Augmenting Wild Populations and Food Resources

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Juan José Negro and José Hernán Sarasola
Estación Biológica de Doñana CSIC
Avda de María Luisa s/n, Pabellón del Perú 41013 Sevilla, España

John H. Barclay
Albion Environmental, Inc.
1414 Soquel Avenue, No. 205, Santa Cruz, CA 95062 U.S.A.

INTRODUCTION

Many populations of raptors, including several in North America, have substantially declined or currently exist at levels that merit population augmentation (Stattersfield and Capper 2000; see below). **Augmenting wild populations** has been defined as *"increasing a population whose numbers have been reduced"* (Barclay 1987). We retain that definition and continue to separate population augmentation into (1) techniques that take advantage of a population's ability to increase by its own reproductive efforts, and (2) those that involve adding individuals from outside of the population.

Management programs must be based on an understanding of the life history of the species in question and a thorough assessment of the conservation status of the population. They should include research to identify factors that have contributed to reducing the population, and an evaluation of whether the population is likely to respond favorably to management attempts. What follows is based on the assumption that there is sufficient information about the life history of a species, including its past and present conservation status, to select and employ effective management techniques; and that any critical limiting factors will not nullify input from population-augmentation techniques.

Raptors are long-lived species that produce relatively few fledglings when they attempt to breed (Newton 1979). In species with this demographic strategy, adult survival is the life-history trait that contributes most to population growth (Lande 1988). In other words, even small changes in adult survival rates may have a larger impact on the persistence of populations over time than, for example, breeding success (Hiraldo et al. 1996). Keeping in mind that the best strategy to augment a raptor population is to enhance adult survival, we have to acknowledge that this parameter may not be amenable to human alteration, and that productivity can become the only parameter susceptible to improvement. As this is often the case, we have focused on management techniques aimed at increasing productivity.

REPRODUCTIVE MANIPULATION

"A population can be increased by manipulating [its] reproductive biology, i.e., increasing the number of young produced by each breeding pair so these individuals will eventually contribute to the breeding segment of the population" (Barclay 1987). Below we discuss various methods for population augmentation in order of their place in the reproductive cycle.

Clutch Manipulation

Consider a situation in which fertile eggs of a nesting population hatch below the normal rate due to eggshell thinning or other causes. Historically, this occurred in some populations of Bald Eagles (*Haliaeetus leucocephalus*), Ospreys (*Pandion haliaetus*), and Peregrine Falcons (*Falco peregrinus*) as a result of pesticide contamination (Hickey and Anderson 1968, Ratcliffe 1970, Anderson and Hickey 1972, Jefferies 1973, Peakall 1976, see Chapter 18 for details). In such situations, vulnerable thin-shelled eggs can be removed shortly after the start of incubation and replaced with artificial eggs, so that incubation continues. The real eggs are incubated artificially and the young produced are returned to the nests (Fyfe and Armbruster 1977, Burnham et al. 1978, Engel and Isaacs 1982). The overall production of young obtained should be higher than if the original eggs had been left with the pairs (Cade 1978, Fyfe et al. 1978, Spitzer 1978). This method has been used successfully with Peregrine Falcons (Burnham et al. 1978, Fyfe et al. 1978, Walton and Thelander 1983, Cade and Burnham 2003) and Bald Eagles (Wiemeyer 1981, Engel and Isaacs 1982).

A variation of clutch manipulation involves transplanting eggs from a population that is producing uncontaminated eggs to one where hatching success is low (Bennett 1974, Armbruster 1978, Burnham et al. 1978). Whole clutches can be relocated or single eggs can be removed from selected pairs. Care should be taken to ensure that transplanted eggs placed in the same nest have had about the same amount of incubation so some degree of hatching synchrony is maintained. Egg relocations have been successful with Ospreys (Spitzer 1978), Prairie Falcons (*F. mexicanus*) and Peregrine Falcons (Walton 1977, Armbruster 1978). Translocations of Bald Eagle eggs have been less successful, particularly when using eggs produced by captive pairs, and overall, egg transplants are not effective for managing Bald Eagle populations (Wiemeyer 1981, Engel and Isaacs 1982).

The technique of forced renesting or "double clutching" also can be used to increase productivity. Initial clutches of eggs are removed early during incubation and are not replaced with artificial eggs. Removal of an entire clutch early in incubation usually results in the production of a replacement clutch, which is left in place for the pair to incubate. The initial clutch is incubated artificially, and the young raised from these eggs are returned to the population by fostering or hacking (techniques discussed in the next section). This technique has the potential of doubling the productivity of manipulated pairs (Monneret 1974, 1977; Kennedy 1977, Burnham et al. 1978, Fyfe et al. 1978, Cade 1980). This technique requires careful monitoring of the nesting pairs to determine when to remove the first set of eggs. It is used routinely in captive breeding of raptors to increase annual production of young, and from this work it appears that the best time to remove the first eggs is after about one week into incubation. Bird and Laguë (1982a,b,c) provide details of the influence of forced renesting on captive-breeding American Kestrels (*F. sparverius*).

Management programs involving manipulation of incubation behavior should not be considered unless technical resources and expertise in incubating raptor eggs and rearing their young are available. If such a technique seems applicable, we recommend that a small number of pairs, perhaps two or three, be tested first, so that field logistics and other details involved in handling live eggs can be worked out. If the resources are available, this technique offers the greatest potential for increasing the productivity of a nesting population.

If a population of nesting pairs is producing fertile eggs with normal hatching success and the technical resources to incubate eggs and rear young are not available, then it is better to defer from any management involving egg manipulations. The nestling stage is the next part of the reproductive cycle in which techniques can be applied to increase productivity.

Brood Manipulation

The number of young reared to independence can be augmented by increasing brood size to the normal maximum for a species. This has been done with species that experience death of young nestlings due to fratricide (aka siblicide or cainism). Brood size is reduced to one by removing nestlings at an age before sibling rivalry develops. These young are hand-reared and then returned to the nest at an age beyond which fratricide is likely. Another alternative is to place the removed young in a duplicate nest separated physically by a barrier, and allowing the parents to raise both young. This variant, called "siblicide rescue" (Cade 2000), has been applied mostly in large eagles, and allows the weaker young, the so-called biblical "Abel" to be separated from its sibling "Cain," during the period during which sibling attacks are most likely to occur.

When an outside source of young to "foster" to breeding pairs is needed to increase the number of young reared to fledging, additional young can come from other wild populations or from captive breeding projects (Cade 1980, Wiemeyer 1981). Nestlings can be removed selectively from breeding pairs in a population that can withstand such harvest, and then placed in nests in the population to be augmented (Spitzer 1978). The optimum time for these translocations varies with the species, but is usually about mid-way through the nestling stage. Burnham et al. (1978) recommended placing Peregrine Falcon nestlings into nests when they are 2 to 3 weeks of age. Young that no longer require brooding and are at the stage where they start to tear their own food from prey delivered to the nest are the best candidates for such translocations (Fyfe et al. 1978). Care should be taken to ensure that the translocated young are about the same age as the young with which they are placed (Wiemeyer 1981). Close observations should follow the translocations to ensure that the fostered young are accepted by the adults and that enough food is being delivered to provide for the entire brood. Broods should not be increased if there is any indication that local prey availability might be inadequate to enable the adults to provide for additional young. Nor should they be increased above the normal maximum for the species unless "supplemental feeding" is feasible (see below).

In some populations, there will be local differences in prey availability and feeding rates by different nesting pairs, which often is reflected in locally lower brood sizes and production of fledged young (Newton 1979). The technique of translocating and fostering young can be applied in these situations by reducing brood size in areas with low prey availability, and placing removed young into nests in areas where prey availability and feeding rates are higher.

The technique of fostering captive-reared young to nests containing young of the same age also can be used to augment a population. When using captive-reared young for fostering, one should consider how they have been raised and whether they will respond appropriately to their foster parents (Cade 1980, Wiemeyer 1981). Ideally, captive-reared young to be used for fostering should be raised by conspecific parents so they will adjust easily to their eventual "wild" parents. In cases where this is not possible, young should be placed into foster nests at an earlier age. Captive-reared young that have been hand-raised to an advanced age should not be used for fostering in wild areas. It also is advisable to place the young in the surrogate nest early in the day to allow time to thoroughly evaluate the behavior of the adults. In the event the fostered young are not being fed or accepted, the researcher should remove them, return them to the captive breeding facility or a raptor rehabilitation facility, or, perhaps, place them in another nest.

DEMOGRAPHIC SUPPLEMENTATION

Cross-fostering

Cross-fostering consists of placing young of one species into the nest of another species. Many raptors have been cross-fostered, either in captivity or in the wild (Bird et al. 1985). There always is a risk though, that cross-fostered individuals will become imprinted upon the surrogate parental species. If this occurs, the former choose individuals of the latter species as mates. In captive experiments using American Kestrels and Common Kestrels (*F. tinnunculus*), females made "mistakes" (i.e., chose a mate of the wrong species) about half of the time (D. Bird, unpubl. data). Successful breeding with the correct species though, has been observed in captive-raised Peregrine Falcons fostered into nests of heterospecific raptors in both California (B. Walton, unpubl. data) and Germany (C. Saar, pers. comm.). There are no current raptor management programs based on cross-fostering in the wild so far as we know. However, there have been attempts to use cross-fostering to develop phylopatry of the foster parents to a particular nesting locale. A pair of Ospreys that had lost their clutch and were at risk of leaving the area was kept in place by introducing Black Kite (*Milvus migrans*) nestlings into the nest (M. Ferrer, pers. comm.). In this case, the focus of management was the adoptive parental Ospreys, not the kites. Cross-fostered kites were immediately adopted and, whether they became imprinted to the Ospreys was not of immediate concern, as Black Kites were abundant locally. In Montreal, Canada, American Kestrel nestlings were successfully fostered to a nest of Peregrine Falcons to maintain their breeding interest in the nest site until peregrine nestlings could be exchanged for them (D. Bird, unpubl. data).

Hacking

Hacking, the controlled release of young raptors into the wild, is the most frequently used technique to reintroduce or augment raptor populations (Sherrod et al. 1981). Nestling raptors raised in captivity or in wild nests are translocated alone or in small groups of three to five individuals to the hacking site. The hacking site generally consists of a wooden or metal tower with a large enclosure at the top constructed in such a way as to provide the birds with a view of their surroundings. For some time, individuals are fed in the enclosure, without seeing their handlers. At about the natural fledging time for the species, the front of the enclosure is opened and the birds inside have the opportunity to fly freely and explore the surroundings. Food continues to be provided in the enclosure for some time after it has been opened, and released individuals often stay in the area for weeks or months before dispersing or migrating. This technique has been successful in many situations, including the reintroduction of Ospreys in the U.S. and United Kingdom; Bald Eagles in the U.S.; Bearded Vultures (*Gypaetus barbatus*) in the Alps; Red Kites (*M. milvus*) in the United Kingdom; Peregrine Falcons in the U.S., Sweden, and Spain; and Lesser Kestrels (*F. naumanni*) in Spain (Table 1).

For the migratory and colonial Lesser Kestrel, a species in which colonies seem to grow due to conspecific attraction (Serrano and Tella 2003, Serrano et al. 2004), the hacking procedure has been combined with the use of captive individuals that serve to lure back the hacked individuals at the end of their return migration in the spring. We know of four independent hacking projects in Spain that have created new colonies of Lesser Kestrels using this technique. Intriguingly, a hacking project in the city of Sevilla in southern Spain where no live birds were placed failed to establish a breeding colony at the hacking site after several years and the release of more than 150 hacked individuals, some of which were observed as breeders in nearby colonies.

SUPPLEMENTAL FEEDING

Historically, supplemental feeding has not been particularly successful (Archibald 1978). Early attempts to increase breeding output by supplemental feeding did not work as expected in both White-tailed Eagles (*H. albicilla*) (Helander 1978) and California Condors (*Gymnogyps californianus*) (Wilbur 1978). Clutch and egg sizes and hatching success did not differ between Burrowing Owl (*Athene cunicularia*) pairs supplemented and those not supplemented during incubation (Wellicome 2000). However, Burrowing Owl pairs supplemented during the nestling stage raised more young, suggesting that supplemental feeding was more effective at that stage (Wellicome 1997). On the other hand, Newton and Marquis (1981) found that supplemental feeding increased clutch size for Eurasian Sparrowhawk (*Accipiter nisus*).

Supplemental feeding may be used to increase the likelihood of raptors breeding in certain locales. It also can be used at critical periods of the breeding season to increase productivity. These efforts are not to be confused with the controversial practice of putting out food to attract raptors for ecotourists. To date, scavenging species have been supplemented with food more often than has been done with predatory raptors (Knight and Anderson 1990). Most of these species in which supplemental feeding has been used as a management technique are highly social and numerous such that large numbers can be fed simultaneously by placing dead animals or meat scraps in designated feeding stations. Often used to enhance populations of carrion-eaters such as vultures, such stations have been referred to as "vulture restaurants" (see below). This management technique also has been used with territorial predatory species such as the endangered Spanish Imperial Eagle (*Aquila adalberti*), in which case both dead prey and live animals, including rabbits (*Oryctolagus cuniculus*) are placed or released in open-top enclosures. In addition, the re-establishment of wild populations of susliks (*Citellus citellus*), a colonial ground squirrel, in mountainous regions in Hungary, has helped support breeding pairs of Saker Falcons (*F. cherrug*) and Asian Imperial Eagles (*A. heliaca*) (Bagyura et al. 1994).

Vulture Restaurants

In many places, traditional sources of food for many populations of vultures and other scavengers have declined dramatically in the last 100 years. Wild ungulates that once provided food for vultures in the western U.S., Africa, and Asia, are now absent or severely diminished in many places (Mundy et al. 1992). Changes in livestock management and traditional stock-raising practices (e.g., pastoralism versus intensive production) also have reduced the availability of domestic livestock carcasses. More recently, outbreaks of mad-cow disease in Europe and the measures adopted by government agencies, such as the incineration of dead livestock from farms, has led to a reduction in food availability for scavenger species (Tella 2001). On the Indian subcontinent, the use of the anti-inflammatory drug, diclofenac, to treat cattle has led to the near extirpation of several species of vultures (Oaks et al. 2004). Supplemental feeding thus has evolved as a common

Table 1. Management techniques employed to restore populations of 24 species of birds of prey in North America, Europe, and Africa (after Cade 2000).

Species	Fostering	Cross-fostering	Hacking	Release
California Condor (*Gymnogyps californianus*)			X	
Andean Condor (*Vultur gryphus*)			X	X
Osprey (*Pandion haliaetus*)			X	
Red Kite (*Milvus milvus*)			X	
Bald Eagle (*Haliaeetus leucocephalus*)	X		X	
White-tailed Eagle (*H. albicilla*)			X	
Bearded Vulture (*Gypaetus barbatus*)			X	
Griffon Vulture (*Gyps fulvus*)				X
Cinereous Vulture (*Aegypius monachus*)			X	X
Montagu's Harrier (*Circus pygargus*)			X	
Northern Goshawk (*Accipiter gentilis*)			X	X
Harris's Hawk (*Parabuteo unicinctus*)	X		X	X
Common Buzzard (*Buteo buteo*)			X	
Harpy Eagle (*Harpia harpyja*)			X	
Spanish Imperial Eagle (*Aquila adalberti*)			X	
Golden Eagle (*A. chrysaetos*)	X		X	
Lesser Kestrel (*Falco naumanni*)	X	X	X	
Mauritius Kestrel (*F. punctatus*)	X		X	
Seychelles Kestrel (*F. araeus*)				X
Aplomado Falcon (*F. femoralis*)			X	
Eurasian Hobby (*F. subbuteo*)	X		X	
Bat Falcon (*F. rufigularis*)			X	
Lanner Falcon (*F. biarmicus*)			X	
Peregrine Falcon (*F. peregrinus*)	X	X	X	

management practice aimed at supporting vulture populations that are threatened by declining food resources.

Supplemental feeding also has been used to provide a contaminant-free food resource in areas where poisoning is suspected (Terrasse 1985), and as a way to supplement essential nutrients lacking in depauperate natural food resources (Friedman and Mundy 1983).

Feeding sites should be located to minimize human disturbance and to assure high visibility of food and easy flight access for participants (Knight and Anderson 1990). Stations may be placed at a site that allows researchers an unobstructed view of feeding individuals, facilitating the monitoring of activities at the site (McCollough et al. 1994).

The amount and type of carrion, as well as its frequency of replenishment should vary according to the target species involved and its population characteristics. Friedman and Mundy (1983), for example, estimated that 500 kg of carrion per day are needed to maintain a population of 1,000 Cape Vultures (*Gyps coprotheres*). When determining the daily amount of carrion needed, consideration should be given to seasonal changes in daily energy requirements of the target species (i.e., during breeding [when adults are feeding nestlings] or during winter when metabolic needs increase due to declines in temperature). Carrion provided at feeding stations can come from carcasses of game species (Wilbur 1974, Knight and Anderson 1990, McCollough et al. 1994) or from surplus livestock (Friedman and Mundy 1983, McCollough et al. 1994). The frequency of food supplementation, the amount of food provided during each feeding, and the size of the carcasses may depend on the targeted scavenger species and the age-class that is to be supplemented. For example, Meretsky and Mannan (1999) found that small carcasses favored visits of adult Egyptian Vultures (*Neophron pernocterus*), which dominated younger birds during feeding bouts. These authors suggested use of small carcasses (e.g., chickens) to feed small vulture species when other non-target vulture species that specialize in larger carcasses are present in the area.

A special type of vulture restaurant for the Bearded Vulture — a scavenger that feeds mainly on large bones that are broken when carried aloft and dropped on rocks — consists of the bones of large domestic animals and wild ungulates. Twenty-six "official" Bearded Vulture restaurants are currently maintained in the Spanish Pyrenees, for a population of about 90 breeding pairs of this species (Carrete et al. 2006). Large and small feeding points differ in the number of birds that they attract. Large supplementary feeding points (n = 5) are provided artificially with >5,000 kg of lamb legs each year, and as many as 80 birds may congregate there during early spring. On the other hand, small supplementary feeding points (n = 21) may see only 6–12 birds at once because the food supply is intermittent and less abundant (<3,000 kg of legs of lambs at year). Bone restaurants also have been established in the French Pyrenees, and on the Mediterranean islands of Corsica and Crete, each of which supports populations of fewer than 10 pairs of Bearded Vultures (Godoy et al. 2004). Nevertheless, there are suggestions (Carrete et al. 2006) that supplementary feeding in the Pyrenees should be reviewed given that its usefulness in reducing pre-adult mortality has yet to be proved, and its effect on productivity is negative due to density-dependent effects.

When choosing a location for a vulture restaurant, several things should be kept in mind. First, opportunistic mammalian scavengers, including foxes, wolves (*Canis lupus*), and dogs (*C. familiaris*) may visit the restaurant and be "supplemented" as well. A feeding site originally devised for supplementing a breeding population of Cinereous Vultures (*Aegypius monachus*) in southern Spain, for example, attracted a group of about 1,000 young Griffon Vultures (*G. fulvus*), which were not present in large numbers before.

In Spain, a large network of vulture feeding stations is in place, most of which are maintained by different regional governments or non-governmental organizations. Special permits are required to operate a vulture feeding station in Spain. In most regions, stations are fenced off to deter mammalian scavengers, are located far from water courses that may become contaminated with infectious agents, and are situated in open areas that enable landings and take-offs. Sites near human settlements are discouraged. Few attempts have been made to evaluate how much food is available through feeding locations versus other sources (but see Donázar and Fernández 1990). However, the combination of food provisioning, an increase of both large-game populations and free-ranging domestic animals such as cattle, horses, and sheep, along with poison-control measures are fostering an explosive growth of several populations of vultures in the country. In the last two decades, numbers of Griffon Vultures in Spain have increased from fewer than 12,000 breeding pairs to more than 30,000, establishing themselves as the densest *Gyps* population in the Western Palearctic.

Supplemental Feeding During Breeding

Attempts to increase reproductive success by supplemental feeding have been successful for several species of raptors. A 2-year supplemental feeding program in the Sespe Condor Sanctuary in California that used carcasses of California mule deer (*Odocoileus hemionus*) apparently increased the productivity of California Condors in the area (Wilbur et al. 1974). The creation of artificial feeding sites near the most productive areas of Egyptian Vultures in the Italian peninsula has been proposed as the most effective way to stop declining populations there (Liberatori and Penteriani 2001). In Catalonia, northeastern Spain, breeding pairs of Bonelli's Eagle (*Hieraaetus fasciatus*) have been supplemented with domestic chickens (J. Real, pers. comm.). Spanish Imperial Eagles with a history of low breeding success currently are being supplemented across their breeding range in Spain (González et al. 2006). In the latter instance, birds are provided with carcasses of domestic rabbits on elevated platforms or on high, visible branches of trees within the eagles' territory every two days for broods of three nestlings, and every four days for broods of two nestlings. Feeding begins a few days after hatching and stops when the young have fledged. Platforms are inaccessible to carnivores and carrion-eating mammals such as red foxes (*Vulpes vulpes*) and dogs.

NEST-SITE IMPROVEMENTS

Protecting Natural Nests

Raptors, particularly those using stick nests in trees, may suffer from losses of eggs or nestlings if the nest falls or collapses due to wind, storms or because the branches can no longer support the weight of the nest. Sometimes it is necessary to prevent damage of the nest or its contents by securing the nest using supports or reinforcing the branch or branches carrying the nest. If a tree or branch containing a raptor's nest falls with nestlings still in it, the parents of some species may still provide care to the nestlings placed in a hand-made nest in a nearby tree. This procedure has been used successfully with Black-winged Kites (*Elanus caeruleus*) (R. Sánchez-Carrión, pers. comm.) and Spanish Imperial Eagles (Ferrer and Hiraldo 1991) in southern Spain.

Occasionally, managers may need to translocate a nest because it is situated on a power line or located in a place not conducive to successful nesting. A nest of Peregrine Falcons was successfully translocated from one skyscraper to another skyscraper a few blocks away by removing the fertile eggs for artificial incubation and placing a set of fake eggs in the desired nest site. Once the female resumed incubation of the fake eggs, her real clutch was returned to her (D. Bird, unpubl. data). Osprey nests containing young have been successfully shifted from utility poles to artificial nesting poles (Ewins 1994).

Artificial Nest Sites

Wooden, plastic, and concrete boxes have been used for many cavity-nesting species, including kestrels and owls (Hamerstrom et al. 1973, Collins and Landry 1977). These species readily accept nest-boxes and numerous researchers have taken advantage of this to carry out long-term studies of birds using them (Korpimäki 1988, Dijkstra et al. 1990, Smith and Belthoff 2001, Bortolotti et al. 2002).

Breeding raptors often use artificial structures, including power pylons and utility poles, to support their nests. For such species, nesting platforms can be used to increase nest availability. A large number of falcons, hawks, and eagles, have bred on such platforms (see Bird et al. 1996). The construction of artificial platforms, along with the implementation of other management practices, has been responsible for the successful increase of Ospreys in U.S. from 1981 to 1994 (Hougthon and Rymon 1997).

For species that nest in the abandoned nests of other species (e.g., Great Grey Owl [*Strix nebulosa*]) and Saker Falcon; Bull et al. 1988), this management technique is particularly useful, not only for increasing bird populations, but also for maintaining stable populations.

Numerous publications and web sites describe different models suited for every species. Readers are referred to details in Giron Pendleton et al. (1987), Ewins 1994, Dewer and Shawyer (2001), and Smith and Belthoff (2001).

PREDATOR PROTECTION AT NESTS

The Case of the Mauritius Kestrel

In the 1970s, with only two known pairs surviving in a patch of remnant native forest of approximately 4,000 ha on Mauritius Island, the Mauritius Kestrel (*F. punctatus*) was the most endangered bird of prey in the world (Cade and Jones 1993). Conservation and management actions taken since that time have included most of those presented in this chapter, including the use of artificial nest boxes, food supplementation at the nest, fostering and captive breeding (Jones et al. 1991). Together, these efforts resulted in one of the most impressive population recoveries of a critically endangered species anywhere. By 1993–1994, the population of Mauritius Kestrels reached 222–286 individuals with an estimated 56–58 pairs having established territories in the wild (Jones et al. 1994).

A common threat for island fauna is the introduction of exotic predators that become the dominant predators of indigenous species, and thus regulate the latter's populations. In the case of the Mauritius Kestrel, eggs, nestlings and recently fledged young were vulnerable to introduced black rats (*Rattus rattus*), mongooses (*Herpestes auropunctatus*), and feral cats (*Felis catus*) (Cade and Jones 1993). An important component of the Mauritius Kestrel conservation program has been intensive trapping of these predators in release areas and in breeding territories to safeguard kestrel nests (Jones et al. 1994). Predator control included both live trapping and the use of poisons. Although the effectiveness of this management practice has yet to be evaluated, it is believed to have reduced predation on kestrels in some areas (Jones et al. 1991).

Nest-guarding

The goal of nest-guarding is to protect the nests of target species from depredation by both wildlife and humans as well as from natural disturbances (e.g., flooding of nesting cavities) by actively monitoring individual nests. Nest-guarding has been employed successfully in conservation programs for the Saker Falcon in Hungary (Bagyura et al. 1994), where the number of young fledged in warden-protected nests was almost twice that of nests of routinely monitored nests (2.55 versus 1.66 young, respectively). And indeed, 12 breeding pairs that had consistently failed during preceding years, bred successfully during the 1986–87 breeding season. Based on their experience with Saker Falcons, Bagyura et al. (1994) remarked on the importance of 24-hour nest-guarding. Depending on the behavior and habits of potential nest predators, many nest predation episodes take place at night and cannot be prevented if monitoring is conducted sporadically or even intensively but only during the day.

Nest-guarding programs also have been established to protect cliff-nesting Egyptian Vultures from human disturbance in the Italian peninsula (Liberatore and Penteriani 2001). Human disturbance near nest sites during the incubation period has been responsible for about 8% of vulture breeding failure. Protecting nest sites and supplemental feeding likely has helped to stop the decline of vulture populations there since the early 1990s.

An alternative management strategy is to establish buffer zones around raptor nests aimed at protecting nests from the effects of recreational activities, human development, or habitat management activities. In this case, care and protection of the nest site, although passive, can be as effective as active guarding to stop nest losses for some species. The size of the buffer zone depends both on site-specific considerations and the species involved (Postovit and Postovit 1987, Richardson and Miller 1997).

RELEASE OF REHABILITATED INDIVIDUALS

Each year, thousands of birds of prey are recovered from the wild and placed in rehabilitation centers and wildlife refuges. Many of these individuals eventually are released into natural habitats and, although this practice may not lead to the recovery of wild populations, not releasing them can be detrimental to these populations. Between 15,000 and 26,000 birds of prey are received and treated in 65 recovery centers in Spain annually, and about half are returned to the wild (Fajardo et al. 2000). Individuals released from rehabilitation centers can be used to augment wild populations far from the areas from which the birds were originally recovered. This method was used in Spain when 64 Eurasian Eagle-Owls (*Bubo bubo*) from the central and southern part of the country were released to successfully augment local Eurasian Eagle-Owl populations in northern Spain (Zuberogoitia et al. 2003).

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