

The Maya Project: Use of Raptors as Tools for Conservation and Ecological Monitoring of Biological Diversity

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INTRODUCTION

The Peregrine Fund, founded by Professor Tom J. Cade, is known for its success in restoring the Peregrine Falcon (*Falco peregrinus*) throughout much of the United States. In addition, since the mid-1970s we have cooperated on projects involving more than 40 raptor species in 35 countries. Many factors affect the distribution and abundance of raptors, but increasingly the predominant factor is habitat alteration resulting from humanity's rapidly increasing populations and need for fuel, fibre, food, and minerals. Survival of most species will depend on their abilities to adapt to and persist in highly modified environments, or on mankind's capacity to establish and maintain protected areas of sufficient size and quality to preserve self-sustaining populations. We have found some raptor species to be highly adaptable, but others, such as specialized forest-dwelling eagles, hawk-eagles, and falcons, may not be.

One hundred and eleven of the approximately 296 species of diurnal raptors live in rainforests, and of those, 41 species are listed as threatened in the Red Data Book of the International Council for Bird Preservation while the status of many more is unknown (Thiollay 1990). These facts alone justify actions to preserve this taxon as a significant and disappearing element of the world's biodiversity.

Birds of prey can be effective tools for conservation for several reasons. First, large raptors occur at population densities lower than those of most other tropical forest organisms (Thiollay 1989). Using their spatial requirements for population viability as a yardstick for estimating minimum sizes for effective nature reserves is a first step in providing for whole system viability (Soule & Simberloff 1986).

To conserve raptors and their habitats we must understand their life cycles, their habitat requirements, and the environments in which they live. The research required to gain this knowledge is challenging, and presents opportunities for training of conservationists, students, and resource professionals. Raptor conservation also provides a focus for organizations in developing countries that produce many conservation benefits and assist in building organizational infrastructure.

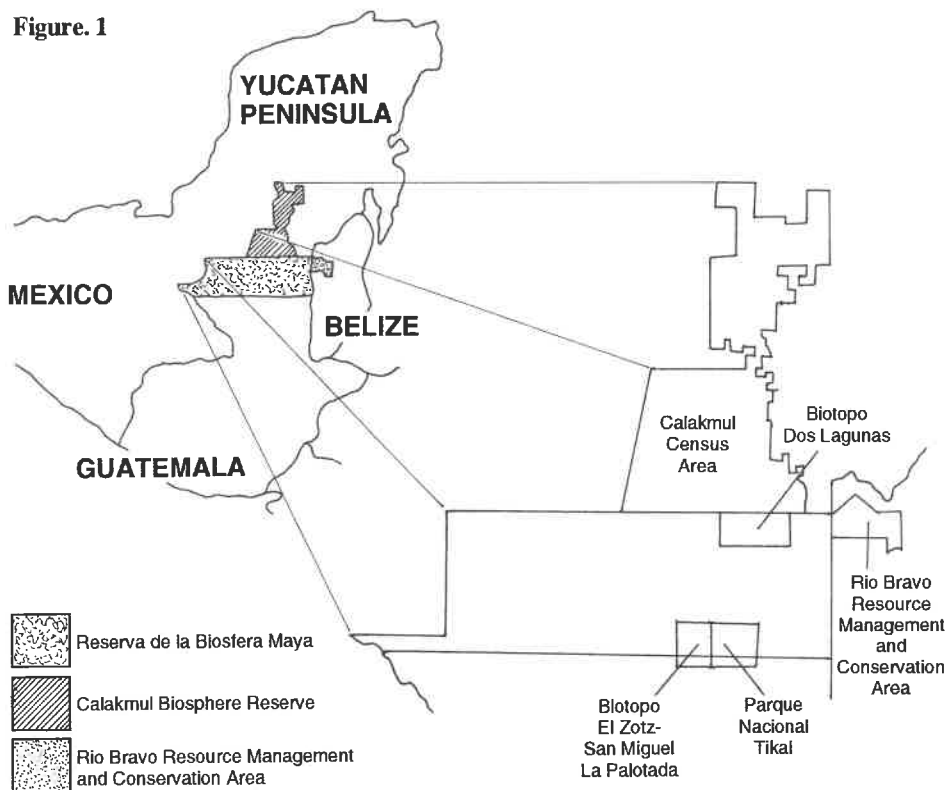
Apart from these fortuitous benefits of studying and conserving raptors, it may turn out that conservation of this group of organisms is particularly critical to the long-term maintenance of biotic diversity, especially in reserves that are - or will become - habitat islands. For example, there is

increasing evidence that vertebrate predators, through their effects on populations of seed consumers and dispersers, may affect seedling establishment patterns, and hence future tree species coemption of the forest (Janzen 1978; Green 1988; Terborgh 1988; Soule & Kohn 1989). If such regulatory roles prove common, maintenance of full complements of raptors and other predators in nature reserves may be an essential ingredient for reserve management schemes. Indeed, presence of intact predator communities is a measurement of the adequacy of conservation efforts, but a disturbing number of nature reserves worldwide fall short of this mark. As D. Janzen (1988) has pointed out, ecological interactions tend to disappear before species. Maintaining complete predator communities in reserves should go a long way toward keeping natural interactions throughout the system.

Finally, raptors are popular, charismatic organisms representing our natural world, and several have become significant "flagships" for conservation, e.g. Peregrine Falcon, Bald Eagle (*Haliaeetus leucocephalus*), Philippine Eagle (*Pithecophaga jefferyi*), etc. Being sensitive to environmental contamination and change in quality and quantity of habitat, they are functional indices of environmental health (Peakall & Kiff 1988; Newton 1979; Leck 1979). In addition, the kinds and density of raptor species in a given locality can reflect overall species richness and diversity in that area (Terborgh & Winter 1980; Olendorff *et al.* 1989).

In 1989 and 1990 the governments of Mexico and Guatemala established the Calakmul Biosphere Reserve (723,000 ha) and Maya Biosphere Reserve (1,700,000 ha), respectively (Fig. 1).

Figure. 1



Additionally, Programme for Belize and cooperators established the 102,000 ha Rio Bravo Resource Management and Conservation Area. These adjacent reserves represent the largest protected contiguous lowland tropical forest area in Mesoamerica. Approximately 420 avian species have been identified in the Guatemala portion alone, of which 87 are migrants (Beavers 1991). This is an especially important wintering location for North American migrant passerines. Fifty-three species of raptors occur in the area (42 diurnal and 11 owl species).

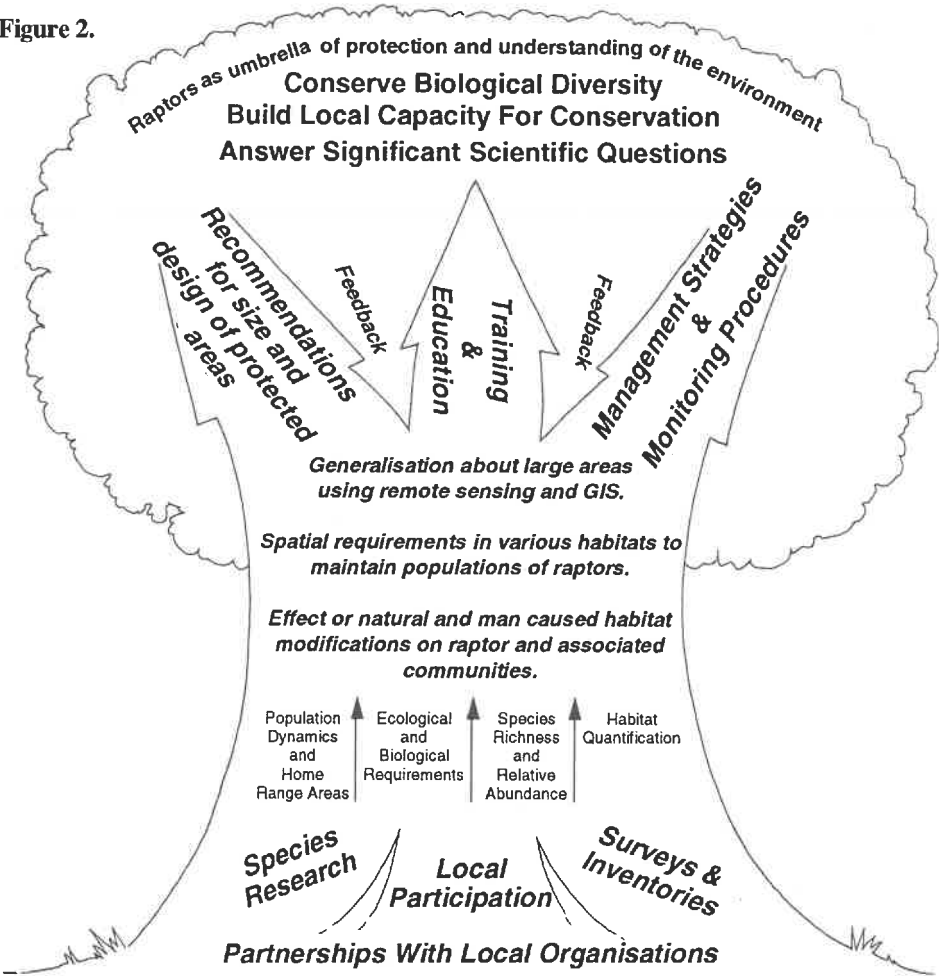
In 1987 W. Burnham and P. Jenny selected the combined areas as a focus for the Maya Project, a long-term conservation and community level research programme providing training and education for

Latin Americans while focusing on tropical forest birds of prey. The endeavour is in cooperation with the Comision Nacional del Medio Ambiente, Guatemala; Consejo Nacional de Areas Protegidas, Guatemala; Instituto de Antropología e Historia, Guatemala; Centro de Estudios Conservacionistas, Universidad de San Carlos, Guatemala; Fundacion "Mario Dary Rivera", Guatemala; Guatemala Audubon Society, Guatemala; Secretaria de Desarrollo Urbano y Ecologia, Mexico; PRONATURA, Mexico; Ministry of Forestry, Belize; Programme for Belize, Belize; Belize Audubon Society, Belize; and those other organisations listed in this paper.

METHODS

The Maya Project is a highly focused yet multi-faceted conservation approach which employs raptors in an umbrella of protection and as instruments for understanding the environment (Fig.2). The approach is rooted in partnerships with local organisations with crowning goals of (a) conserving biological diversity, (b) building local capacity for conservation, and (c) answering significant scientific questions. Research activities fall into two categories: (1) single species studies, conducted in such a way that community-level questions can ultimately be addressed, and (2) baseline inventory and monitoring efforts.

Figure 2.



Training and Education

The Maya Project uses the process of conducting research as a vehicle for training and education. Local people with limited formal education but with considerable experience in the forest are being trained in techniques for studying and monitoring forests and wildlife while they participate in data collection, and - in some cases - project design and data analysis and interpretation. Additionally, through scholarships and other education opportunities, students who are willing to pursue resource management careers are enrolled in formal degree programmes at secondary school and university levels. Collaborating organizations receive the benefit not only of more experienced staff, but of field equipment, funding, and a better-informed local constituency.

Species-level Research

Species-level research focuses on population dynamics and ecological requirements such as prey preference, home range area, and population density of selected raptor species. Single-species research is both short-term (two to five years) and long-term (more than five years). These studies provide the detailed biological knowledge that is needed for future management efforts and aids in interpreting data from censusing and monitoring.

Many of the species we are studying have received little or no research attention in the past, and hence much of what we learn is completely new. Information from telemetry studies of density and home range provides estimates of habitat area required for sustainable populations and hence reserve size. A key feature of the single-species studies is that they are accomplished with sufficient standardization of method so that they can eventually be melded to yield a community-level approach.

Inventory and Monitoring

An important goal of the project is to establish a long-term ecological monitoring programme within the Greater Maya Biosphere Reserve Ecosystem (including Calakmul Biosphere Reserve and other portions of the southern Yucatan Peninsula, Belize, and Peten). This part of the project uses repeated censusing of permanent 1 km² plots and of certain species groups to reveal possible ecological changes over time and to provide baseline comparisons between communities in different natural and modified habitats.

Habitats which are being or will be compared are various primary forest types along a topographic moisture and drainage gradient, as well as forests subjected to various human uses: selective logging of mahogany (*Swietenia macrophylla*) and cedar (*Cedrela mexicana*), extraction of xate palm (*Chamaedorea* spp.), removal of ramon (*Brosimum alicastrum*), foliage for livestock forage, collection of chicle (*Achras zapote*) sap and allspice (*Pimenta dioica*), fruits, removal of Sabal palm leaves (*Ayabal morrisiana*) for thatch, and conversion of forest to a mosaic of successional stages by slash and burn agriculture. Habitat descriptions have utilized 24 to 31 variables, mostly indicating vegetation structure and floristic and topographic information.

This segment of the project includes refinement and comparison of census techniques described by Turley (1989) and evaluated by Whitacre and Turley (1990), and refined by Whitacre (1991). While censusing efforts centre around raptors, several other bird groups and some mammals have been progressively incorporated into census protocols: tinamous, cracids, doves, psittacines, large woodpeckers, certain passerines, and primates. Our goal is to include species that are readily detected and identified and are likely to provide useful conservation information. For example, parrots and cracids are subject to direct human exploitation, while large woodpeckers may well prove sensitive to logging history.

RESULTS

Training and Education

Over 80 Latin Americans (8, 1988; 11, 1989; 29, 1990; 31, 1991; 35, 1992) have received training to date (Whitacre & Burnham 1991). Six are completing their fifth year with the project and manage survey teams and species investigations, and participate in the training of new personnel. Guatemalans are now project leaders for nine investigations. Cooperating organizations and individuals have received equipment (binoculars, books, projectors, motorcycles, etc.) and financial support. We provided four scholarships for bachelor of science degree candidates in biology at the University of San Carlos, Guatemala, through the Fundacion Juan Mario Dary. Additionally, scholarships for completion

of high school degrees exist for some local Guatemalans participating in the field programme. Five master of science students from Boise State University have participated in the project and received support, and volunteers from the United States, Mexico, Guatemala, and Costa Rica have gained experience as part of the field programme.

Species-Level Studies

A number of very poorly-known raptor species are receiving detailed attention for the first time as part of the Maya project. For example, the nests, eggs and young of the Black-and-white Owl (*Ciccaba nigrolineata*), Barred Forest-Falcon (*Micrastur ruficollis*), and Gray-headed Kite (*Leptodon cayanensis*) have been described for the first time. Long-term population dynamics studies are underway on the Barred Forest-Falcon, Ornate Hawk-Eagle (*Spizaetus ornatus*), and Mottled Owl (*C. virgata*). In addition, investigations are being conducted on the Collared Forest-Falcon (*M. semitorquatus*), Black-and-white Owl, American Swallow-tailed Kite (*Elanoides forficatus*), Plumbeous Kite (*Ictinia plumbea*), Laughing Falcon (*Herpetotheres cachinnans*), Orange-breasted Falcon (*F. ruficularis*), White Hawk (*Leucopternis albigollis*), Bicolored Hawk (*Accipiter bicolor*), Black Hawk-Eagle (*Spizaetus tyrannus*), Hook-billed Kite (*Chondroheirax uncinatus*), and Great Black Hawk (*Buteogallus urubitinga*). Incidental information is being collected on other raptor species including the Crane Hawk (*Geranospiza caerulescens*), Gray-headed Kite, Bat Falcon (*Falco deiroleucus*), and Roadside Hawk (*Buteo magnirostris*).

Information on density and home range area, which is particularly valuable for conservation and management efforts, is being collected by the project. The Barred Forest-Falcon has proved to be the most common diurnal raptor in Parque Nacional Tikal. Home range size for breeding Barred Forest-Falcon females was 67 ha (n=3) and 106 ha (n=7) for males (Thorstrom 1990) (all results given utilize the minimum convex polygon method). Among Tikal's raptors, only the Mottled Owl has a higher raptor breeding density, i.e. 15 adults in a 2km² area average home range for males of 24.0 ha (n=4) (Gerhardt & Gerhardt 1990). The largest raptor currently being studied is the Ornate Hawk-Eagle, and in 1990 two females had home ranges of 977 ha and 1,315 ha at 95 days and 45 days respectively, after their young fledged. Additional adult females and males are now being radio-tracked, providing further home-range data. Six young Ornate Hawk-Eagles have been under study via telemetry; these have remained reliant on the adult male for food for over a year. Two yearling birds currently being monitored via telemetry will hopefully reveal much about the interval during which these birds leave to hunt for themselves and achieve full independence (Flatten *et al.* 1990 and Madrid *et al.* 1991). Home range studies continue on these species, as well as on the Collared Forest-Falcon, Laughing Falcon, Bicolored Hawk, and White Hawk.

One type of autecological study is especially germane to conservation questions: studies examining the ecology of a species in both pristine and human-altered habitats. A study currently underway compares the ecology of the Laughing Falcon, a reptile specialist, in primary forest and in slash-and-burn successional mosaic. Results indicate differences in home-range size and diet (Parker 1991).

Bat Falcons bred at the World Centre for Birds of Prey, Boise, Idaho, were released (1989-1990) on Guatemala's Pacific versant by the Fundacion Interamericana de Investigacion Tropical (Vannini 1989 & 1990). These releases serve to test reintroduction procedures and also establish individuals where the species has not been reported breeding for almost twenty years.

Inventory and Monitoring

Evaluation and modification of census methodology continues, and substantial improvements were achieved during the 1991 field season (February - August). We are developing a set of standardized census and habitat description methods which will be highly replicable and practical for use in tropical forests elsewhere. Emphasis is on simple efficient techniques to facilitate use by local personnel with limited equipment or technical training.

Comparison of four raptor census methods has proven point counts from canopy emergent trees to be the most effective method for the bulk of diurnal raptors in closed-canopy forest. An hour of pre-dawn listening reveals the presence of owls and forest-falcons, while two or three problematic species are best revealed by acoustical luring using prey distress calls. Our standardized census protocol combines these three types of censuses at each 1km² census plot. In primary forest, road-based censuses were found to have very limited utility and are not recommended (Whitacre & Turley 1990; Whitacre 1991).

Permanent census plots have been established in the Calakmul Biosphere Reserve, Mexico (10 plots); Rio Bravo Resource Management and Conservation Area, Belize (4); Parque Nacional Tikal, Guatemala, and nearby highly modified-forest areas (24); Biotopo El Zotz-San Miguel La Palotada, Guatemala (10); Biotopo Dos Lagunas, Guatemala (10) (Fig.1). Each plot has been the focus of a quantitative vegetation description and has been censused one to five times annually. The number of plots established and faunal species censused has increased annually.

Principal components analysis ranked primary forest stands at Tikal along a gradient from tall, closed-canopy forest with large vines and little ground cover, to lower forest with more open canopy, many small vines and saplings, and much ground cover, often grasses and sedges. This axis mirrors a topographic moisture and drainage gradient which is probably the predominant influence on Tikal's vegetation; tall, closed, floristically complex forest occupies well-drained terrain, while a lower forest with different tree species composition occupies low, seasonally-flooded sites (*bajos*) (Whitacre *et al.* 1990).

Preliminary results correlate presence of certain raptor species and habitat features. Habitat variables that most often were significantly correlated with abundance of particular raptors were those indicating the forest's position on the gradient from tall, closed-canopy to short, open forest described above (Whitacre *et al.*)

Results to date clearly indicate the value of our census approach for comparing and monitoring the fauna of various habitats and land use categories. Species that occur in greater numbers in human-altered than in pristine forest habitats include the Black-shouldered Kite (*Elanus caeruleus*), Gray Hawk (*Buteo nitidus*), Black Vulture (*Coragyps atratus*), and possibly the Laughing Falcon and Bat Falcon. Species whose numbers were clearly lower in human-altered than in primary forest include the White Hawk and Great Black Hawk. A great many other species also appear to decline or disappear in heavily altered forest, but sample sizes are not yet adequate to permit generalization. Relative abundance of vulture species appears to suggest certain types of human impacts, while presence of rarities such as the Orange-breasted Falcon and large eagles may relate to special ecological conditions or especially pristine environments.

DISCUSSION

The environmental problems we are facing, most of which are associated with rapidly increasing human populations, are staggering, and have no simple solution. National governments are becoming increasingly concerned with and involved in developing solutions. The governments of Guatemala and Mexico, for example, have established the above reserves which, because of their large size, have tremendous importance for conservation. Those countries have taken a further step by establishing the Comision Centro Americana de Ambiente y Desarrollo, a high level multi-national government commission on the environment.

To be realistic, conservation programmes must consider social and economic factors, and they must include local people and organizations in every phase. Typically local people have the greatest understanding of problems and needs, and are a requisite part of any solution. A great deal can be learned from those who spend their lives in the forest. Attempts at preservation of large expanses of land without concern for needs of the local human populace are unlikely to succeed.

As a group, tropical raptors are poorly known. Thiollay (1985 & 1990) reported that nests or eggs of 75 species have been described never, or only once or twice; nor do quantitative survey techniques exist. We are working to change that situation. Future attempts to manage reserves or species must rest on a base of solid biological knowledge, such as that provided by the Maya Project.

Ecological monitoring is an important aspect of the Maya Project. In conjunction with quantitative habitat descriptions and data from remote imagery, census results should allow generalization about large areas, e.g. prediction of avian distributions and species richness. By periodically recensusing permanently located plots, we hope to detect any ecological changes reflected in shifts of abundance of our census species. As more information flows from species-level research and census work in various pristine and human-altered habitats, we should be in a position to develop management strategies, recommendations for size and design of protected areas, and suggestions as to how certain land-use practices may be made more compatible with protection of biodiversity.

In the future, few opportunities for creation of large pristine reserves will exist; the challenge of conservation in the tropics will be largely relegated to the intelligent management of existing reserves, to

habitat restoration, and to finding more harmonious ways for mankind to relate to the tropical environment. For all of these activities, effective means of monitoring ecological processes within the forest are extremely important, yet little work has been done along these lines. Indeed, the number of monitoring programs that attempt to track the species composition and relative abundance of "indicator species" or a functional group such as vertebrate predators over time are very limited. With each passing year, the Maya Project has taken on a wider ecological perspective, and monitoring now embraces bird groups ranging from wrens and migrant warblers through raptors. For the future, there is the possibility of monitoring key pollinators and/or establishment of seedlings and other ecological processes.

We are attempting to combine good science and conservation. Specialized organizations like The Peregrine Fund can make multiple, diverse contributions without losing focus or effectiveness. By working closely with local administrators, managers, and field personnel, we can also instill a level of skill and enthusiasm that is difficult for large, generalized organizations to accomplish. As decreasing northern breeding populations of avian Neotropical migrants illustrate, conservation effects, like wildlife, must cross political boundaries. Close cooperation among organizations and individuals nationally and internationally enhances understanding and effectiveness and magnifies results. At the Inter-regional Consultation on People's Participation in Environmentally Sustainable Development meeting in the Philippines, an Australian aborigine woman summarized, "If you have come to help me you can go home again. But if you see my struggle as part of your own survival then perhaps we can work together". (Sharma 1989).

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