Raptor Research Reports
No. 5

Raptor Conservation in the Next 50 Years

The Raptor Research Foundation, Inc.
1986

THE RAPTOR RESEARCH FOUNDATION, INC.
(Founded 1966)

****

Persons interested in predatory birds are invited to join The Raptor Research Foundation, Inc. Dues are $15 per year in the U.S., $17 per year outside the U.S., $13 per year for U.S. students, and $15 per year for students outside the U.S. Add $2 to dues if membership is received after 15 February. The Foundation's journal *Raptor Research* is distributed quarterly to all current members. Subscription price to institutions and nonmembers is the same as regular membership. Single copies and back issues are available from the Treasurer. A Contributing Membership is $25, a Sustaining Membership is $100, and a Life Membership is $500. All contributions to The Raptor Research Foundation, Inc., are tax-deductible.

Send requests for information concerning membership, subscriptions, special publications, or change of address to the Treasurer. Other communications may be routed through the appropriate Officer or Board member. All inquiries concerning the journal should be addressed to Clayton M. White, Editor, *Raptor Research,* Department of Zoology, 161 WIDB, Brigham Young University, Provo, Utah 84602, U.S.A.

****

Published quarterly by The Raptor Research Foundation, Inc. Business Office: Jim Fitzpatrick, Carpenter Nature Center, 12805 St. Croix Trail, Hastings, Minnesota 55033, U.S.A.

RAPTOR CONSERVATION IN THE NEXT 50 YEARS

Edited by
Stanley E. Senner, Clayton M. White and Jimmie R. Parrish

Proceedings of a Conference held at Hawk Mountain Sanctuary, Kempton, Pennsylvania, U. S. A., on 14 October 1984

Raptor Research Report No. 5

Printed by Press Publishing Limited, Provo, Utah 84602
Printed in U. S. A.

The following organizations are gratefully
acknowledged for their support in the
production of this report.

Hawk Migration Association of North America

Hawk Mountain Sanctuary Association

International Council for Bird Preservation — U.S. Section, Inc.

The Raptor Research Foundation, Inc.

U.S. Fish and Wildlife Service

CONTENTS

PREFACE

Two years ago, raptor enthusiasts and conservationists from around the world celebrated the 50th anniversary of Hawk Mountain Sanctuary, the world's first refuge established to protect birds of prey (see *Raptor Research* 19:32 for a resolution adopted by the Board of Directors of The Raptor Research Foundation, Inc.). As part of a year-long series of events sponsored by the Hawk Mountain Sanctuary Association, a symposium on "Raptor Conservation in the Next 50 Years" was held at the Sanctuary on 14 October 1984.

Hawk Mountain's mission is to foster the conservation of birds of prey and other wildlife, and it has made many contributions toward that goal through its program in education, research and conservation. Given its mission and wide-ranging program, the theme of the anniversary symposium was appropriately a question: "What must be done to ensure the conservation of bird of prey populations in the next 50 years?"

In planning the symposium we sought to invite a diverse panel of experts who would offer a worldwide perspective on the future of raptors. While many such individuals could have contributed to the symposium, we settled on eleven people whose contributions to the biology and conservation of raptors are widely recognized as outstanding. They were, in order of participation:

Introduction. Mark R. Fuller, Patuxent Wildlife Research Center, U.S. Fish & Wildlife Service.

Raptor Conservation Problems in the Old World. Ian Newton, Monks Wood Experiment Station, Institute of Terrestrial Ecology.

Raptor Conservation Problems in the Middle East. Yossi Leshem, Israel Raptor Information Center, Society for the Protection of Nature in Israel.

Raptor Conservation Problems in the Tropics. Robert S. Kennedy, Raptor Information Center, National Wildlife Federation.

Conservation of Migratory Raptors. Chandler S. Robbins, Patuxent Wildlife Research Center, U.S. Fish & Wildlife Service.

Research on Migratory Raptors. John R. Haugh, Resource Sciences Staff, U.S. Bureau of Land Management.

Land Management and Raptor Conservation. Richard R. Olendorff, Division of Research, U.S. Bureau of Land Management.

Public Education and the Future of Raptors. James J. Brett, Hawk Mountain Sanctuary Association.

California Condor Recovery Program. Noel F.R. Snyder, Condor Research Center, U.S. Fish & Wildlife Service.

Reintroduction as a Method of Conservation. Tom J. Cade, The Peregrine Fund, Inc., and Cornell University.

Synthesis. Dean Amadon, American Museum of Natural History.

Discussion. Moderated by Drs. Amadon and Fuller.

I thank the Editor of *Raptor Research* and The Raptor Research Foundation, Inc., for their support and assistance in publishing the proceedings. Additional contributions in support of this publication have been provided by the Hawk Migration Association of North America, the U.S. Fish and Wildlife Service and the International Council for Bird Preservation — U.S. Section.

Stanley E. Senner, Hawk Mountain Sanctuary Association, Rt. 2, Kempton, Pennsylvania 19529.

INTRODUCTION

MARK R. FULLER

Patuxent Wildlife Research Center
Laurel, MD 20708

The 50th Anniversary Celebration (1934-1984) of Hawk Mountain Sanctuary provided an occasion to review the last 50 years of raptor conservation, summarize some current work and to discuss tasks and problems of the future. The history of the Sanctuary has been published in a special edition of *Hawk Mountain News* (Hawk Mountain Sanctuary Association 1984) and was recounted during the first two days of the 50th Anniversary Celebration in rich and colorful commentary given by long-time associates of the Sanctuary. Peter Dunne and Roger Tory Peterson each delivered informative and entertaining presentations about Hawk Mountain and its relationship to the conservation movement. A symposium on "Raptor Conservation in the Next 50 Years" served as a forum for biologists to highlight work with several species, to review management techniques and to discuss the importance of environmental education and of conservation in Europe, the Middle East and the tropics.

"Conservation" is a term used in the title of this symposium, and lately the term is used frequently in discussions and in the literature about natural resources. A contemporary interpretation of how conservation relates to natural resources is emphasized in the rapidly growing field of conservation biology. This introduction to the symposium "Raptor Conservation in the Next 50 Years" briefly describes conservation biology and suggests some ways in which those concerned about birds of prey might participate.

Conservation biology is interdisciplinary, drawing on both basic and applied sciences that cover a range of topics "as broad as biology itself" (Soulé and Wilcox 1980:1). The emergence of conservation biology reflects the participation of many people from many disciplines who wish to contribute to the conservation of a diversity of plant and animal life. More and more people are joining researchers, managers and administrators of traditional disciplines such as forestry, range, fisheries and wildlife management in an effort to understand and manage natural resources. Scientists from disciplines such as ecology, biochemistry, endocrinology, statistics, genetics and demography are contributing to conservation biology and strive to reduce the time between discovery of information and its use for conservation (e.g., Schonewald-Cox et al. 1983). Conservation biologists hope their participation in natural resource issues will allow for management of a greater diversity of plant and animal species than has been possible in the past. In concervation biology there is usually an emphasis on long-term considerations rather than management for only a few generations of a species. "Conservation" is distinguished from "preservation" by Frankel and Soulé (1981:4) as those efforts undertaken to ensure the long-term retention of biological diversity under conditions that allow for continuing evolution of organisms, while "preservation" refers to a short-term retention of individuals or groups.

Early man was relatively sedentary and occurred at low densities, thus only local areas were affected by his activities. Today, no part of the earth or its atmosphere escapes the impact of man. Extinction rates are apparently increasing, habitats are being drastically altered or eliminated and, until recently, little thought has been given to the implications of these dramatic, often irreversible, changes for the future of humanity. Conservation biologists study the impacts of man and of nature on ecological communities (including humans) and help resource managers plan to mitigate factors that reduce biological diversity. The field of conservation biology provides a common ground upon which governments, concerned citizens, forest and range managers, fisheries and wildlife biologists and other scientists can share information and implement conservation measures.

Raptors have received a great deal of study, management and public concern, especially during the 1960s and 1970s (e.g., Olendorff 1980). Such species as the Peregrine Falcon (*Falco peregrinus*), Osprey (*Pandion haliaetus*) and Bald Eagle (*Haliaeetus leucocephalus*) probably have received as much attention as any other species, excluding crop plants, livestock and harvested or hunted animals. In the next 50 years it is likely that a smaller proportion conservation efforts will be directed specifically towards raptors, because conservation biology ultimately deals less with individuals and single species and more with biological diversity in ecological communities. Nevertheless, study and management of birds of prey will be an integral part of conservation biology, because as predators, rap-

raptors are important components of communities. Also, many are vulnerable to local extirpation and ultimately, extinction.

There are numerous criteria for assessing vulnerability (Soulé and Wilcox 1980) and many species of raptors are vulnerable according to these criteria. Relative rarity is considered one of the best indicators of vulnerability, and, as top predators, many birds of prey occur in low numbers relative to other species. Many raptors exhibit delayed maturity and produce few eggs each year. Thus, they are classified as "slow breeders" and are slow to recover from impacts that reduce their numbers. Raptors are relatively large birds and use large areas of land. Therefore, some species are vulnerable to reduction of required habitat by fragmentation and the loss of natural communities. Habitat specialists (e.g., Northern Spotted Owl *Strix occidentalis*) and species occurring only on small islands (e.g., Mauritius Kestrel *Falco punctatus*, Hawaiian Hawk *Buteo solitarius*) are vulnerable to extinction by virtue of their limited distribution and dependence on restricted resources. Additionally, conservation biologists are concerned about raptors because, as top predators, their absence could have widespread affects on food webs in their communities (Soulé and Wilcox 1980).

There are other reasons why raptors will be important subjects during the next 50 years of conservation. Many species of Falconiformes and Strigiformes have been shown to be susceptible to the accumulation of various contaminants (Newton 1979), and study of the biochemistry, physiology and ecology of raptors has led to a better understanding of the threats posed by pollutants to many organisms, including humans. Additionally, people have an aesthetic interest in birds of prey that is reflected in the use of raptors as national and local emblems, figures of strength and persistence and symbols of conservation (e.g., the logo of the International Council for Bird Preservation is the Osprey). Thus, through their symbolism, raptors help carry the message of resource managers and conservation biologists to the general public.

Conservation biology, in turn, provides some useful guidelines and questions for those interested in raptors. How large are the areas required by individual raptors and breeding pairs? How much area is required to provide the resources necessary to sustain a "population" of breeding pairs and immature birds? From the standpoint of population biology, what is a "population," and what are the important genetic characteristics for the conservation of birds of prey (Schonewald-Cox et al. 1983)? What are the implications of each species' dispersal and migratory movements for establishing nature reserves and managing the habitat required by a population? We know little about the resource needs of most raptors during the nonbreeding season, and little of the relative importance of various sources of mortality incurred by birds of prey. Without these basic data, it is impossible to initiate practical management plans, and it will be difficult to effectively integrate raptor biology with conservation biology.

During the next 50 years much information about resource needs and the population biology of raptors must be gathered and interpreted for use in conservation biology. The literature cited in this introduction will provide raptor biologists with information about the field of conservation biology. The audience at the 50th anniversary symposium also included many lay people interested in raptor conservation. Businessmen, farmers or politicians may not wish to read technical literature about resources, biological diversity and extinction (e.g., Myers 1979; Barnet 1980; Ehrlich and Ehrlich 1981). Regardless of one's specific interest, conservation biology provides a framework within which anyone who is concerned about the conservation of natural resources can work. In the proceedings from the symposium "Raptor Conservation in the Next 50 Years" one can read about many of the problems that have been addressed by those wishing to study and conserve raptors. The authors raise numerous questions and issues that still must be confronted. Given the variety and number of predicted threats to raptors, there is ample opportunity for all interested people to participate in and support professional work and volunteer activities related to future raptor conservation.

Ultimately, the extent to which conservation biology develops, and the extent to which raptors are conserved, will depend on cultural, social and political events during the next 50 years. In this context anyone can contribute to ecological literacy among people, and heed this quote from Stanley Senner, the Executive Director of Hawk Mountain Sanctuary Association, when he was a staff member of the U.S. House of Representatives' Committee on Merchant Marine and Fisheries: "You cannot overstate the importance of educating the public. It is not just a matter of going to a Congressman offering your point of view . . . support must come from his/her constituents, and that requires your educational efforts" (United States Department of State 1982).

LITERATURE CITED

BARNET, R.J. 1980. The lean years, politics in the age of scarcity. Simon and Schuster. New York. 349 pp.

EHRLICH, P.R. AND A.H. EHRLICH. 1981. Extinction: the causes and consequences of disappearance of species. Random House. New York. 305 pp.

FRANKEL, O.H. AND M.E. SOULÉ. 1981. Conservation and evolution. Cambridge Univ. Press. Cambridge, Massachusetts. 327 pp.

HAWK MOUNTAIN SANCTUARY ASSOCIATION. 1984. *Hawk Mountain News* No. 62. 50th Anniversary Issue. Kempton, Pennsylvania, U.S.A.

MYERS, N. 1979. The sinking ark. Pergamon. Oxford, England. 233 pp.

NEWTON, I. 1979. The population ecology of raptors. Buteo Books. Vermillion, South Dakota. 399 pp.

OLENDORFF, R.R. 1980. Raptor management — the state of the art in 1980. U.S. Bureau of Land Management Technical Note No. 345, Denver, Colo.

SCHONEWALD-COX, C.M., S.M. CHAMBERS, B. MACBRYDE, W.L. THOMAS (EDS.) 1983. Genetics and conservation: a reference for managing wild animal and plant populations. Benjamin/Cummings. Menlo Park, California. 722 pp.

SOULÉ, M.E. and B.A. Wilcox. 1980. Conservation biology: an evolutionary-ecological perspective. Sinauer Associates. Sunderland, Massachusetts. 395 pp.

UNITED STATES DEPARTMENT OF STATE. 1982. Proceedings of the U.S. strategy conference on biological diversity, Dept. of State Publication 9262. Washington, D.C. 126 pp.

FUTURE PROSPECTS FOR RAPTORS IN EUROPE

Ian Newton

Institute of Terrestrial Ecology, Monks Wood Experimental Station, Abbots Ripton, Huntingdon, England PE17 2LS

ABSTRACT — In Europe, as elsewhere, population declines in raptors can be attributed to: (1) habitat destruction, mainly for agriculture; (2) pesticide use, again mainly for agriculture; and (3) deliberate killing, in the interests of game and stock rearing. Habitat destruction results from the conversion of natural and semi-natural areas to cultivated ones and the further degradation of existing farmland, causing depletion of prey. Persecution of raptors is less than in former times, but still substantial, especially in southern Europe. Most countries have now banned the use of certain organochlorine pesticides, and numbers of peregrines and other species are well on the way to recovery. The growing interest in conservation has also had beneficial effects, including some reintroduction attempts. The larger raptor species are the most difficult to conserve because of the large land areas they require, and because of low breeding rates which make such species less resilient to persecution.

In this account, I shall briefly review the main factors which have affected raptor populations in Europe and speculate on future trends. On no other continent have bird-of-prey populations been reduced to the same degree as in Europe. Writing in 1965, the Dutch ornithologist, Prof. K.H. Voous, surmised that the number of diurnal raptors on the continent was only about 1% of what it was 150 years previously in the early 19th century (Bijleveld 1974). Few who were familiar with the situation in Europe around 1965 would have argued with his estimate, made at the height of the era in which organochlorine pesticides were used. Populations of several species have recovered considerably since then, but some are still below 10% of their former numbers.

As in other parts of the world, this situation has been caused by three main factors: (1) habitat destruction, mainly in the interests of agriculture; (2) pesticide use, again mainly in the interests of agriculture, and (3) deliberate persecution, in the interests of game and stock rearing.

Spanning a wide range of latitude, Europe has great diversity in vegetation, from Mediterranean woodland and scrub in the south through broad-leaved deciduous and then boreal forests to tundra in the north. It also has several large mountain ranges which extend to boreal or tundra zones, extensive wetlands, and, to the east, large natural grasslands. It has a relatively rich raptor fauna, with a total of 36 breeding species, including Osprey (*Pandion haliaetus*) and Honey Buzzard (*Pernis apivorus*), 8 eagles, 4 vultures, 3 buzzards, 3 accipiters, 3 harriers, 3 kites, and 10 falcons. No species has yet become extinct, but all have declined in both numbers and range. Twelve species now have markedly discontinuous distributions, remaining only in isolated pockets, and three are greatly endangered.

HABITAT DESTRUCTION

The surface of Europe, having been settled longer by agricultural man than most other parts of the world, has also been more extensively modified than the rest of the world. Except in the coldest regions, in the north and in the mountains, very few areas of strictly natural habitat remain. In the best areas the vegetation could be classed as semi-natural, but over much of the continent, even this has been replaced by some form of cultivation. The destruction of natural and semi-natural vegetation has accounted for bigger reductions in raptor and other wildlife populations than has any other factor. With the continuing growth in human population and development, it is still the most serious threat in the long-term. Irrespective of any other depressing influence, habitat sets the ultimate limit on the size and distribution of any wild species.

Habitat destruction takes two forms: (1) the reduction of a former widespread habitat to tiny fragments (e.g., forest in many regions) or (2) the degradation of a former habitat by land-use practices which lead to reductions in prey (e.g., over-grazing of natural grassland). In the first instance, the raptor population is restricted in distribution but, within the remaining habitat fragments, it may live at no less a density than before; in the second instance, the population shows no restriction in distribution, but lives at much lower density than before. In practice, most raptor species are affected simultaneously by both forms of habitat destruction.

In the European lowlands the problems stem mainly from the conversion of semi-natural areas to farmland and from the more intensive use of existing farmland. In many countries, such as Britain and Holland, almost all land that can be cultivated has already been brought under the plough, but in southern Europe, where some semi-natural areas remain, these are being increasingly encroached upon by an expanding agriculture. This inevitably means a reduction in the prey available to raptors and in the raptors themselves. In general, the more intensively the land is used for stock or crop production, the less wildlife it supports, at least on a year-round basis. Everyone accepts that natural marshes support a greater wealth of wildlife than the farmland which so often replaces them. Among other open habitats, natural grasslands hold more prey than do similar areas used for stock grazing, and grazed areas in turn often hold more prey than do cultivated lands. Annual ploughing greatly reduces small mammal populations by eliminating their food and cover, and thus renders croplands of limited value to mammal-feeding predators. In wooded habitats, natural areas of varied structure and tree composition generally support more wildlife than do managed, uniform stands of monoculture conifers, which are now so popular. The result of such transitions is either to destroy completely the original habitat structure, or to reduce the prey supply to such an extent that it can no longer support raptors at anything near their former numbers. Modern land-use practices tend increasingly to simplify habitats, and to channel large parts of the annual production into crop plants or domestic stock, leaving little for wildlife. Thus, each step towards more intensive human land-use has a further cost in wildlife terms.

In hilly areas the problems also stem from more extractive land-use, particularly the replacement of rich semi-natural woodland with sterile coniferous or eucalyptus plantations. This process is occurring on a greatly increased scale in such Mediterranean countries as Spain and Greece, and it inevitably leads to a decline in the raptor species which inhabit the native woodlands (Garzon 1977; Hallman 1985; Palma 1985). The process also leads to road building, and to easier human access to areas that were hitherto remote and undisturbed. Even where the habitat remains intact, the invasion of former protected areas by hundreds of hunters results not only in more direct persecution of raptors, but also in the removal of their food supply (Palma 1985; Hallman 1985). The game birds and rabbits which attract the hunters form the mainstay of eagles and other large predators. Several recent authors have attributed the decline in large raptors in otherwise suitable habitat to the removal of their food supply by human hunters (Thiollay 1985). Indeed, the opening of previously untouched areas for forestry and other development, the increased mobility of hunters, the increased numbers of hunters, the lack of enforcement of protection laws, and the consequent shortage of game, all put more pressure on other wildlife (Hallman 1985).

We are now faced all of the time in Europe with more intensive land-use of one form or another, especially in the more productive areas. This process has occurred from time immemorial, and it would presumably follow naturally from the increase in human population growth. However, the process has been hastened greatly in recent decades, especially since the formation of the European Economic Community (EEC). From this has followed the increased availability of grant-aid for farmers and of guaranteed markets for produce. For certain widespread crops, including cereals, farmers are now paid a predetermined price for their produce, whether it is needed or not. The result is a huge food surplus, and the destruction of ever more habitat for increasing crop production. This occurred first in Britain and middle Europe, but in recent years it has been especially marked in such Mediterranean countries as Greece and Spain. The signs are that such unnecessary agriculture — and its associated habitat destruction — will continue.

PROBLEMS OF CONSERVING LARGE RAPTORS

The conservation of raptors in a man-dominated environment is the more difficult because many species require huge areas of land. The home-range sizes of raptors are correlated with their body size (Newton 1979): at one extreme, in such small species as the Common Kestrel (*Falco tinnunculus*), a pair may occupy less than 1 km^2 of land, but, at the other extreme, in such large species as eagles, each pair may require more than 100 km^2. Some of the national parks of the type found in Africa and North America are large enough to support populations of such species. Europe has very few national parks, and not all give the degree of protection required to conserve large raptors. It has many nature reserves, but most are too small to hold more than a single pair of eagles. Apart from national parks, therefore, the only areas where large raptors can survive are where land-use is not intensive and it is based on grazing rather than cropping. Raptors then have sufficient wild prey to feed on, or a mixture of wild prey and carcasses of domestic animals.

All the vultures in Europe, and most of the large eagles, depend on habitat of this type — on extensive grazing areas — where stock are kept in relatively primitive conditions. Most such areas are on mountaintops or hills. In general, any more intensive form of stock-rearing leads to insufficient prey, so it is not surprising that large raptors have disappeared from much of Europe, including almost all of the lowland.

The Griffon Vulture (*Gyps fulvus*), which breeds colonially on cliffs and forages widely over open land, presents particular problems (Garzon 1977; Palma and Rufino 1981; Handrinos 1985; Leconte 1985; Marinković et al. 1985; Muntaner 1985; Palma 1985; Vasić et al. 1985). Throughout its European range this species depends wholly on the carcasses of domestic animals, its natural ungulate prey having long since been eliminated or much reduced by man. Last century griffons nested in many areas from which they are now absent, but the decline seems to have been especially great in the 1950s and 1960s. This was associated with widespread poisoning campaigns, in which strychnine meat baits were used against mammalian carnivores, especially the Gray Wolf (*Canis lupus*) (Bijleveld 1974). The baits were often eaten by vultures and other large raptors, and whole colonies of griffons disappeared at that time (Marinković et al. 1985). Such poisoning was conducted in most Mediterranean countries. It is now illegal, although it is still practiced illicitly on a smaller scale.

Meanwhile, changes in husbandry practices have reduced the carrion supply, and it seems unlikely in present conditions that griffons could reach anything like their former numbers. In several countries the numbers of sheep and goats kept on mountain pastures have declined (Garzon 1977; Handrinos 1985; Leconte 1985); more intensive husbandry practices and improved veterinary services have also reduced the mortality. Moreover, new laws require the immediate burial of carcasses in the interests of hygiene, so that such meat is no longer available to vultures. In consequence, food shortage has now become a major new factor in the decline of griffons. Special feeding stations ("vulture restaurants") now established in at least four European countries are helpful, but they can in n way compensate for the former supply of domesti animal carcasses.

If present trends in stock husbandry continue, a seems likely, a further decline in the food availabl for vultures is almost inevitable. In theory the ab sence of domestic animals from mountain pasture may in some areas allow wild ungulates to increas again, but it could be many years before wild pre form a sufficient and regular food source to sup port a substantial vulture population.

The Lammergeier (*Gypaetus barbatus*) is affecte similarly. Its present distribution is correlated mor with stock-keeping methods than with anythin else. The species is often commensal with suc primitive pastural cultures as those in Ethiopia o Tibet, where large numbers of domestic anima are kept in harsh mountain conditions with poo veterinary services. In these places the Lam mergeier thrives in large numbers, benefiting fro the abundance of carrion. But in other parts of i range, where modern stock-keeping and moder sanitation prevail, the Lammergeier is extinct, rar or fast-declining (Brown 1977).

The smaller Egyptian Vulture (*Neophron percn pterus*) feeds mainly on smaller carcasses, includin living prey, and it has also declined. The reasons ar not certain. The woodland-nesting Black Vultur (*Aegypius monachus*) seems to be affected as much b habitat destruction and human encroachment as b food shortage. West of Turkey, it is now restricte to small areas in Spain and Greece, and it could we disappear from Greece during the current wave o economic development (Hallman 1985). Togethe with the Imperial Eagle (*Aquila heliaca*), the Blac Vulture and the Lammergeier are now the mo endangered raptors in Europe.

BENEFICIAL ACTIVITIES

Not all human activities have been detrimental t birds-of-prey. Some have been favourable for par ticular species. The homing pigeons (*Columba* spp kept by hobbyists in many European countries for an important food source for the Peregrine Falco (*Falco peregrinus*). Without such prey it is most un likely that peregrines could reach such high den sities. In Britain they are the fourth commone raptor, with a total population exceeding 800 pai (Ratcliffe 1980). Similarly, in parts of Europe, th Goshawk (*Accipiter gentilis*) breeds at high densitie where the Pheasant (*Phasianus colchicus*) is raised artificially for hunters. The hunters persecute the Goshawks, but without the hunters there would almost certainly be fewer hawks. These are exceptions, however, and the general trend in human land-use is always to reduce wildlife populations and, hence, the raptors that depend on them.

PERSECUTION

Whereas the carrying capacity of the habitat is the main factor we have to contend with, two other influences act to reduce populations below the level that the remaining habitat will support: (1) the deliberate killing of raptors and (2) the use of agricultural pesticides.

With persecution it is often difficult for Americans to grasp the scale of the problem in Europe. With the help of official statistics, Bijleveld (1974) estimated that on the continent as a whole several millions of raptors were killed by game bird hunters alone in the 20 years up to 1970. These totals excluded the large numbers of carrion-feeding species which were killed incidentally in poisoning programmes aimed at wolves or other mammalian predators, as described above. In consequence, several species now occupy only a fraction of their present potential range.

Although in all countries (except Malta) raptors are now protected by law, in many there is a deep-rooted tradition that these birds are harmful, and the law is largely ignored or poorly enforced. Even in Britain, with a good conservation record, the evidence suggests that at least 4 species are currently restricted in numbers and range by continuing persecution, and several others are still below their potential level because of past persecution (Newton 1979, 1984). In Mediterranean countries, with their millions of hunters, the situation is much worse.

The vulnerability of any species depends partly on how easily it can be killed. Some species are fairly tame and easy to shoot; others use conspicuous perches and are easy to catch in leg traps; while yet others eat carrion and are easy to poison. Throughout Europe it is the carrion-feeding species which have suffered most, simply because they can be killed in big numbers with minimum effort. Large species are inevitably more vulnerable to the effects of persecution than small ones. This is partly because they live at lower densities, but mainly because they have much lower breeding rates and more delayed maturity. They therefore take much longer to recover from a population reduction than small species.

Although the problem of persecution is substantial, it is much less now than in the recent past. The growth of the conservation movement, protective legislation and education have all helped to change attitudes and reduce the numbers of raptors killed. Problems remain, however, particularly in Mediterranean countries, and it is here that future efforts need to be directed.

PESTICIDES

The important pesticides are the organochlorines, such as DDT, aldrin and dieldrin, which have been used throughout Europe (Newton 1979), and the alkyl-mercury compounds, which have been used chiefly in Sweden (Borg et al. 1969). In most European countries the use of these chemicals was banned completely between 1969 and 1975, though in some countries their use continued on reduced scale beyond 1980. As in North America, the bird-eating raptors suffered the most marked population declines, and the peregrine and the Sparrowhawk (*Accipiter nisus*) disappeared completely from large parts of their range (Newton 1979). Other species were affected on a more local scale, including the White-tailed Eagle (*Haliaeetus albicilla*), Goshawk and Kestrel. Following reductions in the use of these chemicals, all species have recovered to some extent, both in numbers and breeding success. In the peregrine and Sparrowhawk, the recoveries have been spectacular, and in many areas from which these species disappeared, populations have now reached, or even exceeded, their pre-DDT levels (Ratcliffe 1980; Newton and Haas 1984). It is chiefly in northern and eastern Europe that migrant peregrine populations remain depleted, but in the north there are now signs of recovery (Lindberg 1985; Wikman 1985). In Britain and elsewhere, changes in the numbers of several raptor species have been more closely linked with the use of aldrin and dieldrin than with the use of DDT (Newton and Haas 1984; Opdam et al. 1986). Aldrin and dieldrin affected adult mortality, whereas DDT affected mainly the breeding rate through shell-thinning.

These pesticides have been replaced by other less persistent ones, mainly organophosphate, carbamate and pyrethroid compounds. The total usage of these chemicals, together with fungicides and herbicides, has increased enormously in European agriculture since 1960 (see Kornberg 1979 for Britain). This is true for both the range of chemicals used, and the total quantities. New synthetic herbicides and insecticides were introduced first, but more recently there has been increasing use of fungicides. With the modern trend for cereal or other monocultures over wide areas, and the decline in crop rotations, large areas of land are treated with the same range of chemicals year after year. In fact the main potential problem for the future is the sheer scale of pesticide use. With more and more land cultivated, more and more areas are subject to pesticide applications and also to increasing numbers of applications each year. Some fruit crops may be sprayed more than 20 times during the course of a single growing season.

Some of the new insecticides have a broad enough spectrum of activity to cause an overall depression of invertebrate populations on farmland, but most act selectively and affect some invertebrate groups much more than others. In general, those organophosphate insecticides which are in wide use are short-lived, and do not have drastic overall effects on invertebrate populations. Carbamates tend to be more persistent and have a more broad-spectrum influence. They are very toxic to earthworms, which are important components of several food-chains which end with raptors. The pyrethroids vary greatly in their persistence and toxicity, but some are highly poisonous to fish.

It is not only the insecticides which are toxic to wildlife, but also some of the fungicides and herbecides. The carbendazim fungicides, such as benomyl or methyl thiophanate, are lethal to earthworms and certain arthropods (Edwards 1984). Other fungicides are fatal to a wide range of insect species, which form the food of many birds and other animals. Thus, through elimination of food species, many birds and mammals which form the prey of raptors are likely to decline under such heavy chemical use. Because of herbicides, many crop weeds and other plants have virtually disappeared over wide areas, reducing the numbers of seed-eating birds, butterflies, and other animals which depend on them. To my knowledge, there has yet been no assessment of the overall impact of total pesticide use, but one can hardly expect animals which form the foods of raptors to thrive on farmland. It is merely one aspect of modern ag riculture which reduces the carrying capacity c huge areas for certain kinds of wildlife.

Looking to the future, then, pesticides are likel to be one factor which continue to reduce and hol down the natural fauna of farmland, and, hence, i abilities to support raptor populations. The ne pesticides are not known to kill raptors directly, a did the organochlorines, but are almost certain t influence them indirectly through reducing pre supplies. As none of the pesticides now used widel in Europe persist for long in animal bodies, they d not accumulate in food chains or affect populatior away from treated areas. On the whole, therefor the situation for the foreseeable future is a consic erable improvement over that pertaining in th 1950s and 1960.

CONSERVATION

Interest in conservation has grown everywher including Mediterranean countries, which have li tle or no tradition in this respect. Following fror this has been the strengthening of protective legis lation, the creation of nature reserves, and reir troduction and other management programme aimed to benefit raptors. Current projects includ attempts to re-establish the Lammergeier in th Alps (Géroudet 1977), the Griffon Vulture in th Massif Central (Terrasse 1983), the peregrine i parts of Germany (Saar 1985), and the White-taile Eagle in Scotland (Love 1983). As these initial prc jects prove successful, more attempts are likely. Ol vious candidates for future projects include the Re Kite (*Milvus milvus*) to Scotland, the peregrine t various other areas, including Poland, and th Golden Eagle (*Aquila chrysaetos*) to Ireland an Wales.

Meanwhile interest in raptors has grown rapidl and for the first time reasonable population est mates have become available for several species i Mediterranean countries to match those previousl obtained elsewhere. The future is likely to brin much better knowledge of the whereabouts an numbers of raptors, continued monitoring of ce tain populations, and awareness of problems. Fo conservation it is a race against time, to ensure tha sufficient large areas of wild habitat are saved be fore they are lost to development, and certain isc lated declining populations are saved before the are gone completely.

CONCLUSIONS

In the lowlands, the increasing conversion of natural and semi-natural areas to cultivated ones, and the more intensive use of existing farmland can only reduce the carrying capacity of the land for wild animals, and the raptors that feed on them. In the hills, the changing husbandry of domestic animals is reducing the carrion-supply for large raptors, and the conversion of native broad-leaved woodland to plantations of conifers and eucalyptus is similarly reducing the populations of wildlife upon which raptors depend. These land-use changes have been occurring for several decades in the middle latitudes of Europe, but are currently most pronounced in such Mediterranean countries as Spain and Greece, which are developing economically at the fastest rates. Large raptor species are likely to suffer most, because they require large areas and have low breeding rates, and they are less able to recover quickly from setbacks. To set against this, reductions in persecution and organochlorine pesticide use have benefited certain species in recent years. The conservation movement is likely to flourish, leading to the creation of more nature reserves, more protective legislation and specific management programmes, such as reintroduction projects. Although it is mainly a depressing picture in Europe, involving a perpetual lowering of the carrying capacity of habitats in the interests of "development", a few bright spots remain.

LITERATURE CITED

BIJLEVELD, M. 1974. Birds of prey in Europe. MacMillan Press, London.

BORG, K., H. WANNTORP, K. ERNE AND E. HANKO. 1969. Alkyl mercury poisoning in terrestrial Swedish wildlife. *Viltrevy* 6:301-379.

EDWARDS, C.A. 1984. Changes in agricultural practice and their impact on soil organisms. *In*: Agriculture and the Environment. D. Jenkins (Ed.). Institute of Terrestrial Ecology, Cambridge.

GARZON, J. 1977. Birds of prey in Spain, the present situation. *In*: Proc. World Conf. on Birds of Prey, Vienna 1975. R.D. Chancellor (Ed.). ICBP, Cambridge.

GEROUDET, P. 1977. The reintroduction of the Bearded Vulture in the Alps. *In*: Proc. World Conf. on Birds of Prey, Vienna 1975. R.D. Chancellor (Ed.). ICBP, Cambridge.

HANDRINOS, G.E. 1985. The status of vultures in Greece. *In*: Proc. World Conf. on Birds of Prey, Thessalonika 1982. I. Newton and R.D. Chancellor (Eds.). ICBP, Cambridge.

HALLMAN, B. 1985. Status and conservation problems of birds of prey in Greece. *In:* Proc. World Conf. on Birds of Prey, Thessalonika 1982. I. Newton and R.D. Chancellor (Eds.). ICBP, Cambridge.

KORNBERG, H. (CHAIRMAN). 1979. Royal Commission on Environmental Pollution. 7: Agriculture and Pollution. HMSO, London.

LECONTE, M. 1985. Present status of the Griffon Vulture on the northern slopes of the western Pyrenees. *In:* Conservation studies on Raptors, I. Newton and R.D. Chancellor (Eds.). ICBP, Cambridge.

LINDBERG, P. 1985. Population status, pesticide impact and conservation efforts for the Peregrine (*Falco peregrinus*) in Sweden, with some comparative data from Norway and Finland. *In:* Conservation studies on Raptors, I. Newton and R.D. Chancellor (Eds.). ICBP, Cambridge.

LOVE, J.A. 1983. The return of the Sea Eagle. University Press, Cambridge.

MARINKOVIC, S., G. SUSIC, B. GRUBAC, J.P.SOTI AND N. SIMONOV. 1985. The Griffon Vulture in Yugoslavia. *In:* Conservation studies on Raptors. I. Newton and R.D. Chancellor (Eds.). ICBP, Cambridge.

MUNTANER, J. AND C.R.P.R. 1985. The status of diurnal birds of prey in Catalonia, northeastern Spain. *In*: Conservation studies on Raptors. I. Newton and R.D. Chancellor (Eds.). ICBP, Cambridge.

NEWTON, I. 1979. Population ecology of raptors. Poyser, Berkhamsted.

NEWTON, I. 1984. Raptors in Britain — a review of the last 150 years. *BTO News* 131:6-7.

NEWTON, I. AND M.B. HAAS. 1984. The return of the Sparrowhawk. *Br. Birds*. 77:47-70.

OPDAM, P., J. BURGERS AND G. MUSKENS. 1986. Population trend, reproduction and pesticides in Dutch Sparrowhawks (*Accipiter nisus*) following the ban on DDT. *Ardea*, in press.

PALMA, L. 1985. The present situation for birds of prey in Portugal. *In*: Conservation studies on Raptors. I. Newton and R.D. Chancellor (Eds.).ICBP, Cambridge.

PALMA, L. AND R. RUFINO. 1981. I censo de buitreras (1979), informe sobre Portugal. *Ardeola* 26-27:273-276.

RATCLIFFE, D.A. 1980. The Peregrine Falcon. Poyser, Calton.

SAAR, C. 1985. The breeding and release of Peregrines in West Germany. *In*: Conservation studies on Raptors. I Newton and R.D. Chancellor (Eds.).ICBP, Cambridge.

TERRASSE, M. 1983. Status of vultures in France. *In*: Vulture biology and management. S.R. Wilbur and J.A. Jackson (Eds.). University Press, California.

THIOLLAY, J.-M. 1985. Falconiforms of tropical rainforests: a review. *In:* Conservation studies on Raptors. I. Newton and R.D. Chancellor (Eds.). ICBP, Cambridge.

VASIC, V., B. GRUBAC, G. SUSIC AND S. MARINKOVIC. 1985. The status of birds of prey in Yugoslavia, with particular reference to Macedonia. *In*: Conservation studies on Raptors. I. Newton and R.D. Chancellor (Eds.). ICBP, Cambridge.

WIKMAN, M. 1985. The Peregrine population in Finland. *In*: Conservation studies on Raptors. I. Newton and R.D. Chancellor (Eds.). ICBP, Cambridge.

RAPTOR CONSERVATION PROBLEMS IN THE MIDDLE EAST

Yossi Leshem

Director, Israel Raptor Information Centre, Society for the Protection of Nature in Israel, Har Gilo Field Study Centre, Doar Na Harei, Jerusalem 91076, Israel

To understand the problems of raptor conservation in the Middle East, we must go back to the 19th and early 20th centuries, when this area was a veritable paradise on earth for birds of prey. The words of British naturalist Canon H. B. Tristram (1865) who toured the Middle East in the late 19th century aptly describe the wealth of raptors nesting in the area. While touring Wadi Ammud in northern Israel, he describes: "... a narrow gorge flanked by steep limestone cliffs, 450 to 600 feet high, in perpetual shade, at times so narrow we were forced to ride in the stream bed. At various points caves are found in the cliffs, far from human paths, sanctuaries for hundreds of noble Griffon Vultures, several Lammergeiers, Lanner Falcons and various Eagle species ...." Of these hundreds of Griffons only seven pairs nest today. The Eagles, Lammergeiers (Fig. 1) and Lanner Falcons are now gone and extinct.

Three principal factors brought about the ideal situation for birds of prey, which existed until the second decade of the 20th century:

1) widespread natural areas almost untouched by man;
2) in most areas human settlement was sparse, and the number of people per square kilometer was significantly lower than in Europe;
3) agriculture was primitive and consisted mainly of sheep and cattle growing in unsanitary conditions, thus providing an important source of food for carrion-eating raptors.

The situation which developed in Israel, and which has been thoroughly studied is a good example of what happened in other parts of the Middle East. The **first critical stage** in the destruction of the delicate ecological balance in this area occurred with the outbreak of World War I in 1914. Weapons and ammunition flowed freely into the Middle East, and practically every male inhabitant of the area now possessed firearms. This, in turn, led to wholesale hunting of wildlife. The main damage to birds of prey did not come as a result of direct hunting, but indirectly, due to the massive liquidation of such large mammals as Oryx, Ibex and Gazelle, as well as populations of smaller mammals and birds, which constituted an important food base for raptors. Within a few decades the local wildlife population was substantially decimated (Fig. 2).

The **second critical stage** occurred only 4 decades ago with the establishment of the State of Israel. In an extremely short period of time and with an intensity almost unknown in other areas, four million people settled a small region of 21,000 km^2, half of which is comprised of uninhabitable desert. This wave of development was based mainly on modern agriculture and on massive, practically uncontrolled use of pesticides (Mendelssohn 1972). If all this were not enough, thousands of poisoned baits were set out to decimate wild mammal populations to prevent the spread of rabies. The results for the raptor population were catastrophic — most of the species in Israel were almost completely annihilated. Results of raptor nesting surveys by the Israel Raptor Information Center (IRIC) during the last few years point to a number of other factors common to developed countries that are also involved. Among these are habitat destruction for construction and development of road networks, harassment of nesting birds by nature lovers and rock-climbing enthusiasts, and electrocution on high-tension power lines. One example of the last of these occurred in the Golan Heights in northern Israel. Between 1982-1984, 43 Griffon Vultures, about one-quarter of the Griffon population in that part of the country, died as a result of electrocution (Mendelssohn and Leshem 1973).

Table 1 lists the status of the 23 species of raptors breeding in Israel since the beginning of the century. Of these species, 34.8% are now completely extinct, 17.4% are endangered, 21.8% have decreased to < 1/3 their original population and **only about one quarter,** 26%, are in no immediate

Table 1. Status of the 23 species of raptors breeding in Israel.

SPECIES	STATUS
White-tailed Eagle (*Haliaeetus albicilla*)	No Longer Breeding
Spotted Eagle (*Aquila clanga*)	"
Verreaux's Eagle (*Aquila verreauxi*)	"
Imperial Eagle (*Aquila heliaca*)	"
Black Vulture (*Aegypius monachus*)	"
Osprey (*Pandion haliaetus*)	"
Peregrine Falcon (*Falco peregrinus brookei*) (Mediterranean Race)	"
Marsh Harrier (*Circus aeruginosus*)	"
Lappet-faced Vulture (*Torgos tracheliotus negevensis*)	Endangered (< 10 known breeding pairs)
Lammergeier (*Gypaetus barbatus*)	"
Black Kite (*Milvus migrans*)	"
Lanner Falcon (*F. biarmicus*)	"
Griffon Vulture (*Gyps fulvus*)	Present Population < 1/3 the Size of Past Population
Egyptian Vulture (*Neophron percnopterus*)	"
Bonelli's Eagle (*Hieraaetus fasciatus*)	"
Golden Eagle (*Aquila chrysaetos*)	"
Lesser Kestrel (*F. naumanni*)	"
Barbary Falcon (*F. pelegrinoides*)	In No Immediate Danger
Hobby (*F. subbuteo*)	"
Sooty Falcon (*F. concolor*)	"
Common Kestrel (*F. tinnunculus*)	"
Long-legged Buzzard (*Buteo rufinus*)	"
Short-toed Eagle (*Circaetus gallicus*)	"

danger. It is worth noting that major damage to raptor populations has occurred in densely populated areas, mainly in northern and central Israel. The southern part of the country, largely uninhabited desert, is the stronghold of birds of prey in Israel, and it possesses a relatively large raptor population. Golden Eagles, for example, breed mainly in the Negev and Judean Deserts. During the past 13 years, the 23 known breeding pairs have successfully feldged 3 young, a total of **21 times.** There can be no better proof of the importance of the desert habitat.

A group of Israeli biologists who realized the extent of the damage done to nature as a result of the accelerated development of the country, established the Society for the Protection of Nature in Israel (SPNI) in 1952. The objectives of the SPNI are to increase awareness of nature conservation and protection among the general public and to lobby for nature conservation legislation by the government. The resulting intensive educational efforts succeeded above and beyond all expectations. In the space of 30 years a network of 24 field study centers was established all over the country. About half a million people pass through these centers each year — more than 10% of Israel's population — where they enjoy a variety of nature tours and learn about nature and its conservation.

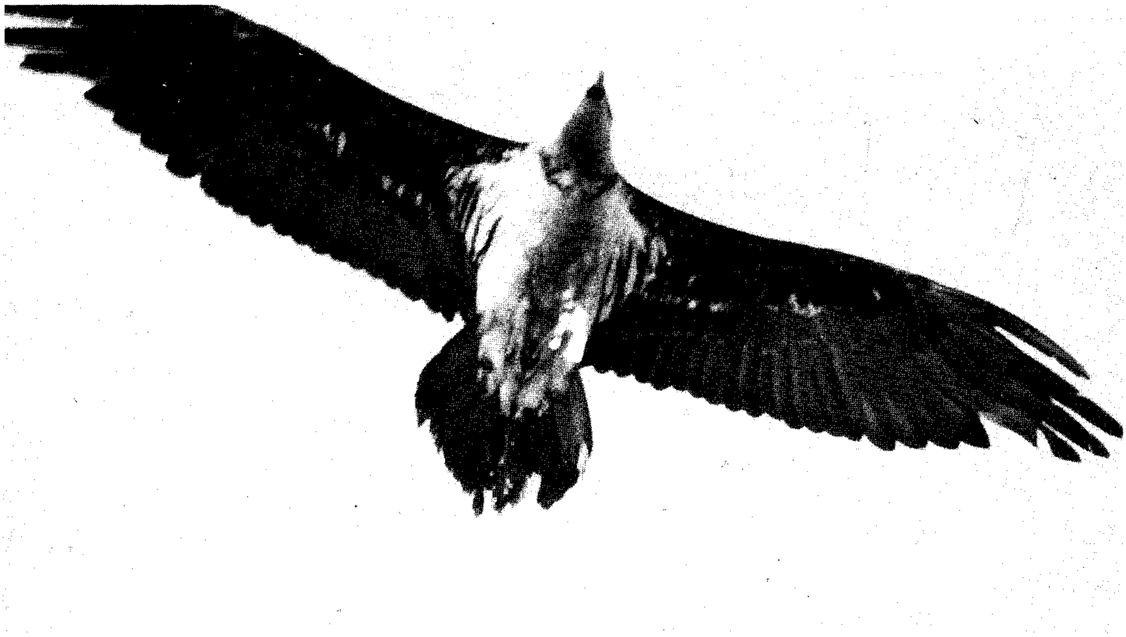

Figure 1. The Lammergeier, one of the four remaining in Israel, April 1981. (Photo: *William S. Clark*).

A corresponding government office, the Israel Nature Reserves Authority was established to implement nature conservation legislation. Strict wildlife protection laws have been enacted: all birds of prey in Israel are protected by law and infringements are severely penalized. There are only about 5,000 hunters in Israel and relatively few cases of illegal hunting. Falconry is against the law, and the use of pesticides has been largely limited. Even in the army, which has serious destructive

Figure 2. Last remaining pair of Lappet-faced Vultures still breeding in the wild in Israel. (Photo: *Yossi Eshbol*).

Figure 3. IRIC — Israel Air Force raptor migration research project.

potential, laws are strictly enforced, and many educational activities are organized for the soldiers (Fig. 3).

In 1980 the Israel Raptor Information Center (IRIC) was established and set up an educational network that bore immediate fruits (Leshem 1985). Within 5 years a core of some 6000 raptor enthusiasts formed around the Center. The IRIC is active in a wide variety of fields: study days and seminars are held, and raptor-related material is published, including a bi-yearly journal *(The Torgos)*, informative booklets, colorful posters and other relevant matter. The IRIC also has an excellent working relationship with the mass media, so that in 1985 alone, 420 different articles and reports on birds of prey appeared. For 3 years, a watch was held over the nest of a Golden Eagle pair in the outskirts of Jerusalem (Fig. 4). Six hundred volunteers participated in the project, and some 45,000 people visited the site.

The IRIC organizes a yearly raptor migration count which takes place in the fields of Kfar Qasem near Tel Aviv (Fig. 5) (Leshem 1985). The station is visited by thousands who come to see migration and to hear lectures by the IRIC staff. Up to now, 7 films on birds of prey have been produced, and photographic exhibitions held in various parts of the country. All these have succeeded in increasing public awareness about raptors and their conserva-

Figure 4. IRIC volunteers watch over Golden Eagle nest outside Jerusalem. (Photo: *Haim Alfia*).

Figure 5. Arab students from Kfar Qasem join the IRIC raptor migration count. (Photo: *Reuven Yossef*).

tion problems in Israel within a relatively short period of time (Figs. 6 and 7).

Unfortunately, the picture in other Middle Eastern countries is far from rosy. Most of them have no nature conservation legislation to speak of. In those countries that have laws protecting wildlife, there is almost no significant enforcement of them. From studies by Woldhek (1980) and others we learn that there are 400,000 hunters in Lebanon and 3,000,000 in Turkey. The number of nature lovers in these countries is minimal. Shooting migrating birds in flight and falconry are two popular sports in the Mediterranean which do nothing to improve the situation.

Figure 6. Poster (color) of an Osprey in Israel. Hundreds of thousands of copies have been sold to the public, (Photo: *Yossi Eshbol*).

MIDDLE-EASTERN RAPTOR CONSERVATION IN THE NEXT 50 YEARS

The main proposals for raptor conservation in the world for the next 50 years, such as land management, reintroduction, and further research have already been recommended by my colleagues at this meeting, and they are undoubtedly appropriate for the Middle East as well. However, there is one central factor, which in my opinion, is of major importance in our unstable area — education. We must invest a major part of our intellectual and financial resources to change the basic conceptions of the general public and governments on birds of prey and the importance of protecting them. Without intensive activity in this field all the effort invested in research and surveys will be practically useless.

Figure 7. Poster distributed in Israel to publicize raptor migration watching in Eilat. (Drawing - *Ze'ev*).

When the State of Israel was established 38 years ago there were almost no conservation laws. A major part of the population originated in North Africa, Western Asia and Eastern Europe, and lacked even elementary education in nature and its protection. As a result, very little serious thought was given to the subject during the first decade of Israel's existence. The damage to the raptor population of the country, needless to say, was enormous.

The SPNI succeeded in completely changing this attitude, both in the public and in the government. Today we can safely say that a majority of the population realizes the tremendous importance of conserving and protecting nature. The network of Field Study Centers and Zoological and Botanical Information Centers that was established and the educational and financial resources invested in the public have shown us that it is possible to change the attitudes of a **whole country** within 2 or 3 decades.

International nature conservation organizations are not doing enough in the important field of education. We feel that because of the delicate political situation in the Middle East, education would be the most valuable activity for these organizations to invest in. Thus, we may possibly succeed in transforming the Middle East back into the paradise for birds of prey it was in the past.

The following quote from the words of an ancient Jewish sage, written 2,000 years ago in the Middle East, best expresses our approach to the protection of raptors in this troubled area: ". . . when the Holy One, Blessed Be He, created the first man, He took him and warned him about the trees in the Garden of Eden, saying: See my works, how beautiful and perfect they are, and all I created, I created for you! Beware, lest you spoil and destroy my world, for if you do, there is no one to repair it after you . . ." (Kohelet Rabba 7,28).

LITERATURE CITED

LESHEM, Y. 1985 a. Israel an international axis of raptor migration. ICBP Technical Publication no. 5, pp. 243-250.

LESHEM, Y. 1985 b. Israel as a model of conservation education on birds of prey in developing countries. Bull. WWG Birds of Prey no. 2, pp. 117-120.

MENDELSSOHN, H. 1972. The impact of pesticides on bird life in Israel. ICBP Bull. II, pp. 75-104.

MENDELSSOHN, H. AND Y. LESHEM. 1983. The status and conservation of vultures in Israel. Vulture Biology and Management. Eds. S. Wilbur and J.A. Jackson. Univ. of Cal. Press, pp. 86-98.

TRISTRAM, H.B. 1865. A Journal of Travels in Palestine, 1863-1864.

WOLDHEK, S. 1980. Bird killing in the Mediterranean, European Comm. for the Prevention of Mass Destruction of Migratory Birds, Ziest, Netherlands.

RAPTORS IN THE TROPICS — THE NEXT 50 YEARS

ROBERT S. KENNEDY

National Wildlife Federation, Raptor Information Center,
1412 16th Street Northwest, Washington, D.C. 20036
Present Address: Cincinnati Museum of Natural History
1720 Gilbert Avenue, Cincinnati, Ohio 45202

ABSTRACT - Of the 418 species of raptors known to exist in the world, 378 can be found in the tropics either as residents or as migrants. Nearly half of the world's raptors (203 species) partially or wholly use the tropical forests. In 50 years, the human population in the tropics will have increased at least 2.6 times (to nearly 8 billion) over that for 1975, and the tropical forests will have been depleted by an estimated 30% or more. During this period of time, we can expect many falcons, large raptors, and rare raptors to become threatened or to become extinct if effective measures are not taken to prevent the demise of tropical forests.

Our knowledge of tropical raptors is similar to our knowledge of other organisms and ecological processes in the tropics, i.e. very sparse. The fact that two new species of South American owls have been described since 1977 (*Xenoglaux loweryi* by O'Neill and Graves 1977; and *Otus marshalli* by Weske and Terborgh 1981) with another yet to be described, and that the African owl *Phodilus prigoginei* is known only from a single specimen (Schouteden 1952), demonstrates clearly how little we know. Despite this lack of knowledge, the majority of the world's raptor biologists (which number more than 1,000) continue to focus their research activities on a handful of Nearctic and Palearctic raptors while the bulk of the world's raptors, those in the tropics, remain unknown.

In this paper, I present: 1) a broad analysis of the distribution and status of tropical raptors today; 2) a comparison of the tropical environment today and what it is expected to be 50 years from now; 3) a preview of the status of raptors in the tropics in the year 2034; and 4) a discussion on tropical conservation.

Before these four sections are presented, let us define the tropics and list the vegetative zones that are found there.

THE TROPICS DEFINED

Simply defined, the tropics are those places that lie between two lines of latitude that mark the north and south journey of the sun. These lines are 23.5° N, the Tropic of Cancer, and 23.5° S, the Tropic of Capricorn. The sun is always above this belt and thus day length is nearly constant year round and temperatures are relatively warm.

There are six generalized vegetation zones found in the tropics. These include:

1) Desert and desert scrub; 2) Hot steppe — dry short grasslands; 3) Wet tropical grassland — semi-desert, savanna and scrub; 4) Semi-evergreen and deciduous tropical forest including thorn forest; 5) Mountain vegetation — subtropical and alpine; and 6) Tropical forest — forest and rain forest or moist tropical forest.

Tropical forests are among the oldest and most complex ecosystems on earth. As we shall see, a large percentage of the world's raptors live in these forests and thus much of our discussion will be centered around tropical forests and what the future holds for them. Myers (1984:) has provided a clear definition of tropical forests that we will use here: "Forests that occur in areas that have a mean annual temperature of at least 75 degrees Fahrenheit [24° C] and are essentially frost-free — in areas receiving 2,000 mm or more of rainfall per year and not less than 100 mm of rainfall in any month for two out of three years. They are mainly, if not entirely, evergreen. We generally find such forests at altitudes below 1,300 meters, though sometimes in Amazonia up to 1,800 meters, and usually in Southeast Asia up to only 750 meters. In mature tracts of forest, there are several more-or-less distinct strata, and the canopy is made up of almost continuous interlocking tree crowns."

Tropical forests are spread over four biogeographical regions of the world including the Neotropical (Central and South America), Ethiopian, Oriental and Australian Regions.

RAPTORS IN THE TROPICS - TODAY

Distribution. — As I began to work on this paper, the first questions I asked myself were: How many species of raptors are known in the world and how many of these are found in the tropics either as

Table 1. Number of species of raptors found worldwide and in the tropics.

ORDER	WORLDWIDE	TROPICS[a]	% IN THE TROPICS
FALCONIFORMES	284[b]	258	90.8
STRIGIFORMES	134[c]	120	89.6
Total	418	378	90.4

a) Based on information in Brown and Amadon (1968).
b) Based on Stresemann and Amadon (1979).
c) Based on Clark, Smith and Kelso (1978) with one additional species added from Weske and Terborgh (1981).

residents or as migrants? In Tables 1 and 2 I have listed the answers to these questions. Surprisingly, 378 (90.4%) of the 418 species of raptors of the world are found in the tropics, making this geographic region far and away the most important one for raptors. Migrant raptors, such as the Swainson's Hawk (*Buteo swainsoni*), the Broad-winged Hawk (*Buteo platypterus*), and other species of falconiforms make up only a small fraction (5.8%) of the tropical raptor fauna. No migrant owls reach the tropics.

Of the resident tropical species, more than half (53.7%) live wholly or partially within the tropical forests. Proportionally more species of owls (68.3%) live in tropical forests than do falconiforms (46.9%). All together, tropical forests provide living quarters for nearly half (48.6%) of the world's raptors (Table 3).

The number of species of raptors that inhabit each biogeographical region of the tropics (Table 4) ranges from a low of 91 species in the Austral asian Region to a high of 125 in the Neotropics More species of falconiforms (89) live in the Ethio pian Region than elsewhere, whereas more specie of strigiforms (40) inhabit the Neotropics.

By and large, the raptors inhabiting one regio do not inhabit another region. To obtain a relativ measurement of overlap of species occurrenc among the four regions, I have used the followin equation:

$$\text{Overlap} = \frac{\sum_{i=1}^{4} P_i}{P}$$

where P_1 is the number of species in region i in th Tropics and P is the total number of species th occur in the tropics. The overlap value can rang

Table 2. Number of migrant and resident species of raptors in the tropics.

ORDER	MIGRANTS		RESIDENTS	
	NUMBER	%IN THE TROPICS	NUMBER	%IN THE TROPICS
FALCONIFORMES	22	8.5	236	91.5
STRIGIFORMES	0	0.0	120	100.0
Total	22	5.8	356	94.2

Table 3. Number of species of raptors that occur in tropical forests.

ORDER	NUMBER	% IN THE TROPICS	% IN THE WORLD
FALCONIFORMES	121	46.9	42.6
STRIGIFORMES	82	68.3	61.2
Total	203	53.7	48.6

from 1, where all species inhabit only one region, to 4, where all species inhabit all four regions.

The low overlap values for both Order Falconiformes and Order Strigiformes (see Table 4) demonstrate that most tropical raptors have restricted ranges. These values would be much lower if it were not for three species — Osprey (*Pandion haliaetus*), Peregrine Falcon (*Falco peregrinus*), and Common Barn-Owl (*Tyto alba*) — which live in all four regions in the Tropics.

Present Status. — With so little known about tropical raptors in general, we cannot accurately discuss their present status. However, by using information found in the *Red Data Book* (1979) and in a recent "List of Threatened Raptors" compiled in 1984 by the International Council for Bird Preservation's (ICBP) World Working Group on Birds of Prey, we can obtain a glimpse of the status of these birds. In Tables 5 and 6, I have summarized the number of raptor forms (including species and subspecies) listed in these references for the tropics, for tropical forests and for islands, almost all of which are tropical (e.g., the island of Mauritius in the Indian Ocean). In all cases, the tropics contain >50% of the raptors listed and tropical forests contain nearly half of those listed. The numbers listed on islands also exceeds 50%. The importance of the island category will be more apparent when we discuss the fragmentation of tropical forests in the next section.

THE TROPICS TODAY AND 50 YEARS FROM NOW

The events taking place in the tropics today will not only affect the raptors there, but they will have a profound impact on all life on earth and will influence the course of evolution (Richards 1952). In this section we will look at the human population projections in the tropics and the rates of, and reasons for, the depletion of the tropical forests.

Human Population. — In Table 7 I have summarized the human population projections for the world and for the major regions in the Tropics.

Table 4. Number of species of raptors in the biogeographical regions of the tropics.

ORDER	NEOTROPICAL	ETHIOPIAN	ASIAN: ORIENTAL	ASIAN: AUSTRALASIAN	OVERLAP[a]
FALCONIFORMES	85	89	67	66	1.19
STRIGIFORMES	40	31	33	25	1.08
Total	125	120	100	91	1.15

a) See text for a definition of overlap.

Table 5. Number of raptors listed in the Red Data Book (1979).

ORDER	NUMBER OF FORMS LISTED	NUMBER (%) IN THE TROPICS	NUMBER (%) IN TROPICAL FORESTS	NUMBER (%) ON ISLANDS
FALCONIFORMES	29	20 (69.0)	10 (34.5)	17 (58.6)
STRIGIFORMES	13	12 (92.3)	8 (61.5)	10 (76.9)
Total	42	32 (76.2)	18 (42.9)	27 (64.3)

Population figures for the years 1975 and 2000 are taken from *The Global 2000 Report* (1980) while those listed for the year 2034 have been calculated using the rate of growth during the period 1975 to 2000. This gain represents an arithmetic growth rate and not the exponential one that demographers are predicting. Thus, the projected figures are probably lower than what the real numbers will be. Nevertheless, 50 years from now we can expect a world with at least 9.426 billion people or 2.3 times the number in 1975. Percent growth in the tropical regions will vary from a low of 141% in Asia and Oceania to a high of 245% in Africa. Such a dramatic increase in the human population will mean that more land will be cleared for farming and grazing, for natural resources, and for living. (For a thorough review of the projected human population growth figures, see Fox 1984.)

Deforestation Rates. — Less predictable than the rate of human population growth is the rate of deforestation. During the period 1981 - 1985, the closed forests (those forests with dense tree canopies and no continuous grass cover) in tropical America, Africa, and Asia were cleared at an estimated rate of from 0.60 to 0.61% per year (Table 8, data from *Technologies to Sustain Tropical Forest Resources* 1984, hereafter referred to as Technologies 1984). Individual deforestation rates for the 76 tropical countries ranged from less than 0.1% in Surinam, for example, to 6.5% in the Ivory Coast. Each year an estimated 113,000 km^2 of closed tropical forest is cleared, an area roughly the size of Pennsylvania. In 50 years 9 of the 76 countries will have eliminated all of their closed forests and 13 other countries will have cleared theirs shortly thereafter.

Reasons for Tropical Deforestation. — Myers (1984) has presented excellent summaries of four of the prominent reasons for deforestation. The first is **forest farming** or, as it is often referred to, slash-and-burn farming. In 1980, there were an estimated 200 million forest farmers who were clearing some 160,000 km^2 per year.

Second, **commercial loggers** clear some 45,000 km^2 per year, an area twice the size of Maryland. Commercial logging *per se* does not pose a permanent threat to tropical forests if the forests are selectively logged and if they are protected once

Table 6. "List of Threatened Raptors" compiled by ICBP World Working Group on Birds of Prey (1984).

CATEGORY	TOTAL LISTED	NUMBER (%) IN THE TROPICS	NUMBER (%) IN TROPICAL FORESTS	NUMBER (%) ON ISLANDS
Acutely Endangered	7	4 (57.1)	2 (28.6)	4 (57.1)
Less Acutely Endangered	24	19 (79.2)	4 (16.7)	11 (45.8)
Possibly Threatened	42	39 (92.9)	28 (66.7)	30 (71.4)

Table 7. Human population projections for the world and major regions in the tropics.

YEAR	POPULATION IN MILLIONS 1975[a]	2000[a]	2034[b]	% INCREASE BY 2034
World				
More developed	1,131	1,323	1,584	40
Less Developed	2,959	5,028	7,842	165
World Total	4,090	6,351	9,426	130
Major Regions				
Latin America	325	637	1,061	226
Africa	399	814	1,378	245
Asia Oceania	2,274	3,630	5,474	141
Total	2,998	5,081	7,913	164

a) Source: *The Global 2000 Report* (1980).
b) Straight line projection based on the growth rate between 1975 and 2000.

they have been logged. However, in the Philippines, as I am sure is true elsewhere in the tropics, the forests are usually not protected after they are cut and logging roads provide forest farmers with easy access to logged areas.

Third, **fuel wood gatherers** clear some 25,000 km² per year. Little known to the people of the developed world, most of the citizens of the developing countries, more than 2 billion of them, use wood to cook their meals. An estimated 1/2 to 1 ton of wood is used per person per year for this purpose.

And fourth, **livestock raisers** clear around 20,000 km² of tropical forest each year to produce inexpensive beef for the fast food restaurants in the developed world — the so-called "hamburger connection." Nations and Komer (1984) have provided an informative account of deforestation of Central America due to livestock raisers.

Myers (1984) refers to the amount of land cleared

Table 8. Deforestation rates of closed forests in tropical America, Africa and Asia.

	CLOSED FOREST AREA (1000S OF HA)[a]	% OF CLOSED TROPICAL FOREST IN THE WORLD[a]	% OF TOTAL LAND AREA IN CLOSED FOREST[a]	% DEFORESTED PER YEAR 1981-1985[a]	% DEFORESTED IN 50 YEARS[b]
America	678,655	56.5	40.4	0.60	30.0
Africa	216,634	18.0	10.0	0.61	30.5
Asia	305,510	25.4	32.3	0.60	30.0
Range from 76 Countries	--	--	0.3-97.8	0.1-6.5	5.0-100.0

a) Source: *Technologies to Sustain Tropical Forest Resources* (1984).

b) Straight line projection based on rate between 1981-1985.

as "informed estimates" and, as such, they are higher than the estimates released in Technologies (1984). His estimates predict that 2% of the tropical forest biome is being cleared each year. If he is correct, in 50 years tropical forests will have all but vanished from the face of the earth. And let us not forget that the human population is constantly growing. This will accelerate — not retard — the rate of deforestation.

The impacts of tropical deforestation are many, but I will mention only three of the major ones here. First, deforestation destabilizes water flows leading to depletion of ground water, the erosion and eventual siltation of water courses, and the increased periodicity of floods and droughts. All of these will affect food production for humans who will likely turn to the forests to produce more food.

Second, by the year 2000 many scientists are predicting that between 15-20% of all species of plants and animals on earth will become extinct. Of these one-half to two-thirds will be caused by tropical deforestation. Sadly, once they are gone we will never know the potential they might have had as medicine, food, or as some other products beneficial to humankind.

Third, deforestation on the scale predicted will precipitate changes in the earth's climate. As we continue to burn fossil fuels and deplete the tropical forests, carbon dioxide levels will increase dramatically. Scientists predict that a doubling of the earth's CO_2 will result in a "green-house effect," a significant alteration of rainfall worldwide, and 2-3° C rise in temperature overall and 6-12° C rise at the poles. Keep in mind that a 1° C rise would make the earth warmer than it has been for 1,000 years. Polar ice caps would begin to melt and the oceans would rise inundating most of Florida and such port cities as New York. Land area on earth would decrease leaving less room for all life on land, including humans and raptors.

RAPTORS IN THE TROPICS IN 2034

As already stated, many people are predicting we will soon lose about 1 million species of plants and animals if the current rate of deforestation continues. How many of these species will be raptors is impossible to tell. However, if we take the simplest possible scenario and assume that the population sizes of birds of prey are proportional to the amounts of forests remaining, we can predict a 30(based on Technologies 1984) reduction in th number of raptors in 50 years. But, as Diamon (1980) and others have pointed out, "patchy dis tribution of habitat and thus birds is exaggerated i the tropics." Raptors, like other birds, are nc evenly distributed. Because of the patchy distribu tion of habitats and the eventual fragmentation c existing forests, researchers are applying the prin ciples of island biogeography to tropical conserva tion.

Terborgh and Winter (1980) have reviewed th potential causes of extinction in land-bridge island and habitat islands. Here we will look at som generalities that are applicable to raptors. In thei review of 5 major land-bridge islands, they foun falcons "to be particularly extinction prone." Larg species are among the first to drop out of land bridge island faunas (Willis 1974; Wilcox 1980 Willis (1980) has shown that large raptors such a eagles are especially extinction prone in habitat is lands in Brazil. However, hawks, vultures and owl are exceptions, and they show normal-to-good su vival rates in such situations when they are nc initially rare (Terborgh and Winter 1980). Specie that are initially rare because they are at the limits o their geographical range, because they occur at lo populations wherever they live, or because they ar specialists on certain types of patchily distribute habitats are more likely to become extinct. Te borgh and Winter (1980) have concluded from thi that "rarity proves to be the best index of vulnera bility." Therefore, as tropical forests are cleare and fragmented forming habitat islands during th next 50 years, we can expect more falcons, larg raptors and rare raptors to become threatened or t become extinct than other birds of prey.

CONSERVATION IN THE TROPICS

"Conservation tends to be reactive. It is activate when there is an acute threat to natural resource which should be used but not abused. . . Conser vationists must try to foresee threats and to ac before it is necessary to react." (Fittkau and Reich holf 1983:5) The message of this statement coul easily be the main message of my presentation, in deed, of the whole symposium. We must all begin t take a whole-world approach to conservation an we must "act before it is necessary to react." Th

ICBP is currently trying to encourage each and every conservation group, regardless of size, to take on at least one wildlife or conservation project in the less developed countries of the world. But for us to do this we must understand that our tried and true methods of conservation in the USA and in many other developed countries might not necessarily work in the tropics. Conservation is as foreign to most people in the less developed countries as many of their customs are to us.

Golley and Medina (1975) have observed that tropical forest conservation must be geared to the needs of human society and that we must not make the mistake of pitting wildlife against humans, a practice that we can use in the developed nations. In the Philippines, we have on more than one occasion been reminded not to do this. Once we helped establish a sanctuary for the Philippine Eagle (*Pithecophaga jefferyi*) in the mountains of Mindanao — an experience that almost cost us our lives. The native people there ". . . view the remaining forests in the mountains as potential farmland. Their shifting agriculture was the way of their forefathers. To turn a large tract of forest in the mountains into an eagle sanctuary was like telling them that the eagle is more important than they are." (Kennedy 1983:32).

The causes of tropical deforestation ". . . lie in political, economic and social forces (e.g., undefined property rights) that cause people to use forests in ways that are inappropriate to ecological conditions" (Technologies 1984:12). Our goal, one of the most important goals of our time, must be to develop ways for people to use and to protect the forest resources that make it more profitable to sustain them than to destroy them. Our approach must integrate the fields of conservation, agriculture, forestry, and sociology.

Where do we begin to find these ways? There are several methods available now where we can begin to find them. These include (see Technologies 1984 for more details): maintaining sample ecosystems — parks, biological and forest reserves, etc.; harvesting non-timber products — rattan, fruits, resins, wild game, etc.; agroforestry — wood for fuel, for housing and for food; watershed management; selective cutting and rotation harvesting; reforestation; protection of the forests — define ownership of the forests.

The last item deserves special attention. The majority of tropical forest land is owned by the governments of the individual nations. The stewardship of the forests is thus left to the governments who, with all the other social and economic problems facing them today, place a low priority on forest management. Ownership of land is ill-defined — the land belongs to the people — and thus land is abused and not responsibly cared for. Sedjo and Clawson (1983) have stated that most of the problems of excessive deforestation are related to the resource's nature as common property.

What Is Being Done and What Can Be Done. A few years ago the World Wildlife Fund-U.S. and the Instituto Nacional de Pesquisas da Amazonia launched the "minimum critical size of ecosystems" study in Brazil that will give us clues as to how large preserves must be, and how many of them we should have in order to reduce the rate of extinction to some acceptable level (Lovejoy 1980; World Wildlife Fund 1983). The results of this long term study will be particularly useful in Brazil where, by law, 50% of the land in any development project must remain in forest. We have already stated that we know very little about tropical raptors. Surely the minimum critical size of ecosystems study will reveal much about raptors. Recently, The Peregrine Fund, Inc., has opened its World Center for Birds of Prey and has already become involved in the conservation of several tropical raptors. But there is a need, a tremendous need, to conduct baseline studies on raptors and their populations throughout the tropics. Over the past two decades, raptors have been useful as environmental indicators in the developed world. They may serve a similar role in the tropics if and only if we know more about them.

Norman Myers (1984) has devoted a whole section of his book, *The Primary Source*, to "what we can do." He outlines a promising idea formulated by Dr. Ira Rubinoff, the Director of the Smithsonian Tropical Research Institute. Rubinoff's (1984:C5) plan would be to establish ". . . a multibillion dollar system of moist tropical forest reserves, financed by the developed nations. Under the plan, more than 1,000 reserves of approximately 100,000 ha each (nearly 250,000 acres) would be set aside in 48 nations containing the bulk of the world's tropical rain forests."

As important as research is, the conservation of tropical raptors will also depend on education. The Harpy Eagle (*Harpia harpyia*) for example, may survive in habitat patches left in Central and South

America but is particularly susceptible to hunters and will likely become extinct if adequate educational programs are not developed in concert with habitat preserves.

CONCLUSIONS

The prospects for health populations of raptors in the Tropics 50 years from now are not very good. This statement is based largely on the relatively small amount of effort expended to solve the problems facing the Tropics and tropical forests today. This pessimistic outlook can and hopefully will be changed if the developed nations of the world shift more of their financial resources and research and conservation efforts into the Tropics; if other countries follow the lead of Brazil in passing laws (and enforcing them) to establish large forest reserves; if we can develop ways of using forests more profitably without destroying them; and if we can control human population growth.

ACKNOWLEDGMENTS

This paper in part was supported by the Raptor Information Center of the National Wildlife Federation (NWF). I wish to thank my collegues, S. Douglas Miller, Brian M. Millsap and Keith W. Cline for their help during the preparation of this lecture. I am particularly grateful to Sharon Levy and Eileen Hughes of NWF's library for their relentless effort to obtain references for me, to Ricky Dahne for the loan of key books and to Rosa K. Hudson for her assistance through the early phases of this project.

LITERATURE CITED

BROWN, L. AND D. AMADON. 1968. Eagles, hawks, and falcons of the world. McGraw-Hill, New York.

CLARK, R.J., D.G. SMITH AND L.H. KELSO. 1978. Working bibliography of owls of the world. National Wildlife Federation, Washington, D.C.

DIAMOND, J. 1980. Patchy distributions of tropical birds. Pp. 57-74 *In:* Conservation biology: An evolutionary-ecological perspective (M.E. Soule and B.A. Wilcox, Eds.). Sinauer Assoc. Inc., Sunderland, Massachusetts.

FITTKAU, E.J. AND J.H. REICHHOLF. 1983. The Environmentalist 3(Suppl. 5):5-6.

FORSYTH, A. AND K. MIYATA. 1984. Tropical nature. Charles Scribner's Sons, New York. [Not cited but an important reference.]

FOX, R.W. 1984. The world's urban explosion. *Natl. Geogr.* 166:179-185.

GILBERT, L.E. 1980. Food web organization and the conservation of neotropical diversity. Pp. 11-33 *In:* Conservation biology: An evolutionary-ecologica perspective (M.E. Soule and B.A. Wilcox, Eds.) Sinauer Assoc. Inc., Sunderland, Massachusetts.

THE GOLBAL 2000 REPORT TO THE PRESIDENT: 1980. Entering the twenty-first century Technical Report. Government Printing Office Washington, D.C. Vol. 1-3.

GALLEY, F.B. AND E. MEDINA. 1975. Ecological researcl in the tropics. Pp. 1-4 *In:* Tropical ecological systems: Trends in terrestrial and aquatic research (F.B Galley and E. Medina, Eds.). Springer-Verlag, New York.

INTERNATIONAL COUNCIL FOR BIRD PRESERVATION. 1984 List of threatened raptors. Ms. prepared by ICBP's World Working Group on Birds of Prey.

KENNEDY, R.S. 1983. Can Filipinos learn to love this bird? *Int. Wildl.* 13(4):26-33.

LOVEJOY, T.E. 1980. Discontinuous wilderness minimum areas for conservation. *Parks* (6(2):5-10.

MYERS, N. 1984. The primary source: Tropical forests and our future. W.W. Norton & Co., New York.

NATIONS, J.D. AND D.I. KOMER. 1984. Chewing up the jungle. *Int. Wildl.* 14(5):14-16.

O'NEILL, J.P. AND G.R. GRAVES. 1977. A new genus and species of owl (Aves: Strigidae) from Peru. *Auk* 94:409-416.

RED DATA BOOK. 1979. Vol. 2. Compiled by W.B. King International Union for the Conservation of Nature and Natural Resources, Morges, Switzerland.

RICHARDS, P.W. 1952. The tropical rain forest: an ecological study. The University Press, Cambridge England.

RUBINOFF, I. 1984. If we lose the tropical forests, no birds will sing. *Washington Post*, 5 August 1984. Pp. C1 C5.

SCHOUTEDEN, H. 1952. Un strigidae nouveau d'Afrique noire: *Phodilus prigoginei* nov. sp. *Rev. Zool. Bot. Afr.* 46:423-428.

SEDJO, R.A. AND M. CLAWSON. 1983. How serious is tropical deforestation? *J. Forestry* 81:792-794.

STRESEMANN, E. AND D. AMADON. 1979. Falconiformes Pp. 271-425 *In:* Check-list of birds of the world (E Mayr and G.W. Cottrell, Eds.). Vol. 1. Museum of Comparative of Zoology, Cambridge, Massachusetts.

TECHNOLOGIES TO SUSTAIN TROPICAL FOREST RESOURCES. 1984. U.S. Congress, Office of Technology Assessment, Washington, D.C.

TERBORGH, J. 1975. Faunal equilibrium and the design of wildlife preserves. Pp. 369-380 *In:* Tropical ecological systems: Trends in terrestrial and aquatic research (F.B. Golley & E. Medina, Eds.). Springer-Verlag, New York.

———, AND B. WINTER. 1980. Some causes of extinction. Pp. 119-133 *In:* Conservation biology: An evolutionary-ecological perspective (M.E. Soule and B.A. Wilcox, Eds.). Sinauer Assoc. Inc., Sunderland, Massachusetts.

WESKE, J.S. AND J.W. TERBORGH. 1981. *Otus marshalli*, a new species of screech-owl from Peru. *Auk* 98:1-7.

WILCOX, B.A. 1980. Insular ecology and conservation. Pp. 95-117 *In:* Conservation biology: An evolutionary-ecological perspective (M.E. Soule and B.A. Wilcox, Eds.). Sinauer Assoc. Inc., Sunderland, Massachusetts.

WILLIS, E.O. 1974. Populations and local extinctions of birds on Barro Colorado Island, Panama. *Ecol. Monogr.* 44:153-169.

———. 1980? The composition of avian communities in remanescent woodlots in southern Brazil. Papels Avulsos Museu Paulisto.

WORLD WILDLIFE FUND - US 1983 ANNUAL REPORT. World Wildlife Fund-US, Washington, D.C.

CONSERVATION OF MIGRATORY RAPTORS: AN OVERVIEW BASED ON FIFTY YEARS OF RAPTOR BANDING

CHANDLER S. ROBBINS

Patuxent Wildlife Research Center, Laurel, Maryland 20708

ABSTRACT — During the 50-year period 1931-80, 422,000 raptors were banded in the United States and Canada. Encounter rates were calculated, by decades of banding, for all birds reported outside of the 10-min block of latitude and longitude where they had been banded. Encounter rates for the various raptor species decreased from about 15-25% in the 1930s to about 1-5% in the 1970s. The percentage of encounters that were reported as shot also decreased sharply, from 55-85% for most species in the 1930s to 3-16% in the 1970s, reflecting the increase in protective state and federal legislation. During the same period the percentage of raptors found dead increased. In contrast, no such trends were apparent in raptors encountered south of the United States.

The North American Bird Banding program, which began privately in New England in the winter of 1907-1908, has been administered by the U.S. Fish and Wildlife Service, its predecessor the Biological Survey, and the Canadian Wildlife Service since 1920 (Wood 1945). In the early years of the program the numbers of raptors banded were small, and few recoveries were reported. The only raptors with more than 10 recovery records for the 24-year period 1907-1930 were Northern Harrier (82), Cooper's Hawk (32), Osprey (25), Red-tailed Hawk (57), Red-shouldered Hawk (22), American Kestrel (24), Barn Owl (58), Screech Owl (mostly or entirely the Eastern species, 54), and Great Horned Owl (31). Therefore, the present summary is restricted to a report on raptors banded during the fifty-year period, 1931-1980.

The purposes of this paper are: (1) to summarize the data bank and its early history; (2) to examine changes in encounter (or reporting) rate over the years; (3) to examine changes in the circumstances of encounters over the years, both in North America and south of the United States border; (4) to discuss biases in the data; and (5) to suggest more detailed analyses of the banding data.

Early Banders. — During the 1930s, 1940s and 1950s, only 2-3,000 raptors were banded per year. During the next two decades, however, interest in raptor banding increased dramatically (Table 1). Before the establishment of intensive raptor banding stations, such as those at Cedar Grove in Wisconsin, Cape May Bird Observatory in New Jersey, Hawk Ridge in Minnesota, and Whitefish Point Bird Observatory in Michigan, there were only a few banders who devoted a great deal of time to the banding of raptors and who were responsible for establishing the first large data base and encourag ing the banding of raptors by others.

It is not possible in this brief review to mention al of these early raptor enthusiasts, but a few name stand out for their pioneer work: Laurel Van Camp who banded more than 3,000 Easterı Screech-Owls in Ohio beginning in 1928 (Van Camp and Henny 1975); E.A. McIlhenny wh trapped and banded thousands of Black Vulture in Louisiana in the 1930s; Richard H. Pough wh supplied bands to scores of collaborators for th purpose of banding nestling hawks from 1936 int the 1940s; Charles Broley who banded more than thousand nestling Bald Eagles in Florida, 193 1949 (Broley 1952); and Dr. Stuart Houston wh since the mid-forties has traveled extensivel through eastern Saskatchewan, banding man hundreds of nestling Great Horned Owls and othe raptors located by a large network of collaborator Intensive work by banders such as McIlhenny an Broley, concentrated in one or two decades, stand out in contrast with the otherwise increasing tren in banding activity over the years (Table 1).

METHODS

The basic strategy of this paper is to summarize the 422,14 bandings and subsequent encounters of raptors by decades an then look for trends in the data. Decades were used instead individual years for several reasons, chief of which were the sma annual sample sizes for most species and the fact that preci annual banding totals are not available for the early years.

Starting in 1956 the Bird Banding Laboratory (BBL) has sun marized all bandings annually by species and state or provinc and these figures are updated when late reports are receive Prior to 1956, totals were tabulated manually and were publishe by species, in various issues of *Bird Banding Notes*. Those tota were prepared by "banding years," which generally ended abo two months before the close of the government fiscal year, pe mitting totals to be tallied for a timely annual report. Both bandin

Table 1: Raptor bandings by decades.[a]

SPECIES	1930s	1940s	1950s	1960s	1970s	TOTAL
Black Vulture	11,941	10,646	616	137	847	24,187
Turkey Vulture	784	534	139	197	787	2,441
Osprey	894	1,701	1,674	2,288	9,153	15,710
American Swallow-tailed Kite	0	0	0	4	9	13
Black-shouldered Kite	9	78	18	189	165	459
Snail Kite	1	15	0	30	344	390
Mississippi Kite	3	11	59	123	247	443
Bald Eagle	283	1,171	265	1,107	4,524	7,350
Northern Harrier	1,137	825	1,064	1,920	3,619	8,565
Sharp-shinned Hawk	232	462	2,478	14,179	85,390	102,741
Cooper's Hawk	484	899	967	1,496	6,872	10,718
Northern Goshawk	35	39	137	730	5,211	6,152
Common Black-Hawk	0	0	0	1	28	29
Harris' Hawk	2	0	26	129	1,736	1,893
Gray Hawk	0	0	2	6	89	97
Red-shouldered Hawk	331	736	677	1,101	3,257	6,102
Broad-winged Hawk	122	150	249	857	2,281	3,659
Swainson's Hawk	280	186	217	699	4,922	6,304
White-tailed Hawk	8	2	1	0	3	14
Zone-tailed Hawk	0	2	0	4	11	17
Red-tailed Hawk	688	860	3,204	11,118	31,139	47,009
Ferruginous Hawk	251	144	109	610	5,548	6,662
Rough-legged Hawk	112	40	232	653	887	1,924
Golden Eagle	64	128	187	1,076	2,269	3,724
Crested Caracara	13	15	1	6	40	75
American Kestrel	963	1,506	4,530	13,529	49,087	69,615
Merlin	101	70	299	653	4,467	5,590
Aplomado Falcon	0	0	0	0	10	10
Peregrine Falcon	205	339	536	953	3,612	5,645
Gyrfalcon	0	0	20	97	426	543
Prairie Falcon	181	216	331	1,428	7,032	9,188
Common Barn-Owl	1,177	1,092	2,426	2,228	6,341	13,264
Flammulated Owl	0	0	6	29	132	167
Eastern & Western Screech-Owl	1,293	1,392	3,330	3,277	5,378	14,670
Great Horned Owl	571	688	1,735	4,446	9.145	16,585
Snowy Owl	105	39	230	376	670	1,420
Northern Hawk-Owl	0	0	10	68	195	273
Northern Pygmy-Owl	6	3	12	24	34	79
Ferruginous Pygmy-Owl	0	0	1	14	15	30
Elf Owl	0	1	12	96	59	168
Burrowing Owl	833	169	170	538	1,184	2,894
Spotted Owl	3	5	3	0	62	73
Barred Owl	103	214	151	305	835	1,608
Great Gray Owl	0	2	5	19	501	527
Long-eared Owl	327	203	395	1,111	3,174	5,210
Short-eared Owl	233	74	170	927	758	2,162
Boreal Owl	1	7	38	59	210	315
Northern Saw-whet Owl	110	431	1,478	4,610	8,806	15,435
Total	23,886	25,095	28,210	73,447	271,511	422,149

[a]Species represented by fewer than 10 birds are omitted.

years and government fiscal years changed from time to time, so neither the starting month nor the number of months included was constant. Furthermore, once the figures for a year were published they were not updated to include late reports, so the published "annual" figures are often low by a few percent. "Annual" banding totals for raptors for 1931-55 were combined manually to supplement the computer tabulations for the more recent years.

For this paper the BBL prepared a summary of raptors banded from 1956 through 1980, by decades. It also made a summary, by decades of banding, of all encounters (the present BBL terminology for the inclusive category of all banded birds that are subsequently found and reported). This summary included a separate analysis of birds reported shot, those reported as found dead, and those still alive at the time of encounter. Birds retrapped and released at the original banding site were excluded from the tabulations and were not considered in this paper. The summary tabulations included bandings and encounters from throughout Canada and the United States as well as encounters from Latin America and the Caribbean. The BBL also listed the banding and recovery data for all raptor encounters south of the United States (extreme years, 1932-1983). In addition to raptors banded in the United States and Canada, the encounter tabulation includes 35 Ospreys and single birds of four other species that were banded in Mexico: Red-tailed Hawk, Broad-winged Hawk, Gray Hawk, and American Kestrel . The BBL has no separate record of the numbers of raptors that were banded south of the United States prio to 1956, but with the exception of the Osprey there must havi been very few.

Encounter rates were calculated for each species as the percentage of birds banded during the decade that were subsequentl encountered. The percents of encounters in each decade tha were reported as shot and as found dead were also calculated. Th summaries of encounter rates and of reported methods of encounter permit easy comparison among species over the 50-yea period, and they provide the basis for detecting significan changes with time. Linear regression analysis was used to detec significant trends during the 50-year period.

Because encounter/reporting rates south of the United State may differ markedly from those in the United States and Canadz and because the proportions of birds encountered by variou means may also be very different, these data were summarize separately.

RESULTS AND DISCUSSION

The summary of birds banded by decades (Tabl 1) has not previously been assembled in one place

Table 2. Percent of raptors[1] subsequently encountered in U.S.A. and Canada, by decades of banding.

SPECIES	1930s	1940s	1950s	1960s	1970s	MEAN	SLOPE	r
Black Vulture	5.61	1.51	4.38	0.73	0.47	2.54	−1.11	−0.755
Osprey	16.44	8.41	7.65	6.12	3.03	8.33	−2.91	−0.924*
Bald Eagle	5.30	3.50	7.12	5.24	8.64	5.96	+0.84	+0.676
Northern Harrier	16.45	6.55	6.39	3.49	1.13	6.80	−3.37	−0.912*
Sharp-shinned Hawk	10.78	3.25	2.14	1.74	1.04	3.79	−2.10	−0.832
Cooper's Hawk	16.74	9.45	7.96	3.81	2.26	8.04	−3.46	−0.963**
Northern Goshawk	20.00	23.08	12.41	8.08	4.24	13.56	−4.65	−0.930*
Red-shouldered Hawk	24.77	15.22	9.60	4.81	2.36	11.35	−5.52	−0.974**
Swainson's Hawk	15.36	13.44	5.07	4.15	1.97	8.00	−3.61	−0.952*
Red-tailed Hawk	25.44	21.63	12.33	6.72	4.07	14.04	−5.77	−0.984**
Ferruginous Hawk	18.73	10.42	6.42	2.79	3.14	8.30	−3.88	−0.931*
American Kestrel	8.62	4.78	4.83	3.22	1.90	4.67	−1.50	−0.941*
Merlin	4.95	2.86	5.02	2.76	1.59	3.44	−0.68	−0.719
Peregrine Falcon	22.93	11.21	4.85	2.62	3.77	9.08	−4.69	−0.880*
Prairie Falcon	26.52	12.50	6.95	5.25	3.31	10.91	−5.37	−0.905*
Common Barn-Owl	14.53	12.64	7.87	5.39	4.79	9.04	−2.67	−0.971**
Eastern and Western Screech-Owl	9.59	6.90	3.75	3.75	2.32	5.26	−1.77	−0.950*
Great Horned Owl	18.74	14.39	11.70	9.58	7.37	12.36	−2.76	−0.987**
Long-eared Owl	5.20	3.94	2.28	1.62	0.72	2.75	−1.13	−0.988**
Northern Saw-whet Owl	1.82	2.78	1.35	0.82	0.75	1.50	−0.41	−0.776

[1]Including only those species with banded sample ≈ 5,000 and excluding birds retrapped and released in the same 10-min block of latitude and longitude. See Table 1 for sample sizes.

*$P < 0.05$

**$P < 0.01$

It serves several purposes. It provides a base for computing recovery rates. It indicates the sample size for each species for the benefit of future investigators. It also shows the period during which the largest sample is available for each species. It is a rough measure of banding effort for the various species, and it shows the dramatic increase in raptor banding over the decades. Its value in revealing trends in abundance, however, even when using ratios of one species to another, is practically nil. Vulture numbers, for example, reflect largely the efforts of individual banders within the time frames of their particular studies. The ratio of Cooper's Hawks to Sharp-shinned Hawks is strongly biased by means of capture; the mist nets used extensively for capturing songbirds in the last two decades capture many Sharp-shinned Hawks, but the mesh is too small to hold Cooper's Hawks. Similarly, many owl banders concentrate on one or two species and use techniques that favor the capture of these species.

Although the banding totals themselves are of little value in detecting population trends, the encounter rates (Table 2) can be used with caution to reveal changes in human behavior toward the birds. As of March 1935 only half of the 48 states had laws protecting the majority of their hawks and no state protected all hawk species (May 1935). Some states were even paying bounties on hawks. During the ensuing 45 years, changes in state and federal legislation gradually extended legal protection to all species. It was not until March 1972 that all raptors received federal protection (by the addition of species to the 1936 convention between the United States of America and the United Mexican States for the Protection of Migratory Birds and Game Mammals). This change in protection status is reflected in the decrease in the percentage of banded birds subsequently encountered by the public in the United States and Canada (Table 2) and in the percent of encountered raptors that were reported as shot (Table 3). Of the 20 raptor species

Table 3. Percent of encounters in the U.S.A. and Canada that were reported shot, grouped by decade of banding.

SPECIES	1930s	1940s	1950s	1960s	1970s	MEAN	SLOPE	r
Black Vulture	31.0	26.1	11.1	0.0	0.0	13.2	−8.8	−0.964**
Osprey	39.5	33.6	31.2	7.1	4.7	23.2	−9.6	−0.943*
Bald Eagle	66.7	44.6	26.3	13.8	15.0	33.3	−13.4	−0.947*
Northern Harrier	72.7	64.8	47.1	38.8	12.2	47.1	−14.7	−0.979**
Sharp-shinned Hawk	68.0	52.9	54.7	27.9	4.4	41.6	−15.2	−0.950*
Cooper's Hawk	72.8	64.7	44.2	19.3	6.5	41.5	−17.8	−0.988**
Northern Goshawk	85.7	67.7	64.7	37.3	23.1	55.7	−15.6	−0.979**
Red-shouldered Hawk	70.7	54.5	52.3	26.4	7.8	42.3	−15.4	−0.974**
Swainson's Hawk	88.4	76.0	45.5	27.6	2.1	47.9	−22.1	−0.994**
Red-tailed Hawk	70.9	66.7	50.6	32.5	13.5	46.8	−14.9	−0.981**
Ferruginous Hawk	51.1	60.0	28.6	35.3	9.8	37.0	−10.7	−0.864
American Kestrel	37.3	25.0	14.2	9.4	2.7	17.7	−8.5	−0.983**
Merlin	60.0	50.0	46.7	27.8	2.8	37.5	−13.7	−0.955*
Peregrine Falcon	53.2	50.0	50.0	16.0	0.7	34.0	−13.9	−0.913*
Prairie Falcon	64.6	55.6	30.4	9.3	3.4	32.7	−16.9	−0.982**
Common Barn-Owl	31.6	27.5	11.0	5.8	2.6	15.7	−8.0	−0.964**
Eastern and Western Screech-Owl	17.7	9.4	3.2	0.8	1.6	6.5	−4.1	−0.909*
Great Horned Owl	58.9	44.4	35.0	18.3	7.3	32.8	−12.9	−0.997**
Long-eared Owl	29.4	50.0	33.3	22.2	13.0	29.6	−6.1	−0.695
Northern Saw-whet Owl	0.0	0.0	5.0	5.3	1.5	2.4	+0.8	+0.501

*$P < 0.05$
**$P < 0.01$

with banded samples exceeding 5,000 birds for the 50-year period, all except the Black Vulture, Bald Eagle, Sharp-shinned Hawk, Merlin, and Northern Saw-whet Owl showed statistically significant declines in encounter rate (Table 2). Encounter rates of most hawks dropped from the 15-25% range in the 1930s to 1-5% in the 1970s.

Although it is likely that some raptors were illegally shot and reported as "found dead," the decline in "shot" birds is dramatic and is statistically significant for all of the commonly banded species except the Ferruginous Hawk, the Long-eared Owl and the Northern Saw-whet Owl (Table 3). In the 1930s, percentages of encountered hawks that were shot in the United States and Canada were primarily in the 55-85% range, as compared with 3-16% in the 1970s. As the percentage of birds reported shot decreased, the proportion found dead increased. These increases were significant for the Bald Eagle, Northern Harrier, Sharp-shinned Hawk, Cooper' Hawk, Red-tailed Hawk and Great Horned Ow (Table 4).

There is a direct relationship between raptor siz and encounter rate (Table 2). The Red-tailed Hawk, Northern Goshawk, and Great Horned Ow have the highest rate, followed by the Red-shoul dered Hawk, Prairie Falcon, Peregrine Falcon an the Osprey. Those with the lowest rate are th Long-eared Owl, the Black Vulture (an exceptio to the generality), and the Northern Saw-whet Owl.

The protection now afforded raptors in th United States and Canada is not matched in th nations south of the U.S. border, so one would no expect the same degree of changes in encounte reporting rate or in the shift from shot birds t those found dead. There were only 11 migrator raptor species for which more than 10 individual were reported south of the United States, and o

Table 4. Percent of encounters in the U.S.A. and Canada that were reported found dead, grouped by decade of banding.

SPECIES	1930s	1940s	1950s	1960s	1970s	MEAN	SLOPE	r
Black Vulture	26.3	32.3	33.3	100.0	50.0	48.4	11.5	0.603
Osprey	23.8	39.2	36.7	37.9	45.5	36.6	4.2	0.839
Bald Eagle	20.0	26.1	36.8	44.8	40.2	33.6	5.9	0.911*
Northern Harrier	7.5	20.4	32.5	37.3	65.9	32.7	13.4	0.967**
Sharp-shinned Hawk	20.0	20.0	24.5	32.0	35.0	26.3	4.2	0.962**
Cooper's Hawk	4.9	17.6	32.5	52.6	40.0	29.5	10.5	0.889*
Northern Goshawk	14.3	0.0	17.6	42.4	36.6	22.2	8.7	0.797
Red-shouldered Hawk	9.8	19.6	15.4	35.8	28.6	21.8	5.4	0.818
Swainson's Hawk	7.0	16.0	9.1	17.2	39.2	17.7	6.6	0.811
Red-tailed Hawk	12.0	14.0	21.8	33.9	39.7	24.3	7.5	0.978**
Ferruginous Hawk	27.7	33.3	57.1	29.4	51.7	39.8	4.4	0.513
American Kestrel	25.3	29.2	42.5	38.6	33.7	33.9	2.6	0.598
Merlin	40.0	50.0	33.3	44.4	38.0	41.1	−1.0	−0.239
Peregrine Falcon	12.8	13.2	15.4	28.0	16.2	17.1	2.2	0.547
Prairie Falcon	14.6	14.8	30.4	26.7	32.6	23.8	4.8	0.882*
Common Barn-Owl	36.3	40.6	44.5	55.8	47.0	44.8	3.7	0.788
Eastern and Western Screech-Owl	38.7	39.6	46.4	44.7	42.4	41.4	1.2	0.604
Great Horned Owl	19.6	25.2	31.0	30.8	40.8	29.5	4.8	0.964**
Long-eared Owl	35.3	25.0	44.4	50.0	47.8	40.5	5.0	0.766
Northern Saw-whet Owl	50.0	58.3	55.0	44.7	31.8	48.0	−5.0	−0.760

* $P < 0.05$
** $P < 0.01$

Table 5. Encounter rates in Latin America (percent).

SPECIES	n[a]	1930s	1940s	1950s	1960s	1970s
Osprey	379	2.24	1.70	2.33	2.58	2.53
Northern Harrier	15	0.53	0.24	0.28	0.10	0.06
Sharp-shinned Hawk	46	0.00	0.43	0.20	0.04	0.04
Cooper's Hawk	14	0.21	0.00	0.00	0.27	0.13
Broad-winged Hawk	38	0.82	0.00	2.01	2.10	0.61
Swainson's Hawk	47	0.36	0.54	1.84	1.86	0.57
Red-tailed Hawk	60	0.87	0.23	0.06	0.13	0.12
American Kestrel	30	0.10	0.07	0.13	0.04	0.03
Merlin	27	0.00	0.00	1.34	0.31	0.47
Peregrine Falcon	70	1.95	1.18	2.05	0.94	1.16
Common Barn-Owl	12	0.08	0.00	0.12	0.18	0.06

[a]Total number of encounters from Latin America of birds banded 1931-80.

these, only the Osprey was reported in numbers greater than 70 (Table 5). The Northern Harrier shows a "significant" decline in encounter rates ($P < 0.05$), but in view of the small sample size the biological significance is questionable. The species with the largest sample sizes, Osprey, Peregrine Falcon and Red-tailed Hawk, do not show the strong pattern of declining encounter rates south of the border that they do in Canada and the United States. There is little evidence that shooting of raptors south of the United States has declined during the 50-year period. Only the Swainson's Hawk shows a significant decrease ($P < 0.05$) in percentage of Latin American encounters reported as shot (Table 6) and an increase in the percentage of encounters found dead (Table 7).

In a similar study in Europe, Saurola (1985) computed encounter rates of raptors banded in Finland and Sweden from 1950 to 1980. From a total of about 100,000 raptors banded, 10,000 were subsequently encountered. In this analysis Saurola used only birds banded as nestlings and killed or found dead in their first year of life. By comparing birds killed with those found dead, he showed a dramatic decrease in the persecution of migrating raptors in central Europe, France and the Soviet

Table 6. Percent of Latin American encounters reported as shot, by decades.

SPECIES	1930s	1940s	1950s	1960s	1970s
Osprey	80	55	79	78	59
Northern Harrier	83	100	67	50	100
Sharp-shinned Hawk	—[a]	0	80	83	58
Cooper's Hawk	100	—	—	50	0
Broad-winged Hawk	0	—	100	83	71
Swainson's Hawk	100	100	75	54	57
Red-tailed Hawk	50	0	100	69	59
American Kestrel	100	100	67	67	69
Merlin	—	—	100	100	62
Peregrine Falcon	100	75	82	100	38
Common Barn-Owl	0	—	67	25	50

[a]Dash indicates there were no encounters.

Table 7. Percent of Latin American encounters reported as found dead.

SPECIES	1930s	1940s	1950s	1960s	1970s
Osprey	20	28	5	10	14
Northern Harrier	0	0	0	0	0
Sharp-shinned Hawk	—[a]	0	0	0	15
Cooper's Hawk	0	—	—	25	11
Broad-winged Hawk	100	—	6	0	0
Swainson's Hawk	0	0	0	15	18
Red-tailed Hawk	17	0	0	0	8
American Kestrel	0	0	17	17	13
Merlin	—	—	0	0	19
Peregrine Falcon	0	25	9	0	26
Common Barn-Owl	0	—	33	0	25

[a]Dash indicates there were no encounters.

Union in the second half of the 1960s. The decline in Italy did not begin until ten years later, and Saurola found no evidence of a change in persecution rate in Africa.

Although recent conservation efforts have done much to reduce persecution of raptors in North America and Europe, the real challenge for the coming decades is to educate the peoples of the tropical nations regarding the value of raptors in the ecosystem and the importance of preserving wildlife habitats. Many excellent television programs featuring wildlife conservation (largely in the English language, but some with Spanish captions) are becoming available via satellite to an ever increasing number of viewers in the Neotropics. Perhaps through this medium it will be possible to make giant strides in promoting a conservation ethic and in stimulating more interest in wildlife research. At present, Brazil is the only Latin American country with its own banding program. As of the Iberoamerican Congress at Xalapa, Mexico, in 1983, no other country had expressed an interest in starting such a program.

Biases. — Reference has been made to some of the biases inherent in the use of banding data: incomplete banding totals for the early years; and changes in the fiscal year. Other biases that should be mentioned are:

(1) Banding records never submitted by the bander (especially when records for birds encountered are submitted on request but the bander dies or for some other reason fails to report the other birds that were banded th same year). This artificially increases the er counter rate.

(2) Birds still alive at the time of the analysi Probably almost all of the raptors banded i 1931-70 that are ever going to be er countered were processed by March 198 the date of the computer tabulation used i this paper. Although the 1984 tabulatio made it possible to include three years c encounters from the latest bandings include in the study (1980), a future analysis wi probably show that a few encounters for th 1971-80 bandings were processed afte March 1984. Thus, the declines in encounte rate for some species in Tables 2 and 5 may b slightly exaggerated. With the notable e ception of the Osprey, all but about 10% c the encounters were within 5 yrs of the dat of banding, and only 1-3% occurred after 1 yrs. For the Osprey, 20% of the encounte were after 5 yrs and 6% after 10 yrs.

(3) Reporting rate for encounters varies errat cally through time as well as geographicall depending on differences in publicity, ir centive, ignorance, economic status, an many other factors. A low reporting rate expected from countries where the literac rate is low and poverty rate is high. Specif efforts to keep publicity constant b minimizing it have possibly reduced the r porting rate in the United States and Canad

from what it was in the 1930s and 1940s, but no definitive evaluation has been made.

(4) Dishonesty in reporting "how obtained," and failure to report birds illegally taken. Comparatively few persons south of the United States border are aware that migratory birds are protected, so no bias in means of encounter would be expected from below the border. In the United States and Canada, some bias must exist, but it is believed to be minimal. Curiosity promotes the reporting of banded birds, even those that are illegally taken, and many birds that are taken in violation of the law are reported to the banding laboratory either by the person responsible or by someone else.

(5) Mortality rates of young birds (especially of birds banded in the nest) are much higher than those of adults. Over time, the emphasis has shifted from banding nestlings to banding adults, so for some species there is a possibility that data used in this study may be strongly biased. This bias may be partly self-compensating, because mortality in the nest would tend to decrease the encounter rate, while the high mortality rate in the first months after leaving the nest would tend to increase encounters.

These biases have only a minor effect on the usefulness of the banding data. They are mentioned primarily as a caution to other investigators who may not be as familiar with the history of the banding program.

Further Studies. — This paper has merely scratched the surface by reporting on the nature of the banding files and looking for evidence that changes in legislation and attitudes over 50 years have been reflected in the rates and methods of encounter. More detailed analyses, where sample size permits, should be confined to birds of the same age and/or sex, and a smaller geographic area (see, for example, VanCamp and Henny 1975). For species that are migratory in part of their range, migratory populations should be examined separately from sedentary populations.

Field studies that can be continued over a long period of years or can be repeated in the same manner as an earlier investigation are especially important. The value of carefully documenting procedures so that a study can be repeated in the future cannot be stressed too strongly.

ACKNOWLEDGMENTS

M. Kathleen Klimkiewicz of the Bird Banding Laboratory provided the computer tabulations on which this paper is based. I thank George Jonkel and Nancy Mullis for help in finding banding totals for the early years and in checking questionable records. Deanna Dawson, Mark Fuller, Stanley Senner and Stanley Wiemeyer made suggestions for improving the manuscript.

LITERATURE CITED

BROLEY, M.J. 1952. Eagle Man. Pellegrini & Cudahy, N.Y. 210 p.

MAY, J.B. 1935. The Hawks of North America. Nat'l Assoc. Audubon Soc., N.Y. 140 p.

SAUROLA, P. 1985. Persecution of Raptors in Europe Assessed by Finnish and Swedish Ring Recovery Data. Pp. 439-448 *In:* Conservation of Raptors. International Council for Bird Preservation Technical Publication No. 5.

VANCAMP, L. AND C.J. HENNY, 1975. The Screech Owl: its life history and population ecology in northern Ohio. *No. Am. Fauna* 71, U.S. Fish and Wildlife Serv. 65 P.

WOOD, H.B. 1945. The history of bird banding. *Auk* 62:256-265.

Appendix A. Scientific Names of Raptors

Black Vulture	*Coragyps atratus*
Turkey Vulture	*Cathartes aura*
Osprey	*Pandion haliaetus*
American Swallow-tailed Kite	*Elanoides forficatus*
Black-shouldered Kite	*Elanus caeruleus*
Snail Kite	*Rostrhamus sociabilis*
Mississippi Kite	*Ictinia mississippiensis*
Bald Eagle	*Haliaeetus leucocephalus*
Northern Harrier	*Circus cyaneus*
Sharp-shinned Hawk	*Accipiter striatus*
Cooper's Hawk	*Accipiter cooperii*
Northern Goshawk	*Accipiter gentilis*
Common Black-Hawk	*Buteogallus anthracinus*
Harris' Hawk	*Parabuteo unicinctus*
Gray Hawk	*Buteo nitidus*
Red-shouldered Hawk	*Buteo lineatus*
Broad-winged Hawk	*Buteo platypterus*
Swainson's Hawk	*Buteo swainsoni*
White-tailed Hawk	*Buteo albicaudatus*
Zone-tailed Hawk	*Buteo albonotatus*
Red-tailed Hawk	*Buteo jamaicensis*
Ferruginous Hawk	*Buteo regalis*
Rough-legged Hawk	*Buteo lagopus*
Golden Eagle	*Aquila chrysaetos*
Crested Caracara	*Polyborus plancus*
American Kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Aplomado Falcon	*Falco femoralis*
Peregrine Falcon	*Falco peregrinus*
Gyrfalcon	*Falco rusticolus*
Prairie Falcon	*Falco mexicanus*
Common Barn-Owl	*Tyto alba*
Flammulated Owl	*Otus flammeolus*
Eastern Screech-Owl	*Otus asio*
Western Screech-Owl	*Otus kennicottii*
Great Horned Owl	*Bubo virginianus*
Snowy Owl	*Nyctea scandiaca*
Northern Hawk-Owl	*Surnia ulula*
Northern Pygmy-Owl	*Glaucidium gnoma*
Elf Owl	*Micrathene whitneyi*
Burrowing Owl	*Athene cunicularia*
Spotted Owl	*Strix occidentalis*
Barred Owl	*Strix varia*
Great Gray Owl	*Strix nebulosa*
Long-eared Owl	*Asio otus*
Short-eared Owl	*Asio flammeus*
Boreal Owl	*Aegolius funereus*
Northern Saw-whet Owl	*Aegolius acadicus*

RAPTORS IN MIGRATION

John R. Haugh

U.S. Department of the Interior, Bureau of Land Management, Resource Sciences Staff - 705, Washington, D.C. 20240

Abstract — Raptors migrate because chances for survival and successful reproduction are, or historically have been, better than if they remained in a fixed location. Falconiform migration is primarily diurnal and seasonally attuned to environmental variables such as photoperiod and food resources, although distance travelled may influence migration timing in some species. Movements are strongly influenced by topographical features and meteorological factors in the lower atmosphere. Concentrations of birds tend to occur along leading lines, including mountain ridges and shorelines of oceans and other large bodies of water. In the Northern Hemisphere, most raptors move with following (tail) winds found west of low pressure centers and east of high pressure centers during fall migration, and west of high pressure centers and east of low pressure centers during spring migration. Usually, association with these synoptic weather patterns becomes weaker at more southern latitudes and also the farther the raptors are, both in time and space, from their nesting territories. Important questions needing further study relate to premigratory fattening and migratory energy relationships, high altitude movements beyond the visual limits of ground observers, the possible stimulatory effects of intense storms and low pressure areas and variations in migratory routes in different years. Although migration counts appear to provide some indication of change in raptor populations over large geographic areas, further study is needed to understand this relationship more precisely. To improve our knowledge and answer remaining questions relating to raptor migration, migration counts and counting techniques need to be improved. Observational methods and data collection should be standardized, and observers should attempt to increase their understanding of the influence of local topography and the effects of changing meteorological conditions on movements of birds past individual observation points. Small portable field radar units and rapidly developing telemetry techniques offer the potential for improved understanding of raptor migration and biology in the near future.

I am honored to have been invited to participate in this historic occasion, the 50th anniversary of the founding of the Hawk Mountain Sanctuary and the 50th anniversary of a significant milestone in the development of this nation's conservation ethic. Although the Hawk Mountain Sanctuary Association has made many significant contributions to raptor conservation and improving the image of birds of prey and predators in general, the major reason for the establishment of the Sanctuary was to protect birds of prey during their migrations past this concentration point on the Appalachian ridges. The role of the Sanctuary and the focus of interest here has always been on migration. Thus, I am doubly honored to have been selected to speak to you today on the migration of raptors.

Characteristics of Raptor Migration

Raptors, like other birds, migrate because chances of survival or successful reproduction are, or historically have been, better than if they had remained in one location. In the evolutionary sense, migration has probably evolved in response to influences that have been referred to as ultimate factors. Such factors are identifiable only from indirect evidence and deduction, but most likely include such environmental variables as food supply and seasonal climatic variations. Once a species has evolved a migratory pattern, the fact that it migrates at approximately the same time each year may be controlled by some precise environmental factor that varies in the same way each year. Evidence indicates that the length of photoperiod acting through the endocrine system is the proximate factor controlling the migratory timing for many raptors, although actual changes in food supply or food quality is probably a proximate factor in some short distance or periodic migrants. Once physiologically prepared to migrate, take off is generally assumed to occur in response to various distinguishable aspects of weather. Such weather variables have also been classified as proximate factors by some students of bird migration (Richardson 1978).

Like most migratory birds, raptors migrate primarily in tune with the seasons. In the Northern Hemisphere, direction is predominantly southward in fall and northward in spring. Because of the concentration in the Northern Hemisphere of land masses experiencing marked season changes, the fall north-to-south and spring south-to-north migrations are by far the most common ones. East-west movements are also common in some

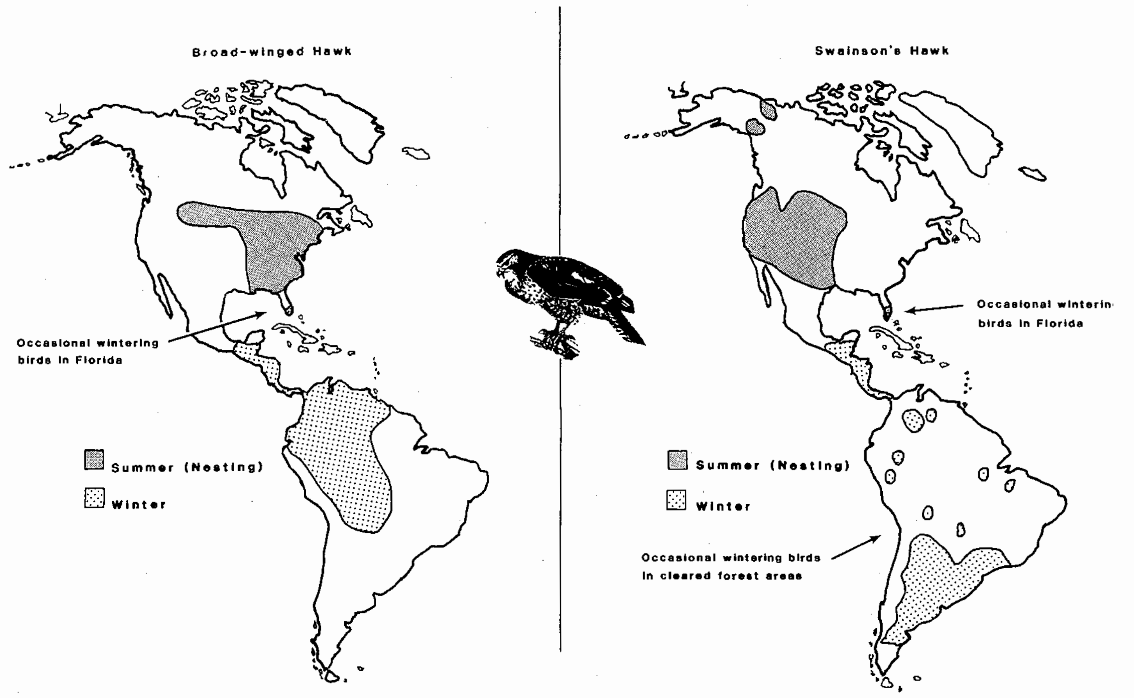

Figure 1. Distribution of Broad-winged Hawk and Swainson's Hawk. Map shows breeding and wintering ranges of the Broad-winged Hawk and Swainson's Hawk, 2 raptors which travel long distances during migration. Distance of travel may have influenced timing of migration for these 2 species.

species. For example, the Prairie Falcon (*Falco mexicanus*) moves eastward on the North American prairies each autumn after breeding in mountainous areas farther west. Some raptors, especially in tropical and subtropical areas, migrate from one area to another to take advantage of seasonal rainfall that, in turn, influences prey availability.

Although the timing of migration for an individual species probably has evolved in response to one or a combination of environmental variables, it is also possible that distance to be travelled may have played some role in the evolution of timing. The Broad-winged Hawk (*Buteo platypterus*) is one of the earliest North American raptors to move south in fall, migrating by the way of Central America to its winter range in South America, travelling farther than most other raptors which pass Hawk Mountain (Fig. 1). The early departure of this species may have evolved from a necessity to leave while food was still abundant and an adequate storage of fat could still be accumulated for a long journey through unfamiliar habitat where food resources might be inadequate. Alternately, migration of this small buteo could be timed to take advantage of optimal flying conditions, including good thermal development in the United States and updrafts associated with tropical weather conditions further south. In some parts of the world availability of prey en route may have influenced the timing of migration for some species. This may be particularly true of those species that regularly feed during migration, especially accipiters and falcons. Whether en route food availability has influenced the timing of migration of Broad-winged Hawks is open to question. Some observations indicate they may take advantage of migratory insects during fall migration and feed while in flight (Michael Harwood, pers. comm.). Raptors which do not feed during migration, or which do so only occasionally, have probably been influenced relatively little by availability of prey while en route.

Some species of raptors perform irruptive migrations or so-called invasion movements. These migrations are primarily related to fluctuating or cyclic food resources. In North America the Goshawk (*Accipiter gentilis*) and Rough-legged Hawk (*Buteo lagopus*) perform such migrations.

Within their seasonal migration periods, raptors primarily fly during the daylight hours. Especially among soaring species, flight tends to be concentrated during hours when solar heating is more intense and when maximum instability is present in the lower atmosphere. Some observations in the Mediterranean area (Beamon and Galea 1974) and in the southeastern United States along the Atlantic coast suggest that some raptors may occasionally migrate at night (Michael Harwood, pers. comm.). Whether or not nocturnal migration only involves birds caught in unfavorable environments at inappropriate times, such as over open water at sunset, or whether some falconiform birds actually initiate or continue moving at night needs to be more closely examined.

Migrating falconiforms exhibit a number of characteristics rendering them of considerable interest to students of migration and amateur bird watchers. These large birds are mainly diurnal in their behavioral activities, including migration. To a considerable extent they are dependent upon certain meteorological features of the lower atmosphere, many of which are associated with or influenced by topographic features of the earth's surface. Although raptors tend to follow features that provide favorable habitat or create favorable conditions, they also tend to avoid other features which, for one reason or another, provide unfamiliar habitats or are associated with unfavorable flying conditions. Such responses to meteorologic and topographic features frequently result in birds being concentrated at certain points or along certain topographic features as they migrate to or from their nesting areas. These features have been referred to as leading lines (Malmberg 1955). The mountain ridge on which Hawk Mountain is located extends from New England to Tennessee along the eastern edge of the Appalachian Mountains and is an example of one kind of leading line.

Raptors concentrate along leading lines during migration because conditions there are especially

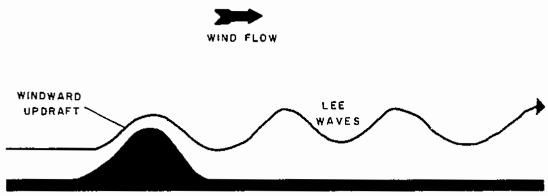

Figure 2. Example of air flow over mountains. Topographical obstructions such as mountains create updrafts and air turbulence which raptors are quick to take advantage of during their migration flights.

favorable for flight or because conditions in adjacent areas are unfavorable. The concentration at Hawk Mountain may result from both situations. Upward deflection of air currents creates favorable updrafts along the ridge (Fig. 2). At the same time, birds moving toward the southeast or being drifted in that direction by the wind would encounter the relatively flat Atlantic Coastal Plain if they leave the mountain. While brisk northwesterly winds create favorable updrafts along the mountain, the same wind conditions over the coastal plain are probably less favorable.

Large bodies of water such as the Great Lakes, Mediterranean Sea and various oceans act as barriers to many terrestrial raptors, and leading lines frequently occur along shores (Figs. 3 and 4). Unlike raptor concentrations that occur along mountain ridges because of favorable flying conditions, general opinion has been that raptors concentrate along bodies of water, not because conditions along the shore are favorable for flight, but because they are reluctant to continue over unfamiliar habitat where updrafts are lacking and conditions are generally unfavorable. Although these ideas are probably valid, with certain weather situations, conditions along the shoreline may be more favorable than inland or over the water.

Water warms more slowly than land in the spring and cools more slowly than land in the fall. The result is that the air over water is likely to be cooler than air over land in the spring but warmer than air over land in the fall. Because warm air is lighter and more bouyant than cold air, the interaction of such air masses frequently results in areas of instability where the two masses meet. Rising air currents are common in such areas. Figure 5 illustrates local meteorological conditions that may be favorable for raptor flight along shorelines and near large bodies of water.

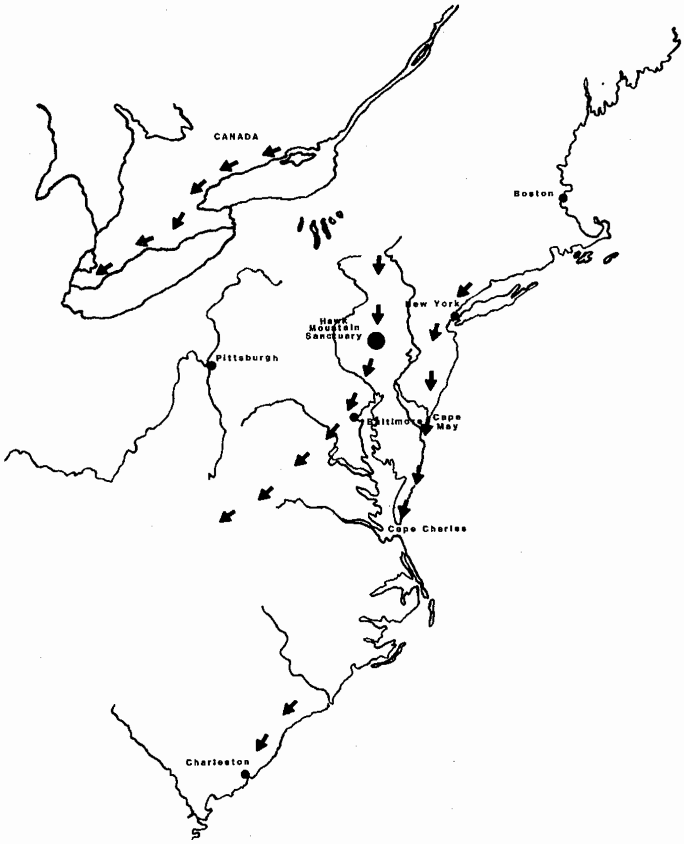

Figure 3. Fall migration route of hawks in eastern North America. Major flyways usually occur along leading lines such as long mountain ridges and shorelines of large bodies of water.

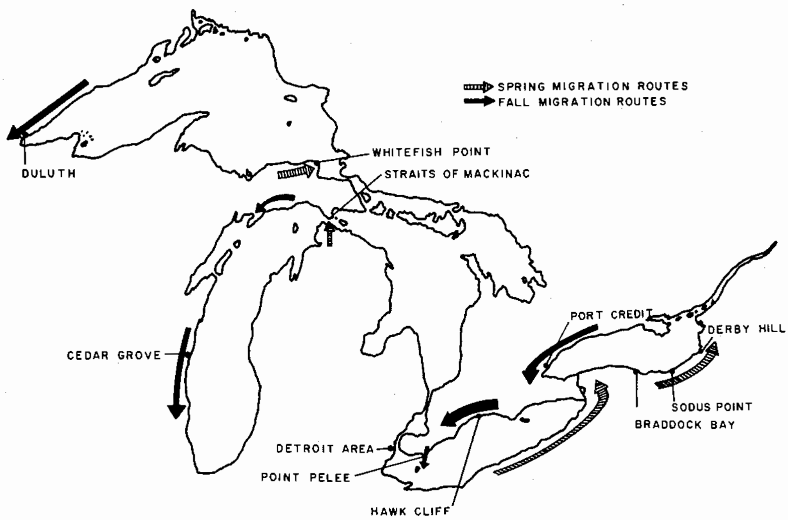

Figure 4. Major known migration routes followed by hawks around the Great Lakes during spring and fall flights. The Great Lakes shorelines provide numerous observation points for observing the migrations of diurnal raptors.

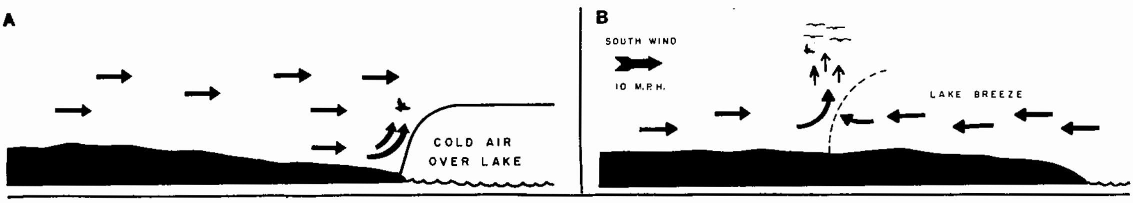

Figure 5. Example of updrafts associated with boundary zones between adjacent air masses over land and water. Especially in spring, contrasts between cold air over water and warm air over land create favorable updraft situations as more bouyant warm air is deflected upward over cold air along the boundary zone. Such updrafts are frequently utilized by migrating raptors travelling parallel to shorelines.

Where do raptors migrate when not following leading lines or moving along barriers? Probably much migration takes place on a broad front as the hawks move north or south. Many move as individuals, but some species, and perhaps most, tend to be somewhat gregarious at this time and join together in inter- or intraspecific groups. Such gregarious behavior is most evident among some soaring species where large flocks are frequently seen using thermal updrafts, but it also occurs among such species as the Sharp-shinned Hawk (*Accipiter striatus*), which are less dependent on rising bubbles or columns of air (Haugh 1972).

In areas where there are no obvious leading lines or barriers, certain transient or ephemeral features may for a time concentrate birds which might otherwise be randomly distributed over a broad front. Boundaries between air masses or linear cells of rising air occurring parallel to the prevailing wind are two such features that hawks may use while flying over flat or featureless terrain (Fig. 6). Stationary standing waves of rising air occurring downwind from hills or other ground obstructions are another example (Fig. 2).

The Influence of Weather on Migration Timing

Because of the tendency of birds of prey to initiate or continue migration with certain weather conditions, it has been possible, at least in central and eastern North America, to fairly accurately predict the occurrence of large flights at many locations, including Hawk Mountain. Before reviewing weather conditions associated with hawk migration, I will briefly consider weather phenomena as they occur in temperate areas of North America.

Established meteorological study is based on the concept of large moving masses of air (areas of high pressure), the physical properties of which are more or less uniform over large areas. Large masses of air generally acquire definite characteristics as a result of remaining over a large uniform topographical area until an equilibrium of temperature and moisture is reached (Taylor 1954). Within these air masses, winds circulate in a clockwise direction and have a tendency to flow outward from the center. The boundary between two different air

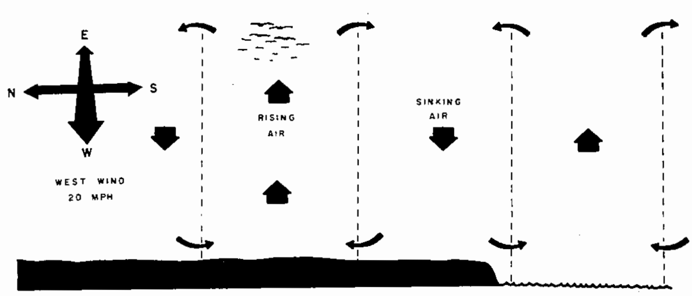

Figure 6. Example of linear soaring in a strip cell. Under certain conditions, alternate linear bands of rising and sinking air occur over water or relatively flat land. Such linear cells occur parallel to the direction of wind flow and may extend for hundreds of miles. Raptors have been observed to concentrate in the cells with rising air during migration. When these cells extend parallel to the direction of migration, the sustained lift allows raptors to glide for many miles without employing flapping flight.

masses is called a front. Along fronts, great contrasts of energy are often found, and it is here that low pressure areas or depressions develop. Air circulation around a low is in a counterclockwise direction and tends to flow inward toward the center of the low. In north temperate latitudes large masses of air with associated fronts and depressions move across the continents generally in an easterly direction (Fig. 7).

As an area of high pressure approaches from the west, air circulation to the east is usually from a northerly direction because of the clockwise circulation. This air is generally cool and dry. Once the high has moved to the east, a southerly flow of air develops behind (west of the high). Normally, this air is slightly warmer than the air in front of the high, but the difference is not great because of the uniformity of the air within the mass. As the center of the high moves further eastward, a low usually follows. The counterclockwise circulation about the low reinforces the southerly circulation of the previous high and typically brings a flow of warmer and more moist air, which continues until the low also moves on to the east and another northerly circulation occurs between it and the next advancing high (see Fig. 7).

Soon after the establishment of the Hawk Mountain Sanctuary, Maurice Broun observed that large fall hawk flights at Hawk Mountain were associated with northwest winds and the passage of a low pressure system across New York or New England a day or two before (Broun 1951). A number of investigators have since confirmed Broun's observations at Hawk Mountain and at other observation areas in the northeastern United States and in southeastern Canada at locations such as the north shores of lakes Erie, Ontario and Superior. Some have emphasized the approach of the area of high pressure from the west rather than the departing low, but a northerly component to the wind has been a common factor emphasized by most observers (Haugh 1972).

Haugh and Cade (1966) pointed out that spring hawk migration along the southern shore of the Great Lakes in the northeastern United States was associated with southerly winds in advance of a low pressure area approaching from the west and following a high pressure area departing to the east. Haugh (1972) found that migration occurred under similar conditions on the Canadian prairie in southern Manitoba. Although some investigators point out that conditions which seem favorable to spring and fall migration are also conditions that would likely drift birds toward the leading lines along which the observation points are located, it is unlikely that drift is a complete explanation for the association of raptors with the observed favorable conditions (see Murray 1964).

In Europe and Asia raptors migrate to and from wintering areas in Africa by two major routes. In the west the major movement is across the Strait of Gibraltar, while in the east it is via the Bosphorus and through the Near East. Most investigators have either not attempted or have not been successful in

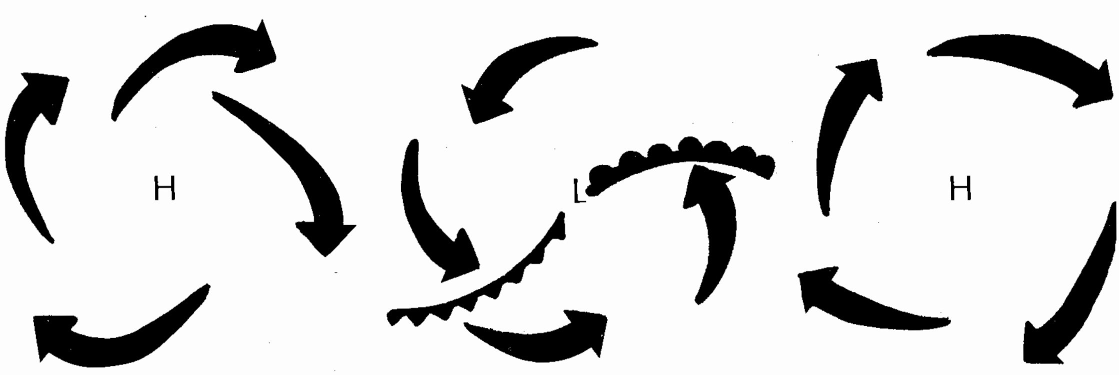

Figure 7. Example of air circulation around pressure areas. In north temperate latitudes pressure areas tend to move from west to east over the surface of the earth. Northward migration of raptors is most pronounced in the southerly air flow behind (west) of high pressure areas and in front (east) of low pressure areas. Southward migration is most pronounced in the northerly air flow west of low pressure areas and east of high pressure areas.

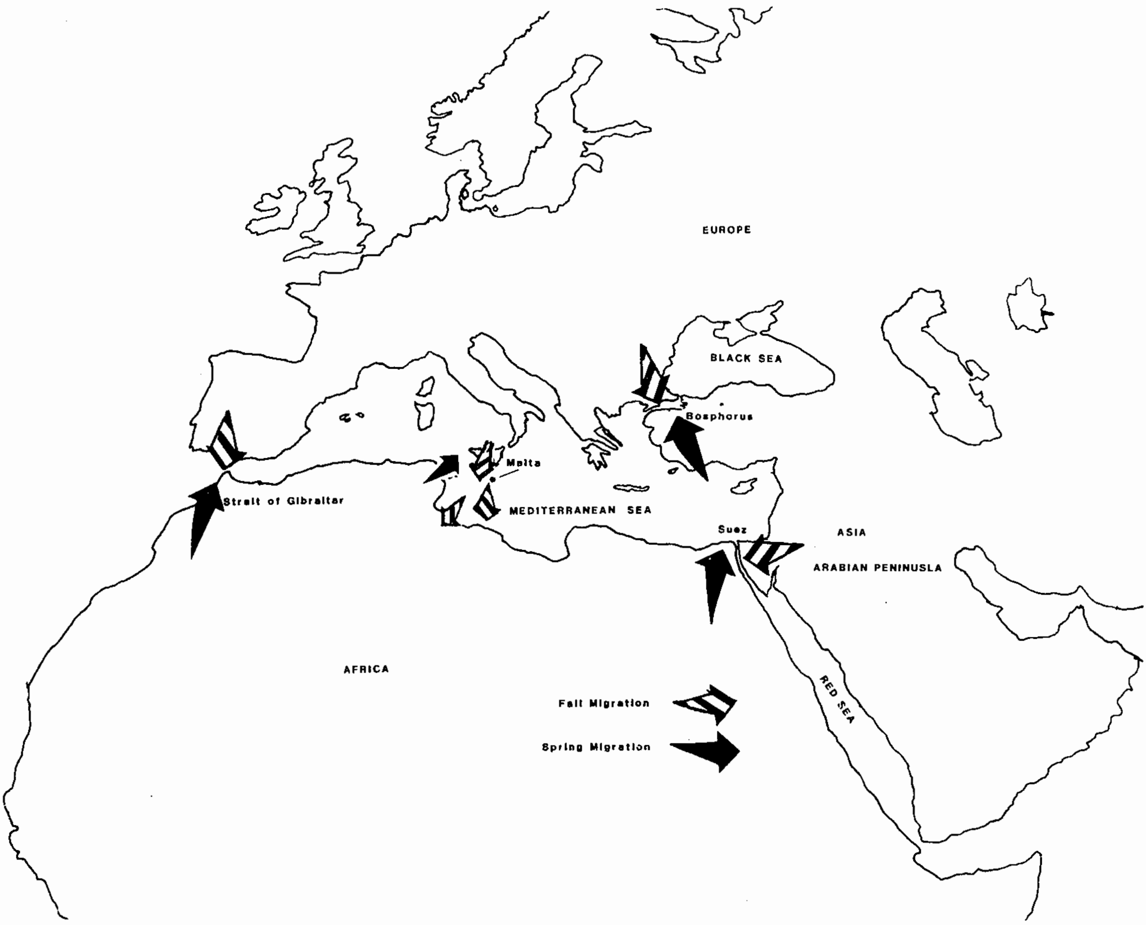

Figure 8. Spring and fall migration routes between Eurasia and Africa. Arrows indicate major concentrations of migrating raptors moving between Eurasia and Africa. Migration across the central Mediterranean Sea near the island of Malta is small compared to movements around the eastern and western ends of the Sea.

finding a relation between synoptic weather features and the migration of raptors there. Where attempts to associate migratory movements with weather have been made, the association has been primarily attempted with local conditions. While local conditions certainly influence such characteristics of migration as local flight path through the region, altitude of flight and speed of progress, they do not indicate the conditions which stimulated birds to begin their migration from wintering or nesting areas or those conditions which influence them en route in areas other than where the birds are concentrated by topography. Thus, the attempts that have been made in Europe and Asia to relate migration to weather are not comparable to studies in North America.

In attempting to identify weather conditions that stimulate migration, the most instructive observations may be those at localities closest to nesting territories of birds involved; that is, the point of initial takeoff. Broad-winged Hawks move south rather rapidly because of the long distance of their migration and perhaps because their migration is timed to coincide with favorable weather en route and food availability, or to minimize time in areas where food is inadequate. Once stimulated to begin migrating, they tend to continue as long as conditions are at all supportive for soaring flight. They are no doubt assisted by good thermal soaring conditions found early in the fall and late in the spring when the ground is warm and the sun has considerable heating capability. The greater the distance an observer is from the initial departure point, both in time and space, the less likely he will be to find a clear association between weather conditions and the number of Broad-winged Hawks migrating. Thus, for birds departing from Quebec or northern Ontario, observations on the north shores of Lakes Erie and Ontario provide a good idea of stimulatory weather. In Pennsylvania a fair idea would be provided, while by the time birds passed through the Virginias and Tennessee, weather systems may have changed considerably and no longer reflect conditions that existed when the birds initiated migration.

For several reasons, the Red-tailed Hawk (*Buteo jamaicensis*) may provide a better picture, at least in the central Appalachians, of the relationship between migration and weather. Red-tailed Hawks are common nesting birds there and, when conditions become favorable to begin migration, many can be expected to pass local observation points within a few hours of initiating flight and before weather has a chance to change. In addition, since they have a much shorter distance to travel, they are more likely to cease migration when conditions become unfavorable, then resume migration when the preferred meteorological conditions again develop.

In Europe and Asia migrating raptors may respond similarly to meteorlogical factors; however, as pointed out above, significant studies of migration at latitudes corresponding to those of the Great Lakes and central Appalachians are either lacking or attempts to interpret migration in terms of synoptic weather factors have not been attempted or have not been successful. A number of studies of raptors have been conducted near concentration points (Fig. 8) at the Strait of Gibraltar, (western end of the Mediterranean Sea) (Evans and Lathbury 1973), in the Mid-East at the southwest corner of the Mediterranean Sea and north end of the Red Sea (Wimpfheimer et. al. 1982), and at Bosphorus near the southwest corner of the Black Sea (Porter and Willis 1968). These studies have primarily focused on species and numbers of raptors, timing of migration, local migration routes and the influence of local weather phenomena, primarily wind direction. The situation, at least in the Mediterranean region, is somewhat analogous to that in southern United States and Central America. Birds observed at these locations have mostly been en route for several days or weeks, in unfamiliar territory and are highly concentrated in an area where food resources are limited. Under such conditions, they migrate on most days as long as weather is not particularly adverse. Pulses in migration occurring from day to day have not been adequately explained, but probably relate to the differential time of migration for individual species, distance of travel from the breeding or wintering areas, availability of prey en route, stimulating weather at point of origin and any delaying weather encountered en route.

ADDITIONAL QUESTIONS RELATED TO RAPTOR MIGRATION

Energy Relationships.—Another intriguing aspect of migration behavior is the question of premigratory fattening, weight loss and feeding while en route. Some raptors, perhaps most, are likely to show premigratory fattening prior to migration. While some data exist for the American Kestrel (*Falco sparverius*) and Red-tailed Hawks, there is a paucity of information on this subject, and additional studies are badly needed. It would be particularly interesting to examine the differences between long distance migrants such as the Broad-winged Hawk and Swainson's Hawk (*Buteo swainsoni*) (Fig. 1) in comparison to those that move shorter distances, such as the Red-tailed Hawk and Red-shouldered Hawk (*Buteo lineatus*).

Some raptors, such as the falcons, accipiters, Northern Harriers (*Circus cyaneus*) and Red-tailed Hawks appear to feed regularly while en route. There is disagreement among raptor biologists relating to whether or how often Broad-winged and Swainson's Hawks feed, and some authors have speculated that these latter birds may migrate the entire distance of their migration, over 8000 km (5000 mi), without feeding (Smith 1980). Neal Smith, who has studied the passage of Swainson's Hawks, Broad-winged Hawks and the Turkey Vulture (*Cathartes aura*) through Panama, reports he has never observed Swainson's Hawks or Turkey Vultures to drop down from migrating flocks to feed, nor has he ever found feces at roosts where thousands have roosted. Skutch (1971) has made similar observations in Costa Rica. Smith speculates that Broad-winged Hawks may fast for at least 30 d during migration and Swainson's Hawk perhaps doubles this. Although the energetic cost of soaring flight may be quite low, the possibility of such long-term fasting during migration is an interesting behavioral problem and perhaps an interesting physiological one as well. Nearer to the point of origin for fall migration (i.e., nesting territory or area occupied prior to initiating migration) observers have reported migrant Broad-winged Hawks to feed by catching and eating insects in flight and believe this may supply a substantial amount of food and be a common practice during migration (Michael Harwood, pers. comm.). A few observations have also been made of Swainson's Hawks descending to fields to roost and catch insects. I have observed a flock descending to feed on insects, probably grasshoppers, during their fall migration in a field in southern Arizona.

In the Palearctic, the small Eastern Red-footed Falcon (*Falco vespertinus*) crosses at least 3000 km of water on itsr way from India to Africa, and many species of raptors make long flights through extensive desert areas where food is scarce or nonexistent. Fasting during migration is probably common place among many of these species.

High Altitude Migration.—Related to my earlier discussion of hawks migrating at such high altitudes as to be invisible to the ground observer, another interesting problem is the question of how high raptors fly and how frequently they are invisible from the ground. Smith provides evidence that hawks and vultures soar to over 6,400 m (20,000 ft) as they pass through Panama, apparently utilizing the convective currents atop tropical storms. Laybourne (1974) has reported the collision of a Rupell's Griffon (*Gyps ruepellii*) with an aircraft at over 11,212 m (36,000 ft), above the altitude that man can tolerate.

Infleunce of Storms.—Another behavioral tion that needs further investigation is the relation of migrating raptors to storms. I have previously pointed out that some of the largest hawk flights observed in eastern North America, both in spring and fall, have occurred in proximity to particularly intense storms or low pressure areas (Haugh 1972). On the north shore of Lake Erie more than 70,000 hawks were observed in one day following the movement of a dying hurricane through the eastern Great Lakes in fall. Over 4,000 hawks were observed in one flock riding the updrafts along the squall line of a particularly severe spring storm advancing along the southern shore of Lake Ontario (Fig. 9). Smith (1980) has pointed out that in Central America large numbers of hawks use tropical storms during their passage and has speculated

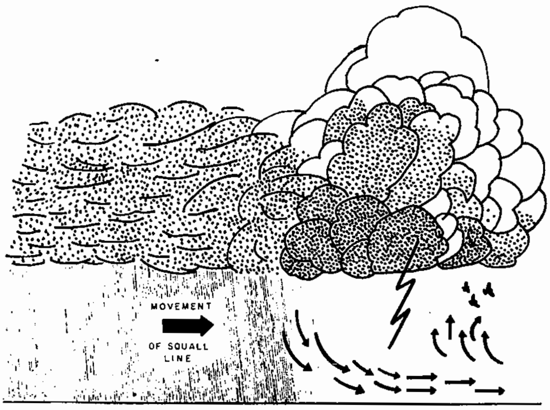

Figure 9. Diagram of updrafts occurring in front of advancing line squall. When a line squall is moving parallel to the direction of migration, raptors can obtain lift and be carried for considerable distances as long as they remain in the updraft zone in advance of the squall. In the Great Lakes area of North America, flocks composed of several thousand raptors have been observed gliding in the updrafts in advance of line squalls.

that some Broad-winged Hawks may regularly use updrafts associated with tropical storms to cross the Gulf of Mexico.

Man's experience in aircraft has taught him the wisdom of avoiding storms and flying in stable air usually associated with areas of high atmospheric pressure. This knowledge seems to have influenced the thinking of some students of bird migration. However, regardless of what other birds do, most hawks are masters in using updrafts and air currents associated with atmospheric instability. We also know that some birds are capable of sensing small changes in atmospheric pressure and probably can use this ability to sense changing weather conditions. This ability is likely to be present in raptors as well. The relationships between migrating raptors, atmospheric instability and storms is an area worthy of further investigation.

PROBLEMS IN COUNTING RAPTORS

For the last 50 yrs, a primary objective of students of raptor migration at Hawk Mountain and elsewhere has been to carefully identify and count each hawk as it flies by the observation point. Such observations have by now resulted in millions of man-hrs of effort. Have these observations been of any value in providing us with a better understanding of the biology and behavior of these birds? I think we would all agree that the answer to this question is affirmative. Perhaps a more difficult question to answer would be "from the scientific perspective, is there anything more we can learn by continuing these same observations for the next half century?" Again, I think the answer is affirmative, but the rewards, scientifically speaking, may be less than they have been in the past. In the future it is likely that the more exciting information and findings related to raptor migration will be made using new techniques.

In the past, one objective of counting raptors was to obtain information on population status; that is, are populations of individual raptor species increasing or decreasing because of natural environmental changes or fluctuations or changes caused by man. Use of raptor counts to estimate raptor populations of given geographical areas is fraught with difficulties because of many unknowns related to the migratory behavior of these birds. Over the years Maurice Broun expressed doubt that the annual hawk totals at Hawk Mountain had much scientific value. More recently, Harwood and Nagy (1977) pointed out some of the problems in using hawk counts for estimating populations. Several questions need to be answered before we can begin to understand how counts from Hawk Mountain and other lookouts relate to actual populations. Until these questions are answered, raptor counts will be of limited value in assessing population levels and population fluctuations. Among the questions needing answers are:

1. What is the extent of the geographic area from which birds passing Hawk Mountain originate? Does the area vary from year to year depending on meteorological conditions occurring at the time migration is initiated?

2. Do individuals follow the same approximate route each year, or are there pronounced geographical variations? For example, will a Red-tailed Hawk nesting in eastern Ontario and migrating south along the Appalachian ridges in one year migrate south the following year along the north shore of the Great Lakes and through the Mississippi Valley if strong northwest winds, necessary to push the bird east of the lakes and on to the Appalachian Mountains, are lacking?

3. To what extent is wind drift a factor in changing migration routes in different years?

4. What percentage of the hawks migrating along the Appalachian ridges pass Hawk Mountain and under what conditions do birds follow more easterly ridges or move to the east and out over the coastal plain?

5. To what extent do immature birds follow different routes or behave differently than adults? With Goshawks, for instance, we know a much greater percentage of immatures than adults migrate, perhaps because the immatures are less efficient than adults in using a limited winter food resource. Mueller, Berger, and Allez's (1977) paper on Goshawk migrations observed at Cedar Grove, Wisconsin, is a good example of how migration studies can reveal information about a species' ecology and behavior. Other examples of differences in behavior between immatures and adults are found among the Osprey (*Pandion haliaetus*), where the young birds of the year do not return to the species' nesting area the following spring but remain in the wintering area until they are two years old, and among the Peregrine Falcon (*Falco peregrinus*) where adult males may follow a somewhat different migration route than do the females and young, since adult males are rarely trapped or observed along the Atlantic beaches.

6. On warm days with light winds and strong thermal development, what percentage of hawks fly at high altitudes and escape detection by ground observers? We know that when winds are light and thermals well developed, large numbers of birds may pass by observation points above or beyond the visible range of ground observers. Although high altitude migration may occur anytime during the migration period, it apparently is more common early in the fall or late in the spring when the sun is more intense, the ground warmer, and the thermal activity better developed. Since the Broad-winged Hawk migrates mostly at such times, they are particularly likely to be missed. This is probably a major factor in the pronounced fluctuations in numbers observed from year to year, and it limits the value of migration counts as far as helping to understand the population biology of this species.

If the objective is to gather information on populations or year-to-year population changes,

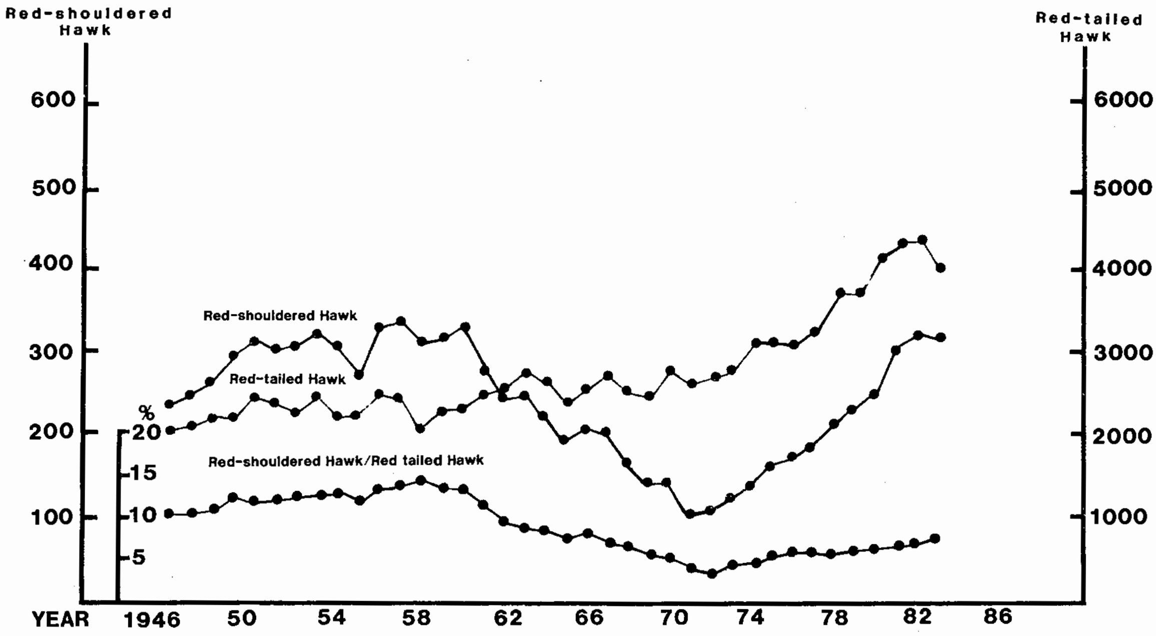

Figure 10. Red-tailed Hawk and Red-shouldered Hawk counts at Hawk Mountain, 1946-1983 (north lookout only). During the 1960s counts at Hawk Mountain show an absolute decline in the number of Red-shouldered Hawks as well as a decline relative to the number of Red-tailed Hawks, another large buteo migrating at approximately the same time. The decline, which seems to have been reversed around 1970, is in agreement with other observations of the Red-shouldered Hawk in parts of its breeding range. In order to reduce yr-to-yr variation in annual counts, each point on the graph represents a 5-yr average of the indicated year and the 2 previous and 2 following years.

observations should be as frequent as possible, preferably every day during the migration range of the species in question, and from early in the morning to late in the afternoon. Observations only on weekends provide a partial picture, and may only add confusion to serious monitoring efforts since important flights and large numbers may be missed. With some species, the majority of the population may pass in 1 or 2 days. If observations are not made on those days, then the data may be distorted to such an extent as to lead to highly erroneous conclusions.

Despite the many unknowns and the need for answers, raptor counts during the past several decades do appear to provide some information on population trends, and in most cases these trends do not appear out of line with what we know about raptor populations from other sources (see Nagy 1977). However, once we are able to answer some of the present unknowns, we will have a better understanding of just what hawk counts mean (see Fig. 10).

IMPROVING THE VALUE OF MIGRATION COUNTS

As witnessed by the number of people visiting Hawk Mountain and other observation points, watching and counting hawks has become an annual pastime for an increasing number of people. Since many like to feel that what we are doing has some value, we keep records and hope they will be useful as a contribution to our overall knowledge of hawk migration. How can the value of these observations be increased?

Standardization of Obsrvations. — The value of data collected can be increased if collection is standardized as much as possible. This is, however, not as simple as it may seem. A major problem of popular observation points occurs because of the varying number of watchers making observatios on diffe-rent days. Although two observers would be unlikely to see twice as many birds as one, additional birds would be counted. Such bias is likely to be a problem in comparing yearly totals at observation sites when these sites vary in popularity over time.

However, observer bias can also be a major factor influencing day-to-day counts when, for example, fewer observers are present on a cold blustery day, when a threat of snow is in the air, than on a pleasant sunny day.

Meteorological Considerations.—A serious hawkwatcher should at least have a superficial knowledge of meteorology. This is especially important at key observation points where a concerted effort is made to maintain a daily record throughout the migration period. The routes followed past an observation point and the altitude of the birds is strongly influenced by local weather, and a failure to understand how local weather interacts with local topography can result in missing many or most birds.

Local weather observations such as air temperature, wind speed and direction and cloud cover should be recorded on an hourly basis. This data could prove of value in later analyses of migration data. Changes in local atmospheric pressure are also valuable in providing local insight to changes in synoptic weather. If a barometer is not available at the observation point, the data for nearby locations can generally be obtained later from U.S. Weather Bureau reporting stations. Unlike temperature and wind, which may show pronounced local variation, pressure changes generally occur over a much broader area. Atmospheric pressure change is one of the best predictors of future weather changes. Although man cannot usually sense these changes without special instruments, birds are capable of detecting even small pressure changes.

Both local weather and characteristics of the migration are also influenced by changing synoptic weather situations, and a conscientious hawk observer should not only understand these changing patterns but should be aware of them on a day-to-day basis. Daily synoptic weather maps are prepared by the U.S. Weather Bureau and can be obtained later, if needed.

Recording Data.—The Hawk Migration Association of North America has produced a daily reporting form that is available to all hawkwatchers upon request. The form has spaces for recording weather data as well as hawk species common to North America. Data can be tabulated in a format that can later be key punched for computer use. With the expanding volume of data on migrating birds of prey, a central computerized system is essential. For data in such a system to be useful, all data must be carefully recorded. Questionable data should not be recorded. The value of this system to its users depends on the accuracy of the data entered.

Earlier, I asked the question "Is continued counting of hawks worthwhile?" I said that I thought the answer was affirmative. I should probably qualify my answer by saying some data are more worthwhile than others. A primary objective of future hawkwatching will be to monitor the status and health of the world's raptor populations. If this is true, then how many monitoring stations do we need? Sites should be carefully selected to cover as many raptor populations and as large a geographic area as possible. An important question is how much duplication we should have along a given flyway. Should we attempt to keep complete records for one, two or three sites along the Appalachian ridges? Although it is probably worthwhile to maintain hawk watches at a location on the north shore of Lake Erie or Lake Ontario, should extensive monitoring efforts be attempted along both lakes? The expense of recording and preserving data may limit our choices. Data from some smaller lookouts and isolated observations may not be worth maintaining. Still, some isolated observations could provide important insight into raptor behavior. Answers to such questions as — "What species of raptors fly across water and how frequently do they do so?" and, "Do any raptors regularly migrate at night?" — might come from isolated observations and not from established lookouts. I am not here to suggest a solution to the questions of how much or from what locations data should be stored. However, the questions must be addressed. Moreover, just because every observation is not recorded does not mean it was not worthwhile. I think few of us would disagree that just the sight of a raptor in flight is a rewarding experience in itself.

If we agree that our ability to store data is not unlimited and that information from some lookouts is more meaningful than others, then we want to limit our data bank to key observation points and perhaps unusual or particularly instructive observations. Such decisions might best be made jointly by representatives of concerned organizations such as the Hawk Migration Association of North America and Hawk Mountain Sanctuary Association. Key observation points need not be those already established. It might be worthwhile to attempt to establish new observation lookouts at locations where particularly instructive data might be obtained. Such areas might include observation points along the Atlantic coast in South Carolina, the Florida Keys, the western Gulf of Mexico, a Rocky Mountain site, a Pacific coastal site and perhaps a site in Panama.

New Observational Methods.—Finally we should ask the question: "Can we improve our observational methods to improve the value of our data ?" Although I will not dwell on the possibilities, two technological improvements are worthy of mention. The first is radar. Although radar has its limitations — especially relating to identification of species, inability to determine the number of birds in a group, and interference by terrain and weather — improvements are being made. Small field versions may be feasible for key observation points. Radar in combination with field observers would improve the accuracy of counts. Second, the expanding possibilities of telemetry, especially satellite tracking of birds, may soon be able to provide us with answers to a number of critical questions that are highly significant in putting together a picture of raptor migration. The U.S. Fish and Wildlife Service is presently experimenting with satellite tracking of swans (*Olor* spp.) and the Bald Eagle (*Haliaeetus leucocephalus*), and hopefully the transmitter can be miniaturized to permit use on smaller birds of prey. Among questions which may be answered are: "distance and speed of overwater migrations by Peregrine Falcons; location of hawks and times of takeoff in relation to meteorological conditions; speed of passage of individual birds and possible delays en route; whether or not a hawk follows a similar migration route each year or whether different routes are followed depending on weather and other factors; degree to which birds are drifted by wind; and what species of raptors, if any, migrate at night?" Although these revolutionary techniques will not be available to the average hawkwatcher, information they will provide will help all of us to understand better the migrations and behavior of falconiforms.

CONCLUSIONS

I have discussed some of the characteristics of raptor migration and emphasized that most of what we know of migrations of these birds comes from studies in eastern North America and the Mediterranean regions. We know much more about the migratory behavior of raptors than we did 50 yrs ago when this sanctuary was established. The Hawk Mountain Sanctuary Association has played a key role in this learning process and should, in cooperation with such groups as the Hawk Migration Association of North America and The Raptor Research Foundation, continue to lead the way during the next half century.

There remains much to be learned about hawk migration. We still have only a superficial knowledge of how weather influences birds. More study is needed on how hawks use phenomena such as thermal streets, lee waves and storms to facilitate migration. We need information on fidelity, or lack thereof, of raptors to specific migration routes. We need to know frequencies of extended water crossings in such areas as the Gulf of Mexico and Mediterranean Sea. We need to know routes raptors follow when they are not concentrated along leading lines. Do they still follow specific flyways or are they scattered on a broad front? We need to know what populations are being sampled by various hawk observation stations and how these counts reflect population densities and changes. We need more information on feeding, or lack thereof, by migrating hawks especially in areas through which large concentrations pass such as Central America and the Near East.

To learn more about hawk migration we need to employ both old and new techniques. Visual observation is still important, but we need to standardize our techniques and find ways to limit observational bias. While isolated observations may be of value and contribute to our knowledge of raptor behavior, our primary objective should be to maintain continuous observations at key sites. We must recognize that while every observation has value, we are limited in the amount of data that can be reasonably managed with available resources. With this in mind, we must accept that some observations are primarily worthwhile for their recreational value. If economically feasible, mobile radar units may be worthwhile at key observation stations and could be of considerable help to supplement visual observations.

Banding will continue to be worthwhile and will provide additional insight into understanding raptor migration patterns. However, telemetry, especially satellite telemetry, provides increased information and has greater potential for unlocking many key mysteries of raptor behavior. Development and use of this technique should be supported by all organizations interested in raptor migration and behavior.

There is obviously still much to be learned. There is plenty of work to keep us all busy during the next 50 yrs.

ACKNOWLEDGMENTS

Partial funding for the publication of this paper was provided by the Bureau of Land Management's Snake River Birds of Prey Research Project.

LITERATURE CITED

BEAMON, M. AND C. GALEA. 1974. The visible migration of raptors over the Maltese Islands. *Ibis* 116:419-431.

BROUN, M. 1951. Hawks and the weather. *Atlantic Natur.* 6:105-122.

EVANS, P.R. AND G.W. LATHBURY. 1973. Raptor migration across the Straits of Gibraltar. *Ibis* 115:272-285.

HARWOOD, M. AND A.C. NAGY. 1977. Assessing the hawk counts at Hawk Mountain. Pp 69-75 *In:* Ogden, J.C., (Ed). Trans. North Amer. Osprey Res. Conf. U.S. Dept. of Interior, Natl. Park Service Trans. and Proc. Series No. 2.

HAUGH, J.R. 1972. A study of hawk migration in eastern North America, Cornell Univ. Agric. Exp. Sta. *Search* 2(16):1-60.

——— AND T.J. CADE. 1966. The spring hawk migration around the southeastern shore of Lake Ontario. *Wilson Bull.* 78:88-110.

LAYBOURNE, R.D. 1974. Collision between a vulture and an aircraft at an altitude of 37,700 ft. *Wilson Bull.* 86:461-462.

MALMBERG, T. 1955. Topographical concentration of flight lines. Acta XI Congr. Internatl. Ornith. Basel: 161-164.

MUELLER, H.C., D.D. BERGER AND G. ALLEZ. 1977. Goshawk invasions. *Auk* 94:652-663.

MURRAY, B. G. JR. 1964. A review of sharp-shinned hawk migration along the northeastern coast of the United States. *Wilson Bull.* 76:257-264.

NAGY, A.C. 1977. Population trend indices based on 40 years autumn counts at Hawk Mountain Sanctuary in northeastern Pennsylvania. Pp 243-252 *In:* Chancellor, R.D., (Ed). Proc. World Conf. Birds of Prey, Vienna, 1975.

PORTER, R. AND I. WILLIS. 1968. The autumn migration of soaring birds at the Bosphorus. *Ibis* 110:520-536.

RICHARDSON, W.J. 1978. Timing and amount of bird migration in relation to weather: a review. *Oikos* 80:224-272.

ROBERTS, J.L. 1979. Observations of the migrations of raptors and other large soaring birds in Bulgaria, 1975-1978. *Ibis* 121:301-312.

SKUTCH, A.F. 1945. The migration of Swainson's and broad-winged hawks through Costa Rica. *Northwest Sci.* 19:80-89.

SMITH, N.G. 1980. Hawk and Vulture migrations in the Neotropics, Pp 51-65 *In:* Keast, A. and E.S. Morton, (Eds). Migrant Birds in the Neotropics.

TAYLOR, G.F. 1954. Elementary meteorology. Prentice Hall, Inc., New York.

WIMPFHEIMER, D., B. BRUUN, S.M. BAHAEL DIN AND M.C. JENNINGS. 1983. The Migration of Birds of Prey in the Northern Red Sea Area. Holy Land Conservation Fund, New York.

LAND MANAGEMENT FOR RAPTOR CONSERVATION: 1984 - 2034

RICHARD R. OLENDORFF

U.S. Bureau of Land Management
2800 Cottage Way, Sacramento, California 95825

Whenever I try to project the past and the present into the future, I am always reminded of a very religious man who was sitting in his living room one Sunday morning after church watching the 49ers demolish the Steelers, when he heard sirens and a loudspeaker imploring everyone to evacuate the area. A cloud had burst upstream and the river was going to rise way above historical flood levels during the next two hours. The sheriff knocked on his door and personally told the man to leave, but he insisted on staying. "I'll be all right, God will save me," he said. "I *know* God would not let anything happen to *me*." The sheriff really didn't have time to argue so he went on. About half an hour later he drove back by, pushing water ahead of his vehicle and again tried to get the stubborn man to leave his home, which was now an island. "No. I'm not leaving. The Lord is with me and I'm with Him — all the way." The next time the sheriff made it by he was in a Coast Guard rescue boat. The guy was kneeling on top of his house, because the water was up to the top of the window sills, but his response was the same and the sheriff floated on by. Next came an Air Force helicopter. The man sat astraddle the peak of his roof waist deep in water, his hands clasped in a prayerful pose reaching to the heavens, but he just would not grab the rope ladder dangling from the helicopter. Then suddenly he slipped from the top of the house, disappeared into the water, drowned, and immediately ascended into heaven. As he walked over to the pearly gates he saw God standing there with a few of the Steelers talking about the game and so he asked Him why He hadn't saved him from the flood. God shook his head from side to side and said, "I gave you all the warning you needed. I sent you the sheriff twice, the Coast Guard and the Air Force; what the hell else did you want?"

Across North America there are geographical areas and raptor species for which the cloud hasn't even burst yet, or at least the sheriff is only on his first visit — giving his first warning. In such areas, nature is still doing most things correctly and on cue. In others, raptors and their habitats are astraddle the peak of the trophic pyramid about to slip into the teeming floodwaters. It is to these problem areas and problem species and to the land management and species management actions being taken there that we can look for 50-year predictions of what is in store for the relatively pristine habitats and relatively abundant species of today.

In California, where most of my recent experience has been obtained, we can find excellent examples not only of all that is good in wilderness but also of all that is bad, environmentally speaking, in intensive (or exclusive) agriculture, forest management, urbanization, and all that comes with feeding, clothing, sheltering, and providing recreational opportunities for earth's burgeoning population. The floodwaters have brought us a conservation mode characterized by increased trade-offs and complex mitigations, by increased law enforcement activities and political involvement, and by increased expenditures of manpower and money to conserve renewable resources. I liken our predicament in this regard to the Fram oil filter analogy: "Pay me now or pay me more later." In California and many other parts of the country we *are* paying more and now *is* later!

We are not totally without options, however, and this is where the optimist in me shows, because even the Peregrine Falcon (*Falco peregrinus*) has returned to downtown Los Angeles and several cities in the East. The Black-shouldered Kite (*Elanus caeruleus*) has returned to us in remarkable numbers. We are beginning to look with guarded optimism at Peregrine and Bald Eagle (*Haliaeetus leucocephalus*) recovery, and Ian Newton mentioned some similar trends in Europe earlier this morning. In this air of hope tempered with realism I would like in the next few minutes to discuss four basic questions which address the issue of Land Management for Raptor Conservation in the next 50 years, including the following:

First, what *problems* will face raptors during the next 50 years?

Second, what *conditions* — biological and political — will these problems produce?

Third, what will be *needed* to solve these problems?

And fourth, what will we actually *do* to conserve raptors during the next 50 years from a land management perspective?

Many of the problems which face raptors in the future are already here today. They will undoubtedly worsen as the years pass. The Global 2000 report prepared by the U.S. Council on Environmental Quality and Department of State placed the world's population at 4.1 billion people in 1975 and at 6.35 billion by the end of the century. The prospect for October 14, 2034, is even more gloomy, though we need not dwell on overpopulation itself here — just recognize it. It's the habitat implication of overpopulation that maybe we can identify and address if not globally, at least locally or regionally, with a measure of success.

Most of the ultimate causes of declining raptor populations are the ones which make it impossible for those populations to reproduce: direct habitat destruction related to increased demand on resources, environmental contamination that interferes with reproduction physiologically, and an accumulation of human disturbances that drive breeding raptors away from increasingly urbanized areas, i.e., severe indirect habitat destruction. Most species can still tolerate the more proximate causes of individual mortality, such as shooting, disease, low-level human disturbances, weather damage to nests, electrocution, etc. Thus, at least on this continent, we still have, in most cases, the relative luxury of focusing our efforts on the ultimate problems. Except for the California Condor (*Gymnogyps californianus*) and perhaps a few others, we are not yet in North America reduced to supreme efforts to prevent every individual mortality.

The dark clouds that make focusing difficult are the conditions that the relentless pressures of urbanization, agricultural development, resource use, and human disturbance will bring to bear over the next 50 years. We will see, for example, continued deterioration of habitat diversity and stability, at least locally, and diminished concern for historical but unoccupied habitat as nest territories stand idle for years — and then decades. Because of the constitutional freedoms of private landowners in this country, more and more private land will be developed, and this will place greater conservation demands on remaining Federal lands. Increased political involvement will result, not only with regard to land or habitat, but also with regard to mo
and more species. The politicization of raptor ma
agement will breed unprecedented protectioni
activity and greater divisiveness between gover
ment, industry, conservationists and protectionist
Unless we take greater interest in what is needed
solve or at least to mitigate the ultimate problen
and thereby to ameliorate the divisiveness, then th
politics of development and increased resource u
are certain to win out.

There will be no real substitute in the next 5
years of raptor management for excellent and a
gressive land-use planning and coordination. Th
principal people in government, industry and th
private conservation sector need to be talking wi
each other about zoning, open space and local t
bases; about tradeoffs, mitigations and stipulation
about environmental law, courtroom procedure
real estate brokerage and tax incentives; abo
easements, administrative closures and compens
tion; and about land exchanges, land withdraw
and land purchases — a virtual checklist of conse
vation mechanisms that must be put into effect ju
after the easier-said-than-done decision to establi
a megapreserve, to recover a species, or to file
lawsuit in the name of conservation. Thus, o
critical need over the next 50 years will be bett
preparation of conservation arguments before th
reach the county planning commission, the r
gional director's office in a responsible feder
agency, the boardroom of the involved industri
firm, or the courtroom where everyone will gath
to solve things in the legal arena. And this will ta
economic, legal, as well as biological preparati
based on the best available facts.

Preparation implies another need — the need f
more research into optional sizes and shapes
raptor preserves; the efficacy of the buffer zo
concept; the importance of raptors as indicators
the impacts of human disturbance; and the exte
to which we can rely on raptor habituation to d
turbance, raptor use of man-created situations a
other modifications of raptor behavior, i.e., t
contribution of the birds themselves to their futu
well-being.

Another need during the next 50 years will be t
topic of our next talk; so I will just mention
passing the necessity for more and better pub
education to change public attitudes. Educati
must be an integral part of the development of
conservation ethic powerful enough to count

political, economic and legal considerations that will come increasingly to bear on our efforts to conserve raptors.

So far, I have discussed the problems, the conditions the problems will produce, and some of the things needed to address the problems. It's time now to use the crystal ball again and answer the fourth question: What will we actually do during the next 50 years to conserve raptors from a land management perspective?

Following from increasing human pressure and a continuing deterioration of habitat diversity and stability, we will rely more and more heavily on intensive habitat management. Intensity will imply artificiality in the form of increased dependence on artificial nesting structures, on artificial feeding, and on manipulation of habitats, manipulation of raptor populations, and manipulation of people who want to use these habitats for purposes inconsistent with raptor conservation. While you may now find this artificiality somewhat repugnant, those of us who make it will look back in 50 years to the 1970s and 1980s as the two most important decades of raptor management research in history.

The artificiality which we are now researching will be more acceptable then because it is going to play two very important roles. First, artificiality is going to perpetuate populations adjacent to refuges, sanctuaries, wilderness areas, and megapreserves in North America, where 50 years from now raptors will still be very much in evidence. Every raptor nesting on a power line tower, an artificial nest structure, a bridge, or a building will produce young that can disperse into the available preserves which will likely be too small to support viable, self-sustaining populations wholly within their boundaries. Second, artificiality is going to save species from widespread extirpations and extinction while mankind atones for its environmental sins — if it does. We know now that if enough genetic material from the eastern *anatum* Peregrine Falcon had been saved, the Peregrine Fund could have put that very same peregrine back into much of its former range. The task still would have taken this same period when the birds had to be bred in captivity and when they used man-made nest structures. The same level of behavior modifications would also have been necessary, but these birds would have eventually found their old nesting haunts in spite of the temporary artificiality. So artificiality has its place in the long-term, however repugnant it might be in the short-term.

Earlier I brought up the need for land-use planning and coordination, and I foresee several things happening in this regard. During the coming decades, there will be more innovative and frequently more expensive mitigations of the impacts of resource development. This century we have spent several decades studying raptor life histories and distributions. We spent the decade of the 1960s elucidating the pesticide syndrome and other contaminant issues. We are now in an era of management research — both species and habitat management research. But we are woefully inadequate and very vulnerable in the environmental assessment process, the land-use decision-making process, and therefore, in the courtroom when asked: How close will a Bald Eagle tolerate the noise and activity of a new road? How much old growth timber does a pair of Spotted Owls (*Strix occidentalis*) really need? How important are the innumerable types of impacts of man's activities, not only to the nesting success of individual pairs, but also to the dynamics of populations and the continued existence of species?

The extent to which raptor populations will exist 50 years from now as we know them today will depend in part on quantitative analysis, using sound scientific method, of the short-term impacts of direct human disturbance and the long-term impacts of habitat disturbance, both permanent and temporary. I believe that this research will be done during the rest of the 1980s and the 1990s and that our arguments for raptor conservation will be vastly more effective as we enter the next century. Only in this way will we avail ourselves of the facts that will make innovative mitigation possible: How large should a conservation easement be, and how much compensation should be given to cooperative private landowners? We are talking tens of millions of dollars here! How much Federal land and for how long should a government agency administratively close an area to allow raptors to breed relatively undisturbed? We are talking losses of millions of visitor-use days to very vocal publics who do not give two hoots of an owl about raptors or their conservation. And how large a megapreserve do we need to preserve a raptor species? The U.S. Government, the State of California, The Nature Conservancy, and the community developers near Palm Springs, California, have just put together a $20 million land acquisition package that should provide protection for the Coachella Valley fringe-toed lizard in perpetuity. Unfortunately, one of these lizards probably doesn't travel as far in its lifetime as a Bald Eagle or Peregrine can fly in just one minute. We are talking hundreds of millions of dollars for megapreserves large enough to ensure the continued existence of even a few species of raptors.

I do foresee continued efforts to establish megapreserves using raptors as at least a partial justification; but is is not foreseeable to me that the acreage given long-term protection in this country as national parks, national wildlife refuges, wilderness areas, endangered species critical habitats, and other effective protective categories, will increase in the next 50 years by more than 2 to 5 percent of what it is today. There may never be another area like the Snake River Birds of Prey Natural Area where the land-managing agency, the politics of the hour, the concentration of raptors, and the opportunity to set aside a viable raptor management un will coincide in space and time sufficiently well to le it happen. The quality, then, of raptor population 50 years from now will depend on their fortuitou occurrence on government land already preserve or lacking in mineral character, recreational poter tial, or other developmental value, or else on pr vate land of similar character or owned by peopl with an enlightened conservation ethic. Suc species will probably persevere.

Where a species occurs primarily outside of suc areas we can expect diminishing numbers; ir creased artificiality in their behavior, managemer and protection; and increased attention to ind viduals through eyrie wardening and other mear — indeed, all that is necessary to ensure the cor tinued existence of the endangered raptors of tc day!

PUBLIC EDUCATION AND THE FUTURE OF RAPTORS

JAMES J. BRETT

Hank Mountain Sanctuary Association
Route 2, Kempton, Pennsylvania 19529

They used to say, "If you can't do anything else, teach." Those of you who have had any connection with the teaching profession have heard that. I was a member of that profession, and I still consider myself a teacher. Last night Roger Peterson told us he was a teacher. Whenever there are gatherings of raptor people it seems as though education has been relegated to the back seat. At Hawk Mountain Sanctuary, where raptor education probably began on a formal basis, it is the most important part of our program. But elsewhere, it is still perceived as a necessary evil.

Before we can look into the future, we must talk a bit about the past. Where did education concerning birds of prey really begin? In my mind's eye, I can see some young boy on the steppes of Mongolia being taken out and being taught about the majesty of those birds of prey on his falconer-father's fist. I can also picture a scene in a pharaoh's courtyard where sons were encouraged to look upon falcons as deities and to admire the godlike attributes that surrounded those creatures. Perhaps there were also children of American Indian fathers who were led to high points throughout the Americas and had their eyes directed towards a Golden Eagle, a manifestation of the Great Spirit.

Each of you present today probably has had at least one person who was responsible for developing that initial love affair with raptors. You were being educated.

There were negative educational endeavors, some taken from as far back as the Book of Deuteronomy in the Old Testament, where birds of prey were considered unclean and to be avoided. The destruction along Pennsylvania's ridges in the early days was further amplification of the negative aspects of education, but it was still education. Fathers took their sons to the fields and woods and provided them their first exposure to wildlife. In most instances youngsters were taught that hawks and owls were detrimental to other wildlife populations, and therefore, they needed to be controlled.

During these anniversary festivities, we have heard of the influence that Hawk Mountain Sanctuary has had on the world, whether it was raptor education, or conservation, or research. It was Maurice Broun with his "school in the clouds" who was the godfather of these educational pursuits. It was a perfect forum, if you will, for the dissemination of information. A captive audience on the North Lookout. They couldn't get away because of the enthusiasm of the people who surrounded them, who reached out and drew them in and said, "Become enamored with the earth and its creatures." At Hawk Mountain, birds of prey were used as the catalyst.

So Broun and his predecessors watched, and they counted hawks, and they talked informally to folks; the message that raptors were not bad was passed on, and so it furthered the appreciation of the resource we are all so vitally interested in. But I think that long before there was active interest in raptor research there were the Maurice Brouns of the world, who sat on top of remote piles of rocks simply looking toward the sky.

The "school in the clouds" continued on a more or less informal basis for many years until the Hawk Mountain Sanctuary Association's board of directors took the initiative to construct an education center and hire a staff member to be a teacher on a formal basis. So, we have come a long way, haven't we? We have come a long way since Rosalie and Peter Edge first walked to the top of this mountain 51 years ago to see the shooting grounds.

Nearly every article that has been written about Hawk Mountain and every slide program that has been presented contains some reference to education. Our yearly budget, an ever expanding one, contains a substantial portion devoted to education. It all looks very impressive. Very impressive indeed, until you climb down off this mountain and enter the realm of raptor research and conservation. When we first began to formalize our education and awareness programs we began attending conferences throughout the country and later abroad. Very few of the conferees had ever heard of the Sanctuary's programs. True, the Sanctuary itself was known, but it received little more than passing interest.

I remember a Raptor Research Foundation conference held almost ten years ago in Allentown, Pennsylvania. There was an educational workshop scheduled and no one attended! I remember other gatherings where workshops on education were placed in obscure corners of the agenda, almost like, "Well, we've got to recognize them; we've got to tolerate them, but we don't have to give education prime time." It was as though token educational sections were scheduled, but never encouraged. In fact, earlier this year I solicited papers on education and awareness projects to be presented at The Raptor Research Foundation conference in Blacksburg, Virginia, two weeks from this weekend, and I received no response. It seems as though raptor education is a "bastard child."

When I look at the accomplishments of the Israel Raptor Information Center, I am pleased, and — at the same time — painfully embarrassed. When I remember the original mission of the National Wildlife Federation's Raptor Information Center founded by Jeffrey Lincer and William Clark, I think of those who were interested in awareness and the dissemination of information, and I think we were all enthusiastic over the promise such an organization held. But our hopes were dashed when the Raptor Information Center became the collector of information, and not the disseminator. Very recently, however, the Raptor Information Center has shifted some of its focus and information is being disseminated. Yossi Leshem in Israel has, without a doubt, been one of the most vibrant raptor educators in the world. The seed was planted in Yossi's brain back in 1982 when he heard several presentations about Hawk Mountain Sanctuary in Thessaloniki, Greece, at the Second World Conference on Birds of Prey sponsored by the International Council on Bird Preservation World Working Group. At the same time, Yossi was being encouraged by Bill Clark to begin a raptor information organization in Israel.

I have nothing against research. In fact, I've spent part of my professional career as a research biologist. I am much in awe of those individuals who have dedicated themselves to the conservation of this resource as a result of the research they have carried out. But I am concerned about the effectiveness of the money spent. Thousands of dollars are poured into research efforts each year, but how much of it is readily available to and understandable by the public? The research field has among it players an elite group of individuals who ar knowledgeable about problems affecting birds c prey and who share that information in academi halls or through technical journals. The informa tion seldom goes further. When I think of th mileage which could be received from a few wel placed dollars combining education with researcł the results could be exciting.

We have a young lady here at Hawk Mountai who has been working since September, every da giving three or four programs a day to all the ir ner-city elementary schools in Reading. She re ceives four hundred dollars a month. A radic tagged Bald Eagle tracked by satellite carries a extremely high price tag. What could be done i education with the same money?

The School Yard Hawk Watch, the children wh came from Concord, New Hampshire, to be with u for the anniversary weekend, paid their own wa here. They conducted sandwich sales throughou the year until they had enough money to hire a bu and pay their expenses for the weekend. Th School Yard Hawk Watch has had remarkable suc cess at the grassroots' level. The High School Haw Watch in New Jersey, the brain-child of Pete Dunn and Debbie Keller, was begun on a shoestrin budget, and it has since become a self-sustainin program — another grassroots endeavor. Th Pennsylvania Raptor Association is educatin thousands of children and adults each year, and a the money to operate the program comes from ver few individual donations.

We have seen examples of educational projec going on throughout the world. Briefly mentione were the projects at Hawk Mountain, in Ne Hampshire, New Jersey and Israel. There are othe very effective ones. The work of Michael Terrass in France, with both his cinematographi techniques and cartoon illustrations, have don much to change attitudes throughout souther Europe. John Ledger in South Africa has advance the cause of vulture protection there through series of well-planned educational activities. Ther are undoubtedly others we have never heard abou

I am terribly uncertain about projections for th next 50 years. We hear of the persistence of habita destruction. Pesticides still run rampant in unde veloped countries where raptors spend part of th year. The ICBP Bird Red Data Book (King W. 1981. *Endangered Birds of the World.* Smithso nian Institution Press) constantly reminds us that species are disappearing at an alarming rate each year. But there is some encouragement.

Butch Olendorff has been working diligently in planning for an international gathering of raptor biologists and educators to be held in Sacramento, California next November. The Raptor Research Foundation and The Peregrine Fund are looking to the Sacramento Conference as being one of the most important gatherings of Western Hemisphere raptor biologists ever assembled. Ideas on conservation and preservation will be shared.

Education.—Yossi Leshem and I have been planning for the Third World Conference on Birds of Prey to be held in Eilat, Israel in 1987 for over a year. The conference will be sponsored by Hawk Mountain Sanctuary Association, the Society for the Protection of Nature in Israel, and the World Working Group on Birds of Prey. One of the major themes will be education. The plans call for an international poster contest for children. Roger Peterson has agreed to be a judge, and with the help of the United Nations Environment Program a handbook on educational techniques will be distributed to educators in Third World nations where raptors are commonly seen.

I am confident that new and innovative educational endeavors are forthcoming on behalf of raptors. In the long run, however, it has to be the marriage of conservation, research and education that holds the promise for the health and well being of the resource.

CALIFORNIA CONDOR RECOVERY PROGRAM

Noel F.R. Snyder
P.O. Box 105, Portal, Arizona 85632

Abstract — The current California Condor Recovery Program was initiated in 1980 following the development of a consensus that the passive conservation measures implemented in earlier years (primarily habitat protection) had not been successful in maintaining or increasing the wild population. To sustain the species through its present crisis and to identify the key stresses affecting the wild population, the program relies heavily on intensive measures, such as multiple-clutching, captive-breeding and radio-telemetry. However, concentrated research and conservation efforts are also being continued along more traditional lines, such as habitat preservation and nonintrusive observations of breeding pairs. Intensive photographic efforts have revealed that the wild condor population now consists of fewer than 20 birds and is still declining rapidly — at a rate which could lead to extinction in less than 10 years. Nevertheless, multiple-clutching efforts with the remaining wild pairs in the last two years have led to an overall increase in the number of condors if the 16 birds now held in captivity are included in the totals. Continued multiple-clutching of wild pairs may lead to the establishment of a viable captive population and permit limited releases of captives to the wild in the next few years. However, quantitatively significant releases await the maturation of captives and the initiation of reproduction in captivity, probably in the early 1990s. The goal of a self-sustaining wild population will probably not be achieved until the factors producing the long-term decline have been identified and reduced in intensity. The principal causes of the decline do not appear to be reproductive deficiencies, but as yet poorly understood mortality factors.

The California Condor (*Gymnogyps californianus*) ranks today as one of the world's most severely endangered species. Only 15 of these giant cathartid vultures have been documented in the wild in 1984, and the number has been diminishing by about three individuals each year since 1982. If this trend continues, the last wild condor may disappear within 10 years. Long before then, however, the population could become effectively extinct through an irretrievable loss of genetic diversity or through the development of a skewed sex ratio. The present situation is critical.

The current precarious status of the condor represents the tail end of a decline that has been continuing throughout historical and at least recent prehistorical times. Judging from fossils and the reports of early explorers, condors once ranged from British Columbia south to Baja California along the Pacific coast and from California east to Florida along the southern border of the United States (Koford 1953; Wilbur 1978). By 1900, however, the species was limited to California and northern Baja California, and the range has continued to shrink in more recent decades. The species is now found only in a J-shaped area surrounding the southern San Joaquin Valley of California just north of Los Angeles (Fig. 1).

The first significant efforts to preserve the California Condor from extinction began in the mid-1930s, spearheaded by C.S. Robinson of the U.S. Forest Service; R. Easton, a local rancher; and J.R. Pemberton, a geologist and accomplished wildlife photographer. Easton and Robinson were largely responsible for the establishment of the Si quoc Condor Sanctuary in Santa Barbara County i 1937. In 1939, with the promotional and fun raising backing of Pemberton and sponsorship the National Audubon Society and University California at Berkeley, a monumental study of th condor was undertaken by Carl Koford. Koford field studies continued through 1946, and his 195 monograph on the condor still serves today as th most thorough discussion of the species' biology y published.

The recommendations that Koford develope for condor conservation placed heavy emphasis o minimizing contacts between condors and man an on educational efforts to reduce certain know mortality factors, especially shooting and poiso ing. Koford's efforts led to the establishment of th Sespe Condor Sanctuary in the Los Padres Nation Forest and ultimately to protection of other parce of important condor habitat. His recommendatio also led to U.S. Forest Service and Audubon Socie support for a succession of condor patrolmen protect the sanctuaries, starting in the 1950s. Un fortunately despite these considerable achiev ments, the species continued to decline.

The worsening status of the condor led to add tional studies, first by Alden Miller and the McMi lan brothers in the early 1960s (Miller et al. 1965 then in the late 1960s and 1970s by Fred Sibley an Sanford Wilbur of the U.S. Fish and Wildlife Se vice, assisted by John Borneman of the Nation Audubon Society (Sibley 1969; Wilbur 1978). Wi bur carried out an ambitious program of suppl

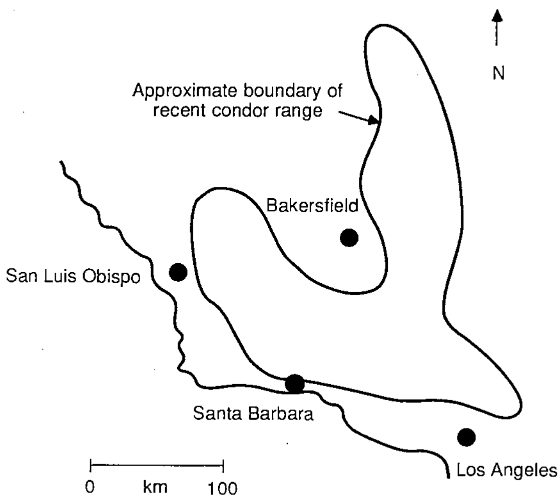

Figure 1. Current range of the remnant California Condor population.

mental feeding of condors during the 1970s in an effort to increase reproduction of the population (Wilbur 1977). Meanwhile, passage of the Endangered Species Preservation Act in 1966 led ultimately to the formation of a California Condor Recovery Team, and by 1974 the team had prepared a Recovery Plan for the species (U.S. Fish and Wildlife Service 1975). This was the first Recovery Plan developed for an endangered species, and it emphasized and elaborated on many of the noninterventionist measures advocated by Koford. The decline of *Gymnogyps* continued unabated through this period.

By the mid-1970s it had become obvious that fundamentally new and intensive approaches were needed if there was to be a reasonable chance of preserving the species. Major steps in the evolution of an intensive research and conservation program included a contingency plan prepared by the Recovery Team in 1976 and a demographic study published by Verner in 1978. The contingency plan emphasized the importance of captive breeding in ensuring the survival of the species, while Verner's study painted a gloomy picture of the species' prospects if conservation measures continued to be limited to traditional approaches.

In 1977 a committee of the American Ornithologists' Union (A.O.U.) and the National Audubon Society was formed under the leadership of Robert Ricklefs to assess the status of the species and make recommendations for future conservation efforts. This committee drafted a report urging immediate implementation of intensive techniques such as captive breeding and radiotelemetry (Ricklefs 1978). The U.S. Fish and Wildlife Service and other conservation organizations endorsed these recommendations, and in 1979 Congress passed a special add-on appropriation to launch an expanded condor conservation program based on new techniques. The major developments that have occurred since the initiation of this program in 1980 are summarized in this presentation.

THE CURRENT CONSERVATION PROGRAM

The expanded condor program was originally set up receiving support from five organizations — the U.S. Fish and Wildlife Service, the National Audubon Society, the U.S. Forest Service, the California Department of Fish and Game, and the Bureau of Land Management — with a principal research role being assumed by the Condor Research Center, a newly-formed joint agency of the U.S. Fish and Wildlife Service and the National Audubon Society. More recently, other organizations have joined the conservation and research efforts, most notably the San Diego and Los Angeles Zoos, the Biological Sciences Department of California Polytechnic State University at San Luis Obispo, the Santa Barbara Museum of Natural History, the Western Foundation of Vertebrate Zoology, the Illinois Natural History Survey, a number of local chapters of the Audubon Society in California, the Condor Survival Fund and Hawk Mountain Sanctuary Association. The effort now receives part-time to full-time assistance from well over 100 individuals in California and elsewhere.

Research endeavors ranging from passive observations of nesting pairs to highly manipulative techniques, such as radio-telemetry and multiple-clutching, form the core of the present field program. However, the central hope for success rests on the potentials of captive breeding to sustain the species and on the reasonable expectation that captive-bred birds can be successfully re-established in the wild. The species is now so close to extinction and is declining so steadily that there can be essentially no hope of preserving it in the absence of captive breeding. Ultimately, however, the recognized goal of the program is to achieve at least one naturally self-sustaining wild population that is not dependent on intensive and manipulative conservation measures.

Censusing Efforts. — Because of the mobility of individuals and the inaccessibility of much of the species' range, the California Condor has been difficult to census. The first comprehensive estimate of condor numbers was offered by Carl Koford for the 1930s and 1940s. Koford suggested there were only about 60 individuals left, apparently basing his judgment mainly on a belief that the largest flocks of condors he could document included most of the birds in the population. Flocks of more than 40 birds were still being seen at the time of his study.

Observed flock sizes showed a progressive decline following Koford's study, and primarily because of this, Alden Miller and the McMillan brothers estimated a 30% decline of the wild population to about 40 birds by the early 1960s (Fig. 2). Shortly after the Miller-McMillan study, however, the U.S. Fish and Wildlife Service placed Fred Sibley in California to conduct field studies of condors. Sibley (pers. comm.) concluded that there were still at least 60 condors or so in the wild and that there had been many more birds at the time of Koford's study — perhaps as many as 200. Sibley's estimates were based largely on the results of the annual October survey, a giant simultaneous count of condors covering the entire known range. This count was initiated in 1965 and was continued each year until 1981, with the exception of 1979. Some of the early October surveys gave totals of more than 50 birds, and it was reasonable to assume that some birds may have been missed by the survey procedures. Because Sibley was unable to document any flocks close to as large as the largest flocks seen by Koford, it was also reasonable to assume that the actual condor population in the 1930s and 1940s was far larger than the 60 birds suggested by Koford.

Following Sibley's studies, Sanford Wilbur continued efforts to document the population size of the condor. Wilbur (1980) concurred with the estimates by Sibley for the late 1960s and estimated that the population had dropped to only 25 to 35 birds by 1978. Wilbur's estimates were based on a variety of kinds of information, including decreases in flock sizes observed and simultaneous counts such as the October survey. Nevertheless, the degree of uncertainty about the number of condors remain-

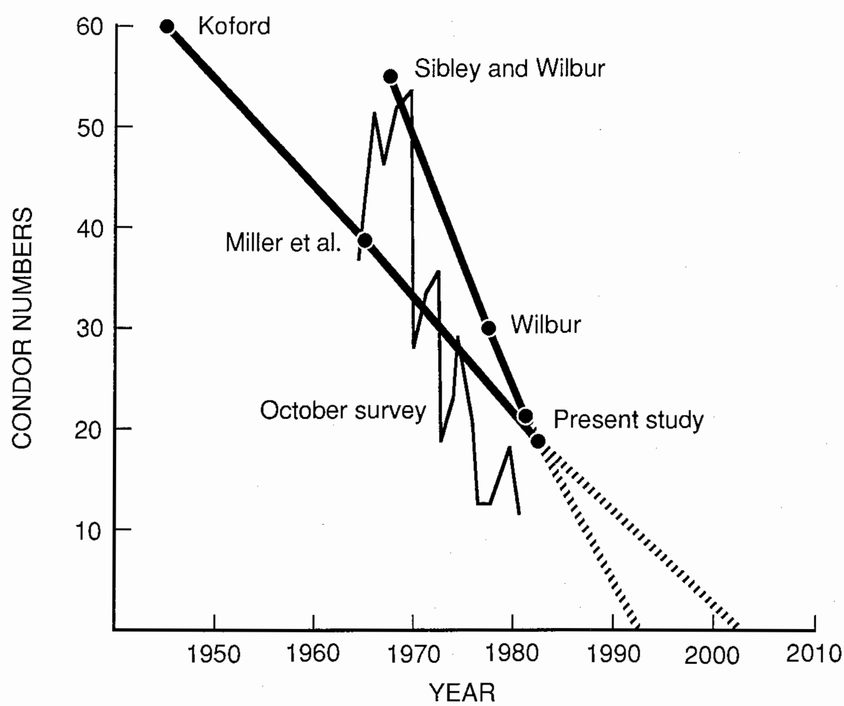

Figure 2. Population estimates for the California Condor from the time of Koford to the present.

ing was still great enough in 1980 that some observers still questioned whether the species was truly declining and whether last-ditch efforts to preserve it should be initiated. Clearly, the existing methods of censusing condors were far too imprecise to provide the sort of fine-tracking of population trends that would be crucial in maximizing chances of preserving the species, and there was a need for alternative methods with much less inherent error.
rent error.

In 1981 the staff of the Condor Research Center began efforts in cooperation with Eric Johnson and his students at California Polytechnic State University in San Luis Obispo to estimate condor numbers on the basis of individual identifications of birds through flight photographs (Snyder and Johnson 1985). The photographic efforts have revealed that individual differences in primary feather patterns give a highly reliable means for recognizing individuals through time. Analyses of many thousands of photographs from throughout the range of the species have led to population estimates of 21 to 24 individuals, including 7 immatures, for late summer 1982; 19 to 22 individuals, including 5 immatures, for late summer 1983; and 15 to 18 individuals, including 2 immatures, for late summer 1984. There is nothing in the recent population figures to suggest a spontaneous recovery of the wild population.

Causes of the Decline. — The reasons for the continued population decline have not been easy to determine, although a considerable variety of hypotheses have been advanced (Snyder 1983). Logically, the decline of any species must trace either to reproductive problems or to mortality problems, or to both. Both sorts of explanations have been offered in the case of the condor, but without a large amount of supporting data.

Reproductive Studies. — In 1980 the staff of the Condor Research Center began an intensive effort to study the breeding biology of the species to determine if poor reproduction was a major problem. All active nests located since that time have been observed on a nearly continuous basis from distant blinds, allowing a steadily increasing understanding of the factors affecting reproduction. Presently, five productive pairs are known in the wild population, including one recently-discovered pair nesting in a remarkable location, a natural cavity of a giant sequoia (*Sequoiadendron giganteum*) in the Sierra Nevada (condors usually nest in potholes or other sorts of caves in cliffs). The search for the nests of the remaining pairs has entailed thousands of man-days of effort, as has the monitoring of these nests once found, and many dozens of people have contributed their time and energy to these endeavors.

Recent breeding success, like historical breeding success, has averaged about 40-50% and most adults have apparently been breeding (Snyder 1983). As this nest success rate closely resembles that found by Mundy (1982) for several species of large vultures in southern Africa and by Jackson (1983) for the Black and Turkey Vulture (*Coragyps atratus* and *Cathartes aura*) in the United States, it seems unlikely that poor reproduction has been the major cause of the species' decline. Nevertheless, the detailed observations at nests have revealed a number of reproductive problems and have allowed the development of several strategies by which breeding success and frequency can be increased.

A number of threats to breeding success have been identified. Common Ravens (*Corvus corax*) apparently caused the loss of two recent condor eggs and have been observed attempting to take others. Condors respond aggressively to ravens in their nesting areas, repeatedly attempting to drive them off, but not usually with much success. In addition, adult condors have twice been seen intercepting Golden Eagles (*Aquila chrysaetos*) attepting to take their nestlings. The eagles were driven from the area with energetic flapping chases. We also have witnessed one persistent, albeit unsuccessful, attempt of a Black Bear (*Ursus americanus*) to scale a nest cliff to get to a condor nestling.

Besides problems with natural enemies, several condor pairs of recent years have experienced problems resulting from nest-site deficiencies. One pair in 1982 nested in a site with a sloping bottom and lost their egg shortly after the start of incubation when it rolled out of the nest cave and over the edge of the cliff. Another pair active since 1980 has had problems with hatchability of eggs; still another has been producing unusually small, but nevertheless viable, eggs; and yet another has produced several chicks with minor to severe physical deformities. Finally, one pair has had compatibility problems resulting in recurrent egg-neglect, as they have fought over whose turn it is to incubate.

As yet, the efforts to improve breeding success by reducing the impacts of natural enemies have been limited to raven control and have been only partially successful. Improvement of defective nest sites has been standard practice. No methods are presently known to reduce problems resulting from mate incompatability, poor hatchability of eggs, or production of abnormal young, other than what can be accomplished by taking eggs into captivity for artificial rearing.

Surely the most significant result of the nesting studies has been the discovery of ways to increase breeding frequency, principally by artificially-induced multiple-clutching and annual-nesting. In 1981 and 1982, we obtained excellent evidence of wild pairs laying replacement eggs following natural egg loss. Because of these observations, we were able to obtain Federal and State authorization to take eggs of wild pairs into artificial incubation, with the expectation that this might greatly increase the annual production of young and allow the establishment of a captive flock with minimal impact on the wild population.

Deliberate multiple-clutching of wild pairs in 1983, including one case of triple-clutching, led to a total production of six fledglings from seven eggs laid by four pairs — three times the average annual production of fledglings documented since the start of the present program (Fig. 3). Production was even better in 1984, with a total of seven young produced from nine eggs laid by five pairs, including another case of triple-clutching by a different pair.

When nestlings reared in the wild are allowed to fledge naturally, the production of eggs is inhibited in the next year because of the long period of fledgling dependency on adults. Nearly maximal production of eggs was achieved in 1984 by taking all wild nestlings into captivity in 1983. All nestlings have again been taken into captivity in 1984 for the same reason.

If most of the remaining breeding pairs continue to survive and can continue to be successfully multiple-clutched in the years ahead, it may prove feasible to release to the wild some of the extra young produced in the process without compromising the formation of a viable captive flock. Thus, with reasonable luck it may be possible to split the future benefits of increased productivity between the captive and wild populations.

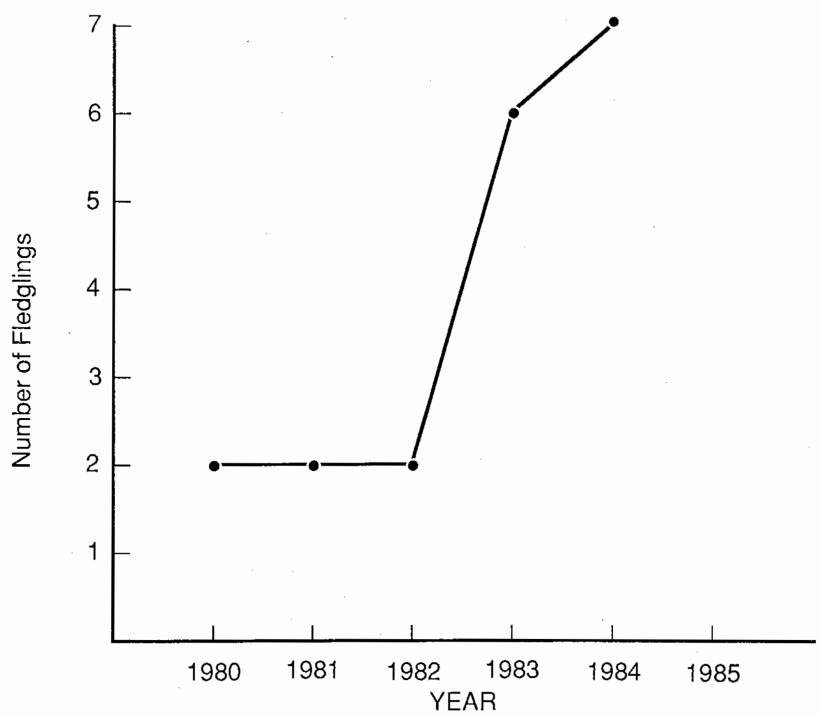

Figure 3. Known production of fledglings by the remnant California Condor population during the past 5 years Production of 1983 and 1984 augmented by multiple-clutching efforts.

While the great increase in condor reproduction achieved in the last two years is probably the most encouraging recent development in the efforts to preserve the condor, it is important to emphasize that the level of reproduction that can be sustained in the future is dependent on how well the remaining breeding pairs survive. In view of recent population trends, the number of breeding pairs and consequently the production of wild eggs can be expected to decline in the years immediately ahead. Production of young may not increase again until captives become old enough to reproduce.

Mortality Factors. — If the available data do not suggest severe reproductive problems for the condor, the major causes of decline must lie in excessive mortality. Indeed, birds have been disappearing from the wild population at an alarming rate in the past few years, especially immatures. Since 1982, three of six wild immatures have been lost. Unfortunately, it is far more difficult to study mortality factors than it is to gain an understanding of reproduction, as the remaining condors are spread out over an enormous and largely inaccessible range. From photographs we know that a nesting condor on a day's flight may move as far as 150 km from its home base. Obviously, with the birds covering this much terrain, the chances of finding freshly dead condors to learn causes of death are very small. Dead condors have been located occasionally over the years, but most have been too decomposed to allow comprehensive necropsies, and the birds found, many of which were shot, may represent a very highly biased sampling of causes of death (see Wilbur 1978). What has been needed is a means of greatly increasing the discovery rate of dead condors and a means of ensuring that birds that die are found quickly after death.

The only presently available means for efficient discovery of dead condors is radio-telemetry, and in 1980 a cooperative effort to develop a suitable radio-transmitter for use with condors was begun by William Cochran, Michael Wallace, Mark Fuller and the Condor Research Center staff. Various designs and attachment methods were tried with Black and Turkey Vultures, and the Andean Condor (*Vultur gryphus*), both in captivity and in the wild, and by 1982 a light-weight patagially-mounted transmitter was available for use with the first two wild California Condors trapped for radio-telemetry. Telemetry studies conducted since then have been under the supervision of John Ogden.

One of the first two radio-tagged birds, an adult male, is still alive and fathered young both in 1983 and 1984. The other bird, a subadult male, survived for a year and a half after capture, but was found dead in March 1984 in a location where it doubtless would never have been found if it had not been wearing a radio transmitter. The cause of death proved to be one that no other condor had ever been found dead from before, but one that we now suspect may be one of the most important threats to the species — lead poisoning. Tissue concentrations of lead in the body of the bird were high in the toxic range, and a small fragment of a lead bullet was found in its digestive tract. Because condors feed entirely on carrion, and some of their food is animals that have been shot and not recovered by gunners, it is reasonable to suspect that lead poisoning has been a chronic problem for the species for many decades. However, a single case of lead poisoning does not in itself constitute enough evidence to give a clear picture of how severe a threat lead poisoning may be. As the sources of lead in the diet of condors promise to be difficult to control, it may be hard to do very much to reduce the incidence of lead poisoning in the near future. Nevertheless, if other condors are found dead from lead poisoning in the years ahead, it is possible that enough leverage may develop to begin to reduce this threat. Obtaining such evidence is crucial to changing established practices.

Only one other condor has been found dead since 1980 (although many others have disappeared) and this was not a radio-tagged bird. Its apparent cause of death, however, has proved to be one that is much more susceptible to control than lead poisoning. This bird was a yearling picked up freshly dead next to a ranch road in the foothills of the southern San Joaquin Valley. The cause of death was very difficult to determine, but since the bird was found only hours after death, it was possible to get an excellent necropsy through the efforts of Marilyn Anderson of the San Diego Zoo and the environmental contaminants staff at the Patuxent Wildlife Research Center. The results of the analyses indicated probable cyanide poisoning from an M-44 device set for Coyotes (*Canis latrans*). This is the first case known of a condor poisoned by an M-44, and it is as yet unknown whether cyanide poisoning has been a significant source of mortality for the species. However, since all M-44 poisoning is done by government agents, specifically the Animal

Damage Control branch of the U.S. Fish and Wildlife Service, it was possible to obtain immediate suspension of use of these devices within the condor range. Intensive investigations are now being conducted as to what methods of coyote control may be allowed in this region in the future.

The recent cases of lead and probable cyanide poisoning represent only a small sampling of potential causes of death. Another mortality factor, which unquestionably has been an important problem, at least in the past, is shooting. Still another threat of apparent importance is collisions. Over the past 50 years several cases have been documented of condors dying as a result of flying into overhead wires or stakes, and it is worth emphasizing that recent studies of the Whooping Crane (*Grus americana*) show that collisions are an extremely important cause of mortality in that species (Brown et al., in press). Another risk of potential importance is fouling in oil ponds. Condors are among the most abundant species in the La Brea tarpit deposits in Los Angeles (Howard 1930), possibly resulting from their propensity to feed on carcasses of animals that become mired in oil seeps or because of a tendency for them to mistake oil seeps for water sources. Risks of oil-fouling still exist. Several regions within the condor range, including foraging areas in the southern San Joaquin Valley foothills, are areas of intensive oil development. By law, all open oil pits have to be covered with screening, but infractions do occur, and losses of condors to oil-fouling problems remain a possibility.

Other potential sources of mortality include poisoning by compound 1080, zinc phosphide and strychnine used in small mammal control programs. At present, no evidence exists to suggest that these programs pose a significant threat to the species.

In summary, data are still too few to allow confidence that all important mortality factors have been identified. Moreover, the relative importances of the known threats are still quite speculative. At current rates of decline, it is doubtful that enough progress in reducing mortality threats can be made quickly enough to ensure a turnaround in the wild population before it is lost. The time factor in assessing and countering sources of mortality makes the establishment of a viable captive population of condors an absolute necessity.

The Captive Breeding Program. — The ease with which cathartid vultures can be bred in captivity has been demonstrated repeatedly over recent decades (e.g., Lint 1960; Heck 1963, 1971; Klös 1966; Dekker 1967; Cuneo 1968; Antas and Da Silveira 1980; Zwart and Louwmann 1980), with numerous institutions and individuals obtaining good production of Andean Condors and King Vultures (*Sarcoramphus papa*) and to a lesser extent Black and Turkey Vultures. The Patuxent Wildlife Research Center has had a surrogate program of studying captive breeding of Andean Condors since 1966, and effective husbandry methods are by now well known (Carpenter 1982). While California Condors have never been bred in captivity, no serious attempts to do so have ever been made, and it is likely that the species will breed as readily as other captive cathartids.

Presently, there are 16 California Condors in captivity. Ten are females and six are males, and altogether they represent six different family lines. Most are still quite young. One was trapped as a yearling in 1982, one was taken as a nestling in 1982, and 13 were taken as eggs or nestlings in 1983 and 1984. Aside from attempts to obtain a relatively old bird as a mate for Topatopa, the only adult in captivity, the future acquisitions of captives will probably continue to be limited primarily to eggs and nestlings, unless the wild population declines catastrophically in the next few years. Since condors take about six years to reach adult plumage and breeding has never been observed in immatures, these captives will presumably be largely too young to breed for a number of years.

All captives are held at the San Diego Wild Animal Park and the Los Angeles Zoo, and are housed in large flight cages permitting ample exercise and the opportunity to associate with conspecifics. All young hatched in captivity have been puppet-reared to minimize the chances of improper imprinting.

The artificial incubation of eggs has been conducted at the San Diego Zoo under the direction of Cyndi Kuehler. Ten of the 12 eggs taken for artificial incubation in 1983 and 1984 have produced surviving condors, for a fledging success rate of 83%, a remarkably high rate in comparison to the historical fledging success rate of 40-50% for eggs in the wild. Thus the taking of eggs into artificial incubation has led not only to much greater production of eggs by the wild pairs but also to much increased fledging success of the eggs that are laid.

Because of both these factors, the overall number of condors in existence, including captives, increased significantly in the last two years — to more than 30 birds — the first increase known since efforts to conserve the species began.

Releases to the Wild. — Between 1980 and 1982 the U.S. Fish and Wildlife Service sponsored Michael Wallace and Stanley Temple of the University of Wisconsin in an experimental program to release captive-reared Andean Condors to the wild in Peru (Temple and Wallace 1983). Eleven young condors, ranging in age from fledglings to three-year olds, were released under a regime of gradually decreasing food-subsidization. Of these, seven (64%) still survived at the end of the study. All were fully independent and appeared to be completely integrated into the wild population. Compared with the results of other captive-release programs, 64% survival after 3 years is an outstanding achievement. Equally positive results were obtained earlier with experimental releases of Turkey and Black Vultures to the wild in Florida, also conducted by Wallace and Temple (Wallace and Temple 1983). The successes achieved in these release efforts offer considerable hope that the planned releases of captive California Condors may likewise be successful.

The source of birds for release in California will presumably be eggs and nestlings of wild or captive birds. With the present age structure of the captive population, substantial breeding by captives cannot be expected before the early 1990s. Thus, whether birds will be available for releases in the next few years will depend necessarily on continued good reproduction by the wild pairs.

Continued existence of the wild breeding pairs is important to the success of the release program not only in providing birds for release but also, potentially, in the transmission of knowledge of various nesting, roosting and feeding areas to the released birds. However, with the current rate of decline of the wild population, it is questionable that a "teaching force" of wild condors might still be in existence by the early 1990s. A disappearance of the existing wild population and its traditions prior to that time could make the process of reestablishing captives in the wild more difficult than otherwise.

On the other hand, it could be argued that preservation of the existing traditions of the wild population should be avoided, as these traditions may have some fatal flaws that have been contributing to the species' plight. For example, it is possible that continued traditional use of certain foraging areas is exposing the remaining individuals to high risks of mortality. Nevertheless, on the assumption that preservation of the traditions of the wild population might be more advantageous than disadvantageous, the Recovery Team has given high priority to beginning releases in the next few years in an attempt to forestall loss of the wild population, even though the success of these releases can be expected to be limited until much more has been learned about sources of mortality for the wild birds.

The scale of anticipated releases will represent a compromise between maximizing the benefits of releases versus the benefits of establishing a sizeable and genetically-diverse captive population. The Recovery Team has recommended the establishment of a captive population comprised of 32 individuals taken from the wild, including five progeny per wild pair, with no releases of captives to involve family lines with less than five progeny held for captive-breeding. As two family lines are already represented by five progeny apiece in the present captive flock, releases could start as early as 1985 if these particular pairs survive and produce progeny in the 1985 breeding season. Preparation of birds for release will be primarily a responsibility of the Los Angeles Zoo.

Habitat Protection. — Almost all known nesting areas of the condor are on national forest lands and receive excellent protection from disturbance by comprehensive U.S. Forest Service regulations. In contrast, most of the foraging regions so far identified and many of the roosts are in privately-owned oak-savannah or grassland foothills of the San Joaquin Valley. Tse lands are currently used for livestock operations but are under increasing pressures for development from various sources.

While it is unlikely that the principal current problems of the condor are ones of insufficient habitat, ultimately habitat protection can be expected to be of critical importance to sustaining the species. The continuing growth of the human population of California will make it increasingly difficult to protect important condor use areas. Thus, it is of crucial importance that areas of prime value to condors be identified quickly and efforts be initiated soon to guarantee protection of these areas while it is still possible to do so.

An example of the continuing efforts to

safeguard heavily used condor use areas has been the recent establishment of a protected region surrounding the traditional condor roost at Blue Ridge in Tulare County. Close to 800 hectares of land in this region have been recently acquired by the California Department of Fish and Game and the U.S. Fish and Wildlife Service, and these lands, together with lands already controlled by the Bureau of Land Management and the U.S. Forest Service, are being developed into a condor management area.

DISCUSSION

It is clear that preservation of the condor is not something that depends on any one approach. Many different problems have to be attacked simultaneously. Some problems can be addressed using traditional nonintrusive observations of wild birds; others require sophisticated solutions involving advanced technology. Too narrow a focus in any one direction must be avoided.

Events of the past few years have been encouraging in certain respects, especially the increases in reproduction that have been achieved through multiple-clutching and the considerable progress that has been made toward establishment of a viable captive population. The advances achieved in these areas may, if all goes well, provide enough time to solve the much more difficult task of identifying and countering mortality problems. Under current plans, it may be possible to begin some experimental releases of captive California Condors to the wild in the next few years, and when the existing captives become old enough to breed in the 1990s, the scale of releases may reach even 15 to 20 birds annually. Initial releases will probably be made within the present range of the species in an effort to bolster the existing wild population, but ultimately efforts will also be made to establish new populations in other portions of the species' former range.

The greatest threat to the ultimate success of the program may be genetic. Is there enough genetic diversity left within the remnant population to ensure that it may pull out of its present crisis of endangerment? No one knows. What we do know is that the longer a population remains at a very low level, the more genetic diversity will be lost and the greater the chances that inbreeding problems will set in. Some of the reproductive problems seen in recent years, especially the abnormal young and poor hatchability of eggs in certain pairs, may already be an indication of developing genetic difficulties. Ultimate survival of the species may depend on preserving as much of the genetic diversity left in the remaining individuals as is possible. For this reason, it is imperative that all efforts be made to increase the number of condors as rapidly as possible, and increasing the size of the captive population, together with continued multiple-clutching of wild pairs, offers the best hope of accomplishing this. Other endangered species have recovered from population sizes lower than the level the condor has now reached, and the situation is not hopeless. Success is by no means assured at this point, but the prospects look somewhat brighter now than they did a few years ago.

LITERATURE CITED

ANTAS, P.D.T.Z. AND C.L. DA SILVEIRA. 1980. Breeding of the King Vulture at Rio de Janeiro Zoo. *Int. Zoo Yb.* 20:202-204.

BROWN, W.M., R.C. DREWIEN AND E.G. BIZEAU. Mortality of cranes and waterfowl from powerline collisions in the San Luis Valley, Colorado. *In* J.C. Lewis (Ed.), Proc. 1985 Crane Workshop, National Audubon Society, Tavernier, Florida, (in press).

CARPENTER, J.W. 1982. Medical and husbandry aspects of captive Andean Condors: A model for the California Condor. 1983 Annual Proc. American Assoc. of Zoo Veterinarians, pp. 13-19.

CUNEO, F. 1968. Notes on breeding the King Vulture *Sarcoramphus papa* at Naples Zoo. *Int. Zoo Yb.* 8:156-157.

DEKKER, D. 1967. Hand-rearing the Andean Condor at Amsterdam Zoo. *Int. Zoo Yb.* 7:227-228.

HECK, H. 1963. The successful breeding of the King Vulture (*Sarcoramphus papa* [L.]) in captivity. *Zool. Garten* 27:295-297.

HECK. H. 1971. The artificial hand-raising of a King Vulture (*Sarcoramphus papa* L.) at Catskill Game Farm. *Zool. Garten* 41:45-48.

HOWARD, H. 1930. A census of the Pleistocene birds of Rancho La Brea from the collections of the Los Angeles Museum. *Condor* 32:81-88.

JACKSON, J.A. 1983. Nesting phenology, nest site selection, and reproductive success of Black and Turkey Vultures, chapter 17 *In* Vulture biology and management, S.R. Wilbur and J.A. Jackson (Eds.,), Univ. California Press, Berkely and Los Angeles.

KLÖS, H-G. 1966. Hand-rearing the Black Vulture (*Coragyps atratus*) at West Berlin Zoo. *Int. Zoo Yb.* 6:105.

KOFORD, C.B. 1953. The California Condor. *Natl. Audubon Soc. Res. Rep.* 4%, 154 pp.

LINT, K.C. 1960. Notes on breeding Andean Condors at San Diego Zoo. *Int. Zoo Yb.* 2:82.

MILLER, A.H., I. MCMILLAN AND E. MCMILLAN. 1965. The current status and welfare of the California Condor. *Natl. Audubon Soc. Res. Rep.* 6, 61 pp.

MUNDY, P.J. 1982. The comparative biology of southern African vultures. Vulture Study Group, Johannesburg, 295 pp.

RICKLEFS, R.E. (ED.). 1978. Report of the advisory panel on the California Condor. *Audubon Conservation Report* 6. National Audubon Society, New York, 27 pp.

SIBLEY, F.C. 1969. Effects of the Sespe Creek Project on the California Condor. U.S. Fish Wildl. Serv., Laurel, Maryland, 19 pp.

SNYDER, N.F.R. 1983. California Condor reproduction, past and present. *Bird Cons.* 1:67-86.

SNYDER, N.F.R. AND E.V. JOHNSON. 1985. Photographic censusing of the 1982-1983 California Condor population. *Condor* 87:1-13.

TEMPLE, S.A. AND M.P. WALLACE. 1983. A study of techniques for releasing hand-reared Andean Condors to the wild. Final report on contract FWS 14-16-0009-78-923, U.S. Dept. of Interior, Washington, D.C.

TERRASSE, M. 1985. Reintroduction du Vautour Fauve dans Les Grands Causses (Cevennes). Fonds D'Intervention pour les Rapaces, 5 pp.

U.S. FISH AND WILDLIFE SERVICE. 1975. California Condor Recovery Plan. Washington D.C., approved April 9, 1975, 63 pp.

VERNER, J. 1978. California Condors: Status of the recovery effort. Gen. Tech. Rep. PSW-28, U.S. Forest Service, Washington, D.C.

WALLACE, M.P. AND S.A. TEMPLE. 1983. An evaluation of techniques for releasing hand-reared vultures to the wild, chapter 27 *In* Vulture biology and management, S.R. Wilbur and J.A. Jackson (Eds.,), Univ. California Press, Berkeley and Los Angeles.

WILBUR, S.R. 1977. Supplemental feeding of California Condors, chapter 17 *In* Endangered Birds: Management techniques for preserving threatened species, S.A. Temple (Ed.), Univ. Wisconsin Press, Madison.

——— 1978. The California Condor, 1966-76: A look at its past and future. U.S. Fish Wildl. Serv., *Nor. Am. Fauna* 72:1-136.

——— 1980. Estimating the size and trend of the California Condor population, 1965-1978. *Calif. Fish Game* 66:40-48.

ZWART, P. AND J.W.W. LOUWMANN. 1980. Feeding a hand-reared Andean Condor and King Vulture *Vultur gryphus* and *Sarcoramphus papa* at Wassenaar Zoo. *Int. Zoo Yb.* 20:276-277.

ADDENDUM

Much has happened since the preceding review of the California Condor program was presented in late 1984. To give some appreciation of how dramatically the situation has changed and how strategies have evolved (or failed to evolve) with the accumulation of new information, I have left the 1984 account essentially intact for publication and have appended here a summary of developments since that time.

Unfortunately, many of the recent developments have been discouraging in their implications. Mortality of wild condors over the winter of 1984-1985 was exceptionally severe, with the loss of single members of 3 of the 5 breeding pairs known in 1984 and loss of both members of a fourth pair. In addition, a new pair that formed early in the breeding season of 1985 was lost before egglaying when one of its members disappeared. Only a single pair laid eggs in 1985, and although this pair was triple-clutched, only 2 of the eggs resulted in surviving nestlings. Altogether, 6 of the 15 wild condors known to exist in late 1984 had disappeared by spring of 1985, and 5 pairs were lost in the process — almost completely destroying the reproductive potentials of the wild population. Neither of the pairs represented by 5 progeny apiece in the captive flock survived to reproduce in 1985, thus precluding any releases of captives to the wild in 1985 under policies agreed upon in late 1984 by the Recovery Team, the U.S. Fish and Wildlife Service (USFWS), and the California Fish and Game Commission (CFGC).

The size of the wild condor population has continued to shrink since the spring of 1985. Three of the remaining wild birds were taken captive between June and September 1985 to increase the genetic diversity of the captive flock, and in January of 1986 another wild bird perished. The present wild population (March 1986) includes only 5 known individuals, while the captive flock now numbers 21. Only one of the last 5 wild birds is female, while the captive flock has 5 more females than males.

On the basis of the best demographic data available for the species, Verner (1978) calculated that the California Condor could not sustain itself with an annual adult mortality rate $> 5\%$ and a juvenile mortality rate $> 15\%$. We now have much more information on the demographic characteristics of the condor population than was available to Verner, especially regarding nesting success and potentials of the species for replacement-clutching and annual nesting. However, these improvements in understanding produce no significant changes in Verner's mortality limits since the improvements are almost completely compensating in their effects on calculations.

With the intensive photographic efforts of the past few years, it has become possible to quantify actual mortality rates of the wild population, based on changes in minimum numbers of birds documented. These rates have far exceeded the limits suggested by Verner. From early 1982 to 1985, the overall annual mortality rate averaged approximately 22%, or roughly 4 to 5 times the maximum sustainable adult mortality rate, and there was no appreciable difference in the mortality rates of immatures and adults. Ominously, the overall mortality rate increased in each of the last 3 yrs and reached 40% over the winter of 1984-1985. If recent trends are extrapolated in linear fashion, the population will become extinct within approximately 2 yrs. Under a constant mortality-rate extrapolation, the population might last several additional years. However, with only 5 known birds left in the wild, including only 1 pair, the question of when the last wild bird can be expected to die has lost much of its significance. The wild population is now clearly in a terminally inviable condition.

While excessive mortality has surely been the primary cause of decline, the specific mortality factors producing recent losses have been only partly determined. Only one of the six condors disappearing over the winter of 1984-1985 was radio-tagged, but both of the bird's transmitters failed at the time of the bird's disappearance, and it has not been seen or otherwise detected since late January 1985. However, one of the nonradio-tagged birds that disappeared was recovered—a moribund individual discovered in early April 1985. This bird had apparently been wasting away, unable to fly, for over a month and died shortly after being found. Analyses of its tissues revealed toxic levels of lead and zinc. The bird dying in January 1986, a radio-tagged individual, was also recovered before death and was also not saveable. It too was a victim of lead poisoning. However, in addition to carrying a bullet fragment in its digestive tract, presumably ingested with its food, this bird was found by x-rays to be carrying 8 lead shot in its tissues from a bygone shooting incident. Thus, while evidence has been accumulating rapidly fo the importance of lead poisoning in the recent de cline, lead poisoning is clearly not the only threa still faced by the species.

With the rapid decline in numbers and repro ductive potential of the wild population, the near term survival of the species has become totally de pendent on success of the captive breeding pro gram. The establishment of viable wild population has become a goal that must await future releases o progeny of captive birds, assuming the captiv population will become self-sustaining. Clearly th most pressing near-term priority has become en suring the viability of the captive population.

In April 1985 the California Condor Recover Team asked a broad sampling of the nation's mos experienced population geneticists to evaluate th genetic adequacy of the existing captive flock. Th unanimous conclusion of these specialists was tha because of the limited number of family lines rep resented in captivity, the existing flock could not b considered to possess a sufficiently safe level o genetic diversity to guarantee long-term survival o the species. Further, each geneticist consulte urged that to even approach a genetically adequat situation, all the remaining wild birds should b added to the captive flock. This recommendatio gains even greater force when one considers th likelihood that some, and perhaps a significan fraction of the captives may never become breed ers.

Shortly after these recommendations were re ceived, preliminary results were obtained by Ken dall Corbin (pers. comm.) on the extent of bloo enzyme polymorphism in most of the remainin condors. Results indicated very low heterozygosit in comparison to levels found in other bird specie suggesting that the remnant condor population i already seriously deficient in genetic diversity Thus the genetic health of the remaining birds ap pears to be far more questionable than was gener ally believed a short time ago.

Acting on the recommendations of the geneticist and on the evidence for catastrophic losses over th winter of 1984-1985, the CFGC authorized the trap ping of all the last wild condors in early June 198 and requested the USFWS to consider similar ac tion. The USFWS followed with initial approval t bring in 3 of the 9 wild birds, but disposition of th other 6 birds was debated vigorously through th summer and fall of 1985, with the USFWS initiall advocating leaving all birds in the wild, while the CFGC continued to recommend their immediate capture. In addition, the USFWS reversed at this time its earlier position that releases to the wild should not involve captives having fewer than 5 siblings in captivity, and now proposed, with support from the National Audubon Society (NAS) but not the CFGC, that 3 captives should be released to the wild in the near term. The USFWS-NAS position at this time was based on an assumption that mortality risks for birds in the wild could be greatly reduced by an intensive feeding program with clean carcasses that was initiated in the spring of 1985.

Meanwhile the Recovery Team recommended unanimously at its April 1985 meeting that there should be no near-term releases of captives to the wild, but the team was split on the issue of how many birds should be brought into captivity. However, at the August meeting of the Recovery Team there was a consensus that at least 3 of the controversial 6 birds should be taken captive. More recently, the team has come to favor, on a nearly unanimous basis, the capture of all the remaining wild condors, although the USFWS has not allowed the team to hold a formal meeting since August 1985.

The AOU Condor Committee, which met to consider the crisis in May 1985, took a stance similar to the initial position of the Recovery Team by recommending no near-term releases of captives to the wild and by failing to take a clearcut stance on disposition of the last wild birds. This committee stated that they felt that all the wild birds should be taken captive on biological grounds, but that to preserve the existence of the research program and to aid in habitat preservation efforts, several birds should be left in the wild, regardless of their poor chances for survival.

In late August a compromise was reached between the USFWS and the CFGC (the two agencies with permitting authority over the program) entailing the capture of 3 more wild birds for captive breeding and an agreement by both agencies to pursue an "aggressive policy" of releases of captives to the wild. Exactly what an "aggressive policy" of releases implied was not clarified. An important component of the compromise was an agreement that all wild condors would be brought into captivity if one more wild bird perished. Nevertheless, although the USFWS had agreed to fully authorize the trapping of 3 more birds by mid-September, it did not do so, primarily because of NAS opposition (including the threat of a lawsuit) to the August compromise. Authorization by USFWS for the capture of 3 additional wild condors did not occur until late October, when to break the impasse, the CFGC specifically agreed to consider release of 3 condors to the wild in the spring of 1986, if 3 birds suitable for release were available at that time, and if agreement could be reached as to where the release might take place. In its October statement to the CFGC, the USFWS failed to reaffirm its earlier support for taking the rest of the wild population captive in the event of any more mortality of wild condors, although this option was left open in the Environmental Assessment written to cover the situation.

In early November 1985, strategies for the California Condor Conservation Program were discussed at length at the Third International Vulture Symposium held in conjunction with The Raptor Research Foundation meetings in Sacramento. As a result of these discussions, a resolution was adopted on a nearly unanimous basis by the meeting participants that all the remaining wild condors should be taken captive as soon as possible, that no releases of captives to the wild should be attempted until a healthy, self-sustaining captive population is achieved; and that releases of California Condors to the wild, once they became advisable, should be limited to regions that offer effective protection from detrimental human influences. Although this resolution represented a strong consensus of a large fraction of the biologists directly involved in raptor and vulture conservation worldwide, there was no immediate comment from the USFWS. However, in late November the female of the last remaining wild breeding pair, a bird not yet authorized for the captive breeding program, was captured to replace her defective radio transmitters. A blood sample taken at this time, but not analyzed until after the bird was released, proved to contain a strongly elevated lead concentration. This led to recommendations of veterinarians and toxicologists advising the program that she be recaptured for treatment. The detection of high lead levels in this bird (she had low lead levels when captured earlier in the fall) proved to be a crucial development in convincing the USFWS that the remaining wild condors were still at high risk, especially since this particular bird was one that both the

USFWS and the NAS had believed was at very low risk because of her supposedly "safe" foraging habits and range.

In mid-December 1985, primarily because of the high lead levels in this bird, but also because it had become apparent that there were no captive birds behaviorally suitable for release in 1986, and because a new pair bond was forming in the wild between one of the birds slated for capture and one of the birds to be left in the wild, the USFWS finally adopted the position of the CFGC that all the remaining wild condors should be brought into captivity and that there should be no near-term releases of captive California Condors to the wild. However, before this decision could be implemented, the NAS filed suit to obtain an injunction against trapping, alleging that the USFWS's decision was arbitrary and capricious and that taking the last birds captive would doom habitat preservation efforts. Legal issues are presently not resolved. Although the NAS has won the initial round to prevent trapping on narrow procedural grounds, the matter is under appeal.

Thus, although the trapping of additional wild condors for the captive flock was first agreed upon by the USFWS and CFGC in August 1985, then again in October and once more in December, and although this action has been supported by the Recovery Team, the AOU Condor Committee, and virtually all biologists associated with the condor program, political and legal pressures from the NAS have so far prevented the trapping of any additional birds for the captive flock, with the exception of the bird brought in with terminal lead poisoning in early January 1986. In February 1986 the NAS agreed, however, to relax the injunction against trapping to the extent of allowing one more condor to be brought into captivity, but this has yet to be accomplished.

The fact that the mortality rate of the remnant condor population has proved to be considerably worse than was suspected earlier has raised strong doubts as to the safety of the habitat occupied by the population and as to whether releases of captives, once they become advisable, should be made in this region. Essentially all documented mortality of free-flying condors in recent decades has been limited to the traditional foraging areas in the San Joaquin Valley foothills and to roosting areas a sociated with these foraging areas, and it has b come increasingly clear that effective reductions the mortality threats in this region pose enormou practical difficulties. Although a comprehensiv identification of the mortality factors affecting th species has not yet been achieved, the princip threats that have emerged in recent years ar proving to be ones that are especially difficu to control.

It would, for example, be extremely difficult t achieve a significant reduction in collision threa from powerlines in the existing foraging range, the expense of rerouting or burying the many line in the area would be prohibitive (powerline presently crisscross the existing foraging range numerous locations). Similarly, effective reductior in the threats of shooting and lead poisoning in th existing foraging range would pose huge difficu ties in the present social environment. Not only ar there powerful special-interest groups that oppos restrictions on shooting and hunting in this regior but the problems of enforcing any such restriction would be enormous, considering the probabilit that a majority of the hunting and shooting th goes on within the condor range today is alread illegal and unregulated. Sweeping restrictions o hunting and shooting would also be likely to invit retaliation directed specifically at the condor.

Unfortunately, the primary threat of lea poisoning to condors appears to come from bulle fragments, rather than lead shot, and no practic alternatives to lead bullets are presently availabl for hunting of deer and other large mammals Thus, unlike the situation with lead poisoning o waterfowl (which can be hunted with steel shot), th lead-poisoning threat to condors cannot be quickl countered by a switch to steel ammunition.

The alternative of attempting to control threat such as shooting and lead poisoning by purchasin or leasing a major fraction of the foraging rang would necessitate an investment of many hundred of millions of dollars. Such monies are not presentl available, nor are they likely to become available Moreover, unless additional large and continuin expenditures might be made to greatly enhance lav enforcement efforts, it is questionable that ever outright ownership or lease of a large fraction o the foraging range would allow effective contro over the poaching and other illegal activities tha are a severe problem for the present owners o these lands. As these activities appear likely to continue in the forseeable future, regardless of potential habitat acquisitions and potential hunting and shooting restrictions, the practicality of achieving effective control over mortality factors in the existing range is highly questionable.

If indeed the principal mortality factors are ones that are impractical to counteract in the existing foraging range, it might be best to consider the existing foraging traditions of the wild population to be lethal traditions that should be deliberately phased out rather than preserved.

Do these considerations mean that viable wild California Condor population are unattainable within the existing range? Not necessarily, although it now seems likely that naturally self-sustaining populations completely free from intensive and manipulative conservation measures may well be beyond reach. However, the level of overt assistance that future populations of wild condors may need from man may be relatively minimal if releases are done intelligently. Recent releases of captive European Griffon Vultures *(Gyps fulvus)* in southern France have demonstrated the feasibility of establishing wild breeding populations of large vultures in quite confined areas so long as these areas are characterized by reliable food supplies, abundant nest sites, and good control over human influences. Over the last five years, Terrasse (1985) has succeeded in creating a wild population of over 50 griffons, including 9 egglaying pairs, which limit their activities almost entirely to an area of only 100 km^2. As this population is still increasing, it is possible that many more individuals and breeding pairs may ultimately be sustainable in the area. It is important to note that European Griffon Vultures, like California Condors, are normally long-distance foragers, yet the short-range foraging traditions that have developed in this release effort appear to be as comfortable for the birds as the more expansive foraging traditions of natural populations elsewhere. There does not appear to be any innate "wanderlust" in the released birds, and they are reported to be ill at ease when they get any distance from the release area and to be reluctant to land except in familiar places.

If released California Condors can be similarly confined to relatively small areas, certain parts of the existing condor range appear to offer strong potentials for supporting viable re-established condor populations with only minimal mortality threats. A prime example is the 210 km^2 Sespe Sanctuary together with the adjacent Hopper Mountain National Wildlife Refuge and surrounding areas in the Los Padres National Forest. This region holds the largest known concentration of historic condor nests and is currently well protected from most human threats, including hunting and various kinds of poisoning. Unfortunately, the wild birds now using the Sespe Sanctuary cannot be confined to this region as they all have traditions to forage primarily in the foothills of the San Joaquin Valley about 50 km distant. These traditions receive regular reinforcement by the continued presence of food in the foothills region. But if a new population could be established in the Sespe Sanctuary, provided with a reliable local food supply and shielded from the present foraging traditions of the wild population by preventing contact of released birds with the existing wild birds (most logically by bringing the last wild birds into captivity), it seems reasonably likely that the released birds would remain in this area and remain free of most of the problems currently threatening the species. The region surrounding the Sespe Sanctuary is not good foraging habitat, so there should be little inducement for condors to leave the sanctuary so long as it possesses a reliable food supply. Judging from former densities of breeding condors in the sanctuary, this region might comfortably host several dozen breeding pairs before the population might begin to expand into adjacent areas.

Another area offering similar potentials as a release site is the region surrounding the Sisquoc Sanctuary in Santa Barbara County, now largely included in the San Rafael and Dick Smith Wilderness Areas, all in the Los Padres National Forest. Like the Sespe region, the Sisquoc region has abundant former condor nest sites and an overall freedom from human influences. Although limited legal hunting now occurs along the northern boundary of this region, it should be feasible to bring this activity under control since access to the area is quite limited and controllable.

Thus, it is possible that the best way to counter the mortality problems currently producing the decline of the condor may be to avoid them spatially by rebuilding populations and foraging traditions in limited, secure areas that are isolated from the existing foraging range. While this approach implies a continued commitment to feeding programs for the wild populations, such programs are not difficult or expensive to maintain. Moreover, feeding programs will almost certainly prove necessary in the long run for maintenance of wild condor populations wherever they may be re-established.

To test the feasibility of confining California Condors to selected safe areas, a number of participants in the program have suggested temporary experimental releases of juvenile female Andean Condors in these areas. The Andean Condor is virtually identical to the California Condor in size, behavior and ecology, and has been the surrogate of choice for testing many other procedures that have been used with the California species. Moreover, abundant captive Andeans are available for release from zoological institutions around the country, including the Patuxent Wildlife Research Center. With releases limited to one sex, there would be no chance of this species breeding in the wild, and experience with Andean releases in Peru indicates that there should be no difficulties in retrapping released birds into captivity when this becomes advisable. Such releases could reveal unsuspected difficulties in release procedures without sacrificing any California Condors in the process, and would allow refinement of these procedures as well as development of optimal habitat management strategies for the regions in question. Later releases of California Condors in the same regions might then proceed with maximal efficiency and with enhanced prospects for success. Experimental releases of Andean Condors, however, are illegal under current federal regulations, and implementation of this approach would entail a special exemption to these regulations.

Although the foregoing strategies offer considerable promise from biological, political, and economic standpoints (no significant changes in human use patterns of condor habitat and no public purchases of expensive condor habitat would be needed), some participants in the recovery program have continued to advocate a more traditional approach, emphasizing the acquisition of existing foraging habitat of the species in the San Joaquin Valley foothills, preservation of traditions of the existing wild population, and attempted modification of detrimental human practices throughout the current foraging range. Recent proponents of this approach have argued that a continued presence of condors in the wild in the years just ahead is critical for habitat preservation efforts and to preserve existing foraging traditions. To sustain condors in the wild in the near term they have oppose further removals of condors for the captive breec ing flock and have advocated near-term releases c captives, regardless of the risks this strategy repr sents to viability of the captive population.

A cornerstone of this approach has been th proposed acquisition of Hudson Ranch, a 50 km area in the southwestern San Joaquin Valley foo hills where condors have commonly foraged durin the summer and early fall months in recent year Although this ranch represents much less than 1% of the current foraging range, it has been er visioned by its supporters as providing an ide location for releases and an opportunity to subs dize the wild population with "clean" food and thu significantly reduce threats of mortality resultin from ingestion of contaminated materials. How ever, despite an intensive feeding program o Hudson starting in the spring of 1985, it has bee clear that the wild condors are continuing to fee throughout the recent foraging range and primar ily on carcasses that are not provided by the re search program. In fact, the bird that most recentl died of lead poisoning (and had also been shot) wa an individual that was an especially frequent for ager on Hudson in past years. Yet despite the on going feeding program, this bird fed frequently i regions far to the east of Hudson in the fall of 198 and may well have been poisoned there.

Once foraging traditions are established, the apparently become very difficult to modify signifi cantly so long as they continue to be reinforced b continued availability of food sources. Moreover any condors released into the existing wild popula tion can be expected to soon acquire the full forag ing traditions of the population by their propensit to follow experienced wild birds. In addition, it i doubtful that condors could ever be confined t Hudson Ranch even if there might be no wild bird left for released birds to follow. The ranch is sur rounded on all sides by contiguous open foraging habitat with abundant (but not always uncontami nated) food supplies resulting from livestock oper ations, predator control operations, and legal and illegal hunting.

The intensive feeding program has also revealed another problem with Hudson Ranch as a release area. This ranch, like other ranches in the southern San Joaquin Valley foothills, has an extraordinarily dense year-round population of Golden Eagles mostly immatures, which compete vigorously with condors for carcasses. In fact, the eagles are normally dominant to condors at carcasses, often preventing them from gaining access to food. Juvenile condors are especially subordinate to eagles, and releases of naive young condors into this region promise to be difficult in the sense of ensuring adequate nutrition of the released birds and preventing their dispersal into uncontrolled regions. Golden Eagles are primarily birds of open country and are much more abundant in the grassland foothills of the San Joaquin Valley than in the mountainous regions of the condor range, including the Sespe and Sisquoc Sanctuaries.

Still another problem with releases on Hudson (or anywhere else in the San Joaquin Valley foothills) is the absence of confirmed historic condor nest sites in this region, despite the presence of apparently suitable cliffs in a number of locations. The absence of nesting activity in this region is probably not accidental, and we suspect that the primary reason for it may lie in high populations of eagles and ravens which represent high risks of predation on condor eggs and nestlings. Thus, even if released birds could be established in the Hudson region, it is questionable whether they could maintain themselves there reproductively, unless they could somehow learn associations with adequate nest sites elsewhere. The nearest historic nest sites to the foothills region lie many miles distant, and the intervening terrain is a type that would be very difficult to lead birds through by baiting. Unfortunately, the alternative of allowing the birds to learn historic nest site locations from experienced wild birds, either by leaving wild birds in the wild or by releasing former wild birds at the time of introductions, would also promise that the released birds would pick up all the old foraging traditions of the existing wild population along with all the excessive mortality threats represented by these traditions. In contrast, releases in the Sespe or Sisquoc Sanctuaries could be done using historic nest sites as "hack sites", and there should be no great difficulties in getting released birds to form proper associations with nest sites there. Judging from Terrasse's (1985) results and results of the Peregrine Falcon (*Falco peregrinus*) release efforts in the eastern states, re-establishment of reproductively viable wild populations of large raptors and vultures from captivity is perfectly feasible in areas lacking wild populations for the released birds to join.

Thus, releases on Hudson Ranch pose a number of severe problems that would not exist for releases in other areas. As of this writing (March 1986), the purchase of Hudson Ranch, although authorized by Congress at the urging of NAS, has been stalled because of its $4,000,000 price tag and uncertainties as to its value for the future conservation of the species.

To conclude, the controversies over the best strategies to be followed in preserving the California Condor show no signs of abating, and it is probably naive to expect that unanimity will ever develop among the agencies and individuals involved in the condor program. While a strong consensus has developed among most biologists that the remaining wild birds should be taken captive and that releases should be put off until the captive population becomes reproductively competent, it remains to be seen if this consensus will prevail. It is likewise unsure whether future releases of captives will be conducted within the existing foraging range or in remote protected areas with greater potential safety from the mortality factors that have been stressing the current population. Presently, decisions are in the hands of the courts and are being made on narrow procedural grounds with essentially no relationship to the biological realities facing the species. If decision-making can return to the hands of the responsible agencies, and if future strategies can be developed on the basis of open discussions of scientists capable of understanding the biological imperatives underlying conservation of the species, rather than through threats, intimidation, and legal action from special interest groups, there is still considerable hope for eventual recovery of the species.

Additional note added in proof: As this account goes to press, a recent development of ominous portent must be mentioned. The last remaining female in the wild population followed through in forming a new pair bond over the winter of 1985-1986 and laid an egg in early March 1986. Unfortunately, this egg had an extraordinarily thin shell and was crushed and destroyed in the wild before it could be taken into artificial incubation. Results of organochlorine analyses of membranes of the egg fragments (D. Peakall and R. Risebrough, pers. comm.) have revealed a high concentration of DDE (130-180 ppm lipid) that seems likely to have been causally connected to the thinning and breakage. Although recent eggshell thickness of the remnant population has been close to normal (Snyder et al., in prep.), this development raises additional concerns as to the safety of the present foraging range of the species and as to the wisdom of leaving the last few condors in the wild.

REINTRODUCTION AS A METHOD OF CONSERVATION

TOM J. CADE

The Peregrine Fund, Inc., Cornell University, Laboratory of Ornithology, 159 Sapsucker Woods Road, Ithaca, New York 14853

Abstract - A review of literature on the reintroduction of raptors and other birds into areas from which they were extirpated and of introductions into areas where they never occurred naturally provides a basis for evaluating these techniques for species preservation. More than 1,670 attempts have been made to establish several hundred avian species worldwide. At least 6 species of owls and 15 species of diurnal raptors have been successfully established. Examples of raptors that have been reintroduced or newly introduced are: Little Owl (*Athene noctua*) in Britain, Eagle Owl (*Bubo bubo*) in Sweden and Germany, Goshawk (*Accipiter gentilis*) in Britain, White-tailed Sea Eagle (*Haliaeetus albicilla*) in Scotland and Europe, Bald Eagle (*Haliaeetus leucocephalus*) in New York and California, Seychelles Kestrel (*Falco araea*) on Praslin, and the Peregrine Falcon (*Falco peregrinus*) in the USA, Canada, and Germany. An examination of successful introductions of such non-raptorial species as herons, storks, cranes, and puffins adds further insight into future applications. Reintroduction is a feasible but costly method of species preservation. It will become increasingly necessary in the future as natural environments dwindle in size and species populations become reduced to isolated relicts. I conclude that the future is not all bleak, for many of the conservation projects examined here are working, even though habitats may be different now and may continue to change.

My subject is reintroduction, and I am supposed to summarize how it will help raptors in the future. Because of the rapid rate at which the remaining natural areas of the world are being altered by human uses and because of the continuing increase in human population, it is impossible to make very meaningful predictions about the course of raptor conservation in general over the next 50 years. Even the closing years of the 20th century — there are only 15 remaining — even these few years hold many uncertainties; but perhaps one can make some informed guesses about the role of reintroduction based on present and past experiences with efforts to establish released raptors in outdoor environments.

One conclusion is certain: The world 50 years from now, and the diversity of species it will be able to sustain, will be far more different from the world of today than today's world differs from the conditions that existed in 1934 when Rosalie Edge and her small company of stout-hearted companions established the Hawk Mountain Sanctuary. It is meditative to recall that some of my earliest memories reach back to 1934, when I was a six-year-old growing up on my father's homestead on the border west of Columbus, New Mexico, where Pancho Villa's raid was still a favorite topic of conversation, where a fantastic bunchgrass and tree yucca savannah stretched for miles around our adobe, and where I am sure Aplomado Falcons (*Falco femoralis*), White-tailed Hawks (*Buteo albicaudatus*), and Zone-tailed Hawks (*Buteo albonotatus*) were in the immediate environs. All of that is gone now. Artesian wells, discovered afte my dad had to sell out, have turned the valley wher we lived into rich irrigated croplands. The tre yuccas are gone, the kangaroo rats are gone, an most of the raptors are gone.

Despite those particular and personal losses, remain somewhat optimistic about the possibilitie for a significant accommodation of human being to the needs of other species, and I want to digres briefly to share some perspectives I have gaine during recent trips to various parts of the world First to Alaska where, in July, I spent a marvelou two weeks, at the expense of the Fish and Wildlif Service, I am happy to note, traveling by boat on th Yukon and Colville Rivers with Skip Ambrose an Ken Riddle. These are regions I first visited in 195 and 1952 as a young biologist at the University o Alaska. Despite the construction of new roads bridges, pipelines, and other appurtenances associated with the production and transport of oi from the Prudhoe Bay fields, these northern taig and tundra environments have changed remarkably little in more than 30 years. Certainly thei capacities to hold species have not been significantl diminished; indeed, there were more Peregrin Falcons (*Falco peregrinus*) nesting on the Yukon in 1984 than there were in 1951, when I floated dow from Dawson to Circle in a 16-foot canoe (Cad 1953). The Colville River still holds one of th greatest assemblages of Arctic raptors anywhere in the world, and there are actually fewer people on the river today than in 1952 (Kessel and Cade 1958). Many of you, I am sure, could name similar situations that have endured for 30 or more years. The point is that not all natural areas of the world are deteriorating at a rapid rate, and there is still time to consider ways of protecting such wilderness regions from human incursions that would diminish wildlife populations if allowed to go uncontrolled.

I have recently returned from a trip to the Netherlands, where I attended the *Fourth World Conference on Breeding Endangered Species in Captivity* held at Flevohof on a reclaimed portion of the Zuider Zee, 10 meters below sea level. I was fascinated by these Dutch polders, as they are called: 40 percent of the country is completely artificial, man-created habitat; but "wild" animals are not absent from this landscape. There is a great variety and abundance of waterfowl and shorebirds on these reclaimed lands — and raptors too. This little country has no fewer than 400 to 600 nesting pairs of the Goshawk (*Accipiter gentilis*), far more than 50 years ago, 1000 pairs of the Hobby (*Falco subbuteo*), more than 1,200 pairs of the European Sparrowhawk (*Accipiter nisus*), 1,700 pairs of the Common Buzzard (*Buteo buteo*), and so many of the European Kestrel (*Falco tinnunculus*) — more than 6,000 pairs (data from Teixeira 1979 and *Vogels* 1980-1984) — nobody has attempted to count them all. Man-created and man-dominated lands are not necessarily devoid of wildlife.

On my way home from the Netherlands, I stopped to visit my student, 'Olafur Karl Nielsen, in Iceland. He has been studying the Gyrfalcon (*Falco rusticolus*) and Rock Ptarmigan (*Lagopus mutus*) for the past four years with support from The National Geographic Society. Again, Iceland has been brutalized by a thousand years of overgrazing by man's horses, cattle, sheep, and goats, and vast areas of heathlands have eroded into barren sand dunes. And yet, on Nielsen's 5,200 km^2 study area, this summer he found 55 occupied territories of Gyrfalcons, and the ptarmigan population had increased 2.4-fold since 1981.

Living forms persist in the face of great adversity, and conservationists of the next 50 years can perhaps find some hope in that enduring fact. In short, vertebrate evolution has not yet come to an end, despite what some authors would lead us to believe.

There is urgency, however, if we are to save a significant vestige of nature's wild species. The actions we take in the next 10 to 15 years to preserve large areas of natural or semi-natural habitats and to develop ways of reducing the impact of human land uses on co-inhabiting wildlife populations will largely determine how many and what kinds of raptors will be present in the global ecosystem 50 years hence. I believe conservationists cannot be passive — that is, protection of habitat, the setting aside of nature preserves alone, will not suffice, because such preservation simply cannot occur on a large enough scale to take care of everything. In the face of current and projected needs of the human population for resources, all forms of "nature protection" that aim to preserve the status quo are delaying actions at best.

Thus, manipulative techniques such as reintroduction have some as yet poorly defined role to play in the preservation of species in the outdoors. No doubt mistakes will be made in applying these techniques in specific cases, but I believe we must think more and more in terms of how we can help species to adjust and to survive in the altered environments of a world that is increasingly dominated by one species, *Homo sapiens*.

SOME DEFINITIONS

What do we mean by reintroduction? It is not always clear, in part because the word literally means "to introduce again," and that is not what we are talking about when we use the term. We mean the re-establishment of a species by the release of individuals in an area where it naturally occurred but has been extirpated, usually through human influences. But that is only one of several kinds of situations which can result from the release of animals to outdoor environments, and so we need to make some distinctions. The 1976 *Manifesto on Animal Reintroductions* of the World Wildlife Fund (British Section) has tried to do so by distinguishing *reintroduction* from *restocking*, which is "the release of animals of a species into an area in which it is already present," and *introduction*, which is "the release of animals of a species into an area in which it has not occurred" — in other words, exotic introduction.

None of these terms and definitions is completely unambiguous, however, because we actually deal with a broad spectrum of intergrading possibilities when animals are released in outdoor environments; but the term, reintroduction, has become international in use, and I think we are stuck with it. To give an idea of the range of situations, captive produced or wild-captured animals may be used: (1) to establish individuals of the original local or regional genetic stock to vacant habitat (reintroduction in its "purest" sense, as we are doing, for example, with Peregrine Falcons in vacant areas of the Rocky Mountains and in southern California); (2) to establish individuals of different local or regional stocks in areas where other populations of the same species have been extirpated [reintroduction in an "impure" sense, as we are doing it with Peregrine Falcons in the eastern USA; the Scottish Sea Eagle (*Heliaeetus albicilla*) project is another example]; (3) to establish individuals of the same local or regional stock in areas where the indigenous population still exists (restocking in the purest sense, as we do it with Peregrines in Colorado or on the central coast of California); (4) to establish individuals of a different local or regional population in an area where an indigenous population exists, resulting in the mixing of genotypes from different local populations of the same species [restocking in an impure sense — for example, the release of Alaskan Bald Eagles (*Haliaeetus leucocephalus*) into New York State]; (5) to establish individuals of a species in new areas, exotic introduction, which can occur on a micro-scale into new habitats — Peregrine Falcons nesting in salt marshes of the Atlantic Coast or in urban areas) or on a macro-scale [into new geographic range — the South American Chimango Caracara (*Milvago chimachima*) on Easter Island].

These different results from the release of animals in outdoor environments are subjects of considerable discussion and controversy. The World Wildlife Fund Manifesto (1976) sets forth nine essential criteria which it says should be fulfilled before any form of release into the "wild" of any animal is permitted. Briefly they are: (1) there should be an intensive study of the species and its environment past and present, upon which to form a firm objective basis for reintroduction; (2) it must not have a disruptive effect on the ecosystem in which it is carried out; (3) the catching, transport, and release of the animals should be carried out legally, humanely, and sympathetically in the first interests of the animals themselves; (4) a contingency plan should exist to discontinue the program if initial predictions are not satisfactorily fulfilled; (5) the local human population should be informed, on the whole sympathetic, and not subject to serious economic consequences as a result; (6) appropriate protective legislation should ready exist; (7) the program should be carried c objectively, scientifically, and sensibly; (8) the a mals used must be of the closest available stock; the original causes of extinction (extirpation) ha been largely removed, and the habitat requi ments of the species are satisfied.

THE HISTORY OF INTRODUCTIONS AND REINTRODUCTIONS

What has been the history of avian introductio and reintroductions? I am sure it would have be quite different had these nine criteria always be followed, but they were not. Even so, the ecologic consequences of establishing avian species, on tl whole, appear not to have been as disruptive other species and ecosystems as has been the ca for many introduced mammals and fishes.

John Long (1981) of the Agricultural Protectic Board of Western Australia has published a mo informative compendium entitled *Introduced Bir of the World*. He has missed very little up to the la 1970s. In the 1800s and early part of this centur numerous so-called "naturalization" or "acclimat zation" societies were active, especially in Britai USA, New Zealand, Australia, Hawaii, and som other places. According to Long, more than 1,67 attempts have been made to release and establis several hundred species of birds in all parts of th world; of this number, at least 425 or about 25 resulted in successfully-established breedin populations in the outdoors. In North America 11 species have been attempted, and 39 (33%) are de finitely established. In Europe the figures are 6 attempted and 27 (39%) established; in th Hawaiian Islands, 162 attempted and 45 (28%) es tablished; in New Zealand, 133 and 38 (29%); i Australia, 96 and 32 (33%); in the Seychelles, 1 attempts and 10 (a whopping 71%) established.

A disproportionate number of these artificiall established populations are gamebirds or waterfow of the Order Galliformes and Order Anseriforme but there are also a fair number of doves, parrots and passerines. Among the birds of prey, ther have been attempts with at least 6 species of owls The Barn Owl (*Tyto alba*) has been successfully in troduced into the Seychelles, Hawaiian Islands, an St. Helena; the Masked Owl (*Tyto novaehollandiae*) on Lord Howe Island; the Little Owl (*Athene noctua* in Britain and New Zealand; and the Eagle Ow (*Bubo bubo*) has been reintroduced into southwest ern Sweden and in Germany. There have been unsuccessful attempts with the Spotted Boobook Owl (*Ninox novaeseelandiae*) and Tawny Owl (*Strix aluco*).

Attempts have also been made with at least 15 species of diurnal raptors. The successful establishments include the Turkey Vulture (*Cathartes aura*) introduced into Puerto Rico and Hispaniola, the Swamp Harrier (*Circus aeruginosus*) in Tahiti and other Society Islands, the Chimango Caracara on Easter Island, the Goshawk reintroduced into Great Britain, and possibly the Common Buzzard in Ireland (Long, 1981, lists this species, but there are no data). Partial successes include the Andean Condor (*Vultur gryphus*), the Griffon Vulture (*Gyps fulvus*), White-tailed Sea Eagle, Bald Eagle, Harris' Hawk (*Parabuteo unicinctus*), Seychelles Kestrel (*Falco araea*), and Peregrine Falcon (Cade 1984). It is too early in the efforts to say how other attempts will turn out, but it appears likely that all of these partially successful cases will eventually result in fully-established, self-maintaining populations.

There have been many failures, of course, particularly with attempts to introduce exotic game birds by mass releases involving little or no conditioning of the birds for their new environment. One only needs to recall the repeated failures of many state game agencies to establish Coturnix Quail (*Coturnix coturnix*) in the United States. Hundreds of thousands of these birds were released — over 360,000 in the years 1956 to 1958 alone — but no breeding populations ever became established (see Long 1981). Or the futile attempts to establish migratory Sandgrouse (*Pterocles exustus*) in Nevada. Of some 2,030 birds, the only 2 ever seen again after release were shot in Sonora, Mexico (Christensen 1963).

There are two main reasons for these failures. The first is use of genetic stocks or species that are poorly adapted or nonadapted to the environments into which they are introduced. The second has been lack of understanding of the behavioral, physiological, and ecological processes required for successful establishment: phenomena such as habitat imprinting in the broad sense, including fixation to nest sites, to navigational guides, winter quarters, food (search images), and roost sites; innate dispersal mechanisms and timing in relation to maturation and life cycle; entrainment to photoperiod; predator avoidance; and social organization required for survival and reproduction.

Given the poor record of success with many species, particularly when captive-produced individuals have been used, the recent reintroductions of raptors have been more successful than most biologists would have predicted. The application of knowledge about behavior and ecology has been primarily responsible for these successes, as I have discussed in my paper on "Husbandry of Peregrines for Return to the Wild" (Cade 1980).

EXAMPLES OF RAPTOR INTRODUCTIONS AND REINTRODUCTIONS

1. The Little Owl in Britain. — In the late 1800s the fourth Lord Lilford and Col. Meade Waldo, along with other landed gentry, imported many Little Owls into Britain from the Continent and liberated them on their estates. The owls became established as breeders, locally at first, but by the 1930s they were expanding their range rapidly, and today they occupy the whole of England and Wales and some of the Scottish borderlands. Apparently the English countryside had a vacant niche for a small, largely diurnal and principally insectivorous owl, and this vacancy the Little Owl fills today in an entirely innocuous way, adding variety and interest to the British avifauna (Lever 1977).

2. Eagle Owl in Sweden and Germany. — The Eagle Owl has declined greatly in Sweden, from approximately 455 known territories in the 1940s to only 171 in the mid-1970s, and the population is now broken up into discrete, small isolates (Broo 1977). Starting in the 1960s, a number of private owl breeders banded together under the joint aegis of the Swedish Sportsman's Association and the Swedish Ornithological Society to breed Eagle Owls for release in southwest Sweden, where an isolated population had been reduced to no more than 4 occupied territories by 1972 (Broo 1978). Nearly 600 young owls have now been released from special breeding cages, in which captive pairs are held at more than 40 locations in suitable owl habitat. I learned at the *Fourth World Conference on Breeding Endangered Species in Captivity* that there are now more than 50 pairs of Eagle Owls nesting in southwest Sweden (70 occupied territories in 1983), and Project Eagle Owl has become so popular that the Scansen Zoo in Stockholm and other zoos have joined with the private breeders to produce more owls for release in all parts of Sweden (Torsten Morner, paper; Flevohof 1984 see also Broo 1982).

The Uhu or Eagle Owl has also declined greatly in central Europe, to such an extent that by the 1960s it was gone as a breeding bird in West Germany except for a small population in Bavaria. Several captive breeding projects began to be organized in the 1950s and 1960s under the auspices of the *Aktion zur Wiedereinburgerung des Uhus* (AZWU) to raise owls for release. By 1972 there were 90 owls in the cooperating projects, and by 1982 this number had increased to 250 birds in the care of about 85 breeders, including zoos and private aviaries (Frankenberg et al. 1984).

By 1979, over 550 owls had been released in 3 regions — 330 around Harz, 168 around Eifel, and 40 in Baden Württemberg. In 1981 releases also began in Schleswig-Holstein. The owls have been released in 4 ways: by fostering young into nests of wild pairs, by releasing fully-fledged young owls after a period of training and adapting them to feed on locally available prey, by establishing a fully adult owl into the territory of a single, inexperienced bird of the opposite sex, and by releasing young directly from the enclosures in which their parents are held for breeding (the Swedish method).

In the Harz and Eifel regions combined, the first recorded nest produced 3 young in 1973. The number of nesting pairs has slowly built up over the years, so that by 1982 there were 25 nests that fledged 51 young. The total number of known nestings in the 10-yr period was 112, yielding a production of 218 offspring, not including 86 fostered young. The nesting population doubled about every 2 years in this decade, except for the last 2 recorded years. The main limitation on further expansion appears to be the quality of available habitat (Frankenberg et al. 1984).

Captive-bred Barn Owls are also being released and established with some success in various parts of North America and Europe. Warburton (1984) has described such a project in England.

3. The Goshawk in Britain. — Deforestation and human persecution had more or less exterminated the Goshawk from Britain by the end of the 19th century, with only sporadic breeding thereafter. In the mid-1960s breeding became regular again, the species increased in the 1970s, and by the 1980s Goshawks had been found nesting in at least 60 different places in 14 areas of Britain, and pairs had been seen in 34 other places. There were at least 39 successful nestings in 1979-80. Marquiss and Newton (1982) have summarized the information which clearly indicates that this re-establishment has resulted in part from escaped falconers' birds and in part from the deliberate release of Goshawks largely of Finno-Scandinavian origin.

4. White-tailed Sea Eagle in Scotland and Europe. — This species also had largely disappeared from Great Britain by the end of last century, the last recorded nest having been robbed by an egg collector in 1910. Beginning in 1975 a project conceived by Ian Newton and sponsored by the Nature Conservancy Council of Britain started reintroducing Sea Eagles by releasing birds obtained in Norway on the Isle of Rhum in the Hebrides. The actual work has been carried out by John Love (1983), who has recently written a delightful book summarizing the project. A total of 63 eaglets had been released through the 1983 season. Survival has been remarkably high, and most of the eagles have been seen following their release, not only on Rhum, but also in many other parts of Scotland and Northern Ireland. In the summer of 1983 Love obtained information on the presence of at least 6 pairs that had established breeding territories, 2, possibly 3, of which laid eggs, but none of which, unfortunately, hatched. Ian Newton (pers. comm.) has informed me that the situation remained essentially the same in 1984, but it seems certain that Sea Eagles will soon again be breeding in Britain. (In 1985 four pairs laid; 4 eggs hatched; 1 young fledged from a nest; John A. Love, pers. comm.)

On the Continent, Claus Fentzloff (1984) has been breeding Sea Eagles in captivity for release in Germany and Czechoslovakia. Twenty-four eagles from 2 captive pairs have been released through 1984, following several months of training and flying before final liberation in each case (Fentzloff, poster presentation; Flevohof 1984). One pair has built a nest in Czechoslovakia and laid eggs, but again they did not hatch. There is hope for the future.

5. Bald Eagle in New York, Tennessee, and California. — Captive production of Bald Eagles at several zoos, but especially at the U.S. Fish and Wildlife Service center at Patuxent, Maryland, has provided more than 80 eaglets (71 from Patuxent alone, J. Carpenter, pers. comm.) for release in several states which have projects for restoring eagle populations by the establishment of either captive produced or transplanted wild eaglets (Cade, in press). Alaska and Canada have been providing numbers of wild eaglets for these projects since 1981. Eagle restoration, which has become a very popular activity of state endangered species units, began in New York in 1976 through the efforts of The Peregrine Fund, Inc., under contract from the state and the U.S. Fish and Wildlife Service. Of the 6 eaglets we hacked out at the Montezuma National Wildlife Refuge in 1976 and 1977, 3 are now members of breeding pairs in New York, and a fourth eaglet released by the New York Department of Environmental Conservation in 1979 is breeding in Pennsylvania (Cade 1983; P. Nye, pers. comm.) Some 117 eaglets have now been released in New York; the release phase has 1 more year to go, after which the state hopes to see the successful establishment of several breeding pairs in subsequent years (Nye 1984).

Since 1980, 38 eaglets have been released at 2 sites in Tennessee under the auspices of the Tennessee Valley Authority. A 3-yr-old male, produced at the Columbus Zoo and released in 1981, nested with an unmarked female in 1984, fledging 1 young in 1984 and again in 1985 at a nest 13 km from the hack site in the Land-Between-the-Lakes (LBL). Two other non-breeding pairs with nests started in 1983 and 1985 and located 30 km and 80 km from the LBL hack site may also involve hacked eaglets (D. Hammer, pers. comm., 1985).

In California, about 20 eaglets have been hacked out on Catalina Island from 1980 to 1984. Again, survival has been high. Only 1 bird so far has dispersed to the mainland, a few are visiting neighboring San Clemente Island, but most are permanently resident on shoreline territories around Catalina itself. Two pairs have established territories, and one has built a nest, but laying has not yet occurred (David Garcelon, unpublished report). It appears that a breeding population will soon be re-established on this island, which historically held several nesting pairs.

6. The Peregrine Falcon in the USA, Canada, and Germany. — Today there are private and institutional breeding projects for the Peregrine Falcon throughout the world — quite literally on every continent — and the total production in the last 10 years well exceeds 3,500 falcons, probably closer to 4,000 (Cade, in press). There are 4 national programs involving propagation for release and reintroduction in the United States, Canada, West Germany, and Sweden.

In the United States, the first program began at Cornell University in 1969-70 and soon became known as The Peregrine Fund. Today that organization operates 3 breeding and reintroduction facilities. Through the 1984 season our combined efforts have resulted in the production of more than 1,450 Peregrine Falcons, and we have released to nature more than 1,340 young by hacking, fostering into wild nests of Peregrines, or cross-fostering to Prairie Falcons (Cade and Hardaswick, 1985). In the eastern States we had 27 pairs occupying territories in 1984, and 16 of them produced 30 young in a region where no Peregrines had nested for more than 20 years prior to 1980, when the first of our released birds raised young (Cade and Dague 1984). This newly-established breeding population is currently in a logarithmic phase of growth and is more than doubling in size every 2 years (Table 1). If this rate of growth continues, by releasing approximately 100 birds/yr into the eastern environment we can have 200 or more pairs established by 1990.

In the Rocky Mountains, we have increased the greatly diminished population in Colorado from 6 pairs to 13 pairs, and we have established new breeding pairs in Utah, Wyoming, and Montana. On the West Coast between Monterey and Santa Barbara, California, the nesting population has increased from 1 unproductive pair to 11 occupied and productive eyries since we began introducing falcons into that region in 1977. There are four pairs established on buildings in the metropolitan Los Angeles basin, birds are seen regularly in Long Beach and San Diego, and there is a pair on the Oakland Bridge in San Francisco Bay. Elsewhere in North America released Peregrines are nesting on buildings or bridges in New York City, Baltimore, near Philadelphia, Atlantic City, in Montreal, Calgary, and Edmonton (Cade, in press).

The other main North American program began about the same time in Canada under the supervision of Richard Fyfe (1976), Canadian Wildlife Service. His establishment located at Wainwright, Alberta has produced 575 fledged Peregrines since 1974, and 506 of them have been released. Several of these released falcons are known to be nesting in the wilds of northern Alberta, in addition to those

Table 1. Peregrine Falcon Nesting Summary, 1979 - 1984 (Eastern Region).

YEAR	LOCATION	TYPE	OUTCOME	TOTAL
1979	New Jersey	tower	failed, egg predation	1 attempt 0 young
1980	New Jersey	tower	1 young	3 attempts 6 young
	New Jersey	tower	3 young	
	Quebec	cliff	2 young	
1981	New Jersey	tower	2 young	4 attempts 10 young
	New Jersey	tower	3 young	
	New Jersey	tower	3 young, killed by raccoon	
	New Hampshire	cliff	2 young	
1982	New Jersey	tower	2 young	5 attempts 12 young
	New Jersey	tower	3 young	
	New Jersey	tower	4 young	
	New Jersey	tower	failed, female disappeared	
	Virginia	tower	3 young	
1983	New Jersey	tower	1 young	9 attempts 23 young
	New Jersey	tower	3 young	
	New Jersey	tower	4 young	
	New Jersey	tower	4 young	
	Maryland	tower	2 young	
	Maryland	bridge	failed late in incubation	
	New York	bridge	2 young	
	New York	bridge	3 young	
	Virginia	tower	4 young	
1984	New Jersey	tower	2 young	16 attempts 30 young
	New Jersey	tower	2 young	
	New Jersey	tower	2 young	
	New Jersey	tower	2 young	
	New Jersey	tower	2 young	
	New Jersey	tower	3 young	
	New Jersey	tower	failed	
	New Jersey	tower	1st clutch removed, no re-nesting	
	New Jersey	bridge	failed	
	Maryland	tower	3 young	
	Maryland	bridge	3 young	
	Maryland	building	4 young	
	Maryland	tower	failed	
	Virginia	tower	2 young	
	Virginia	tower	2 young	
	New York	bridge	3 young	
	Montreal	building	2 young	
Total	38 attempts	31 successful (82%)	81 young hatched	2.14 young/attempt 2.62 young/successful attempt

that have taken up residence in the cities mentioned previously (Cade, in press).

Professor Christian Saar in Berlin and his associates in the *Deutscher Falkenorden* have been raising Peregrines for release in the vacant, former breeding range of the species in Germany (Saar et al. 1982; Gerriets 1984). Since 1977 they have released 191 young, again by hacking, fostering into Peregrine nests, and cross-fostering into nests of Goshawks, Common Buzzards, and Kestrels. The first reintroduced pairs nested successfully in the Harz Mountains of East Germany and on an old lighthouse in the sea near Bremen in 1982. Seven to 8 pairs have been established in Germany so far as a result of these releases, including 1 pair that nests 200 m up on a television tower in Frankfurt. These are very encouraging results, indeed, considering the small number of falcons released (Cade, in press).

7. The Seychelles Kestrel on Praslin. — In 1977, J. Watson (1981; see, also, Collar and Stuart 1985) removed 6 males and 7 females, including the members of 3 established pairs, from territories on the main island of Mahé in the Seychelles, and released them on the northern island of Praslin, where this species had been extirpated for a number of years. This release resulted in at least 2 successful nestings in 1978, and by October 1980 there was a minimum of 10 pairs in the more wooded southern half of the island. Although exact numbers could not be stated, the species was known to be still present and thriving on Praslin in 1983 (Anne Gardner, pers. comm. 1985).

INTRODUCTION AND REINTRODUCTION OF NON-RAPTORIAL BIRDS

The methods that are currently so popular for restoring raptor populations in outdoor environments can be used for many other kinds of birds as well. Hacking, fostering, and cross-fostering techniques have, in fact, been more widely applied than most raptorphiles realize.

As early as 1892, E.A. McIlhenny (1934) began releasing hand-reared Snowy Egrets (*Egretta thula*) from a large flight cage on Avery Island, Louisiana, an idea he got from hearing stories as a boy about the fabulous "flying cages of Juraspore" in India. Soon his released egrets were returning to Avery Island to breed in an artificially created habitat where no heronry had been before, and in the following years they and their progeny multiplied and also attracted many other herons and egrets to join them. By 1911 there were tens of thousands of nesting birds, and the population eventually reached a level of 100,000 or more individuals of eight ardeid species, in addition to several other wetland species — a "Bird City" of staggering proportions and variety, all in immediate proximity to a busy Tabasco sauce factory!

In 1909 McIlhenny (1934) shipped two train carloads of Snowy Egrets to Charles Deering in Miami, in all 2,100 birds, which were held in large flight-cages covering more than three acres of the Deering estate. The egrets were not given their liberty until they had started nesting in the spring of 1910. According to McIlhenny, "The colony thrived splendidly, and to these birds is largely due the re-establishment of Snowy Egrets in Florida."

More recently, Wingate (1982), following McIlhenny's example, has successfully reintroduced the Yellow-crowned Night Heron (*Nycticorax violacea*) to Bermuda, where over a three year period he conditioned 46 young herons obtained from Tampa Bay, Florida, to feed on a diet of native land crabs (*Gecarcinus lateralis*), an abundant pest species on the island. By 1982, there were 14 resident breeding pairs, which fledged 30 young, and an additional 12 or more non-breeders, all feeding happily on land crabs.

In Germany, the method of allowing young reared by their parents in an aviary to fledge into the surrounding countryside has also been used to establish a new colony of Grey Herons (*Ardea cinerea*). This mode of release leads the young birds to become strongly fixed on the locale before dispersing, so that many return as adults to establish their nests nearby (Fentzloff 1984).

The White Stork (*Ciconia ciconia*) is another species that has been successfully reintroduced in parts of Europe. In Switzerland from 1948-1979 young storks were raised in captivity to be released when sexually mature and paired at 4 years of age. The pairs formed in captivity were then released near stations where other captives are kept to serve as attractants to hold the released birds in the area until they build nests. In 1979 storks again occupied 59 nests in the Altreu district where none remained in 1950 (Bloesch 1980). Similar efforts are being carried out with zoo-reared birds in Holland, where the released storks have become non-migratory and remain through the winter (Dutch Zoo, pers. comm.).

The effort to establish a new population of Whooping Cranes (*Grus americana*) with different breeding and wintering grounds from the parent population is instructive in several ways. First, the new population is being established by cross-fostering both captive-produced and wild-taken eggs into the nests of Sandhill Cranes (*Grus canadensis*) (Drewien and Bizeau 1978). The same technique has been used to introduce the Scarlet Ibis (*Eudocimus ruber*) into South Florida, with the White Ibis (*Eudocimus albus*) serving as the foster parent. This experiment, however, has resulted in the production of some hybrids between these two species (Long 1981), one of the main problems with cross-fostering as a method. Second, the new crane population is being introduced into range in which both the potential nesting habitat in Idaho and adjacent states and the wintering grounds in southern New Mexico are different from those occupied by the remnant wild population (muskegs of northern Alberta; coastal, tidal flats of Texas). One result of this difference in habitats is that the transplanted cranes have had to alter their dietary regime rather drastically, particularly on the new winter quarters, where grain is the main food consumed, in contrast to the Texas coast where aquatic plants (bulbs and tubers) and tidal zone invertebrates are the main items. This is a rather major shift in food habits, and it would be interesting to know whether it has produced morphological or physiological adjustments in the cranes' digestive system.

Steve Kress (1978) and his associates have re-established a nesting population of Common Puffins (*Fratercula arctica*) on Eastern Egg Rock, off the coast of Maine, following an absence of the species there for 100 years. After rearing more than 700 chicks translocated from Grand Island, Newfoundland in artificial nest burrows between 1973 and 1981, Kress and his co-workers observed the first five pairs breeding on Eastern Egg Rock in 1981. Since then the population has fluctuated around 14 pairs; but many of the released puffins have also appeared at the nearest breeding colonies on Machais Seal Island and Matinicus Rock (Kress 1981-84).

CONCLUSIONS ABOUT REINTRODUCTION AS A TECHNIQUE

Given enough biological knowledge about a species and enough time, effort, and money, reintroduction can be made to work. It is an expensive and labor-intensive procedure, especially whe captive-produced birds are involved. It usually r quires a tremendous amount of cooperation amon numerous private individuals, government ager cies, conservation organizations, corporations, an so on. Since so many different interests are usuall involved, especially with an endangered species, almost always becomes a highly politicized activit For all of these reasons, it should remain a metho of last resort for those species or populations th truly can be helped substantially in no other way.

HABITAT PRESERVATION *Vis a Vis* REINTRODUCTION

Having said that, I would like to end by examin ing briefly the future of reintroduction in relatio to other aspects of conservation, particularl habitat preservation. I think no one would disagre that preservation of suitable natural or quasi natural habitats is the paramount requirement fo the conservation of raptors and other wildlife dur ing the next 50 years. This need includes sufficien area to hold self-maintaining populations througl time as well as maintaining suitable environmenta quality to meet the ecological requirements o species.

Maintenance of suitable habitats is probably no going to be a big problem for most species of Nortl American and Eurasian raptors, so long as perva sive environmental contaminants such as DDT an dicofol are kept under control. Acid rain is anothe such problem, which may well affect raptor through its influences on habitat and prey popula tions, as is the projected change in climate resultin from increasing CO_2 concentrations in the atmo sphere. But most northern, temperate-zone specie are adaptable to a range of conditions, includin highly altered environments in some cases, and we have witnessed some remarkable recoveries ir numbers in recent years once decimating factor have been corrected — the Peregrine Falcon ir Britain being a notable example (Ratcliffe 1984) Also, most North American and Eurasian specie exist in very substantial species populations numbering in the thousands to 10s of thousands, and even 100s of thousands of individuals. As long as raptors are not unduly persecuted by shooting and similar actions, at most there should be only local or regional concerns about preservation throughout much of the Northern Hemisphere above the tropics in the next 50 years.

Here reintroduction can be justified only for major regional losses of population (e.g., Peregrine Falcon, White-tailed Sea Eagle, Bald Eagle, Lammergeier) or to restore or supplement extralimital populations of southern, tropical species such as the Aplomado Falcon, perhaps, or the Snail Kite (*Rostrhamus sociabilis*), or the Harris' Hawk. In North America, the California Condor (*Gymnogyps californianus*) really is the only raptor threatened with extinction. Captive breeding and reintroduction appear to be the only way to bring its numbers back up to long term, sustainable levels for species survival, as Noel Snyder has recounted.

Island endemics and tropical forest species are the critical ones for future concern and action, as well as a few species like the Orange-breasted Falcon (*Falco deiroleucus*) and Teita Falcon (*Falco fasciinucha*) that occur at extremely low natural densities and are patchily distributed over vast ranges. Most endangered species of birds are island endemics, which have small, restricted populations easily subjected to a variety of perturbations caused by human activities. Examples among raptors include the Mauritius Kestrel (*Falco punctatus*), Philippine Monkey-eating Eagle (*Pithecophaga jefferyi*), several species on Madagascar, the New Guinea Harpy Eagle (*Harpyopsis novaeguineae*), Gurney's Eagle (*Aguila gurneyi*) and possibly others which are insufficiently known. Of these, only the Mauritius Kestrel (Jones 1984) and the Philippine Eagle (Krupa 1984) have captive-breeding programs aimed toward eventual reintroduction.

Tropical forest species usually have specialized niches, and it is not so easy for them to adjust to drastic changes in habitat. Such species are dependent upon preservation of undisturbed forest ecosystems to a greater extent than Northern Hemisphere species are dependent on pristine habitat. Also, tropical eagles require large, continuous tracts of forest, but not much is predicted to remain in another 20 to 50 years. Most of the large, tropical forest eagles can be expected to be drastically reduced in numbers, existing as relicts in small islands of marginal habitat widely separated by completely unsuitable, man-dominated landscapes.

As natural environments inevitably become further reduced in extent, fragmented into islands, and degraded in their capacity to hold a diversity of species, captive breeding and reintroduction can be used to help maintain some species in outdoor environments. Nature preserves that become too small or too degraded to sustain a population of raptors indefinitely can be repopulated at intervals, as needed, through various reintroduction techniques such as fostering, cross-fostering, hacking, and establishing trained breeding pairs at hack. Also, the same methods can be used to infuse new genes into small, isolated populations that begin to suffer from the effects of inbreeding depression or other genetic problems (Schonewald-Cox et al. 1983).

In some cases, captive-raised raptors can be trained and modified by behavioral conditioning to survive and breed in degraded or changed environments, thereby shifting their ecological requirements enough so that they can continue to survive in new situations or changed conditions. Habits we already know we can alter significantly include such important biological traits as selection of nest-sites and nesting habitat (Hildén 1965; Klopfer and Hailman 1965), food habits (e.g., Whooping Cranes, Yellow-crowned Night Herons), breeding range and wintering range, migratory urge, and "wildness" or tolerance of man's close proximity (McIlhenny 1934). The work which James (1983) did with translocated eggs of Red-winged Blackbirds (*Agelaius phoeniceus*) shows that even growth and development of non-indigenous Peregrines in the eastern United States, this the normal distribution of phenotypes in the foster (host) populations. As Barclay and Cade (1983) pointed out in regard to the release of non-indigenous peregrines in the eastern United States, this sort of phenotypic plasticity makes it easier to establish a founding population from exogenous sources than would be the case were the genotypes of the released birds highly selected to fit specific kinds of environments.

We are just beginning to understand the nongenetic potential which birds have to alter their phenotypes (including morphology, physiology and behavior) in response to new or changed environments. Again, these adjustments may be easier for north temperate species and for generalists like the Peregrine Falcon. Success with tropical specialists has yet to be demonstrated, but Carl Jones and co-workers are starting to apply this approach to the Mauritius Kestrel in an attempt to establish pairs in degraded forest.

In his essay presented for the centennial of the American Ornithologists' Union, entitled "Captive Birds and Conservation," William Conway (1983) gives us a realistic picture, I believe, of what outdoor environments will be like 50 to 100 years from now. For one thing, he agrees with Soulé et al. (1979) that the largest nature preserves will probably be too small for the long term maintenance of large mammals and, perhaps, birds such as eagles. By that time conservationists will be much more concerned about sustaining many wild creatures in minimal spaces, often in the absence or scarcity of critical ecological resources, so that some nature preserves will inevitably become what Conway terms "megazoos" or "zooparks."

Such futuristic concepts are perhaps unpalatable to those of us who remember what wilderness is; but I think they are realistic, and I believe we should be forcing ourselves to think more about them now — about how they should be structured and maintained and where they should be located. McIlhenny's "Bird City" on Avery Island might well repay closer examination as a prototype of an ecologically well-constructed zoopark. The California Condor may well be the first raptor candidate to be considered for inclusion in a megazoo such as Santa Cruz Island might one day become.

We also need to develop enough ecological foresight to predict and to effect intelligent and benign exotic introductions as an additional method of conservation. The Mauritius Kestrel badly needs a new home; Réunion could well be a possibility. The situation needs study. The Bateleur (*Terathopius ecaudatus*), threatened over a great portion of its range in southern Africa (Steyn 1982), might someday make an interesting and beautiful addition to the fauna of the southwestern United States. As a generalized predator feeding on a wide variety of live mammals, birds, reptiles, and insects, as well as on carrion (Steyn 1982), the Bateleur would be unlikely to have a measurable impact on any one species of prey and might well enter our arid-zone fauna as unobtrusively as the Little Owl did in Britain. As Charles Elton (1958), the father of population ecology, stressed in his book on the invasions of animals and plants, such introductions should not be rejected out of hand just because some exotic species have proved to be harmful from the human point of view.

It is to address these problems of how to help raptorial species to adjust and to survive in a rapidly changing, human-dominated world that The Peregrine Fund, Inc., began a new facility and program in Boise, Idaho called The World Center for Birds of Prey. Our objectives are: (1) to support basic scientific studies in the field and laboratory on all aspects of raptor biology pertinent to species preservation and conservation in nature; (2) to maintain self-perpetuating, genetically diverse populations of certain threatened or particularly valued species in captivity; (3) to propagate rare or endangered species for the purpose of reintroductions or translocations when and where feasible and desirable in the future; (4) to collaborate with other breeders and researchers to further the overall goal of raptor preservation around the world; (5) to cooperate with other concerned organizations in identifying, cataloging and preserving critical lands and habitats needed for the survival of species in nature; and (6) to develop educational and recreational programs involving raptors.

CONCLUSION

The future is not all bleak. Rather, I find it challenging. Barring nuclear holocaust or some similar tragedy, many species will persist — more perhaps than some pessimists now think. In 1965, who among us would have predicted the remarkable natural recovery of the Peregrine Falcon in Britain, or that in the 1980s captive produced and released Pererines would be nesting successfully in major North American cities, or that a reintroduced population would be on the verge of recapturing a significant portion of the species' lost range in eastern North America?

Are captive breeding and reintroduction a realistic strategy for conserving raptors? Work underway with the Eagle Owl, Peregrine Falcon, White-tailed Sea Eagle, Bald Eagle, Lammergeier, and the California Condor will provide major tests of this question. Technically the answer is already "yes," these methods can be made to work; but they are financially costly (Cade 1984). Such procedures are realistic, therefore, only so long as enough people are willing to commit the time, effort and money needed to make them work for particular species of concern. Peregrine recovery in the eastern United States is an absolutely predictable outcome of continuing to release about 100 birds/yr for another five years, but there are already indications that this recovery program could fail in mid-stream through an erosion of public interest and support. That being so, I hesitate to think what may be the fate of the California Condor program, which will require many, many more years and much more money for a successful outcome.

Finally, I believe that Aldo Leopold's vision of "Game Management," really land use management, is still our best guide for the next 50 years. In 1933 Leopold said: "The central thesis of game management is this: Game can be restored by the creative use of the same tools which have heretofore destroyed it — axe, plow, cow, fire, 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.

"The conservation movement has sought to restore wild life by the control of guns alone, with little visible success. Management seeks the same end, but by more versatile means. . ."

LITERATURE CITED

ANONYMOUS. 1976. Re-introductions: techniques and ethics. Manifesto World Wildlife Fund (British Section). *In* Wildlife introductions to Great Britain. Report by the working group on introductions. UK Committee for International Nature Conservation. Nature Conservancy Council. London.

BARCLAY, J.H., AND T.J. CADE. 1983. Restoration of the Peregrine Falcon in the eastern United States. *Bird Conservation* 1:8-40. ICBP-US.

BLOESCH, M. 1980. Drei Jahrzehnte Schweizerischer Storchansiedlungsversuch *Ciconia ciconia* in Altreu, 1948-1979. *Ornithol. Beob.* 77:167-194.

BROO, B. 1977. Project Eagle Owl in south-west Sweden. *Proc. ICBP World Conf. on Birds of Prey, Vienna* 1975:338-343.

______________. 1978. Project Eagle Owl, south west. *In Birds of prey management techniques*, T.A. Geer (Ed.), pp 104-120. British Falconers' Club. Oxford.

______________. 1982. Ăr Berguven Fortfarande Hotad I Sycluăstra Sverige? *VILTNYTT* 16:14-22. SNV. Swedish Environmental Protection Board.

CADE, T.J. 1953. The Peregrine Falcon in the Yukon valley. *Proc. Second Alaska Sci. Conf.*, 1951:330-334.

______________. 1980. The husbandry of falcons for return to the wild. *Int. Zoo Yb.* 20:23-35.

______________. 1983. Restoration of Bald Eagles in New York and elsewhere. *Bird Conservation* 1:109-112.

______________. 1984. The role of captive propagation in the conservation of raptors. *In Proc. Second. Symp. African Predatory Birds,* J.M. Mendelsohn and C.W. Sapsford (Eds.). Natal Bird Club, Durban. Pp. 231-239.

______________. 1986. Propagating diurnal raptors in captivity. *Int. Zoo Yb.* 24 (in press).

CADE, T.J., AND P.R. DAGUE. 1984. *The Peregrine Fund Newsletter* 12:1-16. Cornell University Laboratory of Ornithology.

CADE, T.J., AND V.J. HARDASWICK. 1985. Summary of Peregrine Falcon production and re-introduction by The Peregrine Fund in the United States, 1973-84. *Avicult. Mag.* 91:79-92.

CHRISTENSEN, G.C. 1963. Sand Grouse released in Nevada found in Mexico. *Condor* 65:67-68.

COLLAR, N.J. AND S.N. STUART. 1985. Threatened birds of Africa and its adjacent islands: The ICBP/IUCN bird red data book, Part I. International Council for Bird Preservation. Cambridge.

CONWAY, W. 1983. Captive birds and conservation. *In Perspectives in Ornithology,* A.H. Brush and G.A. Clark, Jr. (Eds.). American Ornithologist's Union. Cambridge University Press. Pp. 23-36.

DREWIEN, R.C. AND E.G. BIZEAU. 1978. Cross-fostering Whooping Cranes to Sandhill Crane foster parents. *In Endangered Birds,* S.A. Temple (Ed.). University of Wisconsin Press. Pp. 201-222.

ELTON, C. 1958. The ecology of invasions by animals and plants. Methuen and Co., LTD. London.

FENTZLOFF, C. 1984. Breeding, artificial incubation and release of White-tailed Sea Eagles *Haliaeetus albicilla. Int. Zoo. Yb.* 23:18-35.

FRANKENBERG, O.VON, E. HERRLINGER AND W. BERGERHAUSEN. 1984. Reintroduction of the European Eagle Owl *Bubo b. bubo* in the Federal Republic of Germany. *Int. Zoo Yb.* 23:95-100.

FYFE, R.W. 1976. Rationale and success of the Canadian Wildlife Service Peregrine breeding project. *Can. Field-Nat.* 90:308-319.

GERRIETS, D. 1984. Unterschungen am Wanderfalken (*Falco peregrinus*) im Rahmen eines Artenschutzprojektes. Inaugural — Dissertation. Klinik und Poliklinik fur kleine Haustiere des Fachbereichs Vẽterinarmedizin der Freien Universitat Berlin.

HILDÉN, O. 1965. Habitat selection in birds. *Annls. Zool. Fenn.* 2:53-75.

JAMES, F.C. 1983. Environmental component of morphological differentiation in birds. *Science* 221:184-186.

JONES, C.G. 1984. The captive management and biology of the Mauritius Kestrel *Falco punctatus. Int. Zoo Yb.* 23:65-82.

KESSEL, B. AND T.J. CADE. 1958. The birds of the Colville River northern Alaska. *Biol. Papers Univ. Alaska,* No. 2.

KLOPFER, P.H. AND J.P. HAILMAN. 1965. Habitat selection in birds. *Advances in the Study of Behavior* 1:279-303.

KRESS, S.W. 1978. Establishing Atlantic Puffins at a former breeding site. In *Endangered Birds,* S.A. Temple (Ed.). Univ. Wisconsin Press. Pp. 373-377.

KRESS, S.W. (ED.) 1981-84. *Egg Rock Update.* Newsletter of the *Fratercula* Fund of the National Audubon Society.

KRUPA, R.E. 1984. The Philippine Eagle conservation project. *Salaysayan* (U.S. Peace Corp/Philippines) June:4-5, 13.

LEOPOLD, A. 1933. Game management. Charles Scribner's Sons. New York.

LEVER, C. 1977. The naturalized animals of the British Isles. Hutchinson & Co. London.

LONG, J.L. 1981. Introduced birds of the world. Universe Books. New York.

LOVE, J.A. 1983. The return of the Sea Eagle. Cambridge University Press. Cambridge.

MCILHENNY, E.A. 1934. Bird City. Christopher Publishing House. Boston.

NYE, P. 1983. DEC's eagle program still soaring. *Conservationist* 38(3):23.

RATCLIFFE, D.A. 1984. The Peregrine breeding population of the United Kingdom in 1981. *Bird Study* 32:1-18.

SAAR, C., G. TROMMER AND W. HAMMER. 1982. Der Wanderfalke. Bericht uber ein Artenschutzprogramm — Methoden, Ziele und Erfolge. Deutscher Falkenorden. Bonn.

SCHONEWALD-COX, C.M., S.M. CHAMBERS, B. MACBRYD AND L. THOMAS. 1983. Genetics and conservatior The Benjamin/Cummings Publishing Company, In Menlo Park, Calif.

SOULÉ, M.E., B.A. WILCOX AND C. HOLTBY. 1979. Benig neglect: a model of faunal collapse in the game re serves of East Africa. *Biol. Conserv.* 15:259-272.

STEYN, P. 1982. Birds of Prey of southern Africa. Davi Philips. Cape Town.

TEIXEIRA, R.M. (ED.) 1979. Atlas van de Nederland broedvogels Vereniging tot Behand van Natuu monumenten, 'S-Graveland, The Netherlands.

WARBURTON, T. 1984. Breeding and reintroduction the Barn Owl *Tyto alba. Int. Zoo Yb.* 23:88-95.

WATSON, J. 1981. Population ecology, food and conse vation of the Seychelles Kestrel (*Falco araea*) on Mah Ph.D. Thesis, University of Aberdeen.

WINGATE, D.B. 1982. Successful reintroduction of tl Yellow-crowned Night-Heron as a nesting resident Bermuda. *Colonial Waterbirds* 15:104-115.

SYNTHESIS

Dean Amadon

American Museum of Natural History,
Central Park West at 79th Street, New York, New York 10024

If that redoubtable lady, Mrs. Rosalie Edge — who, with the aid of Richard H. Pough, Willard Gibbs Van Name, and a few others, founded Hawk Mountain Sanctuary some 50 yrs ago — could have returned for this symposium on raptor conservation, she would have been astounded at the present scope and breadth of the subject. Fifty yrs ago the goals were protection from shooting and education of the public as to the beauty and usefulness of birds of prey. Her longtime curator, the late Maurice Broun, ably assisted by his wife Irma and later by Alexander C. Nagy, was exactly the right person to see Hawk Mountain through this phase of its existence. Now raptor conservation has become global in its outlook. This is reflected in the widened horizons of the Hawk Mountain Sanctuary Association under the leadership of its president, Joseph W. Taylor, and its staff, headed by Stanley E. Senner and James J. Brett. Today's far-ranging symposium reflects the truth of this observation.

Raptor management now embraces a host of specific techniques whose number is increasing almost daily. Previously one heard occasionally of nesting platforms for Ospreys or nest boxes for Screech Owls. Platforms are now provided in suitable circumstances even for Bald Eagles, Golden Eagles and Ferruginous Hawks, and cliff ledges are improved or created for Prairie Falcons and peregrines. Management techniques range from such details as fencing-in lone nesting trees on the prairie to prevent their destruction by cattle, to continent- or world-wide efforts to control pesticides, or to design transmission poles that do not electrocute raptors and other large birds but rather provide attached nesting platforms. Richard R. Olendorff told us of many of these raptor management methods, and he has set up a computerized data bank of publications on the subject which makes available hundreds of publications classified by species and topic.

The captive propagation of threatened or endangered raptors has received great attention and publicity. Much has been done in various countries, but the classic example of this technique is the peregrine restoration program, centered first at Cornell University, then with a western branch in Colorado and, more recently, at a World Center for Birds of Prey in Idaho. Tom J. Cade has summarized this program for us, but more importantly, he has discussed in depth the goals and prospects of such projects globally. As species after species become threatened, the need for preservation by any means will become more acute.

Already, for example, efforts are being made to breed the endangered Philippine Eagle in captivity on its native islands. It is hardly supposed that such a species could be preserved in captivity indefinitely like, for example, Pere David's Deer, for which one needs hardly more than a sufficiently-large paddock. But if a stock can be maintained until the present mad exploitation has run its course, things may improve.

What will the Arctic be like 50 yrs after the last oil well stops pumping? Perhaps if we can preserve a nucleus of its wildlife, it will lapse back into something approaching an earlier day. The same may be true elsewhere. Captive propagation and preservation of endangered species in zoos and parks is justified in part as a holding action, awaiting better times that may or may not come.

The remarkable proliferation of rehabilitation centers for raptors is in part related to captive propagation, and some of them such as the Raptor Rehabilitation and Propagation Project near St. Louis are already making important strides. Others, such as those connected with universities (e.g., University of Minnesota and at San Jose in California) are performing basic research on such problems as the detection and prevention of lead poisoning, which is a threat to eagles and other species that consume crippled waterfowl containing lead shot.

At some rehabilitation centers, as one walks past cage after cage, each with its disabled Great Horned Owl or Red-tailed Hawk, it becomes a question of whether the game is worth the candle. But even then, if properly handled, there are great opportunities for instructing the public as to the beauty of raptors and the part they play in nature. The same is true in theory of falconry, but here the demand for birds, often rare ones, which inevitably becomes commercialized, may pose a threat unless captive-produced stock becomes available on a far greater basis than at present.

The heroic efforts to save the California Condor bid fair to become an object lesson, not only in captive propagation and reintroduction, but also in almost all aspects of raptor conservation and management. The species is desperately reduced, fewer than 10 wild birds now survive, but even if success is elusive, much will be learned. The program, in recent years under the supervision of Noel F.R. Snyder and John C. Ogden, is financed by several cooperating public and private agencies. The value of intensive field observation immediately became apparent when it was found that even in this vestigial population there were 4 or 5 pairs that were nesting or attempting to do so. Such advanced techniques as radio-tracking and double-clutching have provided a captive group of 30 or so individuals. Perhaps a nucleus of condors can eventually be released in areas more hospitable than the present range near Los Angeles. One such area might be the Grand Canyon and its environs. All of this is set forth by Dr. Snyder in his contribution to this symposium.

Let us briefly consider the globe as a habitat for raptors, now and as it may be 50 yrs in the future. In general, the picture is better in the temperate regions, in part because they are home to the more economically-advanced countries, which have been able to afford certain conservation programs, wildlife refuges, and the like. Set against this is the pollution and over dependence on chemicals which come with the industrialization, first of manufacturing and now of agriculture. Ian Newton has given us a rather pessimistic overview of trends in Europe that are inimical to raptors and other wildlife. Yet in tiny Israel, where we were told a decade ago that virtually all the raptors had been eliminated by reckless use of chemicals, the situation as described by Yossi Leshem has improved greatly, in large part because of his own strenuous efforts. As I personally observed in a visit in 1982, one can now see such splendid species as the Barbary Falcon, the Lappet-faced Vulture, and others in that ancient land.

When one turns to the tropics and the so-called Third World, the prospects are far grimmer. A tremendous surge in human population is on a collision course with exhaustion of natural resources. When the collision comes there are variou scenarios, none pleasant either for raptors or humans. Perhaps the rampant use of chemicals i agriculture will produce insects so hardy that w cannot kill them without killing ourselves, or th dousing of livestock with antibiotics will secondaril undermine the human immune system and suc new afflictions as Legionaires Disease or AIDS wi be the mere precursors of worse to come. Mean while, our political soothsayers tell us that popula tion growth is no problem, and that if the world ca support 5 billion souls today, then why not 15 or 2 billion in the future? Well, perhaps it can, but predict that before that day comes all of us are a to be on shorter rations than a Turkey Vultur trapped on Hawk Mountain in a January blizzard

The grim details of tropical deforestation in som areas and desertification in others are set forth b Robert S. Kennedy. Already Madagascar has lost a endemic genus of serpent eagle. The more favore countries are helping to some extent through suc agencies as the World Wildlife Fund, but this more than overbalanced by exploitative activitie American timber companies hold vast concession in the Philippines and elsewhere. The Japanes carefully manage their own forests, but they ar stripping huge tracts in New Guinea and elsewher as bare as a billiard table.

Some northern raptors in America and to a even greater extent in the Old World penetrate fa into the southern hemisphere in winter. John I Haugh and Chandler S. Robbins have outlined fc us some of the problems they meet, both in passag and on their winter quarters. Hawk Mountain itse is a testimonial to the hazards these birds face e route. Fortunately, the northern migrants tend t winter in semi-open country that is a little less a fected by deforestation and land abuse, as in Afric and to be nomadic in search of areas where loc rainfall has meant an increase in termites and othe food resources. In America, the Swainson's Hawl perhaps finding the Argentine representative c the migratory locust less prevalent than it once wa is beginning to winter in other areas.

A pervading element in the symposium has bee the need for further education as to the essenti role of raptors in the ecosystem and for the wid appreciation of their aesthetic and cultural poter tial. Jim Brett has focused on the issues involved. would merely stress that most of our efforts to co serve birds of prey have or can be given an educ tional slant. Some, for example, have complained about the financial cost of the program to save the California Condor. But *Gymnogyps californianus* is, after all, the largest bird on the North American continent, and it deserves special attention. It has become a unique example of the many techniques useful in saving a bird in peril. Enough money is wasted every second in the United States to bankroll the condor program for a century. To give another example, the public outrage when scores of Bald and Golden Eagles were shot and poisoned in Wyoming and Colorado created powerful allies for conservation; these eagles did not die in vain.

What then are the portents for raptor conservation and welfare in the next half century? Barring nuclear war followed by a nuclear winter so cold and grim that even a Snowy Owl would perish, one must expect some losses and gains. That ultimate loss, the extinction of species, can hardly be avoided, especially on tropical islands that are being stripped of their forests. Countering this, some raptors are proving to be adaptable. Merlins are nesting in Canadian cities such as Saskatoon, and some of them are even wintering there, hundreds of miles north of their traditional quarters. On the other side of the globe, in South Africa, groves of eucalyptus and other exotics, usually thought of as wildlife deserts, are now favored nesting sites for Long-crested Eagles and Black Sparrowhawks, and have even led to a range extension in the Ovambo Sparrowhawk.

Scores of dedicated young people and some oldsters are enthusiastically lending their efforts to the conservation of our birds of prey. New techniques and approaches are being devised. One must retain some measure of optimism for the future of raptors, despite all of the problems that exist.

MEMBERSHIPS IN THE HAWK MOUNTAIN SANCTUARY ASSOCIATION

Route 2, Kempton, Pennsylvania 19529

The mission of the Hawk Mountain Sanctuary Association is to foster the conservation of birds of prey and other wildlife and to create better understanding of the natural environment. The Association owns and operates Hawk Mountain Sanctuary, a 2200-acre wildlife refuge established in 1934, and it sponsors a year-round program in conservation policy, education, and research that is international in scope.

The most important sources of income supporting operation of the Sanctuary and our program are the annual dues and contributions of Association members. We do not rely on funds from any government agency to help finance day-to-day operations of the Sanctuary.

Everyone who supports the objectives of the Association is earnestly invited to become a member. Memberships, good for one year, are available in the six categories described below. Dues and contributions are tax-deductible to the extent allowed under federal law.

Individual – $15

- Free admission to the trails and lookouts
- Hawk Mountain News (two per year) and an Annual Report
- Fall lecture series and a variety of seminars, workshops, and events
- The satisfaction of helping to support a program that has been a leader in wildlife conservation for more than 50 years

Family – $20

Also receive:

- Free admission for dependent family members

Sustaining – $40
Supporting – $75

Also receive:

- Use of the Aspen Cut Campground and Adirondack Trail Shelters

Sponsors – $150
Patron – $300

Also receive:

- Limited free guest admission passes
- Invitations to occasional special events
- Special reports from Association staff members

Memberships for businesses, corporations, and nonprofit organizations are also available. Contact the executive director for more information.