kaibab Plateau.

Efforts to Eliminate Lead from the Food Sources of Condors. There are various ways to approach the politics of eliminating exposure of condors to lead ammunition. A federally mandated, national switch to non-lead ammunition such as Japan has adopted to protect White-tailed (*Haliaeetus albicilla*) and Steller's Sea Eagles (*H. pelagicus*) is one approach. Working through local hunters and national organizations for a voluntary conversion to non-lead ammunition is another. Threats to human health due to lead fragments in game meat may be theoretically convincing, although largely dismissed by hunters, based on their own personal experience and lack of symptoms.

Copper or other non-lead bullets can be a solution to the lead problem. Legislation in California in 2007 (the Ridley-Tree Condor Preservation Act, AB 821) to require the use of non-lead ammunition in big-game hunting within the range of the condor in California was a very important step, but without education and enforcement it is not a complete solution. The California Fish and Game Commission adopted regulations in December 2007 to require the use of "lead-free" ammunition, including .22 rimfire cartridges, for all forms of hunting (excepting upland game bird hunting) within the condor range as of July 1, 2008. The effectiveness of these actions in eliminating lead ammunition has not yet been evaluated. Enforcement of lead-free hunting regulations may be highly problematic because of the lack of enforcement personnel to apprehend violators, and the difficulty for enforcement officers to distinguish between lead and non-lead ammunition in the field, and to document any illegal shooting with lead ammunition.

The Tejon Ranch, which has a major hunting program for pig, deer, elk, bear, and pronghorn antelope, upland game birds, and "varmints", which include coyotes, bobcats, badger, grey fox, and ground squirrels, switched to the use of non-lead ammunition, including .22 rimfire ammunition, in January 2008. This action is part of a Habitat Conservation Plan (HCP) that is the result of a long negotiation with USFWS. Two other facilities, Camp Roberts, and Fort Hunter Liggett, both military instillations with hunting programs within the foraging range of the condor, also have gone to non-lead ammunition, with their programs beginning 6 months earlier than Tejon Ranch's. All three facilities report little resistance from hunters, and general acceptance of the regulation change. Tejon's education program prior to requiring non-lead ammunition was reported to have had a positive impact on attitudes, and initial indications are that the shift to non-lead ammunition has not hurt the ranch's hunting business. Tejon does not expect enforcement to be an issue because they expect high compliance due to their zero tolerance policy. California Fish and Game is requiring copper ammunition for depredation of pigs and deer in agricultural areas, and there does not seem to be much resistance to this from ranchers. Recreational shooting of ground squirrels may be a bigger enforcement issue, especially because there is no current alternative to lead ammunition for .22 caliber, rim-fire rifles commonly used to shoot small game such as rabbits and squirrels.

Thus, there have been many recent actions designed to reduce exposure of condors to lead from spent ammunition and attitudes about these actions appear to be positive. However we are not convinced these actions will reduce incidences of lead poisoning sufficiently as long as lead ammunition is freely available due to issues with compliance and enforcement. Tejon's new policy was implemented through notification by word-of-mouth and letters to all hunters, followed up later by spot checks in the field. Yet in May of 2008 high lead levels were detected in seven condors, and GPS data indicated all these condors had been feeding on Tejon Ranch in addition to provisioned carcasses at Bitter Creek NWR. These birds were taken to the Los Angeles Zoo for treatment, and one subsequently died. Evidence suggested the birds might have picked up lead from carcasses available through Tejon's year-round pig hunting program. This possible exposure event caused Tejon to close down their hunting program for a one-month review, and resulted in the tightening of their enforcement program. The possibility that condors were exposed to lead-contaminated pig carcasses on the Tejon Ranch despite the prohibition of lead ammunition points to the necessity of enforcement to insure compliance with non-lead regulations, and the difficulty of achieving 100% compliance even in highly controlled hunting programs.

Enforcing the statewide prohibition on lead ammunition in California will be even more problematic. California Fish and Game has done little to educate hunters about the new requirement to use non-lead ammunition, and such ammunition is not readily available or identifiable in many retail outlets. The Ridley-Tree Condor Preservation Act provides for subsidies to hunters for non-lead ammunition, but California has not provided any funding for the program. Given these conditions, it is difficult to imagine that compliance will be high, at least initially, despite the best intentions of the hunting community, and California Fish and Game has little capacity to enforce the non-lead requirements. Furthermore, poachers take large numbers of animals in California and are unlikely to comply with the non-lead requirement, as long as lead bullets are easily purchased.

Arizona has instituted a voluntary program to encourage hunters to use copper bullets in areas where condors feed. The Peregrine Fund has teamed with the Arizona Department of Game and Fish to initiate a public education program with all hunters drawing permits to hunt deer on the Kaibab Plateau. All hunters are provided with lead-free ammunition at no charge. Outreach efforts in Arizona have been highly successful, with voluntary compliance by greater than 80% of hunters in the Kaibab Forest range of condors. Despite this success, condors continue to be exposed to lead while foraging on the Kaibab.

In Arizona and Utah, birds have access to a large supply of their preferred food, deer, during the late summer, fall and early winter. Green et al. (2008, unpublished abstract TPF conference) have modeled the exposure and cleansing of the population during the hunting season, and have postulated that the population is just at the brink of disaster each year, because of frequent low-level lead exposure. Their model suggests that without trapping and intervention, sufficient mortality would occur in the population to prevent sustainability, even at the current high rate of compliance in use of lead-free ammunition by deer hunters in the Kaibab Plateau. In future years, as more birds move into Utah during the hunting season, the problem will become worse, unless a very successful hunter education program is undertaken, and hunters widely accept the use of lead-free ammunition. Even so, Green et al. hypothesized that only a few lead exposed carcasses would be sufficient to cause mass mortalities of condors, if there is not a successful way of trapping birds during the hunting season in Arizona and Utah. As a result, virtually a 100% compliance with the voluntary lead-free ammunition program will be needed to avoid severe lead poisoning incidents.

Exposure of condors to lead fragments in carcasses is analogous to die-offs of Asian vultures in which populations of several species have been reduced nearly to extinction because of feeding on cattle carcasses containing the veterinary non-steroidal anti-inflammatory drug diclofenac. Diclofenac is a very effective anti-inflammatory drug, but if a treated animal dies, a single carcass may contain multiple lethal doses of toxicant and can poison multiple birds feeding communally. Green et al. (2006) created models of the exposure scenarios to determine the proportion of carcasses that needed to be contaminated to adversely affect the population of Asian vultures feeding on carcasses, and found that if as few as 1% of the carcasses contained diclofenac, they would intoxicate so many individuals that the vulture population would not be sustainable. The broad pattern of having a contaminated carcass that is capable of poisoning multiple birds feeding communally is very similar between the diclofenac situation in Asia and the lead situation in Arizona and California.

Lead and Condor Recovery under the ESA. We are convinced that condor recovery cannot be achieved unless exposure to lead from ingesting spent ammunition while feeding on carcasses and gut piles is eliminated. We conclude that as long as lead ammunition is available, even with excellent compliance voluntary programs promoting the use of non-lead ammunition are unlikely to reduce lethal exposure to lead sufficiently to enable condor populations to be self-sustaining. Similarly, the efficacy of area-specific requirements for non-lead ammunition such as the local regulations on the Tejon Ranch or even the state regulations in California remains extremely uncertain. We therefore conclude that total replacement of lead with non-toxic ammunition at least within the potential range of the condor, and preferably nationally, is necessary (but perhaps not sufficient) for condor recovery. We recommend that USFWS work with ammunition manufactures, state game agencies, and shooting and hunting organizations to spearhead an effort to replace lead ammunition with non-lead alternative ammunitions nationally or at least within the potential range of the condor. The program requires national leadership from USFWS on this issue, but state wildlife agencies must be full partners in this effort because of their jurisdiction over hunting regulations.

We conclude that progress toward recovery is not sustainable under current conditions because reintroduction of more condors simply increases the costs required to keep wild birds alive rather than improving the viability of the wild populations. The program thus has reached an impasse involving tradeoffs between number of birds, mortality rates and program costs. As more condors enter the population, partners may be unable or unwilling to sustain the increased level of support required to prevent mortality rates from rising. The ultimate goal of many of the partners is to be involved in lower intensity monitoring of a self-sustaining population, or to exit the program entirely when populations become self-sustaining, not to continue increasing expenditures indefinitely. That goal is unattainable as long as the lead threat remains, and the longer the lead issue continues to impede progress, the more difficult it will be to sustain the support of existing partners or secure additional support for the recovery program.

Elimination of lead ammunition should not be accomplished by a reduction in hunting, but rather by replacement of lead ammunition with non-lead alternatives. Hunters are the dominant predators in most of the condor’s range, and dead animals and gut piles left by hunters provide important food sources for condors. It is essential that hunters continue to harvest deer, pigs and other wildlife throughout the condor range using non-lead ammunition, so that a clean source of wild food is available to condors beyond food subsidies. This is the only way that condors will be able to be sustained in the wild after food subsidies are reduced. Therefore eliminating the threat of lead must be accomplished while simultaneously promoting sport hunting for large game and depredation hunting for feral pigs. The campaign to convert the hunting community from lead to non-lead ammunition should include increased awareness of that community’s important role in condor recovery as a critical source of the condor’s food supply.

The campaign should also include awareness of the potential for adverse effects of lead exposure from spent ammunition on other species, including humans. The levels of lead exposure documented in condors are sufficient to suggest adverse effects on the health of humans who consume game killed with lead ammunition. Removing lead ammunition is not only right for condors, it is right for other scavengers, and it is right for hunters and their families. Effects of exposure to spent lead ammunition in humans should be vigorously researched, both to protect human health and to facilitate conversion to non-lead ammunition at the national level.

The evidence that use of lead ammunition results in deaths of condors is sufficiently compelling that use of such ammunition could be interpreted as “take” of condors under the Endangered Species Act. The birds reintroduced in Arizona are classified as an experimental 10J population and hence are treated legally as threatened rather than endangered. Still the birds are subject to protection from take on federal land. BLM and USFS have not required non-lead ammunition on their lands because of the 10J promise of no change in land use (Austin et al. 2007). One could argue, however that BLM and USFS should have to consult on allowing use of lead in depredation and hunting permits on their lands, and that USFWS should rule that such permits constitute take of condors. USFWS could treat lead like a regulated toxin, and recommend in their consultations that it not be used. At the very least, it seems that consultation would result in limits on take based on use of lead by hunters. In California the same reasoning applies to forms of lead ammunition that are still permitted.

It is conceivable that the microtrash problem, like lead, could be elevated to a take issue. This would allow BLM and USFS to make removal of trash a requirement for oil and gas leases, which appear to be the source of much of the microtrash at Hopper Mountain.

Foraging and Supplemental Feeding

Food subsidy with lead-free carcasses plays a major role in all condor release sites as a means of minimizing the lead-contamination risk until better ways of countering the threat can be implemented. The potential effectiveness of food subsidy as a means of keeping condors from consuming contaminated food was a justification for initiating releases in the 1990s (Snyder and Snyder 2000). At the time of the first release it was believed that captive-reared condors might become strongly dependent on subsidies as was observed in similar releases of Eurasian Griffon Vultures (*Gyps fulvus*) in France (Terrasse 1985) and Andean Condors (*Vultur gryphus*) in Peru (Wallace and Temple 1987; 1988). However, California Condors have not become strongly dependent on clean food subsidies at release sites, which parallels the findings from earlier feeding programs for the original wild population (Wilbur 1977; Snyder and Snyder 1989). Moreover, proffered foods have been provided at multiple locations at all release sites, especially in the 1990s when efforts were made to lure the birds away from human activity. As the birds became more mobile and more adept at keying in on other scavengers, especially ravens, they quickly adapted to feeding at non-proffered sites. As released condors have strayed from food subsidies the incidence of lead poisoning has increased, although levels of adherence to subsidies and incidence of lead poisoning vary among sites. For example, adherence to subsidy has been strongest in southern California where feeding stations have been few and non-proffered food sources are limited (Snyder and Snyder 2000; Grantham 2007; Hall et al. 2007). In contrast, sites where adherence to subsidy has been weaker had multiple feeding stations used to encourage exploration, and more abundant non-proffered food such as hunter-killed game and its remains in Arizona, and dead marine mammals at Big Sur (Woods et al. 2007; Hunt et al. 2007; Sorenson and Burnett 2007).

The released condors make extensive use of subsidies, which are usually offered on a regular schedule (e.g., every 3 days) at a site or several sites relatively close together. Stillborn calves from dairies are the most common food, although domestic rats, rabbits, sheep, feral pigs, and several deer species are offered, depending on availability (see chapters in Mee and Hall 2007). Return of captive-reared condors to feeding stations has proven especially useful for flock management. For instance, releasing young, captive-reared condors near feeding stations promotes their socialization through interactions with older, experienced conspecifics and facilitates their integration into the wild flock (Grantham, pers. comm.). Additionally, the feeding stations allow for routine re-trapping of condors in order to replace transmitters, conduct health checks (e.g., blood tests for lead or West Nile virus post-vaccination antibody titers), and, when warranted, provide chelation treatment for lead exposure (Austin et al. 2007). Finally, attraction of condors to fixed feeding stations allows for routine observation and provides opportunities for experiments related to food choice or nutrition, such as providing bone chips to test the hypothesis that microtrash ingestion is related to calcium deficiency (Mee et al. 2007a).

Feeding condors at fixed sites and fixed time intervals may decrease a captive-reared condor’s exposure to lead, but it retards development of normal wide-ranging foraging behavior, alters time and energy budgets, and appears to adversely affect other natural behaviors (Mee and Snyder 2007). For instance, food subsidy has been hypothesized to disrupt the normal pattern and rate of food delivery to condor nestlings by their parents (Mee et al. 2007a). Reliance on subsidized food provided in a predictable fashion near nest sites may contribute to temporal synchronization of food deliveries by parents to the chick, resulting in the later arriving parent attempting to feed a satiated chick. As a consequence, the late arriving parent may subsequently fail to visit the nest, visit only briefly, or visit but not feed the chick (Mee et al. 2007a). This contrasts with the relatively asynchronous patterns of food delivery observed historically when parents foraged independently and covered wide areas in order to locate food that was unpredictable in space and time (Meretsky and Snyder 1992). The suggestion by Mee et al. (2007a) that chicks may actually receive less total food biomass in food-subsidized populations is interesting and merits further investigation. Another likely consequence of reliance on food subsidy is that chicks may not be fed when the subsidized food becomes temporarily unavailable (due to loss to other scavengers, to activities such as trapping at the station, or weather or fire hazard conditions making the site inaccessible to managers). For instance, observations in southern California suggest that periods of food deprivation were more frequent for chicks whose captive-reared parents were provisioned on a 3-day feeding cycle (Mee et al. 2007a) than for chicks in the wild population of the 1980s (Snyder and Snyder 2000). Although occasional periods of food deprivation may not be critical to chick development, repeated bouts of deprivation could be debilitating and/or lead to inappropriate behavior such as ingestion of microtrash (Mee et al. 2007a). When only a single feeding site is used, social hierarchy issues become pronounced and less aggressive birds, particularly ones feeding chicks, may not have an opportunity to secure a full crop or the more nutritious parts of a carcass.

Even when multiple feeding sites are used, supplemental feeding greatly reduces the foraging range of individual condors and the time they expend in locating food. As discussed more fully below, food subsidies may actually provide condors with “excess” time that normally would be devoted to extensive searches for carrion and thereby promote unnatural and/or inappropriate behaviors, such as the exploration of human developed sites and ingestion of trash (Mee and Snyder 2007).

As food subsidies have become predictable in space in time, the feeding stations have attracted not only condors, but also other scavengers and predators (e.g., feral pigs, coyotes, cougars, bears, bobcats, Golden Eagles), thereby increasing competition with condors, as well as predation risk. To deter food loss and interactions with mammalian predators and scavengers, “permanent” feeding stations have been protected with electric fences at two sites in southern California and similar protected feeding stations have been established in central California

(Figure 5). Although these protected feeding stations have reduced food loss to mammalian scavengers, risk of predation by Golden Eagles may exist as birds concentrate at fixed feeding stations (Mee and Snyder 2007). Furthermore, these feeding stations can promote an abnormal level of sociality among condors as observed in southern California where it is possible to find the entire reintroduced population of that area together at a feeding site (Mee and Snyder 2007). Such concentrations of condors at a single site were never observed in the wild population, as much of the condors' time was occupied in searching for food leaving little time for aggregating at a site (Snyder and Snyder 2000, Meretsky and Snyder 1992). Effects of increased levels of sociality at feeding sites are unknown, but it is likely that dominant birds control the food source making it difficult for young birds and less dominant condors to obtain food.

Figure 5. Condors and Golden Eagle at protected feeding site. Photo courtesy of USFWS.

Given that food subsidy at a fixed site or a few fixed sites near the release site is required to limit lead exposure, most problems arising from subsidy cannot be alleviated until the lead problem is solved (Mee and Snyder 2007). Increased linkage of monitoring with foraging patterns and lead exposure would be useful in developing a feeding strategy. Once the lead issue is solved, problems associated with food subsidy will likely diminish, and those that remain may become more tractable to management intervention. Continued food subsidy may be required at sites with inadequate food supplies or seasonal shortages of carrion, such as in Arizona where condors may continue to require subsidized food during the winter (Hunt et al. 2007). In fact, it is not yet clear whether condors could subsist without food subsidies at any of the reintroduction sites. The impact of feral hogs as scavengers on the condor's food base is one concern and all the changes in the landscape wrought by humans since the days when stable condor populations existed is another. Investigation, including experimentation, into this issue could help prevent this from becoming the next impediment to condor recovery once the lead problem is solved.

Foraging habitats at reintroduction sites vary considerably and include beaches and coastal redwood forests at Big Sur, oak savannas, grasslands and chaparral at Pinnacles National Monument, grasslands and oak savannas in southern California, high desert and forested plateaus in Arizona and Utah, and arid, scrub habitats of Baja California. This variety provides a rich context for studies of the foraging abilities and requirements of condors on current landscapes. Their ability to feed on marine mammals is an encouraging development with respect to the potential for condors to be self-sufficient in central California and farther north. At this point southern California appears to be the most problematic area where natural foraging potential is concerned, but the recent protection of habitat on Tejon Ranch, the gateway between historical foraging ranges of the southern California population in the coastal ranges and the southern Sierra Nevada (Mee and Snyder 2007), provides opportunities for this area.

We recommend initiating new research studies to ascertain the capacity of condors to become self-sufficient foragers within the extant landscapes where they are being released. The condors currently on the landscape are pioneers. We learn much from them, albeit at considerable cost to the birds and the partners involved in the condor program. Hence we endorse efforts, in southern California and elsewhere, to encourage the birds to forage more widely by use of multiple feeding sites at strategic locations. Although this increases risk of lead exposure, it provides benefits in learning opportunities.

Problematic Behavior of Released Birds

From the first releases of captive condors back into the wild, the behavior of released birds, specifically their attraction to humans and human-built structures, has been an issue (Figure 6). The inquisitiveness of condors makes tame birds unusually prone to interacting with humans, and because of their large size and gregariousness such interaction is inevitably problematic. As a consequence of the condor’s social nature, bad behavior is contagious: even well-behaved birds will learn inappropriate behaviors from other condors. The survivors among the first birds released in 1992 and 1993 were recaptured and returned to captivity because of their tameness, general attraction to human activity and tendency to engage in the high-risk behavior of perching on utility poles (USFWS 1996). Subsequent examples of bad behavior range from mundane destruction of property to the truly fantastic. In southern California a cohort of birds raised and released together began associating with hang-gliding enthusiasts on weekends, roosting on a communications tower at the launch site, mingling with the humans on the ground to pick through food wrappers and other trash, and soaring with the hang-gliders when they took to the air (Mee and Snyder 2007; Grantham, pers. comm.). Another group of condors descended on the Pine Mountain Club property near Mt. Pinos in 1999, destroying satellite dishes, roof shingles and a screen door, and entering the bedroom of a former critic of the condor program to take bites out of his mattress (Snyder and Snyder 2000).

It is likely that supplemental feeding promotes the development of inappropriate behavior involving attraction to humans and human-built structures because it provides the birds with more time for activities other than foraging. Captive rearing and socialization techniques affect the expression of abnormal post-release behavior as well. Since the first releases, development of rearing and release techniques that produce well-behaved birds has been a major issue and an important focus of research, conducted largely through trail-and-error. Much progress has been made, especially in recent years (Clark et al. 2007; Wallace et al. 2007b). Two rearing methods are used, parent-rearing and puppet-rearing (Wallace et al. 2007b). Condors learn survival skills and appropriate social behavior through interaction with other condors (Wallace 2000; Alagona 2004), and in the wild young birds learn from their parents during a long period of independence (Snyder and Snyder 2000). In the early years of the program puppet-reared birds were raised in cohorts and thus lacked adult mentors (Bukowinski et al. 2007). These birds were prone to bad behavior (e.g., the hang-gliding condors described above) (Meretsky et al. 2000; 2001; Snyder and Snyder 2000) and were seemingly lacking in social skills (Cade et al. 2004) and wariness of humans (Meretsky et al. 2001). The puppet-rearing procedure has subsequently evolved to include interaction with older mentors as an important component of the rearing routine (Clark et al. 2007). In addition birds now are held in outdoor pens at release sites for a considerable period and have further opportunities to learn from mentors placed within the pen, as well as through interactions with wild birds that visit the pen. Thus, the birds are integrated with the existing flock prior to their release to some extent.

Figure 6. Condors attracted to a human-built structure. Photo courtesy of USFWS.

Rearing and release now involves close integration between captive and field facilities geared toward releasing a well-behaved bird and managing subsequent behavior in the field. Managers have learned to recognize appropriate and inappropriate behavior and monitor individuals closely in order to decide if and when a bird is suitable for release. Such monitoring continues post-release, and problem birds are caught and returned to captivity for a “time-out” period of months or years during which they undergo behavioral rehabilitation. Intensive monitoring is also required so managers know when to apply negative conditioning responses (i.e., hazing) in response to inappropriate behavior. This may be effective in deterring young condors from approaching humans or their structures as occurred in Arizona (Hunt et al. 2007), although it was not in southern California (Grantham 2007). Similarly, by responding quickly with hazing, managers in Arizona have been able to deter newly released condors from roosting on the ground, thereby training them to roost in sites less exposed to predators (Woods et al. 2007). Negative conditioning of young birds in the form of aversion training prior to their release has also been effective in discouraging condors from landing on utility poles, contributing to a reduction of power line-related mortalities (Mee and Snyder 2007**).** Management of behavior is, of course, effective only when training can be promptly and consistently accomplished. Problematic behavior is much less an issue today than it was previously, but occasional problem individuals who interact inappropriately with humans or other condors still occur, and one pervasive behavioral problem (microtrash ingestion in southern California) still exists. Perhaps the biggest change is that managers have gotten much better at recognizing bad behavior earlier and removing these individuals from the wild populations before they cause problems.

There is widespread belief among the program's biologists that parent-rearing is superior to puppet-rearing in producing desired behavior (Meretsky et al. 2000; Wallace et al. 2007b), and we concur. However, because breeding pairs will relay when their eggs are removed and sometimes fail in raising young, puppet-rearing results in considerably higher productivity than parent-rearing (Wallace et al. 2007b). There are trade-offs between producing a better bird for release versus producing a greater number of birds. The current emphasis on parent-rearing is facilitated by the fact that some release sites, for example Arizona, are at or near capacity in terms of the number of birds they can handle given the intense, post-release monitoring requirements. Use of puppet-rearing will increase if demand for birds for reintroduction increases in the future, and hence further research designed to improve the puppet-rearing technique is warranted. Therefore we endorse the current effort to evaluate puppet-rearing and group socialization techniques in the current Baja California release (Wallace et al. 2007b). Carefully designed experiments such as this one, as opposed to the trial-and-error approach of the past, will provide the most definitive results (Meretsky et al. 2000). Designing experiments that will produce clear interpretations is challenging, however, because of the influence the existing wild flock has on the behavior of newly released birds. Indeed one of the current issues is the extent to which improved behavior in recent years is due to more use of parent-rearing versus the presence of older wild mentors. This problem was avoided in the Baja experiment because there was no previously existing flock there. We would hope that a similar experiment would be conducted with parent-reared and parent-socialized birds if and when such an opportunity arises in a new and separate release area.

There is good coordination between rearing methods and demands at release sites between partners who work closely (e.g., Boise-Arizona, San Diego-Baja, LA Zoo-Bitter Creek), and this is reflected in the emphasis on parent-rearing in Boise and the LA Zoo, and greater use of puppet-rearing at San Diego. However, matching overall demand with overall production program-wide may need some attention. In particular the central California release site (Big Sur and Pinnacles) would like more birds than they are currently receiving, and there is interest in releasing birds in the Pacific Northwest in the near future. At the program level genetic and demographic considerations drive decisions about how many and which birds are available for release (Ralls et al. 2000; Ralls and Ballou 2004). Currently an age structure skewed toward the older age classes in the captive population is a particular concern (Wallace et al. 2007a; Ralls, pers. comm.). To correct this problem requires retaining some of the young birds produced in captivity, thereby reducing the number available for release. Therefore decisions will need to be made based on prioritization among the competing needs for retaining more birds for breeding, producing better behaved birds (parent-rearing) and producing more birds (puppet-rearing) in order to meet the needs of all the partners. In our opinion producing a well-behaved bird should be the highest priority. Annual breeding and transfer recommendations should follow established procedures for Species Survival Plans in coordination with the Lincoln Park Zoo.

Despite the great progress that has been made in developing rearing techniques that produce well-behaved birds, concerns about behavioral problems remain. For example, in central California program managers are concerned that condors have frequent opportunity to interact with people in Pinnacles National Monument, and on the coast along Highway 1 where birds roost immediately adjacent to the highway above the coastal sea lion colonies. There is a continuing need for post-release monitoring and behavioral management of released birds.

There is room for further experimentation with rearing techniques as well. In general the improvements that have been made represent shifts toward procedures that more closely resemble natural processes of rearing and socialization, the emphasis on parent-rearing being the most obvious example. Rearing techniques could be shifted further in this direction (Mee and Snyder 2007). Managers could leave chicks with their parents longer, and avoid mixing young birds until the age when they naturally would separate from their parents. There is some concern that exposing young birds to one another at an early age could trigger incest avoidance mechanisms and thereby impact pair-bonding (Mee and Snyder 2007). Once the lead problem is solved, we recommend the release of established breeding pairs from the captive population. Old birds from the original wild population should be included in these releases since their knowledge could be invaluable in reestablishing traditional seasonal movements and foraging patterns (Mee and Snyder 2007). For example the old birds might lead the younger condors back to historic foraging grounds in the Sierras.

We conclude that sufficient progress has been made in refining captive-rearing and release techniques to produce better behavior that inappropriate behavior is no longer an impediment to successful reintroduction, but more work needs to be done. The close integration between captive and field facilities in managing behavior should continue. We recommend continued emphasis on parent-rearing while demand for birds for release remains relatively low. Until the lead problem is solved the emphasis should be on the quality of the birds produced, not quantity. Numbers were needed early in the program, but now quality is needed.

Microtrash Ingestion. Condor parents feeding nestlings small items of trash, termed microtrash, has been the major cause of nest failure in southern California. While hatching success in this reintroduced population compares well with those documented in the historic condor population and other vulture species, fledging success has been substantially lower than would be expected (Mee et al. 2007a,b; Snyder 2007).

Of 12 nestlings hatched in the wild in southern California between 2001 and 2006, eight died prior to fledging (Table 2). Although only two deaths (SB #285 and SB #308) can be directly attributed to trash, trash ingestion was probably a contributing factor in the deaths of five additional nestlings. Between 2001-2006, only a single nestling (SB #326) successfully fledged without assistance, although three other nestlings (SB #328, SB #370, and SB #412) were removed from the wild for medical treatment and were either returned to the nest or re-released into the wild following their recovery. Nestling SB #328 had 222g of foreign material removed by surgery yet appeared healthy, whereas nestling SB#370 had 200g of microtrash removed by surgery yet was clearly debilitated. Ingested items are diverse and have included rags, nuts, bolts, washers, plastic, chunks of pipe, bottle caps, spent cartridges, and pieces of copper wire. Mee et al. (2007a) examined 650 trash items recovered from condor nests and nestlings and determined that 226 (34.8%) were plastic, 223 (34.3%) were glass, 148 (22.8%) were metallic and 53 (8.1%) were other materials (Figure 7). Interestingly, they also found that trash items were significantly more numerous, larger, and of greater mass in reintroduced condor nests than in historical nests.

Figure 7. Microtrash from a condor nest in southern California. Photo courtesy of USFWS.

Due to the problems posed by microtrash ingestion, and following a successful intervention in 2006 in which a chick from which microtrash was surgically removed subsequently fledged, USFWS initiated an intensive nest monitoring program in southern California in 2007. Nestling feather growth and development are carefully monitored because trash ingestion can cause distention of the crop and gizzard and interfere with food uptake and processing. During nest visits, nestlings are palpated, and checked with a metal detector to ascertain the presence of metallic trash. Trash items are removed from the floor of the nest cavity, and bone fragments are provided. Nestlings are also vaccinated for West Nile Virus during these examinations. During the 2007 breeding season, all six breeding attempts were successful, although two fledglings were subsequently lost to a wildfire (SB #434) and another (SB #444) to an unknown cause. As of July 2008, seven nestlings are being monitored in California nest sites: microtrash has been found in all nests, and some chicks have microtrash in their digestive tracts (Grantham, pers. comm.). We conclude that successful nesting in southern California currently is contingent upon intensive nest monitoring and corrective intervention when needed, and recommend that this monitoring, albeit time and labor intensive and costly, be continued until the behavior of feeding microtrash to chicks is extinguished. We believe the rationale for such monitoring - that it is more desirable to have a chick fledged naturally into the wild by wild parents than to raise and release a captive reared chick, and that a wild reared chick will likely adopt natural behaviors more quickly than captive reared birds – is sound.

Table 2. Causes of post-hatching nest failure of California Condors in California, 2001-2006. Modified from Mee et al. (2007a).

Primary cause	Effect		%	Additional data (no. of nestlings affected)
	Dead	Removed		
Ingested Trash	2[a]	2[b]	36	Zinc toxicosis (1), retarded growth (2), elevated copper (2), anemia (1), pneumonia (1), perforated gut (1)
Undetermined	3		27	Elevated copper (2), ingested trash (2)
Trauma	1[c]		10	Head and neck wounds
Dehydration	1[d]		9	Visceral gout, ingested trash, elevated copper
Fall from Nest		1[e]	9	Ingested trash, broken wing
West Nile Virus	1		9	Aspergillosis, ingested trash, retarded growth

[a] Chick SB#308 was removed from the wild on 11 September 2003 (~133 days of age), and was subsequently euthanized at LAZ on 24 September 2003.

[b] Chicks SB#370 (116 days of age) was rescued from the wild in 2005 for surgery and treatment; and re-released to the wild in 2006. Chick SB#412 (~130 days of age) was removed from nest to LAZ in 2006 for emergency surgery for impaction at LAZ, returned to its nest the next day, and survived to fledge.

[c] Chick SB#263 died at ~ 2 days of age in 2001. The chick was derived from a captive-produced egg placed in the nest of a “trio” (1 male, 2 females) of adults when their two eggs were not viable. Wounds possibly resulted from adult aggression. Adult female SB#108 subsequently removed from wild.

[d] Chick SB#288 died at 145 days of age and had gone at least 6-8 days without food immediately during hot weather.

[e] Chick SB#328 was found below the nest cave with broken wing. The 131-day old chick was taken to the LAZ for surgery to repair wing and remove trash. The chick recovered and was subsequently re-released to the wild in 2006.

While areas with abundant trash (e.g., oil platforms, visitor overlooks) that are frequented by adult condors are being identified and cleaned up, it seems unlikely that this effort alone will solve the trash ingestion problem due to the scale and diversity of these sites (Mee et al. 2007a; Grantham, pers. comm.). The question as to why condors feed trash items to their chicks remains unresolved, yet clearly merits additional investigation. Snyder and Snyder (2000) suggested trash ingestion might be related to the misdirected search for calcium and food sources needed for egg-laying and chick growth and development, as documented in other large vultures (cf. Mundy and Ledger 1976; Richardson et al. 1986; Benson et al. 2004). While subsequent provisioning of additional calcium sources (i.e., bone fragments and small mammals) at feeding sites in southern California did not seem to reduce the quantity of trash delivered to nestlings, these items were provided irregularly and in inadequate amounts to rigorously test this hypothesis (Mee and Snyder 2007; Mee et al. 2007a; b). Additional efforts to test this hypothesis are warranted, and we agree with Mee and Snyder (2007) that studies on pellet formation and regurgitation in adults and chicks and as well as on the timing and rate of bone mineralization in nestlings could provide valuable supplemental information.

Microtrash ingestion has been especially common in the southern California release population where trash ingestion has caused chick mortality (Mee et al. 2007a;b) in contrast to Arizona where trash ingestion by chicks is rare and has not contributed to chick mortality (Woods et al. 2007). Some of the site differences in frequency of trash ingestion by chicks are attributable to differences in availability of trash – the southern California site has an abundance of trash (especially along roadsides and oil drilling pads) in the vicinity of nest sites in contrast to the more pristine environment of northern Arizona. However, it also has been suggested that the Arizona condors have a lower propensity to bring trash to the nest because they forage more widely on a variety of natural carrion and display less reliance on subsidized food (Mee et al. 2007a). Moreover, in the past the Arizona nests were further from the provisioning site (some are up to 80 km away) than southern California nests, all of which until recently were in the vicinity of the provisioning site (1.5 to 12 km). Therefore, it has been hypothesized that regardless of the food source, breeding pairs in Arizona foraged more widely and had less time available to search for trash (Mee et al. 2007a; b; Mee and Snyder 2007). As of July 2008, however, feeding sites are now 72 km from nest sites in southern California, yet GPS telemetry data indicate some breeding adults continue to make stops at prospective trash sites on their way to or from feeding sites, and microtrash continues to appear in nests (Grantham, pers. comm.). Thus the microtrash issue continues to defy simple solutions.

Nest observations in southern California suggest that nestlings now receive more irregular feedings than historically, a feature that may relate to the timing of food availability at feeding stations and may also influence trash ingestion behavior (Mee et al. 2007a). We agree with Mee and Snyder (2007) that experimental and observational examination of relationships between the regularity and spacing of feedings and frequency of trash ingestion would be of considerable value. It was during periods of food deprivation that nestling Cape Vultures (*Gyps coprotheres*) were most likely to ingest foreign materials including human artifacts and nest material (Benson et al. 2004).

The recent requirements for non-lead ammunition within condor habitat in California opens up the possibility of eventually reestablishing more natural foraging patterns in this population by increasing the number of feeding stations and forcing birds to travel much greater distances. Relocation of the release site and primary feeding station in southern California from Hopper Mountain NWR to Bitter Creek NWR in 2006 (Figure 2), a distance of 72 km, was the first step in this direction. Establishment of additional feeding stations at Tejon Ranch and Wind Wolf Preserve in 2008 following adoption of the non-lead requirement represents a further attempt to improve behavior through impacts on adult movements and activity budgets, and recreates historical geographic foraging patterns. Whether these changes eventually will reduce the incidence of microtrash ingestion remains to be seen, but clearly altered foraging and activity patterns did not immediately extinguish such behavior in the individuals that have a tradition of picking up trash (see above). Still, extant foraging patterns are still far less than those documented historically, and we recommend additional experiments designed to increase parental foraging time and effort be undertaken as soon as lead risks can be minimized and addressed. Perhaps development of more natural foraging patterns will prevent new breeders from acquiring the microtrash habit.

Adult condors also seem to vary considerably in their propensity to feed trash to chicks, and may not visit trash sites until they are feeding nestlings (Grantham, pers. comm.). Suggestions on how to deal with misbehaving individuals range from aversive training to relocating the birds to reintroduced populations in Arizona or Baja California where trash is much less available. Although a single breeding pair that regularly fed microtrash to their nestlings was captured and held in captivity, no aversive training was conducted and the birds quickly resumed the behavior when they were returned to the wild in southern California. To date, there have been no attempts to transfer “problem” birds or pairs from southern California to other release locations. Whether microtrash ingestion can be modified or extinguished through aversive training is uncertain. Although an aversive training study was started at the San Diego Wild Animal Park, no results were obtained as all videotapes of the training sessions were apparently lost (Mike Mace, pers. comm.). We believe that experiments with aversive training should be undertaken in captivity as soon as practicable. Experiments involving young birds prior to their release and adults that have exhibited this problem in the wild would be useful.

Early indications are that microtrash will not be as large an issue at the central California release sites as it has been in southern California. The first nesting in central California occurred in 2007, and only one of two nests had any microtrash. Identifying the source and cleaning it up quickly eliminated the microtrash problem at this nest. This provides some hope that microtrash can be managed. We suggest that the most promising avenues to pursue in reducing the microtrash problem are: (1) eliminating mictrotrash at sites frequented by condors; (2) returning offending adults to captivity for aversive training, as has been done for other problem behaviors; and (3) promoting more natural foraging patterns in nesting adults.

Exposure to Organochlorines

Of greater concern in central California is that contaminants accumulated due to feeding on marine mammals could have adverse effects on survival and especially reproduction. Of particular concern are long-term health effects associated with toxicants such as PCBs and eggshell thinning due to exposure to DDT (Kiff et al. 1979; Snyder and Meretsky 2003). Exposure to DDT has been shown in other large raptors (sea eagles) feeding on marine mammals (Iwata et al 2000). Since breeding is just beginning at this site, and the new breeders are young, it is difficult to evaluate this possibility yet, but initial testing suggests this may be an issue. In 2007 two eggs contained embryos that died during development, a possible result of moisture loss that could be attributed to thin shelled eggs. We recommend vigorous investigation of the possibility that contaminants acquired by feeding on marine mammals interfere with reproduction among the central California birds. The absence of lead from carcasses of marine mammals makes it tempting to take further advantage of this food source in planning condor reintroductions, but it is critical to determine whether this merely constitutes substituting one problem (eggshell thinning) for another (lead poisoning). Specialized protocols need to be developed for the collection of the eggs and tissues of condors inhabiting central California in order to assess and monitor contaminants. Testing of samples and results of analyses must be completed in a timely manner.

PROGRAMMATIC ISSUES

Program Organization and Administration

Recovery partners are currently self-organized into a diffuse network (Figure 8). The central elements of the recovery program are a large and diverse Recovery Team, a field working group, and a USFWS Condor Recovery Coordinator. The Condor Recovery Coordinator is housed proximal to the southern California release site in Ventura, California and is supervised by the Hopper Mountain NWR Project Leader. The 19-person Recovery Team is led by, and comprised primarily of, active participants in the condor rearing, release, and monitoring programs and is weighted toward personnel from the captive breeding facilities. Meeting frequency has declined from semi-annually to irregularly. The field working group, which was established several years ago, includes all technicians from the captive propagation and release management programs who are actively involved in restoring condors. They meet twice per year. There is also a veterinary coordinator charged with ensuring standardized care (e.g., vaccination policies), and a pathology coordinator charged with conducting post-mortem examinations and evaluating causes of mortality.

Issues with Current Structure. Efficient recovery programs require effective, adaptive, and typically task-oriented organizational structures (Clark and Cragun 2002). Outside the newly formed field working group which exhibits all these qualities, we rarely found these characteristics in the condor program. The Condor Recovery Coordinator position highlights many of the inefficiencies we discovered. By locating this position in a local refuge office, the coordinator must report to a supervisor in that office rather than directly to a senior manager in the regional office. This unnecessarily long hierarchy of authority and over use of bureaucracy is characteristic of problematic implantation of the ESA (Yaffee 1982). For condor recovery, it unnecessarily links the coordinator to a single release site, reduces the coordinator’s authority, and stifles the “virtuoso talents” needed by effective recovery program leaders (Westrum 1994). When condor recovery efforts were focused on re-establishment of the southern California breeding population, housing the coordinator at nearby refuges established for the condor made sense. But today, the coordinator needs to monitor and lead a large program that spans two countries and three USFWS regions, and program structure needs to change accordingly.

Housing the Condor Recovery Coordinator at a local refuge office is not typical of national recovery programs. Most coordinators, especially of wide-ranging species like condors (e.g., Whooping Crane [*Grus Americana*], Northern Spotted Owl [*Strix occidentalis*], Gray Wolf, Grizzly Bear), are assigned to ecological services field offices or regional offices of the USFWS. The Red Wolf is an exception, where the coordinator is under the USFWS Refuges chain of command. But the Red Wolf has a narrow distribution in the southeastern US and occurs almost exclusively on Alligator River National Wildlife Refuge, where the coordinator is assigned. In the case of this wolf, it makes biological sense to have the coordinator at the refuge, but in the case of the California Condor such an arrangement is no longer appropriate.

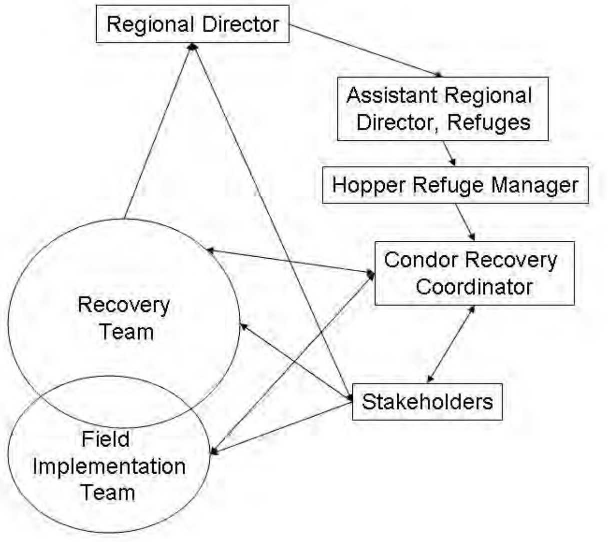

Figure 8. Organization of the current condor recovery program. In the current program the Condor Recovery Coordinator is at the Ventura field office and the Recovery Team includes many active participants in the program.

If the lead issue is resolved, new partners will certainly be needed to expand the program to new locations. We conclude that the current program structure is not conductive to recruiting new partners. Program inequity and lack of shared and effective leadership make new partners feel uninformed and undervalued. They often feel out-of-sight and out-of-mind when it comes to programmatic decision-making and coordination. Similarly, stakeholders outside the program must navigate a confusing programmatic structure to voice concerns and remain informed about recovery. Increasing the profile of the Condor Recovery Coordinator within USFWS would provide stakeholders and new partners more effective entry to the recovery program. This would also enable USFWS to better inform others that are not active partners, such as BLM, USFS and California Fish and Game, of their activities, especially when selecting new release sites. In the past those affected by condors have not always been informed that birds were going to be released and would likely use their lands. It would be advisable to coordinate with other affected parties, e.g. utility companies, as well in order to avoid predictable problems.

Inefficient and earmarked USFWS funding exacerbates the problems with current program structure. Very little of the considerable funds USFWS is investing in the program (Table 1) is going toward field personnel to work with condors at Hopper Mountain and Bitter Creek. As a result, the success of the program in the field depends on the dedication of interns and temporary employees who have little or no experience in working with such a highly visible, critically endangered species and who work long hours under hazardous conditions for almost no pay. Within a week's time of being hired they are in the field monitoring birds and interpreting behaviors that help drive the management decisions of the program. What is missing is long-term continuity and familiarity with the species and strategies and techniques developed from working with animals. There needs to be someone above the field supervisor level that has the bigger picture in focus, and to whom the field supervisor reports. That individual should guide research and management, find funding and have a direct connection with the field program.

Not surprisingly there is high turnover in the current temporary positions, and the zoo personnel, who are much more stable, are growing weary of training new USFWS field crews year after year. The tremendous nesting success achieved at Hopper Mountain NWR in 2007 was due to the work of two temporary USFWS employees who had the passion and commitment to make the program work. For example they kept zoo veterinarians fully apprised of the status of nestlings and gave advanced notice of their needs in the field, so that health problems were handled efficiently and effectively. But results might decline dramatically with new, less experienced personnel in these key positions.

The panel found this situation shocking, and the contrast between this release site and the others is striking. The Arizona site is manned by a crew of 11, and with the base funding increase in the NPS budget, the central California release site will have two biologists and 2-3 interns from Ventana, plus 5 permanent biologists, 2 temporary biologists and 2 interns from NPS. This compares to one supervisory biologist, two GS-7 temporary biologists, two GS-5 temporary biologists and interns in southern California where intensive nest monitoring is added to the list of field activities that occur at the other sites. There is a critical need for a commitment from USFWS either to support long-term personnel in the field positions in the southern California program or instead focus their support on recovery coordination and find partners willing to adequately staff these sites. Reducing the intensity of monitoring in order to reduce budget is not an appropriate solution so long as the lead and microtrash issues are unresolved. The allocated resources are presently insufficient to support the level of monitoring required to keep adults alive and enable successful breeding, and consequently the viability of this release site is questionable.

Inefficient and modest USFWS funding also complicates general program administration, as private partners must place their own budgetary needs before those of the cooperative recovery program. The level of investment by private partners also poses difficulties for program administration, as the partners' need for autonomy in raising funds must be balanced with program coordination. A diverse partnership is essential in the condor program, and while this is bound to lead to some inefficiencies, the situation could be improved.

Finally, the Recovery Team is not providing the leadership the program needs currently. Its large size and membership drawing mostly from program participants limits its effectiveness in providing a vision for the program, making recommendations to USFWS and coordinating new scientific investigations of key issues (e.g., foraging patterns, contaminants, land use patterns and changes, human demographics). The Team has become to some extent a stakeholder group and lacks input from independent scientists outside the program.

Proposed Organization. That the current condor program has enjoyed much success with an inefficient organizational structure is a tribute to the determination of all who have been, and are, involved with the program. However, continued realization that conservation dependent species like condors requiring long-term, active management (Scott et al. 2005) demands that we do better. We conclude that the current structure of the program reflects past rather than current or future conditions, and that a reorganization of this structure is overdue. Our discussions suggested four changes that, if implemented, would evolve the current program into one better able to adapt to existing and new challenges.

(1) At the center of condor recovery there should be a USFWS-funded Condor Recovery Office (CRO) that works seamlessly with a Recovery Implementation Team (RIT) comprised of those organizations raising, rearing, releasing, and monitoring condors (Figure 9). We suggest that basic programmatic coordination be the duty of the Condor Recovery Coordinator. An additional, senior-level USFWS or USGS staff scientist should also join the CRO as the Condor Research and Monitoring Coordinator. This senior endangered species scientist should report to the Recovery Coordinator, and should be reported to by the site-specific field supervisors. This arrangement would increase ability of the CRO to coordinate recovery and the research it depends upon. While coordination is led by the CRO, all members of the RIT should share leadership of on-the-ground restoration efforts in a dynamic, problem-specific manner. Interactions between individuals at the same level in different programs and organizations (e.g., keepers at zoos and field personnel at release locations) are useful, as are the interactions between field and zoo personnel at field team meetings. The RIT should report directly to the Recovery Coordinator, and interact directly with the Scientific Advisory Team (see #3 below).

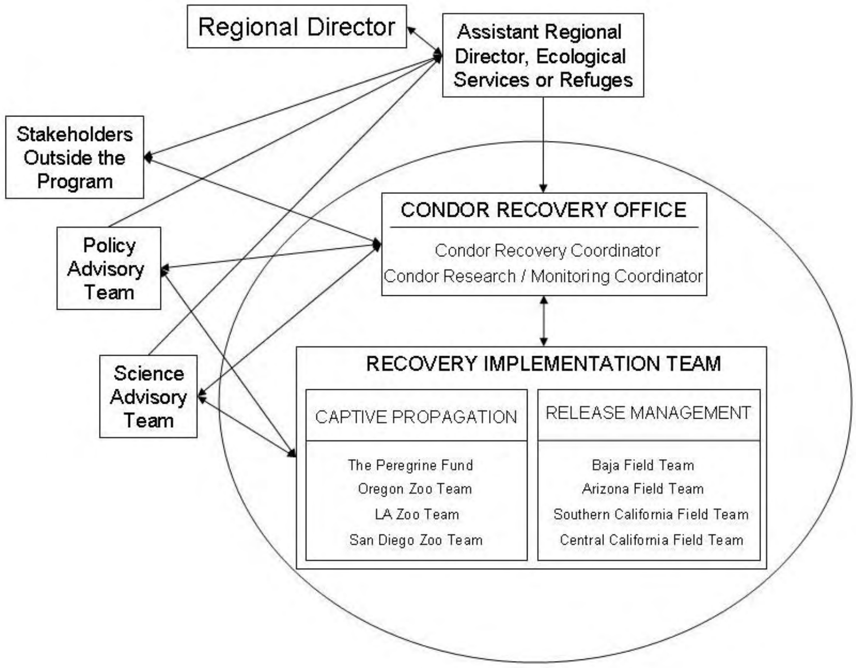

Figure 9. Proposed organization of the condor recovery program. We propose to create a new Condor Recovery Office directly linked to the regional office of USFWS in Sacramento, and an independent Science Advisory Team. The science team's autonomy is further enhanced by the creation of a separate Policy Advisory team and a practical Recovery Implementation Team.

Semi-annual meetings of the RIT and CRO, modeled on the current and productive "field team meetings" are needed. Thus the current field team structure would be formalized as the Recovery Implementation Team. Supervisors need to commit to these meetings by encouraging staff participation in the RIT rather than focusing too much on their own programs and requirements. These meetings enable communication and interaction between isolated field workers, and the participation of staff from California, Arizona, and Baja has been excellent.

Heavy-handed management of private partners that raise and expend millions of dollars on condors is inappropriate, and a close relationship between the partners represented by the RIT and the Recovery Coordinator would avoid that problem. Certainly this team may continue to be organized around release sites and captive populations, but we envision a much more dynamic formation of subgroups as issues arise, perhaps in collaboration with the Scientific Advisory Team. As problems change, leadership would shift between team members allowing those who best understand and can solve the problem to lead (Westrum 1994). For example, new groups are likely to be needed to address land use changes, human demographics and new release sites. This structure is fundamentally different than the current organization-specific, fixed leadership positions.

(2) To reduce the chain of command between the Regional Director and the CRO, the Condor Recovery and Research and Management coordinators should report directly to a Deputy Regional Director or Assistant Regional Director and not be placed within the hierarchy of a field office. As pointed out above, to coordinate a species that crosses USFWS jurisdictional boundaries, spends much of its time on private (rather than refuge) land, and ranges across international boundaries, requires proximity and access to the Regional Director in the lead office for the listed species (Sacramento). The Project Leader at Bitter Creek and Hopper Mountain NWRs will still need to coordinate the actions of the condor field supervisor stationed there, but the current Deputy Project Leader will likely not be necessary to condor recovery with our suggested reorganization.

(3) The Recovery Team, as currently constituted, should be thanked for their past service and disbanded. In its place we suggest a small, scientifically focused, advisory team appointed by the regional director. This Science Advisory Team (Figure 9) would be comprised of 7-9 scientists with appropriate expertise (e.g., avian ecology and conservation, captive management, conservation genetics, analysis of animal movements) and excellent interpersonal skills from a variety of institutions (academic, private, and governmental). Team members would interact with the CRO and RIT at biannual meetings, provide an objective scientific framework to the recovery process, review research results and re-assess future research needs. This group would take on the responsibilities of the current Scientific Advisory Committee as well as some of those currently performed by the Recovery Team, and would differ from both in having greater involvement of scientists outside the program. Independent advisory teams are increasingly common and effective (Stoskopf et al. 2005) as recovery teams transition from planning to implementation. The team should have clear rules and expectations that encourage creativity rather than suppression of novel ideas (Snyder and Snyder 2002; Stoskopf et al. 2005). The team members should be (1) the most skilled individuals available; (2) willing to achieve an informed consensus on issues via open debate and open access to data; (3) able to effectively communicate directly with the public; and (4) independent of financial ties to condor recovery (Snyder and Snyder 2002). The team might strive to prioritize short-term (tasks) or long-term (projects) activities, and encourage publication of results at each meeting (Stoskopf et al. 2005). Working groups, led by team members, involving other scientists and mangers within and outside the RIT, may be effective in addressing specific issues (e.g., lead poisoning, captive breeding, survival of released birds, land cover change, veterinary care). By listening carefully to the CRO and RIT, and applying broad scientific thought, priorities needed by the recovery program would be arrived at by consensus and conveyed to the Regional Director by the team. These priorities should include research rather than focusing exclusively on management.

Leaders of organizations that are involved in the condor recovery effort should not be part of the Scientific Advisory Team, but their insights into program management and involvement in recovery implementation are critical to success. Therefore we suggest that these participants and the Condor Recovery Coordinator form a Policy Advisory Team (Figure 9) that meets at least once a year to set policy direction for the program and helps coordinate communications and management among the various cooperating organizations. The Regional Director may or may not be part of this team, but must be closely attuned to its deliberations. Team members, especially its leader (e.g., a CEO of an involved nongovernmental organization), are expected to be visible, dynamic, technically savvy, high energy, hands on managers who ask key questions of the program and effectively voice the needs of the condor to the political world that ultimately will decide its fate.

The Role of Research and Science in the Condor Program

The best endangered species programs integrate management, monitoring and research in an adaptive management framework, making research a component of the management mission. The adaptive management process developed for the ongoing Everglades restoration provides an excellent example of this process (RECOVER 2006; NRC 2003; 2007). Although there is effective feedback between monitoring and management in the condor program, for example in managing behavior, an adaptive management framework that includes research is not evident. This hinders ability to improve understanding of condor biology and address critical research and management needs. We believe the new organization including a Research and Monitoring Coordinator and Science Advisory Team (Figure 9) will results in more effective use of research in the condor program.

Inside and outside the condor program, there is widespread concern that the role of research is insufficient and widespread support for making more use of a hypothesis testing approach to research. Many partners perceive that the current condor program is run as a management and monitoring operation, and explicitly not as a research operation. Funding for research is extremely limited, and currently no research is being conducted on wild condors. There is a research working group associated with the condor Recovery Team, but no organized research program. Maintaining a research component in the condor program became somewhat problematic with the reassignment of the research arm of USFWS to USGS as the Biological Resources Division (BRD) – other recovery programs have been similarly affected by this change – but this is not an obstacle if the desire to include research exists. We conclude that the program could benefit from more involvement of USGS scientists, whose mission includes research in support of USFWS programs, as well as the academic and zoo research communities. The recently formed California Condor Pacific Northwest Scientific Working Group, a consortium of USGS, U. S. Forest Service and Oregon Zoo researchers who have outlined and prioritized research needs to evaluate the possibility that Condors can be released back into the Pacific Northwest, illustrates the increased role of research we recommend. The Santa Barbara Zoo as a new partner is an excellent resource for increasing science in the program as well.

Behavioral issues, including the microtrash problem, are particularly well suited to an adaptive management approach. Active adaptive management involving experimentation provides the greatest opportunities for learning, but even a passive approach that formally relates management and monitoring to key questions would be far superior to the current situation. Data collected on wild and captive birds needs to be more question-oriented (Meretsky et al. 2000). For example, the microtrash issue has not been addressed in a systematic way, yet could be easily approached via a series of food preference experiments involving microtrash aversion conditioning carried out on captive birds prior to release. Examining food preference and nutritional value in domestic versus wild carcasses would be a simple, yet critical experiment to conduct on wild and captive birds. We recommend adoption of a formal adaptive management process that includes research to address these and other issues, in which hypotheses about the outcome of management actions based on current understanding of biology are stated explicitly, and collection of monitoring data is designed to test these hypotheses.

Another approach to condor research, particularly in areas where birds are being considered for release, is the use of a surrogate species such as Turkey Vultures or Andean Condors to test various hypotheses (C. Stringfield, pers. comm.). While other raptors may use similar habitats, experimental results will be more applicable if close relatives are used instead. In particular, most raptors eat live prey and cast pellets, which eliminate indigestible (bones, feathers) material including lead fragments. In contrast, vultures and Andean Condors are similar to California Condors in that they primarily consume only the soft tissues of carcasses and do not cast pellets as frequently (Snyder and Snyder 2000). Thus, they are less likely to rid their bodies of lead like other raptors and would be more appropriate surrogates for experimentation.

Standardization and Management of Data

Considerable concern about standardization, management and ownership of data exists throughout the condor recovery program. Theses issues encompassed a wide array of topics, including access to historical records, responses to requests for data from individuals outside the program, dispersed storage of information, incomplete inventories of samples and specimens, absence of summary reports, delayed access to GPS movement data, incomplete information concerning law enforcement actions, and general lack of standardization (e.g., multiple IDs for the same bird, multiple reporting formats). Personnel at one site do not always have access to the latest information from another, and as a result sometimes repeat mistakes made elsewhere, or fail to make use of new understanding of biology or management. The task of assembling all data relevant to a particular question, collected and stored in various, non-standardized ways by the various partners, is sufficiently daunting to seriously impede research. Even Ventana and NPS, though managing the central California birds as a single flock, are unable to merge much of their data. Some databases that would be extremely valuable (e.g., reproductive performance of individual breeding pairs, blood levels recorded in wild birds at each recapture) simply do not exist, or are incomplete and have not been systematically examined.

That data management concerns exist is not surprising given the long history of the recovery program, its expansion to include multiple reintroduction sites, organizations, and individuals, and rapidly evolving technologies. We conclude, however, that these problems have reached the point that they seriously impede the effectiveness of the program. Furthermore, there is a great deal of information gathered on condors over the years that needs to be reviewed and organized. As an interim measure we recommend the hiring of a data manager/statistician to work with the proposed Research and Monitoring Coordinator to oversee the existing data and assist in future standardization of data collection, reporting, and storage. While postdoctoral candidates, students, interns and volunteers should also be used in this effort, the data manager position needs secure funding to prevent turnover and provide consistency. Two important initial tasks for this position are to summarize the extant data for critical review and evaluation and to develop standardized databases for record keeping for all program participants.

Data management is a difficult, but critical issue for long-term programs. While computerization is obviously required for effective management, access to stored information can be hampered when computerized systems and programs become obsolete. Similarly, data stored in various programs or formats at multiple locations may not be readily accessible to program participants or other potential users. The condor recovery program clearly faces all of these challenges. The zoos presently involved in the condor program maintain electronic information on each captive specimen using two independent database systems: (1) an Animal Records Keeping System (ARKS), which records information on location, behavior, molt, diet, breeding, transfers, etc; and (2) a Medical Records Keeping System (MedARKS), which contains a record of all health related issues, medical examinations, treatments, and so forth. Additionally, Mike Mace at the San Diego Wild Animal Park maintains the condor studbook using a third database program called Species Animal Records Keeping System (SPARKS), which contains an inventory of all living and dead condors and can be used to complete basic demographic and genetic analyses of the living population. Unfortunately all of these systems must be independently maintained and accessed, which impedes the timely sharing of information. As a result, the International Species Inventory System (ISIS) is presently developing a unified global database system called the Zoological Information Management System (ZIMS), which will combine the independent functions of the ARKS, MedARKS, and SPARKS systems (*http://www.isis.org/CmsHome/content/zims*). This flexible, web-based system is using high-quality code, and will allow authorized institutions to enter, search and retrieve data directly. We recommend that participants in the condor program follow the development, testing and deployment of ZIMS system closely because the benefits of applying this system to store, manage and access information on captive and wild condors are potentially huge.

The matter of data ownership was raised on a number of occasions and is a serious issue because it is not clear who owns collected data, research samples, or collected specimens. This situation has precipitated unnecessary conflict in the past, and unless effectively addressed will continue to inhibit cooperation among partners and across release areas and captive facilities. We believe that standardization of data collection will facilitate cooperation and promote the sharing of data and the testing of ideas among partners. Field, veterinary, and pathology protocols should be evaluated with standardization in mind, although we recognize the need for partners to retain flexibility as appropriate to each program. Current program reporting schemes should also be evaluated in order to secure standardized contents, formats and submission frequencies among cooperators. Feedback loops also need to be examined in order to make certain that important findings are translated into appropriate research and management actions.

Monitoring Released Birds

It is critical to continue long-term demographic monitoring and evaluation of birds in the wild. Currently intensive monitoring of released birds is essential to reduce mortality due to lead poisoning and to detect and treat inappropriate behavior. Once these problems are solved, continued monitoring will be needed to track population dynamics and key aspects of biology such as foraging patterns and dispersal.

Several methods such as photographic identification of individual condors (Snyder and Johnson 1985) and radio telemetry (Meretsky and Snyder 1992) were developed and used successfully in the 1980s to monitor various aspects of wild condor demography, ecology, and movements (Snyder and Snyder 2000). There was no evidence in these early studies that radio transmitters, their attachment, and associated trapping and handling contributed to condor mortality. Since then radio telemetry has become the most important and frequently used method for monitoring released condors as summarized for specific sites in Mee and Hall (2007). All released condors are fitted with a VHF transmitter mounted on the patagium (Wallace et al. 1994) or occasionally on the tail (Hunt et al. 2007), and fitted with vinyl tags attached at the patagium for visual identification. Despite these standard attachment methods, some have suggested that better methods for attaching and/or implanting transmitters should be explored. Some condors also receive GPS satellite-reporting transmitters designed to provide hourly position fixes with an accuracy of 50 m during daylight hours. Most tracking of VHF radio-tagged condors occurs from observers in motor vehicles or on foot at various high points, but fixed-wing aircraft are sometimes used to search for missing birds. Both GPS and VHF transmitters are needed to collect the data required for the monitoring program. Thus we recommend that each bird have one of each transmitter type. GPS transmitters will become increasingly important as the need to monitor foraging movements and dispersal increases. We recognize that funding issues may limit the use of GPS transmitters, however. Managers should be able to do better than 5-month transmitter life, considering the technology now available.

Monitoring individual condors with radio telemetry is essential for evaluating success of releases, determining survival rates and range use, identifying sources of mortality, and alerting managers to situations requiring active intervention or management changes. In addition, scientifically designed monitoring programs based on telemetry are required to identify reasons for failure or success of releases so that future releases can correct problems of the past and replicate successful releases. Currently, monitoring of released condors is required to reduce mortality from lead poisoning because it indicates where (geographic locations), when (season), and from which food sources condors are obtaining lead at various release sites (Hunt et al. 2007; Hall et al. 2007; Sorenson and Burnett 2007) and can identify birds weakened by lead poisoning (Mee and Snyder 2007). Also, monitoring has indicated that the relatively low incidence of lead poisoning in Big Sur condors is associated with their reliance on marine mammals thereby limiting exposure to lead (Sorenson and Burnett 2007). However given the high incidence of pesticides and PCBs in marine mammal tissues, there is a need to determine patterns in, and consequences of, feeding on marine mammals at Big Sur.

Monitoring is also required for detecting problematic behavior of released condors to determine underlying causes so that corrective actions can be taken. For instance, the effectiveness of different captive rearing methods (e.g., puppet-reared, parent-reared) in reducing or eliminating unnatural tameness or attraction to humans and human structures can only be evaluated by close monitoring of released birds (Clark et al. 2007; Wallace et al. 2007b; Mee and Snyder 2007). Monitoring parental movements has identified some sources of microtrash delivered to nestlings (Grantham 2007; Mee et al. 2007a), which has led to cleaning efforts at some trash sources (Mee et al. 2007b; Grantham, pers. comm.). Further reductions in power line mortalities or injuries may be possible by sharing condor movement data and coordinating with the electric utility companies. In central California, the Ventana Wildlife Society is working with PG&E to modify lines by making them more visible (e.g., insulated lines, diverters) or even moving lines to eliminate condor accidents.

There are more radio-tagged condors now than in the wild population of the past, so that more and better data are accumulating on mortality factors (Snyder 2007; Hall et al. 2007; Woods et al. 2007). Identification of mortality factors was one of the justifications for initiating the early releases in the 1990s (Snyder and Snyder 2000). Nevertheless, the cause of mortality is unknown for about 1/3 of the deaths since releases began (Snyder 2007). Improved monitoring has reduced this problem, and the increased use of VHF and GPS transmitters we recommend would improve ability to document mortality events further. Future monitoring also should focus on tracking population dynamics and key aspects of biology such as foraging patterns and resource use (Marzluff et al. 2004) rather than functioning as a form of triage with respect to lead exposure and bird behavior. However, fully implementing these priority studies requires solving the lead problem. Costs will escalate as condor numbers grow, and sustaining the intense level of current monitoring may not be possible. Once the major stresses on condor populations that now exist have been ameliorated, some routine population monitoring activities could be conducted by photographic identification of individual condors (Snyder and Johnson 1985). With the advent of digital photography, photographic identification of individuals has become more cost effective and digital methods eliminate many of the earlier problems associated with film (e.g., Meretsky and Snyder 1992).

Monitoring of reproductive effort and success also is necessary in order to identify factors contributing to reproductive failures so that ameliorative actions can be instituted, if needed, to insure population stability or growth. Although successful breeding has occurred at all release sites except Baja, the presence of breeding trios and divorce of breeding pairs at some sites interferes with reproductive success and may represent unnatural behaviors derived from captive-rearing methods, since such behaviors were unknown in the original wild population (Snyder and Snyder 2000, Mee and Snyder 2007). Whatever the cause of this aberrant breeding behavior, monitoring is needed to determine if the behaviors disappear with breeding experience or with changes in rearing methods as advocated by Mee and Snyder (2007). The intensity of monitoring and frequency of management intervention will vary among sites, depending on nesting success. For instance, at one extreme is intensive nest monitoring and frequent intervention in southern California to counter chick mortality due to ingestion of microtrash and the threat of West Nile Virus. This contrasts with Arizona where nest success has been relatively high (45%) and monitoring is less intensive and nest visits infrequent (Woods et al. 2007). These nest success rates at release sites can be compared to baseline rates from the wild population (Snyder 2007) and combined with reproductive effort and survivorship data in demographic models (e.g., Meretsky et al. 2000) to indicate the likelihood of successful reintroduction at a site.

Managing Population Structure

In addition to addressing specific questions for the species, the condor program suffers from lack of an overall vision for what will constitute a healthy self-sustaining population. Thus, some species-wide population modeling needs to take place in a risk assessment venue so that various hypotheses regarding translocation and reintroduction may be evaluated with multiple stakeholder interests in mind. In essence a detailed recovery target, specifying demographic parameters, numbers and age structure of individuals in multiple populations as well as sustainable and expected amounts of variation is needed. Undertaking such an analysis might be a task for the Science Advisory Team we propose.

The existing release sites for condors represent remote locations in areas of appropriate habitat within the historic range. Initially the birds released at different locations, tied to their nearby supplemental feeding sites, were effectively separate populations. As numbers grow and birds begin to forage more on their own and thus range more widely, the structure of the overall population becomes an important question. As noted above, managers quickly realized that the birds reintroduced at the two release sites in central California, Big Sur and Pinnacles National

Monument, functioned as a single population and have adjusted their management accordingly. But on a larger scale there has not yet been an assessment of the birds' home range, dispersal tendencies, and potential links to release sites other than their own. Therefore, there is no plan for metapopulation development and conservation of the species at the range-wide level. However, detailed movement data, collected via attachment of various types of transmitters, have been collected throughout the course of the program at each release site. Thus, the data are available for analysis and planning, but until recently, there was neither funding nor scientists available to carry out this task. Currently, Matthew Johnson (USGS Forest and Rangeland Ecosystem Science Center) and Jesse Grantham (USFWS) are working on these analyses with the ultimate goal of providing perspective on how to better link existing populations and on where future reintroductions should occur to ensure healthy within and among population structure. Experience with the Eurasian Griffon Vulture illustrates the importance of having a matrix of populations (LeGouar et al. 2008).

We recommend that the utility of current and future release sites be assessed on a metapopulation scale. Developing a range-wide plan to manage population structure and viability will involve evaluation of historic, current and future habitat availability and connectivity. For example, establishment of breeding territories near release sites can necessitate identifying new release sites for existing populations. This was a factor in the decision to open a second release site in central California (i.e., Pinnacles). It may become necessary to develop a more formal process for making such decisions as the program grows and the stakes (i.e., revenue for partners) become greater.

Until the lead problem is resolved we cannot recommend opening additional release sites except in lead-free areas, and few, if any, of these exist. If any new sites are opened in areas where lead ammunition is used, the birds will have to be induced to use supplemental food, monitored intensively for evidence of bad behavior and lead exposure, and regularly trapped and treated for lead poisoning, as they are elsewhere (Meretsky et al. 2000). However, once the lead issue is resolved, additional release sites should be considered. Currently condors are not dispersing into their historic range in the southern Sierra Nevada from the southern California release sites. A Sierra release site identified as a good geographic location previously was rejected because of excessive lead exposure. With the new lead regulations and the recent setting aside of habitat on the Tejon Ranch that links the foraging habitat where the birds are now and the historic foraging areas in the Sierras (see above), this and possibly other sites in the Sierras may now be prime locations for a new release site. We suggest that a site in California's Sierra Nevada be considered as an alternative to Bitter Creek NWR or additional site for southern California, given the problems with Bitter Creek discussed above. However, candidate release sites in the Sierras are distant from abundant nest sites. Perhaps the best goal for these sites is to resolve the lead issue expediently so that the four remaining condors originally captured from the wild, which used to roam this region, could be release there. Additional disjunct sites should be considered as appropriate.

The ability of condors released at Big Sur to locate and feed on marine mammals provides optimism about the viability of additional coastal release sites in similar habitat in northern California and Oregon. However, the contaminant load in these carcasses must be evaluated before sites are selected, as marine mammals are known to bioaccumulate toxins that could be passed on to condors. In northern California, the Yurok Tribe is negotiating with Green Diamond Timber Company (formerly Simpson Timber) to purchase 40,000 acres near the Oregon border as a tribal park where condors could be released in a relatively lead-free zone. This property would link inland forests (and food sources such as elk and deer) with coastal areas, thus provide a good foraging corridor for condors. The tribe is hoping habitat also can be secured close to their tribal park on the Oregon side of the border to provide a wider swath of habitat and more protection for the birds. The Yurok Tribe recently received funds from the tribal Wildlife Program of USFWS to carry out a pre-release assessment of habitat needs, food availability, potential lead exposure, and stakeholder interests within the Yurok Ancestral Territory. A Bureau of Indian Affairs interagency task force and the Tribal Park Task Force will help guide this effort.

Further north in Portland, the Oregon Zoo is interested in participating in a release of condors in Oregon over the next 3-5 years. To that end, they have supported a graduate student in anthropology from Portland State University (David Moen) to identify historic records of condors in the state and document current potential habitat. Supporting modeling work is also being conducted, and the range-wide metapopulation/dispersal analyses described above will be used to determine optimal release sites in Oregon. As mentioned previously, the California Condor Pacific Northwest Scientific Working Group is assessing research that needs to be undertaken prior to the release of birds in Oregon.

To successfully expand the range of condors, future release sites and associated habitat will need to be formally protected as soon as possible. This provides incentive to identify future sites now, even if none will be opened soon. Development is occurring at a rapid pace and the longer it takes to identify and protect potential future release sites the fewer locations with sufficient, well-connected habitat there will be. Potential foraging areas are at risk. Large parcels of land associated with current release sites have been protected, indicating it is possible (although difficult) to protect habitat for new release sites. The Forest Service, BLM, USFWS and a number of tribal groups likely will be important partners in such efforts, and should manage their lands to reduce lead levels.

Disease and Health Management

Effective procedures to monitor and manage the health of the birds, both in captivity and in the wild, have been worked out, and veterinarians within the program have developed written protocols. Monitoring and treating of birds for lead exposure is especially impressive, albeit expensive and labor-intensive. Each zoo maintains a dedicated staff for condor health, and the Peregrine Fund utilizes a local veterinarian as well as a long-term relationship with the Washington State University veterinary faculty. Field teams have contracts with veterinarians and clinical diagnostic laboratories to monitor the health and analyze blood samples for lead and clinical chemistry parameters.

Pathologists at the San Diego Zoo have also prepared written protocols for the handling, shipment and evaluation of dead condors for program participants. While detailed pathology reports are available for most of the condors that have died in captivity or in the wild, we have become aware of two gaps in information. The first involves dead condors that have been seized by USFWS Law Enforcement (LE) personnel as part of ongoing criminal investigations. The second involves the examination of unhatched eggs of both captive and wild origin. These deficits in information need to be corrected. We recommend that the pathology coordinator develop a standardized protocol for submission and evaluation of all unhatched eggs of wild or captive origin. We also suggest close coordination between USFWS LE and the pathologists at the San Diego Zoo to insure consistency in all aspects of post-mortem analyses, including histological examinations and tissue collections. Veterinary and pathology protocols should be reviewed, appropriately revised, and distributed to all program participants annually.

Condors have shown good resilience in captivity, and do not have many health problems in the captive environment. One Arizona free-flying juvenile and one California chick suffered broken wings, which were repaired. Both birds eventually were returned to the wild. Two chicks suffering from trash impaction have been taken from nests, treated surgically to remove the trash and replaced in the nest the following day. Both ultimately fledged successfully. Few health problems other than lead poisoning and West Nile Virus have plagued the program.

We recommend continuing the existing veterinary coordinator position to facilitate information transfer on topics such as vaccines and procedures. The field team meetings have assisted greatly in this information exchange, and should be continued as well, reformed as the Recovery Implementation Team (see above). Addition of a Research and Monitoring Coordinator and data manager to the program will make the veterinary coordinator more effective. One task we recommend the veterinary coordinator undertake is development of general health protocols for the program. These should be carefully reviewed by participating veterinary representatives and updated appropriately.

West Nile Virus. The condor program appointed Dr. Cynthia Stringfield, then a veterinarian at the Los Angeles Zoo, to coordinate the vaccination program for West Nile Virus when this threat hit bird populations on the East Coast in 1999. Dr. Stringfield worked with the Centers for Disease Control to identify the best vaccine to use with condors and other zoo birds (Chang et al. 2007). All captive condors have been vaccinated for West Nile Virus, and protocols are in place to vaccinate all wild chicks before 30 days after hatching and to administer a booster prior to fledging. Effectiveness of the vaccine has been demonstrated by complete protection of the captive flock. The only condors that have succumbed to West Nile Virus were seven birds, including four chicks, at the Peregrine Fund facility in Boise that were not vaccinated. Other birds at the facility became ill, but recovered. Since that event in 2004, all adults and new chicks have been vaccinated at all facilities and all chicks have been vaccinated in accessible nests or when first captured in the wild. One wild chick died in August 2005 in southern California before being vaccinated, indicating that parental transferred immunity will not protect a chick for long, and that chicks must be vaccinated as early as possible after the chicks are 30 days old.

Other Threats. The potential for High Pathogenic Avian Influenza (HP H5N1) could be significant, if the avian flu virus gets imported into the U.S. and infects wild birds and poultry. Vaccines have been produced to immunize avian populations, especially captive zoo collections and endangered species such as condors. The vaccine protocols are managed by the USDA and require federal permits to be employed. To date, no poultry or zoo birds have been vaccinated in the U.S., and no vaccinations are planned unless H5N1 enters the U.S. More information can be found at the University of Minnesota center for Infectious Disease Research and Policy website at http://www.cidrap.umn.edu/cidrap/content/influenza/avianflu/biofacts/avflu.html#_Hosts or the Wildlife Disease Information Node of National Biological Information Infrastructure at: http://wildlifedisease.nbii.gov/diseasehome.jsp?disease=Avian%20Influenza&pagemode=submit

Outreach

Effective outreach programs are a necessity for condor recovery. Outreach builds public support for returning the birds to the wild and helps partners raise the funds they need to continue their contributions to condor recovery. All partners in the condor program are involved in outreach programs that educate the public about condors and highlight issues of concern such as littering (i.e., microtrash) and use of lead ammunition. These materials have ranged from informational websites (e.g., http://www.fws.gov/endangered/i/b0g.html, http://www.sandiegozoo.org/animalbytes/t-condor.html) to outreach videos developed by USFWS and Arizona Fish and Game (http://www.azgfd.gov/w_c/california_condor_lead.shtml) to children's craft projects (http://www.sandiegozoo.org/kids/craft_condor.html). However, outreach is not a core mission for some partners (e.g., The Peregrine Fund). Thus, while partners are active in outreach locally, they look to USFWS for assistance and leadership at the national level. Currently, however USFWS outreach activities are limited. If USFWS is to provide effective leadership in outreach activities this situation must be corrected, and indeed USFWS is seeking to fill a staff position dedicated to outreach. It will also be important to engage the Santa Barbara Zoo in program-wide outreach activities, as this new partner has considerable capability and is willing to commit to a major role in outreach activities.

The prime example of where a national outreach program is needed is the lead issue. We have concluded that condor recovery will not be possible until hunters adopt universally non-lead ammunition, and convincing hunters to support this change and appreciate their important role as a source of food for condors is critical. It will also be important to convince those involved in the hunting business to take the necessary steps to make non-lead ammunition widely and freely available. Hence an extensive outreach effort to rally public support for replacement of lead ammunition, emphasizing human health as well as condors, is an urgent need. An important step forward on this front was put forth by the Peregrine Fund's 2008 conference on Ingestion of Spent Lead Ammunition: Implications for Humans and Wildlife (http://www.peregrinefund.org/lead_conference/default.htm). .

The Arizona Department of Game and Fish outreach program has been highly successful at illustrating the negative effects of lead ammunition and convincing hunters to use copper bullets for deer and elk hunting. We recommend that state wildlife agencies in California, Oregon and Utah participate more actively in outreach and encourage hunting with non-toxic ammunition using programs similar to those in Arizona. Subsidies to hunters for non-toxic ammunition should be implemented in each state. The Arizona model may be an approach to consider as releases are planned for Oregon and other areas as well. Currently, the Cooperative North American Shotgun Education Program (CONSEP) in Klamath Falls, Oregon is working to make Oregon lead-free and there is some interest by Oregon Department of Fish and Wildlife to pursue requirements for non-lead ammunition in the state as well.

The importance of picking up trash to eliminate the threat of microtrash ingestion by condors could be better publicized across the range of the species. Successes of the overall condor program and contributions of partners also could be better publicized. More than 500 people attended the last condor release at Pinnacles National Monument indicating the popular support for the condor program. Viewing condors is one of the top reasons people visit Pinnacles. It is human nature to rapidly disseminate good news, and withhold bad news. Most Americans consider the California Condor Recovery Program to be a success, rather than a work in progress. The public needs to be apprised of the reality of the situation, so that the resources essential for recovery can be secured.

A LOOK TO THE FUTURE

The goal of the condor program is to establish a self-sustaining wild population. If that goal is achieved, the zoos, veterinarians and release site field crews, and most of the current partners, would happily leave the condor business. The intense management, food subsidies and triage activities of today would, hopefully, become a thing of the past. In fact many of the partners acknowledged that this is indeed their long-term vision. That vision may be a while in arriving.

The focus today must be primarily on solving the lead problem, and secondarily the microtrash problem, as currently these are impenetrable barriers between the heavily subsidized populations of today and the self-sustaining populations that are the vision of the future. If these problems are solved, in the heady aftermath of that event it will be easy to be overly optimistic and imagine that recovery is imminent. But it is more likely that, once past the current barriers, the condors will discover new ones, albeit likely less formidable ones. The role of condors as canaries in the vast coalmine of western North America thus may continue. Wind energy and gas and oil development loom as future threats. Changing diseases and global climate change are other possible future issues. The genetic and demographic stability of the captive and wild populations may be another. Still, our review of the condor program leaves us optimistic. We believe that recovery of the California Condor, once almost inconceivable, is possible. Perhaps that is the greatest achievement of the condor recovery program over the past 25 years, to demonstrate the possibility of recovery. But this potential cannot be realized until the lead problem is solved.

Not everyone will agree with this assessment. There are many skeptics who believe the landscape has changed so much that it can no longer support condors. Certainly habitat has changed greatly and many formerly remote areas are now heavily impacted by anthropogenic influences. The mammal community that was the basis of the condor food supply has changed greatly, as has the community of scavengers in which they compete, the addition of feral hogs being a particularly worrisome change in the latter. It is because of this that it will be critical to have hunting throughout the condor range, using non-toxic ammunition, to provide a source of food for the wild birds. There are wild places remaining that appear to be able support condors and interest by many in expanding the wild population. We believe adaptive management provides the means to address whatever news issues that arise, and that there is great hope for recovery of these magnificent creatures.

CONCLUSIONS AND RECOMMENDATIONS

The California Condor has long been symbolic of avian conservation in the United States. Following their extirpation from the wild in 1987, many questioned whether condors could ever be returned to the natural environment. Yet the California Condor Recovery Program, one of the oldest and most complex efforts of its kind in the United States, has achieved success beyond what many imagined possible. Today, in the summer of 2008, there are more than 300 condors, more than 150 of which are in the wild, soaring in the skies of southern and central California, Arizona, Utah and Baja California, Mexico. But the birds survive in nature only through constant and costly human assistance and intervention. Thus the program has reached a crossroads, caught between the financial and logistical pressures required to maintain an increasing number of condors in the wild and the environmental problems that preclude establishment of naturally sustainable, free-ranging populations.

Recognizing this, Audubon California requested that the American Ornithologists' Union (AOU) conduct an evaluation of the California Condor Recovery Program. The AOU convened a Blue Ribbon Panel of independent scientists, appointed as a subcommittee of the AOU Committee on Conservation. The Panel collected information through site visits to captive breeding facilities and release sites, review of literature, interviews in person and by telephone of those involved in the condor program, and solicitation of comments from other interested parties. The following are the primary conclusions and recommendations of the Panel.

Conclusion: Because of the life history of the California Condor as a long-lived species with a low reproductive rate, adult mortality rates must be <10% for populations to be self-sustaining. We conclude that condors suffer lead poisoning from ingestion of spent ammunition in carcasses and gut piles upon which they feed sufficiently frequently to raise mortality rates well above those required for sustainability. The evidence on this point is overwhelming and includes radiographs of lead fragments in sick condors and the carcasses upon which they feed, direct linkages of illness and/or death to feeding on contaminated carcasses, and direct measurements of blood levels indicating acute lead exposure in an alarming number of condors. Alternative hypotheses about causes of mortality and sources of lead exposure, which were plausible only a few years ago, now seem desperate rather than credible. We concur with nearly all of those involved in the condor program with whom we spoke that the species cannot be recovered until the lead threat is eliminated. We conclude that progress toward recovery is not sustainable under current conditions because reintroduction of more condors simply increases the costs required to keep wild birds alive rather than improving the viability of the wild populations. Furthermore, we believe that the longer the lead issue continues to impede progress, the more difficult it will be to sustain the support of existing partners or secure additional support for the recovery program. Early indications are that voluntary programs promoting the use of non-lead ammunition are unlikely to reduce lethal exposure to lead sufficiently, even with excellent compliance. Similarly, the efficacy of area-specific requirements for non-lead ammunition such as the local regulations on the Tejon Ranch or even the state regulations in California, remain extremely uncertain. We therefore conclude that total replacement of lead with non-toxic ammunition at least within the potential range of the condor, and preferably nationally, is necessary (but perhaps not sufficient) for condor recovery. Without such action the reestablishment of viable wild condor populations is improbable.

Recommendation: USFWS needs to generally increase the visibility of its leadership of condor recovery, and specifically do so with respect to the lead issue. We recommend that USFWS work with ammunition manufacturers, state game agencies, and shooting and hunting organizations to spearhead an effort to replace lead ammunition with non-lead alternative ammunitions nationally or at least within the potential range of the condor. State wildlife agencies must be full partners in this effort because of their jurisdiction over hunting regulations. In the meantime, we recommend that portable X-ray equipment be provided to all field crews to facilitate lead monitoring until a successful transition to non-lead ammunition is accomplished.

Conclusion: Hunters are the dominant predators in most of the condor's range. Dead animals and gut piles left by hunters provide important food sources for condors. It is essential that hunters continue to harvest deer, pigs and other wildlife throughout the condor range using non-lead ammunition, so that a clean source of wild food is available to condors beyond food subsidies. This is the only way that condors will be able to be sustained in the wild after food

subsidies are reduced. Therefore eliminating the threat of lead must be accomplished while simultaneously promoting sport hunting for large game and depredation hunting for feral pigs. The levels of lead exposure documented in condors are sufficient to suggest adverse effects on the health of humans who consume game killed with lead ammunition. Removing lead ammunition is not only right for condors, it is right for other scavengers, and it is right for hunters and their families.
Recommendation: Elimination of lead ammunition should not be accomplished by a reduction in hunting, because hunters are critical to the foraging success of condors. Rather replacement of lead ammunition with non-lead alternatives should be implemented immediately. Effects of exposure to spent lead ammunition in humans should be vigorously researched, both to protect human health and to facilitate the conversion to non-lead ammunition at the national level.

Conclusion: The need to protect condors from lead exposure is the ultimate source of other problems that limit reintroduction success. Condors are provided with supplemental food at fixed sites to reduce their exposure to lead incurred while foraging on their own, and to enable managers to trap, test and treat the birds for lead exposure. While providing condors with supplemental food decreases lead exposure, it retards development of normal wide-ranging foraging behavior, alters time and energy budgets, and appears to adversely affect other natural behaviors. Because of the widespread use of supplemental feeding it is not yet clear whether condors could subsist without subsidies in modern landscapes, and this could become the next impediment to recovery beyond lead.
Recommendation: Supplemental feeding must continue until the lead problem is solved, but we endorse efforts to encourage the birds to forage more widely by use of multiple feeding sites at strategic locations. We recommend initiating new research studies to ascertain the capacity of condors to become self-sufficient foragers within the extant landscapes where they are being released.

Conclusion: It is likely that supplemental feeding promotes the development of inappropriate behavior involving attraction to humans and human-built structures because it provides the birds with more time for activities other than foraging. Captive rearing and socialization techniques affect the expression of abnormal post-release behavior as well. Considerable progress has been made in refining captive-rearing and release techniques to produce better behavior, such that inappropriate behavior is no longer an impediment to successful reintroduction, but more work needs to be done. Adult mentors and interaction with wild condors at the release site prior to release have been especially positive innovations. We conclude that parent-rearing generally is more effective than puppet-rearing in affecting more natural juvenile and subadult behavior.
Recommendation: We recommend continued emphasis on parent-rearing while demand for birds for release remains relatively low. However, because puppet-rearing increases the productivity of breeding pairs, development of that technique should continue in order to be able to satisfy increased demand once the lead problem is solved. The close integration between captive and field facilities in managing behavior should continue. We also recommend attempting to improve rearing and release techniques further by making them more closely resemble natural processes of rearing and socialization. We endorse the current effort to evaluate puppet-rearing and group socialization techniques in the current Baja California release, and would hope that a similar experiment would be conducted with parent-reared and parent-

socialized birds if and when such an opportunity arises in a new and separate release area. Additionally, once the lead problem is solved, we recommend the release of established breeding pairs from the captive population. Old birds from the original wild population should be included in these releases since their knowledge could be invaluable in reestablishing traditional seasonal movements and foraging patterns.

Conclusion: The most significant behavioral problem at present is feeding of small items of trash, termed microtrash, to chicks in southern California, which has significantly reduced breeding success there, but has not been an issue elsewhere. We conclude that successful nesting in southern California currently is contingent upon intensive nest monitoring and corrective intervention when needed because of the microtrash problem. We suggest that the most promising avenues to pursue in reducing this problem are: (1) eliminating mictrotrash at sites frequented by condors; (2) returning offending adults to captivity for aversive training, as has been done for other problem behaviors; and (3) promoting more natural foraging patterns in nesting adults. While recent data suggest that the latter may not reduce the frequency of feeding of microtrash by breeders with a tradition of such behavior, extant foraging patterns are still far less than those documented historically.

Recommendation: Ongoing efforts to document and clean up microtrash sites need to be continued. We recommend that experiments with aversive training involving young birds prior to their release and adults that have exhibited feeding of microtrash in the wild be undertaken in captivity as soon as practicable. Additional experiments designed to increase parental foraging time and effort should be undertaken as soon as lead risks can be minimized and addressed.

Conclusion: That condors readily feed on marine mammals in central California is a positive development given that this is a relatively lead-free food source. We conclude, however, that it is quite possible that condors using this food source will accumulate contaminants that will have adverse effects on survival and especially reproduction. We are particularly concerned about the possibility of eggshell thinning due to exposure to DDT and the long-term health effects associated with other toxicants such as PCBs.

Recommendation: We recommend vigorous investigation of the possibility that contaminants acquired by feeding on marine mammals interfere with reproduction among the central California birds. Specialized protocols need to be developed for the collection of the eggs and tissues of condors inhabiting central California in order to assess and monitor contaminants. Testing of samples and results of analyses must be completed in a timely manner.

Conclusion: The condor program includes federal, state and private partners who collectively expend more than $5 million annually. The major partners are the U.S. Fish and Wildlife Service, National Park Service, Los Angeles Zoo, San Diego Wild Animal Park, Oregon Zoo, The Peregrine Fund, Ventana Wildlife Society and Arizona Department of Game and Fish. These partners have developed an effective captive breeding and release program that has produced impressive results and through valiant effort are maintaining growing populations in the wild. Recovery partners are self-organized into a diffuse network, the central elements of which are a large and diverse Recovery Team, a field working group, and a USFWS Condor Recovery Coordinator. We conclude that the current structure of the program reflects past rather than current or future conditions. Specifically within USFWS the program is housed in the refuge office associated with the site of the first releases of captive-bred condors in southern

California and the Condor Recovery Coordinator reports to a Project Leader within this office. But today, the refuges associated with this office represent only a small fraction of the range of the southern California birds, and the coordinator needs to monitor and lead a large program that spans two countries and three USFWS regions. The overly large Recovery Team resembles a stakeholder group in being comprised primarily of active participants in the condor rearing, release, and monitoring programs; it lacks participation of independent scientists outside the program that could bring new vision to the program.
Recommendation: We recommend that the structure of the program be overhauled to better reflect current and future circumstances. Specifically we recommend establishment of a USFWS-funded Condor Recovery Office that works with a Recovery Implementation Team comprised of those organizations raising, rearing, releasing, and monitoring condors. The Recovery Implementation Team should be modeled after the current field working group, which has been very successful. The Condor Recovery Office should be housed in the Sacramento regional office and report to the Deputy Regional Director or an Assistant Regional Director. We suggest that basic programmatic coordination be the duty of the Condor Recovery Coordinator. An additional, senior-level USFWS or USGS staff scientist should also join the Condor Recovery Office as the Condor Research and Monitoring Coordinator. We further recommend establishing a Science Advisory Team, a small, scientifically focused, advisory group composed largely of independent scientists outside of the condor program. This group would take on the responsibilities of the current Scientific Advisory Committee as well as some of those currently performed by the Recovery Team, which should be disbanded. Leaders of organizations that are involved in the condor recovery effort should not be part of the Scientific Advisory Team, but their insights into program management and involvement in recovery implementation are critical to success. We recommend that these participants and the Condor Recovery Coordinator form a Policy Advisory Team.

Conclusion: Although the total expenditures of USFWS on the condor program are substantial, funds for field staff to release and monitor condors at the southern California release sites operated by USFWS are insufficient. Although monitoring requirements there exceed those at other release sites due to the microtrash problem, these responsibilities fall to a small number of temporary employees. Elsewhere they are performed by a larger number of permanent staff.
Recommendation: We recommend that USFWS either support an adequate number of permanent staff in the field positions in the southern California program or instead focus their support on recovery coordination and find partners willing to adequately staff these sites.

Conclusion: Adaptive management requires an effective and continuous integration of research, monitoring and management. Although there is effective feedback between monitoring and management in the condor program, for example in managing behavior, an adaptive management framework that includes research is not evident. This hinders ability to improve understanding of condor biology, and address critical research and management needs.
Recommendation: We believe the new organization including a Research and Monitoring Coordinator and Science Advisory Team we propose will result in more effective use of research in the condor program. We further recommend adoption of a formal adaptive management process that includes research in addressing important issues in the condor program.

Conclusion: Considerable concern about standardization, management and ownership of data exists throughout the condor recovery program. That data management concerns exist is not surprising given the long history of the recovery program, its expansion to include multiple reintroduction sites, organizations, and individuals, and rapidly evolving technologies. We conclude, however, that these problems have reached the point that they seriously impede the effectiveness of the program. Furthermore, there is a great deal of information gathered on condors over the years that needs to be reviewed and organized.
Recommendation: As an interim measure we recommend hiring of a data manager/statistician to work with the proposed Research and Monitoring Coordinator to oversee the existing data and assist in future standardization of data collection, reporting, and storage. Two important initial tasks for this position are to summarize extant data for critical review and evaluation and to develop standardized databases for record keeping for all program participants.

Conclusion: Currently intensive monitoring of released birds is essential to reduce mortality due to lead poisoning and to detect and treat inappropriate behavior. Once these problems are solved, continued monitoring will be needed to track population dynamics and key aspects of biology such as foraging patterns and dispersal.
Recommendation: We recommend that demographic monitoring and evaluation of birds in the wild be continued. As the birds range more widely, it will be increasingly important to integrate monitoring into the adaptive management framework in order to learn about emerging issues such as foraging capabilities, connections between populations and contaminant levels. We also recommend that intensive nest monitoring be continued in southern California until the behavior of feeding microtrash to chicks is extinguished.

Conclusion: As the number of wild condors grows and birds begin to range more widely, the structure of the overall population becomes an important question. Currently there is no plan for metapopulation development and conservation of the species at the range-wide level. Among the current release sites, the southern California site is the least sustainable.
Recommendation: We recommend that the utility of current and future release sites be assessed on a metapopulation scale in order to develop a range-wide plan to manage population structure and viability. We cannot recommend releasing condors at new sites at this time due to the lead issue. However, once this issue is resolved, additional release sites should be considered. We recommend that a site in California's Sierra Nevada be considered as an alternative to Bitter Creek NWR or additional site for southern California, especially for release of the four remaining condors originally captured from the wild. Additional disjunct sites should be considered as appropriate.

Conclusion: Condors have shown good resilience in captivity, and do not have many health problems in the captive environment. Effective procedures to monitor and manage the health of the birds, both in captivity and in the wild, have been worked out, and veterinarians within the program have developed written protocols. Although thorough protocols for processing dead condors exist, there are two gaps in information: (1) dead condors that have been seized by USFWS Law Enforcement as part of ongoing criminal investigations; and (2) examination of unhatched eggs.
Recommendation: We recommend continuing the existing veterinary coordinator position to facilitate information transfer on topics such as vaccines and procedures. Addition of a Research

and Monitoring Coordinator and data manager to the program will make the veterinary coordinator more effective. One task we recommend the veterinary coordinator undertake is development of general health protocols for the program. We recommend the pathology coordinator develop a standardized protocol for the submission and evaluation of all unhatched eggs of wild or captive origin, and closer coordination between USFWS Law Enforcement and the pathologists at the San Diego Zoo to insure consistency of post-mortem analyses. Veterinary and pathology protocols should be reviewed, appropriately revised, and distributed to all program participants annually.

Conclusion: Effective outreach programs are a necessity for condor recovery. Program partners are active in outreach locally, but they look to USFWS for assistance and leadership at the national level. An extensive outreach effort to rally public support for replacement of lead ammunition, emphasizing human health as well as condors, is an urgent need.
Recommendation: We recommend that USFWS provide leadership in outreach at the national level, especially with respect to the lead issue. We also recommend that state wildlife agencies in California, Oregon and Utah participate more actively in outreach and encourage hunting with non-toxic ammunition using programs similar to those in Arizona. Subsidies to hunters for non-toxic ammunition should be implemented in each state. It is human nature to rapidly disseminate good news, and withhold bad news. Most Americans consider the California Condor Recovery Program to be a success, rather than a work in progress. The public needs to be apprised of the reality of the situation, so that the resources essential for recovery can be secured.

Conclusion: Our review of the condor program leaves us optimistic. We believe that recovery of the California Condor, once almost inconceivable, is possible. Perhaps that is the greatest achievement of the condor recovery program over the past 25 years, to demonstrate the possibility of recovery. But this potential cannot be realized until the lead problem is solved.
Recommendation: Resolve the lead issue and move forward.

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We thank all the participants in the condor program with whom we spoke or who otherwise provided us with information for being so generous with their time and experiences, and so candid in their assessments and suggestions. We had wonderfully informative and exciting experiences at all the sites we visited, thanks to the excellent planning and hospitality of program staff. Because of this conducting this review has been a great pleasure for all of us. We have listed those individuals with whom we had formal interviews and conversations in Appendix 2, but each of us individually met and spoke with many others in informal settings during various events at the sites we visited. We apologize for not being able to acknowledge all of these

individuals personally, and assure each of you that your input was valued and has contributed meaningfully to our review.

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The cover photo is by Susan Haig.

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APPENDIX 1: AOU BLUE RIBBON PANEL CHARGE

The California Condor Blue Ribbon Panel will use the following as the basis for its work including an initial problem statement as well as specific tasks the Panel might accomplish.

The California Condor recovery program has not been formally and thoroughly reviewed for over twenty-five years. In that time, much has been learned about the biology and behavior of condors and a great deal of experience accumulated about effective breeding, release, and field monitoring methods. However, the recovery program continues to operate with a recovery plan widely acknowledged to now be outdated. The program has not had the opportunity to rigorously assess and synthesize accumulated knowledge and experience with the benefit of objective outside expertise. As a result, the program is lacking a realistic and scientifically rigorous foundation for planning on a timeframe spanning the next ten to twenty-five years. Therefore, the Blue Ribbon Panel has been assembled with the following goals:

- To collect, review, and synthesize knowledge and experience about condor reproduction, rearing, foraging, mortality, and other aspects of the species' life history and ecology with the goal of characterizing the relative degree of consensus and/or uncertainty about each
- To assess and prioritize the relative importance of physiological, behavioral, and ecological factors in terms of their potential to limit the species' potential for recovery and sustainability
- To recommend scientific research, including controlled field experiments and population dynamics modeling, needed to resolve or bound remaining key uncertainties about factors affecting the condor's recovery
- To review key operational aspects of the recovery program and recommend changes needed to improve the effectiveness, value, quality, and validity of the practices employed and the data generated by research and monitoring
- To assess the organizational and funding structure and the management function of the recovery program and recovery team, and to recommend changes needed to improve the program's overall effectiveness and value
- Based on all of the above, to reassess the program's fundamental goals and recommend needed changes.

APPENDIX 2: SOURCES OF INFORMATION

Individuals Interviewed in Person
Bob Risebrough, Chair of Scientific Advisory Committee
Walter Mansell, California Rifle and Pistol Association

USFWS
Chris Barr, Deputy Project Leader
Joseph Brandt, Temporary Field Biologist
Diane Elam, Regional Endangered Species Recovery Coordinator
Jesse Grantham, California Condor Program Coordinator
Paul Henson, Assistant Regional Director for Ecological Services
Michaela Koenig, Temporary Field Biologist
Marge Kolar, Refuge Chief
Ken McDermond, Deputy Regional Director
Ivett Plascencia, Office Automation Clerk, Hopper Mountain NWR
Richard Posey, CA Condor Recovery Program Field Supervisor
Mike Stockton, Refuge Manager for Bitter Creek NWR
Marc Weitzel, Project Leader

Bureau of Land Management
Ed Lorentzen, Endangered Species Coordinator

California Department of Fish and Game
Ron Jurek, Retired Supervisory Game Warden
Dale Steele, Program Manager

US Forest Service
Art Gaffrey, Director of Ecosystem Conservation

Arizona Game and Fish
Kathy Sullivan, Condor Project Coordinator

The Peregrine Fund
Tom Cade, Founder
Eddie Feltes, Field Manager
Bill Heinrich, Species Restoration Manager
Grainger Hunt, Senior Scientist
Peter Jenny, President
Lindsay Oaks, Veterinarian
Chris Parish, Condor Field Director
Cal Sandfort, Propagation Specialist
Randy Townsend, Propagation Specialist
Rick Watson, Vice President

Ventana Wildlife Society

Joseph Burnett, Senior Biologist
Kelly Sorenson, Executive Director

Pinnacles National Monument
Jim Petterson, Supervisory Wildlife Biologist
Scott Scherbinski, Biologist
Alacia Welch, Biologist

San Diego Wild Animal Park
Don Janssen, Associate Director of Vet Services
Mike Mace, Curator of Birds
David Remlinger, Curator of Birds at San Diego Zoo
Bruce Rideout, Pathologist
Don Sterner, Condor Keeper
Mike Wallace, California Condor Recovery Team Leader

Los Angeles Zoo
Mike Clark, Condor Handler
Cathleen Cox, Director of Research
Chandra Davis, Condor Handler
Leah Greer, Veterinarian
Curtis Ing, Veterinarian
Susie Kasielke, Curator of Birds
John Lewis, President
Janna Wynn, Veterinarian

Santa Barbara Zoo
Estelle Sandhaus, Conservation and Research Coordinator

Oregon Zoo
Jane Heartline, Director of Marketing
David Shepardson, Director of Conservation
Shawn St. Michael, Curator of Birds
David Moen, PSU graduate student in anthropology working on CACO history in
Tony Vechio, Director

Pacific Gas and Electric
Mike Best, Bird Protection Program Manager

Individuals Interviewed by Conference Call
Bob Stine, CEO and Don Geivet, Tejon Ranch Company
Steve Thompson, Regional Director, USFWS
Noel Snyder
Cynthia Stringfield
Kathy Ralls
Lloyd Kiff

Allan Mee
Keith Day and Jim Parrish, Utah Division of Wildlife Resources
Jesse Grantham, California Condor Program Coordinator, USFWS

Individuals Submitting Written Comments
Nancy Sandburg, U.S. Forest Service
Steve Ferry, Santa Barbara Audubon
Don Smith, UC Santa Cruz
Eduardo Peters, Instituto Nacional De Ecología, Mexico
Michael Moore, Camp Roberts
Brian Sharp
Tice Supplee, Arizona Audubon
Dick Dasmann, Arroyo Grande Sportman's Club

Pre-assessment Phone Interviews by Brock Bernstein
Mike Wallace
Chris Barr
*Dave Clendenen
*Jan Hamber
Ron Jurek
Lloyd Kiff
Mike Mace
Allen Mee
Jim Petterson
Noel Snyder
Kelly Sorenson
*Bill Toone
*individuals with whom the Panel did not subsequently interact