

Part 4

Conservation Models for Raptors of the World



Madagascar Fish Eagle *Haliaeetus vociferoides*

Conveners:

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The California Condor Recovery Programme

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ABSTRACT

Relatively widespread over North America through the late Pleistocene, the California Condor has been a rare bird throughout its recorded history. Despite much habitat preservation, research, education, and enforcement measures, it steadily declined in numbers for nearly 200 years, reaching a low point of 21-22 birds in 1983. Losses were due almost entirely to direct human persecution, primarily shooting and indirect anthropogenic causes, including lead and possibly other forms of poisoning. In 1980 a "hands-on" management programme was initiated by the United States Fish and Wildlife Service and the National Audubon Society. Wild birds were equipped with radios to determine causes of mortality and to identify critical habitat, breeding behaviour was studied intensively, and several eggs, young, and adults were taken to zoos to establish a captive breeding programme. Despite efforts to sustain the wild population, the species suffered a disastrous decline in the winter of 1984-85 to only one known breeding pair, and authorities decided to trap the last free-flying individuals for their own security and to add them to the captive breeding programme. The last free-flying individual was brought into captivity on 19 April 1987. The first successful captive breeding was accomplished in 1988, and productivity of the captive flock has increased annually since then at breeding facilities at the San Diego Wild Animal Park, Los Angeles Zoo, and World Center for Birds of Prey. The first releases of captive progeny occurred in 1992. Subsequently, 16 releases have been conducted at four sites in California and two in Arizona. By the end of 1998 there were 147 condors in existence, including 42 in the wild (22 in Arizona and 20 in California) and 105 in captivity. As a result of the aggressive management programme, the total condor population has increased by seven times since the early 1980s, and there is increasing hope that this unusual species can be saved from extinction.

INTRODUCTION

The California Condor *Gymnogyps californianus* has always been rare in modern times. Judging from fossil evidence, it was more common and widespread in the Pleistocene, ranging eastward all the way to Florida (Brodkorb 1964) and New York (Steadman & Miller 1987), but by historical times it occurred only along the Pacific Coast from British Columbia south to northern Baja California Norte, Mexico (Koford 1953). Following the arrival of European man on the Pacific Coast about 200 years ago, condor numbers and range declined even more precipitously, almost entirely because

of anthropogenic factors. As recently as the 1970s, many writers began predicting the California Condor's certain and imminent demise. However, an aggressive management programme begun in 1980 may yet save it. Knowledge gained from both the positive and negative aspects of the programme might be useful to persons attempting to save other problem species.

BACKGROUND

Early history of condor research and management

The first detailed study of the California Condor of any kind was conducted by the wildlife photographers William Finley and Herman Bohlman at Eaton Canyon, Los Angeles County, California in the spring of 1906. The four-part account of their exploits at a condor nest and the behaviour of the nestling, which they took into captivity, still makes fascinating reading (Finley 1906, 1908a, 1908b, 1910).

There was little formal attention paid to the species until three decades later when Cyril S. Robinson, a British-born employee of the U.S. Forest Service, made a pioneering field study of the roosting and feeding habits of condors in the Los Padres National Forest, mostly in Santa Barbara County, California, between 1936-40 (Robinson 1940). The first actual governmental land management action on behalf of the condor was the establishment of the 1,198-acre Sisquoc Condor Sanctuary by the U.S. Forest Service in 1937 at the urging of local rancher-conservationist Robert E. Easton and the National Audubon Society (Koford 1953). The sanctuary area included an important condor roost, nest sites, and bathing pool. In a sense, the condor management era began with this event, since the sanctuary was henceforth closed to public entry without permit.

At about the same time, a prominent amateur ornithologist and wildlife film maker from Pasadena, California, J.R. "Bill" Pemberton, began efforts to film condors in the Sespe area of Ventura County, California. He interested John Baker, president of the National Audubon Society, and Joseph Grinnell, a professor at the University of California at Berkeley and the leading ornithologist in the state, in the idea of supporting a graduate student to conduct a comprehensive study of the California Condor under Grinnell's direction. With financial support from Pemberton and the National Audubon Society, thanks to Baker's efforts, Carl Koford was assigned by Grinnell to the project, and he conducted a landmark study of the species and its breeding behaviour between 1939-46 (Koford 1953). Koford worked mainly in the back country of Ventura County, and his findings led to the establishment of the 35,000-acre Sespe Condor Sanctuary, which was enlarged to 53,000 acres in 1951 (Wilbur 1978). In his 1953 monograph, Koford (*op cit.*) estimated that the total condor population consisted of only 60 individuals, although he privately admitted that this was a conservative figure and that the population might contain as many as 100 birds (Koford *in litt.*).

Condor numbers continued to decline, however, and the National Audubon Society commissioned a short-term assessment of the status of the population in 1963-64 by two California conservationist ranchers, Ian and Eben McMillan. Their findings, which were published with the collaboration of Alden H. Miller of the University of California, Berkeley (Miller *et al.* 1964), suggested that the condor population had declined to 40 birds.

In 1965, Fred C. Sibley became the first U.S. Fish and Wildlife Service biologist charged with studying the condor population with the specific assignment of predicting the effects of a proposed dam on Sespe Creek, which flows through the Sespe Condor Sanctuary, on the species.

Also in 1965, the National Audubon Society hired John Borneman as a "condor warden," armed only with a strong sense of public relations and a finely developed sense of humour. The U.S. Forest Service soon had its own condor biologist, Dean Carrier, and his assignment was to prepare a condor management plan for the vast Los Padres National Forest, which, by then, comprised a large portion of the condor's range (Carrier 1971). Carrier's position was maintained between 1968 to 1973.

Sibley's assignment lasted for four years, and his conclusion that the dam would likely have a disastrous impact on the condor population (Sibley 1969) coincided with the defeat of the project by the local electorate. During his tenure, Sibley, Robert D. Mallette (California Department of Fish

and Game), and Borneman, initiated an annual survey of the condor population, which was held for two days each October from 1966 to 1980 and involved the participation of 50-100 trained observers (Mallette & Borneman 1966). The combined results of several surveys indicated that the total condor population was between 50-60 individuals between 1966-70 (Wilbur 1978) and confirmed what many had suspected, i.e., that the population estimate of the McMillans (Miller *et al.* 1964) was probably too conservative.

Sanford R. Wilbur followed Sibley as the U.S. Fish and Wildlife Service condor biologist in late 1969, and he held that position until 1980. During this entire period, he was the only U.S. Fish and Wildlife Service employee assigned to the condor "programme." Wilbur produced a monographic account on the species, including an exhaustive bibliography (Wilbur 1978), and made detailed studies on condor food resources (Wilbur 1972), plumages (Wilbur 1975), and population status (Wilbur *et al.* 1972, 1976). He also collaborated in a study of DDE-induced eggshell thinning in condors (Kiff *et al.* 1979), conducted supplemental feeding experiments near the Sespe Condor Sanctuary (Wilbur *et al.* 1974), and made several expeditions to the Sierra San Pedro Martir, Baja California Norte, Mexico in a fruitless attempt to confirm the existence of condors in that range (Wilbur & Kiff 1980). Finally, he organized the First International Symposium on the Vultures, co-sponsored by the Western Foundation of Vertebrate Zoology and held at the Santa Barbara Museum of Natural History in 1979. The proceedings appeared as a major book on Old and New World vulture biology and conservation (Wilbur & Jackson 1983), and the symposium greatly facilitated collaboration between vulture researchers on several continents.

As a part of the Federal mandate to recover condor populations, a "California Condor Recovery Team" was established in 1972. Consisting of five members, representing the four government agencies cooperating in the programme, plus the National Audubon Society, the Team prepared a recovery plan for the species (U.S. Fish and Wildlife Service 1974). It was formalized in 1975, the first of its kind ever approved by the U.S. Fish and Wildlife Service. The plan was heavily oriented toward protecting condor habitat as a means of saving the species.

Habitat protection, nest protection, and enforcement had been the themes of condor recovery for many years, yet the trends in the annual survey results and the complete disappearance of condors from areas where they had occurred regularly up until very recent years indicated that the species was continuing to decline. By the late 1970s, Wilbur (1978) estimated that the total condor population consisted of no more than 50, and possibly as few as 40, individuals. By now, even some biologists were predicting the inevitable extinction of the California Condor.

CALIFORNIA CONDOR RECOVERY PROGRAMME

Modern management era

Reacting to the increasingly hopeless situation, Richard Plunkett, then vice-president of the National Audubon Society, proposed enlisting the help of the American Ornithologists' Union to convene a panel of experts from various subdisciplines of biology to consider the situation and suggest steps that might be taken to save the condor. Following several meetings, the panel, headed by Robert Ricklefs, soon recommended that a vigorous condor management programme be set into motion immediately. The principal ingredients of the such a programme were to include radio tracking to obtain information on causes of mortality and critical habitat, detailed behavioural observations of birds in the wild, especially at the nest, and, if necessary, captive breeding (Ricklefs 1978). This amounted to an endorsement of a draft "California Condor Contingency Plan," prepared by the Condor Recovery Team in 1976 under Sanford Wilbur's direction and approved by the U.S. Fish and Wildlife Service in 1977, that had also recommended captive breeding and other "hands-on" actions (U.S. Fish and Wildlife Service 1996).

The appearance of these reports gave momentum to the establishment of the Condor Research Center, situated in Ventura, California, by the U.S. Fish and Wildlife Service (USFWS) and the National Audubon Society in 1980. Noel F.R. Snyder was chosen to serve as the USFWS condor

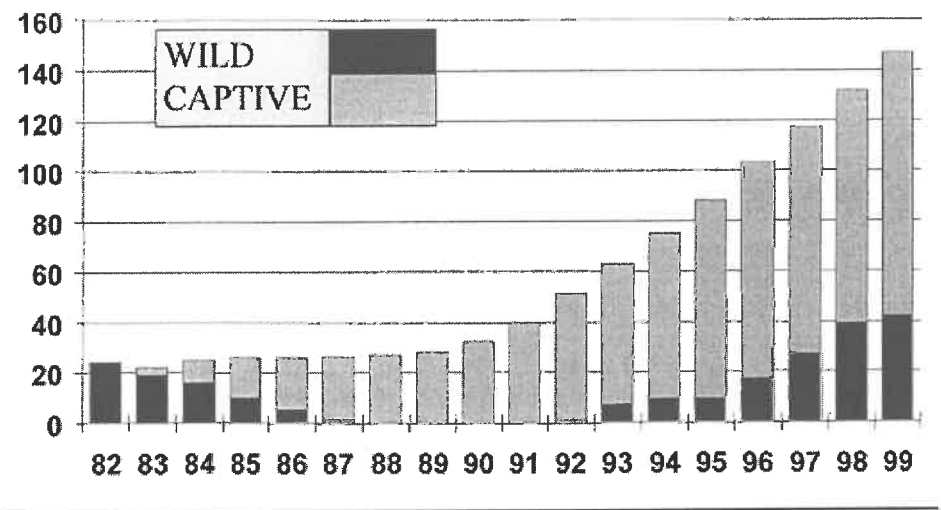
biologist, replacing Wilbur, and John Ogden was placed in charge of the National Audubon Society portion of the programme. The California Department of Fish and Game also maintained a condor biologist position between 1982 to 1989.

A division of labour was determined early in the programme, and Ogden’s crew focused on the identification of critical habitat, while Snyder’s group located nests and made observations of birds throughout their breeding cycle. In May 1980 Federal and State permits authorizing the capture of a condor for captive breeding and equipping 10 wild condors with radiotelemetry devices were approved, but they were rescinded in the following month when a condor chick died while being examined by a field team from the Condor Research Center. After nearly two years of hearings and difficult negotiations, the California State Fish and Game Commission granted permission for researchers to place radios on condors, and nine individuals were eventually tagged by the NAS field crew. Partly as a device to capture birds, the NAS group engaged in supplemental feeding of condors on large ranches where they were known to forage. Captured birds were weighed, blood samples taken, and equipped with patagially-mounted radio transmitters with bold numbers specific to each individual.

Up until this time, the perennial problems in condor management included (1) obtaining an accurate estimate of the number of birds still in existence, (2) understanding the actual range of the species and identifying critical habitat, and (3) identifying causes of mortality.

Noel Snyder and Eric Johnston developed a novel technique to answer the first question (Snyder & Johnston 1985). They censused the population by comparing the distinctive wing patterns, produced by differential patterns of feather loss and replacement, of individual condors from photographs. Based on analyses of hundreds of photographs from all parts of the condor’s range, they concluded that the wild population consisted of only 22 birds in 1982 (Fig. 1). This was the lowest number of California Condors in the recorded history of the species. It was also the first time that the entire condor population had ever been accurately counted down to the last individual, a feat that would not have been possible with conventional observational techniques.

Figure 1. Condor Populations since 1982



Building on the years of information about condor movements compiled by Koford, the McMillans, Sibley, Wilbur, and the annual October surveys, the NAS crew obtained a much better understanding of the current range of the condor by following radioed birds with fixed-wing aircraft and on the ground. In addition, simply having more condor observers in the field led to increased

understanding of the whereabouts of the birds. It was obvious that the effective range of the species had declined greatly since the early 1970s with a particularly conspicuous decline in the number of birds recorded in the coastal mountains north of Santa Barbara County. Meretsky and Snyder (1992) integrated data from the radiotelemetry studies and the photographic survey, reporting that individual condors occasionally travelled more than 200 km, visiting all portions of the still vast condor range in a single day.

Despite the size of the birds and the prominence of the recovery programme, surprisingly little is known about the causes of condor mortality, even in recent times. Shooting was probably by far the most frequent cause of condor losses historically, but such incidents were also more likely to come to the attention of condor chroniclers, especially since many shot birds were saved as museum specimens (Wilbur 1974, 1978). Other known causes of condor losses historically included killing condors for Indian ceremonial use, capturing birds for sport or for pets, egg collecting, and accidental deaths, including striking man-made objects (Koford 1953, Wilbur 1978). Poisoning from various agents may have been a major problem at certain times and places in the condor's history, but convincing documentation of such episodes is surprisingly lacking. Severe DDE-induced eggshell thinning occurred in the condor population during the 1960s, and probably earlier (Kiff *et al.* 1979), but after the banning of DDT use in the United States in 1972, the incidence of thin-shelled eggs declined almost immediately. Inexplicably, two badly thinned eggs were laid by a single female in 1986 (Kiff 1989), but by then this phenomenon was no longer a problem for the condor population as a whole.

Partly as a result of the radiotelemetry programme, the cause of death of three wild condors in the 1980s was shown to be from a previously undocumented cause - lead poisoning (Snyder & Snyder 1989). The birds had apparently ingested lead bullet fragments or lead shot from shot deer or other carcasses within their range in sufficient amounts to cause their deaths. This finding had implications for the past, present, and future of the species. As for the past, this could have been the cause of death of several condors reportedly found sick and unable to fly (Koford 1953). Based on an admittedly small sample size, it was the major cause of condor losses during the 1980s, when the most intensive field studies were made of the species. In the western United States, where hunting and carrying guns are jealously guarded privileges, the incidence of shooting on the open range does not seem likely to decline soon, so lead poisoning could still figure prominently in the future of the condor. Unfortunately, only one of the six birds lost from the wild flock in the winter of 1984-85 was radioed, and the other birds were never found, so the actual causes of their deaths remains unknown.

Snyder and his associates made detailed observations at condor nests, adding greatly to the information provided earlier by Koford (Snyder 1983, Snyder *et al.* 1986, Snyder & Snyder 1989). Following other difficult negotiations with state officials, the team was finally allowed in 1983 to begin taking wild-laid eggs for hatching in captivity in an effort to gradually build up a captive breeding flock. It had already been confirmed that California Condors, like the related Andean Condors, would lay replacement clutches (Harrison & Kiff 1980, Snyder & Hamber 1985), and biologists took advantage of this behaviour to double- and sometimes triple-clutch wild pairs. From 1983 to 1985 15 eggs were taken from the wild and incubated at the San Diego Wild Animal Park with hatchability of 86.7% and a survival rate of 92.3% (Kuehler & Witman 1988, Kuehler *et al.* 1991). The overall condor population began to increase for the first time in recorded history, following the low point in 1981-82 (Fig. 1).

Even though the number of birds in the wild continued to decline (Fig. 1), the situation was looking more hopeful by the fall of 1984, when it seemed possible that there could be as many as five breeding condor pairs in the coming breeding season (Toone & Wallace 1994). Unexpectedly, however, six out of the remaining 15 wild birds (40% of the entire wild population) were lost in the winter of 1984-85, and the number of known breeding pairs was reduced to one. This prompted USFWS officials to recommend in the fall of 1985 that the last remaining individuals be captured for their own security and to bolster the captive flock. Since the principal problem for the condor has always been excessive adult mortality, this was one way of reducing it, i.e., bringing the birds into captivity where they were safer. The plan was strongly opposed by the NAS, who obtained an

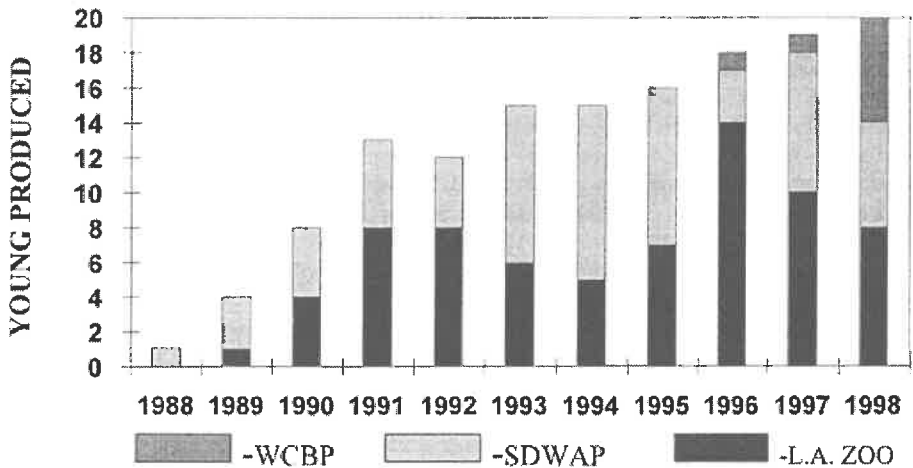
injunction to block capture of the birds, but the USFWS position, which was supported by the majority of condor biologists, prevailed in court in June 1986. The last free-flying condor, a male bearing the tag "AC-9" (= adult condor no. 9), was captured on Easter Sunday, 19 April 1987.

Captive breeding:

When AC-9 was brought into captivity, the captive flock totalled 27 birds, including 10 captured as free-flying individuals between 1967-87, 13 from eggs laid in the wild and hatched in captivity between 1983-86, and 4 removed from the wild as nestlings between 1982-86. Fortuitously, the sex ratio was about even among the 27 birds. The flock was about evenly split between two facilities, one at the San Diego Wild Animal Park at San Pasqual, California and the other at the Los Angeles Zoo. A third major breeding facility was established in 1993 at the World Center for Birds of Prey in Boise, Idaho.

Captive breeding was first accomplished in 1988, when a pair of wild-caught condors at the San Diego Wild Animal Park produced a chick christened "Molloko" (Toone & Risser 1988). Four young were produced in the following year, and chick production of the captive flock has increased annually (Fig. 2), albeit more slowly than anticipated.

Figure 2. Captive California Condor breeding production



DNA fingerprinting analyses revealed that the captive condor flock included 14 founders from three "clans" in which the between-group relatedness seemed to be significantly less than the within-group relatedness (Geyer *et al.* 1993). The implication for condor managers is that the founder gene contributions of the subgroups are more important than the contributions of individual founders. These considerations weigh heavily in determining pairs of the captive birds, which are computer-model generated to maximize heterozygosity in the progeny. There is already known to be a lethal gene within the population that causes embryonic skeletal dysplasia (M. Wallace *in litt.*). Since the homozygous gene responsible is possessed by both members of one of the most productive pairs, it led to greatly reduced egg success in this pair before the cause was determined.

From 1988 to 1998 226 eggs were laid by the captive flock. Of these eggs, 167 (73.9%) were fertile, and 141 (84.4%) hatched. A high rate of infertility among first-time breeders and the effects of the aforementioned deleterious gene account for most of the non-hatching. Of some interest has been the high frequency of egg laying in January, far earlier than any recorded historically in the wild (Snyder & Hamber 1985, Harvey *et al.* 1996), and breeding attempts by five-year old birds

(one successful) and even one four-year old bird. Previously, the age of first breeding in the species was thought to be six years, when the full adult plumage is attained, or later (Koford 1953).

Reintroduction to the wild

Following the capture of the last free-flying California Condor in 1987, the Condor Recovery Team recommended the initiation of an experimental release of the similar Andean Condor in southern California to refine condor release techniques, test the criteria being used to select release sites, field test condor rearing methods, identify potential problems peculiar to the California environment, evaluate radiotelemetry packages and other equipment, and train a field crew for anticipated California Condor releases (U.S. Fish and Wildlife Service 1996). Between 1988 to 1991, 13 yearling female Andean Condors were obtained from several U.S. zoos and released from three different sites in the vicinity of the Sespe Condor Sanctuary area (Wallace 1991). Only one of the 13 birds, an individual that struck a power line, was lost during the experiment. Following their recapture, the female Andean Condors were sent to Colombia and Venezuela to be re-released in areas where males of the same age had been released earlier (Lieberman *et al.* 1991). The surrogate release experiment was judged to be highly successful, and it helped the condor recovery programme and habitat protection efforts to maintain momentum during the period when California Condors were not in the wild.

In October 1986 the Condor Recovery Team established several criteria to be satisfied before a release of captive-bred California Condors could take place. These included having three actively breeding pairs of condors, three chicks behaviourally suitable for release, and retaining at least five offspring from each breeding pair contributing to the release (U.S. Fish and Wildlife Service 1996). In June 1989, a provision was added to retain a minimum of seven progeny in captivity for founders that were not reproductively active.

By 1991, several years earlier than originally predicted, two of the captive-produced chicks met these criteria. Although the aforementioned criteria had called for a minimum of three eligible birds, it was decided to go ahead and seize the earliest opportunity to conduct a release, using two Andean Condor young of the same age to create a larger social group. The first release of captive-reared California Condors occurred on 14 January 1992 in the Sespe Condor Sanctuary, when "Xewe" (a female) and "Chocuyens" (a male) were set free. The Andean Condors were returned to captivity in September 1992, officially marking the end of the experiment with the species in California. Chocuyens was found dead on 8 October 1992, having died from ingesting ethylene glycol, a principal component of anti-freeze, which the bird probably found in a campground parking lot.

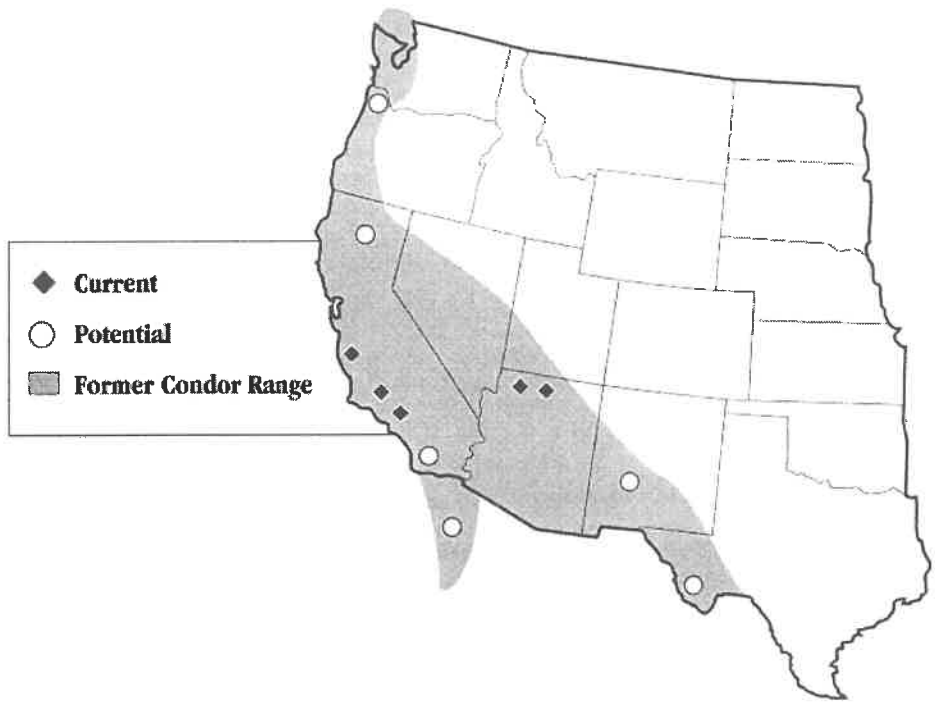
Other releases soon followed, however, with six more condors being released on 1 December 1992 at the same Sespe Condor Sanctuary site. By the end of 1998, 16 separate releases of captive-produced California Condors had been conducted at six localities in two states (Fig. 3, Tables 1, 2). The Arizona releases were finally initiated in 1996 by The Peregrine Fund, eight years after the recovery team had recommended such an action and following years of contentious public hearings, lawsuits, and negotiations between a myriad of governmental agencies and Native American tribes.

The Condor Recovery Team established a protocol for the selection of release sites, and it includes such criteria as remoteness (but with sufficient access for the field team), protection from mammalian predators, availability of suitable roost sites and water, historical condor use, and proper wind conditions for soaring. Not least, areas have been selected where local community support for releases exceeds local opposition, although all of the release sites are on land owned by the Federal government. Part of the overall strategy in adding new release sites has been to find localities that are sufficiently disjunct from earlier sites to allow the new birds to develop their foraging and flight skills without interference from older birds, yet close enough to expect that birds from separate release sites will eventually meet and, over time, incorporate the interstitial areas into their effective ranges.

Although there has been quite a bit of variability in release procedures, depending as much (or more) on political factors as biological ones, the main ingredients have remained the same: Birds selected for release are usually raised together in a specially designated pen at one of the breeding facilities for four-five months (equivalent to their normal nestling period) or less, then helicoptered to the release site, where they are held in an open pen covered with netting for a period ranging from

only two weeks to three months, during which the birds become acclimatised to their surroundings and further socialize with each other. During this period of confinement, they are provided with unlimited food, using techniques to minimize the association of food with humans. The actual release is initiated by the removal of the netting from the enclosure during nighttime, so that the birds are free to leave the pen when they choose. Most birds have been released at about the age when they would have left a nest site normally, but members of one cohort were not released until well into their second year.

Figure 3. Condor Release Sites



Released birds are provided with food (stillborn dairy calves) at designated feeding sites, which are moved from time to time, as long as they continue to utilize such sources. Although released birds have tended to begin feeding to some extent on items they have found on their own after about two years in the wild, all still depend mostly on the food provided to them by biologists. This assures them of a contaminant-free food source, and at least in the early months following release, it encourages them to remain in the more secure area near the release site. It is probable that this species will always utilize such “vulture restaurants” to some extent in the future, depending on the seasonal availability of “natural” food sources (including livestock).

The released birds in California have not proved to be particularly more mobile than the historical condor population, but, as might be expected, they tend to wander more widely as they grow older. As a part of the recovery process, the original Condor Recovery Team designated critical habitat in various portions of the vast (>2 million hectares) recent historical range of the species, and it has been gratifying to see the released birds gradually begin to reoccupy many of these areas. Certain of the individuals released at the Vermilion Cliffs in Arizona have routinely moved widely throughout the region from southern Utah to the central portion of the Grand Canyon. One bird even wandered

as far north as Flaming Gorge, Wyoming, located on the Colorado River, before returning to its release site, a distance of 560 km (S. Farry pers. comm.). Three others also moved north along the channel of the Colorado River to Grand Junction, Colorado, where they spent several days in the vicinity of a park visitor's centre. They returned to the release site, nearly 400 km SW, in less than a day (S. Farry *op cit.*).

Table 1. History of California Condor releases, 1992-1998.

	<i>Male</i>	<i>Female</i>	<i>Unknown</i>
Sespe Condor Sanctuary, Ventura Co., California:			
14 January 1992	1	1	
2 December 1992	2	4	
Lion Canyon, Santa Barbara Co., California:			
8 December 1993	3	2	
8 February 1995	5	1	
29 August 1995	1	7	
19 November 1996	2	2	
14 November 1997	1	3	
Castle Craggs, San Luis Obispo Co., California			
13 February 1996	2	2	
Ventana Wilderness Area, Monterey County, California:			
19 January 1997	3	1	
12 December 1997	3	2	
Vermilion Cliffs, Coconino Co., Arizona:			
12 December 1996	2	4	
14 May 1997	2	2	
27 May 1997	3	2	
20 November 1997	4	4	
23 November 1998	1		
Hurricane Ridge, Coconino Co., Arizona:			
18 November 1998	3	2	2

Table 2. Summary of California Condor release results, January 1992-December 1998 (compiled by Robert Mesta, U.S. Fish and Wildlife Service)

Total releases	16
Total condors released	75
Total died 19	
Losses in wild:	
Collisions with power lines	5
Drowned	2
Cause unknown*	2
Poisoned	1
Electrocuted on power line	1
Killed by Golden Eagle	1
* One possibly killed by coyote	
Disappeared and presumed dead:	4
Recaptured & died in captivity:	
Malnutrition	1
Cancer	1
Gunshot wound	1
Total recaptured for behavioural reasons	14
Total surviving in wild	42
Percent of released birds still in wild	56

Early in the release programme, the birds were attracted to power poles as perch sites, and this led to several fatal collisions with power lines. To address this problem, Michael Wallace, Los Angeles Zoo Curator and also the Condor Recovery Team Leader, placed fake power poles in the pens where the birds were held prior to release, wiring them so that birds landing on these structures received mild electrical shocks. Judging from the fact that only one bird has been lost subsequently from striking a powerline and that none have been recorded attempting to perch on power poles since this technique was initiated, the method seems to have worked.

The principal problem for the release programme, and one not yet solved, is the tendency for many of the birds to be drawn to human structures and activities. This has resulted in many bizarre episodes involving released condors and humans, much to the concern and frustration of the field crews following the birds. In California, some birds have tended to land on the roofs of houses and other structures, where they have torn out insulation and caused other property damage, even to vehicles. In Arizona, the birds have been attracted to the camps of fishermen along the Colorado River, where they have torn up tents, sleeping bags, and other gear. All of these behaviours seem to derive more from the curiosity of the condors and their natural tendency to play, rather than from hunger. While some episodes are initially entertaining, they eventually annoy the general public, especially the victims of condor vandalism, and they erode support for the recovery programme.

In an effort to discourage such behaviour and to make condors warier, some of the earlier release cohorts were subjected to various forms of "aversive conditioning," or systematic harassment, by the Los Angeles Zoo staff. Some biologists have also strongly favoured parent rearing of the birds to be released over puppet rearing, arguing that such individuals remain warier of humans in the wild (see discussion in Wallace 1994). Empirically, however, there seems to have been little correlation between these earlier experiences in the zoo setting, and the eventual behaviour of birds once they are released. The pressure to release as many birds as possible, regardless of their provenance, in an effort to establish the species in the wild as soon as possible has precluded rigorous field testing of rearing methods. Regrettably, the tendency of some individuals to be constantly attracted to anthropogenic situations has forced condor biologists to recapture 14 of them and remove them from the wild permanently (Table 2).

The results of the releases to the end of 1998 are summarized in Table 2. It is encouraging that there is no primary cause of mortality, especially now that the incidence of collision with power lines has been minimized, and it is also encouraging that only one of the birds has been shot. Only about 25% (19 of 75) of the released birds have actually died, and including the birds recaptured and returned to captivity for behavioural reasons as losses, survival of the released condors has been 56%. This is remarkably good for the early, still experimental years of such a programme, and, if this rate of success can be maintained or improved, it is likely that the condor can be successfully re-established in several regions.

One ominous undercurrent of the release programme is that several birds have been recaptured and brought back into captivity because of elevated lead levels in their blood. They were subjected to chelation treatment to reduce the lead levels, apparently recovered, and were re-released to the wild. In the opinion of the attending veterinarian (C. Stringfield pers. comm.) the birds would not have survived without such treatment. One bird has suffered two such episodes, yet is now back in the wild. In one instance, several condors were actually observed feeding on a deer gutpile that was suspected to contain lead bullet fragments, and they were soon trapped by the field team. Blood analyses confirmed that the birds had alarmingly high lead levels. There is some hope that there will be a general conversion to safer non-lead alloys for bullets in the near future, aided by a push from the U.S. military establishment. Short of the abandonment of lead as the bullet of choice by hunters and other shooters in open country, this factor remains a serious threat to wild condors.

Additional release sites being credibly considered or suggested (in descending order of probability) are in Baja California Norte, Mexico (Sierra San Pedro Martir), New Mexico (Ladder Ranch), various portions of northern California, and San Diego County, California (Fig. 3). The Condor Recovery Team has formally recommended that releases be conducted at the first two sites. Other areas, including the Channel Islands off southern California, the Columbia River Gorge of Oregon, and the Big Bend area of West Texas have also been suggested.

Present situation and future directions

The condor recovery programme is unusual among rescue efforts of this type in that both the captive and wild populations are being built up in parallel, and, so far, this strategy seems to be working. By the end of 1998 there were 147 condors, including 105 in captivity and 42 in the wild (Fig. 1), a seven-fold increase in the population since the low point of 1982. From this standpoint the recovery programme has been remarkably successful. Some of the older birds (now five years old) released in California are beginning to form pair bonds and engage in adolescent versions of courtship displays (R. Mesta pers. comm.). Successful breeding by condors in the wild is the last remaining proximate milestone, short of establishing a completely self-sustaining population, always the ultimate goal of the recovery programme.

According to the most recent revision of the California Condor Recovery Plan (U.S. Fish and Wildlife Service 1996) "the minimum criterion for reclassification to threatened is the maintenance of at least two non-captive populations and one captive population. These populations (1) must each number at least 150 individuals, (2) must each contain at least 15 breeding pairs and (3) be reproductively self-sustaining and have a positive rate of population growth. In addition, the non-captive populations (4) must be spatially disjunct and non-interacting, and (5) must contain individuals descended from each of the 14 founders."

The most serious remaining obstacles to achieving these objectives, as I see it, are: (1) Increasing the rate of captive breeding, which has never approached the level theoretically possible, (2) solving the problem of condor attraction to humans and areas of human activities in the wild, and (3) solving the problem of lead use in the range of the condor. Of probable future concern are (1) the possibility of additional deleterious genes appearing in the population, (2) habitat loss in some regions, and (3) political opposition to the condor recovery programme and endangered species programmes in general, resulting in the withdrawal of essential government support.

Funding the programme has always been a problem. It costs The Peregrine Fund about \$2,000/year to maintain each individual condor (W. Burnham pers. comm.), so merely maintaining a captive population of at least 150 individuals would cost \$300,000 annually at that rate. Indeed, some (e.g., Tom Cade) are questioning the wisdom of keeping 150 or more condors in captivity indefinitely. Perhaps eventually the captive flock could be dispersed to many zoo facilities so that the financial burden could be shared by more organizations and more educational opportunities could be created. The field efforts are also quite expensive, since the programme is still at the level where biologists attempt to monitor the whereabouts of each individual. With time and more birds in the wild, this intensive level of management can probably be reduced without harm to the overall wild population.

In the meantime, the condor recovery programme can only survive through the partnership of private sector organizations like The Peregrine Fund and the Zoological Society of San Diego and governmental entities, especially the Los Angeles Zoo and the U.S. Fish and Wildlife Service. Above all, it is the continued success of the programme that maintains broad public interest and support, without which this species would have little hope of survival.

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