CHAPTER 32

USING SCIENCE AND TECHNOLOGY TO REESTABLISH SPECIES LOST IN NATURE

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Science and technology are hardly new to species conservation. Marco Polo related how the great Kublai Khan had an appreciation for their use to increase game-bird populations on his hawking preserves 700 years ago (Komroff, 1926), and the origin of wildlife management goes even further back in human culture to the early empirical practices of aboriginal peoples. The Kutchin Indians were still burning climax spruce forest to create willow browse for moose in the Yukon River Valley when I first visited the region in 1951, and primitive hunters practiced similar manipulations of habitat to favor big game species in many parts of the world.

In 1933, Aldo Leopold wrote the following lines in the preface to his classic textbook *Game Management:* "game can be restored by the *creative use* of the same tools which have heretofore destroyed it—axe, plow, cow, fire, and gun. A favorable alignment of these forces sometimes came about in pioneer days by accident. The result was a temporary wealth of game far greater than the red man ever saw. Management is their purposeful and continuing alignment" (Leopold, 1933, p. vii).

Some of the authors in this section of the book write about the development of highly advanced techniques involving cryogenic processes, embryo transplants, artificial insemination, and other sophisticated clinical procedures. Although these new techniques are certainly needed, we have not yet made the most of many of the older technologies that can be applied to species conservation, and I want to emphasize the creative use of some old methods as important tools for conservation.

Two that I have used are the captive propagation of wild species and the reintroduction of individuals produced in captivity into vacant habitats. I work with the diurnal birds of prey—some 290 species of condors, vultures, eagles, hawks, and falcons, but especially with falcons, principally the peregrine falcon *(Falco peregrinus)*. Some of these raptors, such as the California condor *(Gymnogyps californianus)* and the Mauritius kestrel *(Falco punctatus),* are among the most endangered species in the world, and all seem to have attracted increasing human interest in recent years.

Given the long history of human involvement with birds of prey in the sport of falconry and as tribal and national totems, it is curious that the propagation of these species in captivity is a quite recent activity. The first peregrine falcon known to be raised from captive parents was produced as recently as 1942, and even as late as 1965 only about 23 species of diurnal raptors had been successfully bred in captivity, mostly on a casual or accidental basis (Cade, 1986a). In the early 1970s it was still widely believed that systematic large-scale propagation of raptors was an impossible feat, owing, I suppose, to the wild and fierce nature of such birds and to their apparent need for vast expanses of air space in which to perform their spectacular aerial courtship displays prior to mating and nesting.

The situation has changed markedly in the last 15 years. When it became evident in the late 1960s that populations of many species of raptors in north temperate regions had suffered major declines as a result of exposure to DDT and related pesticides or to other forms of environmental degradation, a nascent interest developed, especially among falconers, in perfecting techniques of captive breeding for some of these species. Of particular interest was the peregrine falcon, whose numbers had been severely reduced by pesticides over most of Europe and North America. This species has always been highly esteemed by naturalists and falconers alike for its near perfection as a flying machine.

In a summary of the worldwide effort to propagate raptors for the Fourth World Conference on Breeding Endangered Species in Captivity held in 1984, I came up with a list of 83 species that had reproduced in captivity—most of them since 1965 (Cade, 1986a). At least three species now need to be added to the list—the pondicherry vulture *(Sarcogyps calvus),* the white-tailed hawk *(Buteo albicaudatus),* and the crested eagle *(Morphnus guianensis)* of the Neotropics (ISIS, Captive Population Information, 31 December 1985). At present, more than 25% of all falconiform species have been bred in captivity. Some species have produced thousands of progeny; certainly the number of peregrine falcons raised in captivity exceeds 5,000 worldwide, and the American kestrel *(Falco sparverius)* is not far behind. At least 12 species have produced more than 100 progeny in captivity since 1975. It is safe to conclude that most if not all diurnal birds of prey can be bred in captivity given sufficient knowledge of their needs and sufficient resources to carry out the work.

What is the explanation for these rather sudden breakthroughs in the breeding of birds of prey in captivity? First, raptor breeders are true zealots with a single-mindedness of purpose to succeed against all odds and at any personal sacrifice. Although they come from all walks of life, most have in common the fact that they are falconers steeped in 3,000 years of accumulated knowledge about handling and training hawks and falcons and possess a special rapport with their birds that gives them an intuitive feel for what is needed in any particular situation.

A second part of the explanation has to do with the rapid and free exchange of information among raptor breeders throughout the world (Cade, 1986a). This exchange has followed the very best tradition of open scientific inquiry, unlike the secretive activities of some aviculturists.

Finally, successful raptor propagation owes much to the application of basic scientific information on avian reproductive physiology and breeding behavior and ecology. One quick example makes the point.

One of the chief bottlenecks hindering the mass production of raptors in captivity has been the frequent failure to achieve fertilization of eggs because of incompatibilities between mates. Thus, breeders must often resort to artificial insemination of egg-laying females. Obtaining usable quantities of semen from male raptors by the standard poultry method of physical massage and forced ejaculation is difficult and yields only small volumes of material over a short time (Weaver and Cade, 1983).

Since the work of the German ethologists Oskar Heinroth and Konrad Lorenz, it has been known that under certain conditions birds reared in isolation from members of their own species will become sexually imprinted on their human keepers and will actually attempt to mate with them. A fascinating body of scientific literature has developed on this subject (Brown, 1975; Immelmann, 1972; Lorenz, 1937). Raptor breeders have capitalized on this information and on their own experiences with hand-reared hawks and falcons raised in isolation to develop human-imprinted raptors into highly effective semen donors for artificial insemination. The birds are usually trained to copulate and ejaculate on a special hat worn by the human companion. Such birds produce copious volumes of high-quality semen for 2 to 3 months and have been great assets in increasing the percentage of fertile eggs laid in raptor breeding projects (Weaver and Cade, 1983).

Other examples of how basic scientific research has provided information useful to propagators involve incubation, photoperiod, hormone physiology, and psychobehavioral factors such as courtship displays, nest-site stimulation, and other factors, which Lack (1937) referred to as “psychological” in nature (Cade, 1980, 1986b).

REINTRODUCTIONS

There have been more than 1,670 attempts to establish avian species in outdoor environments, according to the excellent summary by Long (1981). At least 425 (25%) of these have been successful in establishing breeding populations. For example, in attempts to establish 119 species in North America up to 1980, success was achieved for 39 (37%) species. Comparable figures for Europe are 69 attempted and 27 (31%) established; for the Hawaiian Islands, 162 attempted and 45 (28%) established; for New Zealand, 133 and 38 (29%); and for Australia, 96 and 32 (33%).

Most of these have been *introductions* of exotic species into a new range. Some of these exotics have caused ecological or economic problems, but others appear to have filled vacant niches without seriously disrupting other species in the ecosystem (Long, 1981). There is much to be learned from careful study of these exotic introductions—both the successful and failed examples. We need to develop enough ecological foresight to predict and to effect benign exotic introduction as an additional technique of conservation. For example, the Mauritius kestrel badly needs a new home, and the neighboring Indian Ocean island of Runion could well be the place. This possibility needs study.

Reintroduction—the restoration of a species to its native habitat—has only recently been attempted, and there are fewer successful examples. In North America, one of the earliest successes was the restocking of some western ranges with American bison *(Bison bison)* derived from captive-bred stock held at the Bronx Zoo.

Much public attention has focused lately on the *possibility* of successful captive propagation and eventual reintroduction of the California condor—the most endangered bird in North America. It is perhaps less widely appreciated by the general public that successful reintroductions have already been achieved with several birds of prey. Since the 1950s efforts have been under way in the Federal Republic of Germany and in Sweden to re introduce the eagle owl *(Bubo bubo)* into vacant range, and new breeding populations have been established in both countries through the release of captive-bred owls. Breeding populations of the white-tailed sea eagle *(Haliaeetus albicilla)* and goshawk *(Accipiter gentilis)* have been reestablished in Great Britain, and the griffon vulture *(Gyps fulvus)* has been restored to the Massif Central in France (Terrasse, 1985). Also as a result of reintroduction, several pairs of bald eagles *(Haliaeetus leucocephalus)* and, more recently, ospreys *(Pandion haliaetus)* are now nesting in formerly vacant haunts in the United States. Through the release of young birds produced mostly by falconers, a small nesting population of Harris' hawks *(Parabuteo unicinctus)* has been restored to the lower Colorado River valley of California and Arizona, where the species had disappeared around 1970, primarily because of habitat destruction. (See Cade, 1986b, for details and documentation.)

The best-known case is that of the peregrine falcon. The most widely distributed, naturally occurring avian species in the world, the peregrine suffered drastic reductions in numbers in both Europe and North America in the 1950s and 1960s, primarily because of the effects of organochlorine pesticides such as DDT and dieldrin. Since then there have been major international efforts to restore this species, in part by restricting the use of persistent organochlorine pesticides and by captive breeding and reintroduction. Successes have been achieved from both approaches.

In regions where some breeding pairs were able to persist, the falcon populations recovered dramatically on their own once restrictions were placed on use of these chemicals (Cade et al., in press). Great Britain is the best studied region where natural recovery has occurred (Ratcliffe, 1984). By 1963, the nesting population there had been reduced to 44% of its estimated pre-World War II size: there were some 350 surviving pairs. Once the use of dieldrin and DDT decreased in the latter part of the 1960s, the population began to increase, and today there are more than 1,000 occupied breeding territories in the British Isles. The species is, in fact, more numerous there now than at any time in this century.

In other regions where the species was more severely reduced or entirely extirpated as a breeding bird, restocking or reintroduction through the release of captive-reared falcons has been the main method for recovery. As a result of this work, small breeding populations have now been reestablished in the Federal Republic of Germany, Sweden, the eastern United States, the upper Mississippi River region in Wisconsin and Minnesota, the Rocky Mountain states, California, and several places in Canada (Cade, 1986b; Cade et al., in press). Three methods of release have been used: hacking, an old technique borrowed from falconry by which young are placed outdoors and cared for until they can fend for themselves; fostering, by placing captive-reared young in the nests of wild peregrines; and cross-fostering, by placing them in the nests of other species. The best results have been achieved with hacking and fostering (Cade et al., in press).

The eastern U.S. recovery program can serve as an example of the effort required for one of these regional reintroductions. The original nesting population of peregrines in the United States east of the Mississippi River in 1942 was estimated to be around 350 pairs on average each year (Hickey, 1942); some 250 eyries are actually known to have existed. By the early 1960s, this breeding population had completely disappeared, and no peregrines are known to have reproduced again in the eastern part of the country until 1980, when the first members of the reintroduced population fledged their young.

The Peregrine Fund began its captive breeding program at Cornell University in 1970. By 1974, there were sufficient numbers of young being raised to begin experimental releases. The following year, with substantial support from the U.S. Fish and Wildlife Service, we were able to release 16 young by hacking, and the number increased each year until we were putting out an average of 100 birds annually from 1981 onward (Barclay and Cade, 1983). At the end of the 1986 season we had released more than 850 captive-produced peregrines in 13 eastern states and the District of Columbia.

Falcons that survived their first winter immediately began establishing spring and summer territories, often at or near locales where they had been released. The first pairs formed in 1977 and 1978; the first eggs were laid at a nesting tower in New Jersey in 1979, but they were depredated by crows. In 1980, three pairs bred and raised young, and the nesting population has been increasing each year since. This past season, 43 pairs were known to be occupying territories from North Carolina to Montreal, Quebec; 30 pairs actually laid eggs, and 24 of them produced 52 young. There have been 83 nestings since 1979, and 71 of them produced 180 young.

The reintroduced breeding population has been doubling in size about every 2 years (Figure 32–1). If that rate of increase can be continued, by 1991 we will have achieved the official recovery goal of 175 nesting pairs established by the U.S. Fish and Wildlife Service in its recovery plan for the eastern United States. The complete restoration of the peregrine falcon in North America is now a predictable result of continuing to apply the technology developed for its recovery.

CAPTIVE BREEDING IN WILDLIFE MANAGEMENT

The rearing of captive animals and their use for restocking and reintroduction have not been favored techniques of modern wildlife management. Leopold (1933) dismissed these subjects with 5 pages on "artificial propagation" and 7 pages on "transplantation" in a 481-page textbook. He stressed the cost of such artificial techniques and their aesthetic limitations. Leopold began what can be called the "ecological tradition" in wildlife management with its emphasis on habitat—the preservation and manipulation of all the environmental factors that are necessary to support wildlife populations as being more important than direct manipulation of the populations themselves. This approach has continued to the present day and certainly is the best policy wherever it can be pursued.

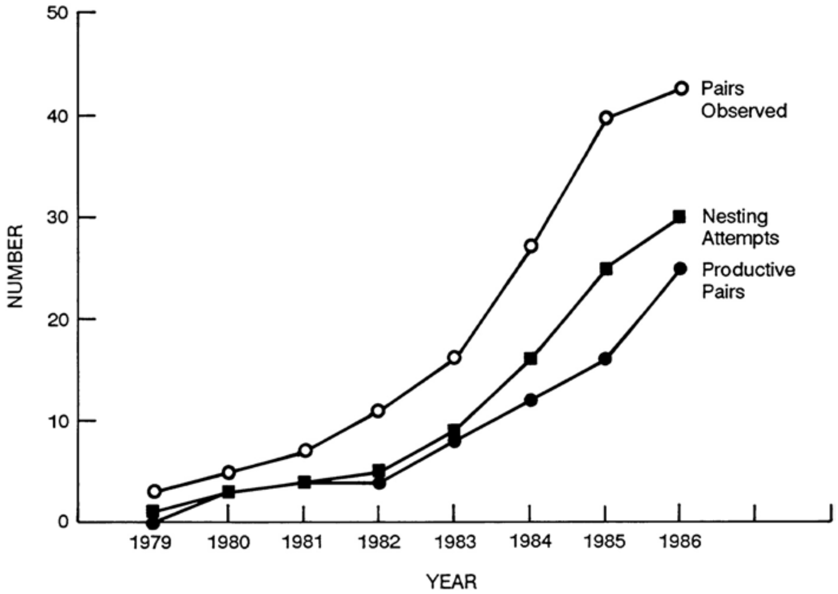

FIGURE 32–1 Growth of reestablished eastern peregrine population.

There have been good reasons for skepticism about propagation and release. Many captive stocks have not been reared in ways that are conducive to their survival after release in the wild (Cade, 1980). There have been many costly failures in attempts to restock or transplant animals into outdoor habitats and, particularly, to introduce exotic game birds by mass releases with little or no conditioning of the birds for their new environment (Bohl and Bump, 1970). One example is the repeated failure of many state game agencies to establish Japanese quail *(Coturnix coturnix)* in the United States. Hundreds of thousands of these birds were released—more than 350,000 from 1956 through 1958 alone—but no breeding populations ever became established (Long, 1981).

There are two main reasons for such failures. First is the use of genetic stocks or species that are poorly or not at all adapted to the environments into which they are introduced. Second is the lack of understanding of the behavioral, physiological, and ecological processes required for successful establishment (Cade, 1986b). Given the poor record of success with many species, especially when captive-produced individuals have been used, the recent reintroductions of raptors have been more successful than many biologists would have predicted.

These results with raptors and some other species in the last 10 years show that given enough biological knowledge about a species and enough time, effort, and money to apply that knowledge, reintroduction can be made to work. It is, however, an expensive and labor-intensive procedure, especially for captive-produced birds. It requires a tremendous amount of cooperation among numerous private individuals, government agencies, conservation organizations, corporations, and so on. Because so many different interests are usually involved, especially with an endangered species, it almost always becomes highly politicized.

The eastern peregrine recovery program is a case in point. Since 1970, the Peregrine Fund at Cornell (Figure 32–2) has spent about $2.8 million to propagate and release peregrine falcons in the eastern United States, but this figure does not include the expenses of cooperating agencies. The total cost has probably been between $3 and $3.5 million, perhaps more. More than 325 people—mostly temporary summertime helpers—have worked directly for The Peregrine Fund, not to mention dozens of federal and state agency personnel who have also helped. Although the U.S. Fish and Wildlife Service, the federal agency that administers the Endangered Species Act, is nominally in charge of the program, The Peregrine Fund has also worked closely with the U.S. Forest Service, National Park Service, and to some extent with other federal agencies, as well as with 13 state wildlife

FIGURE 32–2 Human-imprinted male peregrine feeding young at the Cornell University “Hawk Barn.” Photo courtesy of The Peregrine Fund.

departments and, occasionally, with county and municipal authorities. Last year no fewer than 50 government agencies and offices, conservation organizations, universities, and businesses of one sort or another were directly involved in some aspect of the eastern program. Financial support has come from numerous conservation organizations, foundations, corporations, several thousand private individuals, and federal and state agencies.

Remember, this is only one of the *four* major regional recovery programs for the peregrine in the United States not to mention others in Canada and elsewhere. Similar accounts could also be given for the restoration of the Atlantic salmon *(Salmo solar)* in New England, Kemp's ridley sea turtle *(Lepidochelys kempi)* on the Texas coast, the whooping crane *(Grus americana),* the California condor, the Puerto Rican parrot *(Amazona vittata),* the golden lion tamarin *(Leontopithecus rosalia)* in Brazil, the Arabian oryx *(Oryx leucoryx)* in Oman, or the cheetah *(Acinoynx jubatus)* in South Africa. Each of these restoration programs is a huge enterprise, drawing on the skills and financial resources of many different individuals and institutions. For example, Snyder et al. (1987) give a detailed account of the work to restore the Puerto Rican parrot.

This new trend to rely more on technologies such as captive breeding and reintroduction for the restoration of species has become necessary because we human beings have not paid heed to the ecological imperative to preserve nature. We have not followed the philosophy of Leopold and others like him to keep the land and waters as fit habitats for wild animals and plants. And we are not likely to change our ways, as Norman Myers and many other authors emphasize in this book. Most human beings continue to be captivated more by what engineers do than by what ecologists say. As a consequence we are left with engineering solutions to environmental problems that have been largely created by engineers in the first place. Thus, I am led back to my opening quotation from Leopold: wildlife “can be restored by the *creative use* of the same tools which have heretofore destroyed it….”

As natural environments become more fragmented and degraded in their capacity to support a diversity of living forms, many once common species will be reduced to isolated remnants, existing as small populations in marginally suitable habitats separated by vast expanses of uninhabitable area. Some species—especially large ones and predatory ones—will be unable to maintain populations indefinitely under these conditions, owing to genetic, demographic, or ecological problems. Such populations can be sustained in part through captive propagation and reintroduction or by translocating individuals from one island of habitat to another (Cade, 1986b). I believe we will see an increasing need for these sorts of techniques in the coming decades as the biosphere undergoes the final change from unmanaged wilderness ecosystems to managed nature preserves, megazoos, and zooparks, which will be the final refuges for some species in outdoor environments (Conway, 1983).

Although I have stressed the cost and labor-intensive nature of propagation and reintroduction programs, I hasten to add that they really are not very expensive relative to many of the other things we human beings are willing to spend our public and private wealth to obtain. Consider the hundreds of billions of dollars this nation is being urged to spend on star wars technology, or the billions spent annually on war-making machines. Consider the $10 million one person was willing to pay for an untrained race horse, and single purses of $15 million—win or lose—for a world championship heavyweight prize fight, or the billions of private dollars being spent to support cocaine and heroin addictions. When one takes account of the trillions of dollars human beings are willing to spend on foolish or trivial things, the cost of saving endangered species and endangered habitats pales to insignificance. All the work needed to restore the world's threatened birds of prey could be accomplished with $5 million a year, about what it costs to make one armored tank.

Conservationists spend entirely too much time talking to each other. We do not need to convince each other of the importance of what we are trying to do. We need to convince the vast majority of other folks! We need less talk in any case and more action.

We do not need more science and more technology nearly as much as we need more innovative application of the knowledge and techniques of wildlife management already available. We do not have more action to preserve and to restore threatened species and their environments, first of all, because conservationists have not been persuasive enough to obtain the money needed to do the work. But another and final reason is the excessive bureaucratic incumbrance associated with the work. The number of state and federal regulations impinging on conservation projects these days, the number of permits required for one action or another, the number of agencies that have to be mollified, the number of committees that have to meet—all sap strength from the effort and further dilute the already limited funds.

All endangered species programs suffer from these ills. The California condor must be the premier example, but the peregrine falcon is a close second. To ensure the survival of these and other endangered species, programs must be clearly focused and the responsibilities for their management carefully allocated to those who are best qualified to work with each species.

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