

Part 3

Tropical Rain Forests and Raptors



Harpy Eagle *Harpia harpyja*

Convener:

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A World Review of Tropical Forest Raptors Current trends, Research Objectives and Conservation Strategy

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INTRODUCTORY REVIEW

The total number of diurnal raptor species in the world varies from 292 (Amadon & Bull 1988, Howard & Moore 1991) to 312 (Sibley & Monroe 1990, Clements 1991). Based on the most conservative estimate, 46 % of them (135) are tropical forest species, the richest genera being *Accipiter* (40 species), *Spizaetus* (12 species) and *Leucopternis* (10 species). One third of these tropical forest species (45) may be considered as threatened (appendix) and yet this list does not include some species with limited range or with some subspecies that are endangered. Current status and trends of population dynamics of many species are so little known that more taxa are likely to be added to the red list in the near future. Owls are not considered here because of an even greater lack of knowledge, but their overall situation may be no safer.

The species richness of tropical forests usually decreases from low to higher elevations, from the equator to higher latitudes, from humid evergreen to more seasonal and drier forest types, from well drained soils to seasonally flooded and from high mature to lower more disturbed stands (Thiollay unpublished). So the richest tropical forest type is the undisturbed, wet, evergreen lowland rain forest within 10° of the Equator. We shall mostly refer to this. Other tropical forests include mangrove, swamp, gallery, cloud, montane and monsoon forests. Raptors, like other vertebrate predators, are important in several respects for a general conservation strategy. First, they play the role of "umbrella species" because of their large home ranges. Any area encompassing a viable population of raptors, and even more a complete community of them, would harbour a large set of habitats and sizeable populations of most if not all other species. This is especially true for tropical forests, where many raptors have strikingly low densities or uneven distributions (Thiollay 1989a). Moreover there are some species in every habitat type.

Second, they are "flag" species arousing public interest and supporting wider conservation programmes. The current Philippine Eagle Project is an example of the utilization of a raptor-symbol in a broader habitat conservation and land use management scheme. Third, raptors are often sensitive "bio-indicators" of environmental changes or habitat quality, far beyond their well-known sensitivity to chronic food-chain contamination. For instance, rain forest species in Guiana

are highly responsive to relatively moderate levels of disturbance in primary forest such as hunting pressure, selective logging, road construction or moderate fragmentation (Thiollay 1985c, in press & in prep.) Their abundance and community composition can thus be used to monitor forest degradation as well as tropical landscape changes.

At last, the key biological role of predators in primary rain forest begins to be appreciated (Terborgh 1988, Thiollay 1991). By controlling the population level of smaller predators and other prey species, they ease multi-species coexistence and thus help to maintain a high species diversity. The elimination of some predators from isolated forest fragments or secondary vegetation may have unsuspected consequences and could promote the domino-like extinction of seemingly unrelated species.

Unfortunately little can be changed or added to my first review of the world situation of tropical forest raptors written 10 years ago (Thiollay 1985a & b). The deforestation is still continuing unabated, even if locally it tends to be at a slightly lower rate, most probably because of a lack of forest. The areas that are the most affected are still among the richest in species numbers and proportion of endemics: Southeast Asia (from India to Indonesia and the Philippines) and the humid neotropics (especially along the Pacific and Atlantic coasts of South America). Nor has the situation improved on islands such as the Solomons, the Caribbean and Madagascar. There is still no sign of a significant decrease of the rate of logging or shifting cultivation per unit area of remaining tropical forest (Mather 1990, WRI 1990, UNEP 1991). There is no more indication of a compensatory increase in number, size and enforcement of protected areas. Finally, our knowledge of the life history and ecology of the rain forest raptors is slowly and locally improving, but at a pace that probably does not match their rate of extinction.

THREATS TO FOREST RAPTOR POPULATIONS

Most currently identifiable threats to raptors in the tropical forest belt are related to habitat destruction. Other classical threats such as direct killing, trade or pesticide poisoning are of local occurrence and most often of little significance. Moreover they are almost always a consequence of increased human penetration after forest degradation and opening.

Areas undergoing broadscale conversion of their tropical forests at rapid rates and where little forest will be left at the turn of this century are: most forests below 1000 m in India, Bangladesh, Sri Lanka, Thailand, Philippines, South China, Indochina, Malaysia, Madagascar, West Africa, Central America, Pacific coast of Colombia and Ecuador, Atlantic coast of Brazil. The remaining forests of Melanesia, northern Australia, many Indonesian islands and east Africa will also be reduced to tiny patches. The lowest rates of change are expected in the Guianas, Brazil's western Amazonia, Zaire Basin and the mountains of Papua New Guinea.

Three different threats are involved under the general term of habitat loss. They are often concurrent and their detrimental effects are additive:

- 1/ **deforestation**, i.e. the conversion of forest to various open habitats, including tree plantations;
- 2/ **disturbance** or secundarization of the forest cover, resulting in an important change of the vegetation structure and in an impoverished plant and animal community;
- 3/ **fragmentation** of large forest tracts leading to a mosaic of forest patches and open areas.

1. Deforestation

The total destruction of forest and its replacement by cultivated, pasture, urban or even fallow unproductive lands is the most drastic habitat change, usually fatal to most, if not all, forest raptors. The annual rate of tropical forest clearance was 11.3 million ha around 1980, of which 7.5 million ha were closed forests and the remainder were more open woodlands (Lanly 1982). This rate had increased to 17 million ha for the decade 1981-90 (UNEP 1991). Only in the Brazilian Legal Amazon is there any sign of a declining trend, from 8.0 million ha deforested in 1986 to 2.6 in 1989 although this is partly due to changes in measurement methods (Fearnside 1989, UNEP 1991) but also recently to decreasing financial incentives. This continuing world rate of tropical deforestation

amounts to at least 1 % of the remaining forest cover per year.

Numerous estimates of potential species loss are being made on theoretical grounds, mostly from island biogeography theory. Yet the prospects and the scale of a mass extinction about to occur remain controversial. However, the most conservative estimates of overall species loss in tropical forests are 0.3 % of all species each year (Wilson 1989) and a total of 12 % of the bird species by the year 2000 (Simberloff 1986). In this general prospect one must remember that raptors, as relatively large species and top predators, are among the most extinction-prone species. Moreover, from a detailed examination of current status of threatened species in the appendix, it is not unreasonable to fear that 12-24 species could disappear within the next one or two decades, i.e., 9-18 % of all the rain forest raptor species. When the immediate threat is the disappearance of sizeable tracts of forest for narrow habitat specialists with limited distribution ranges, there is little hope that any management or the gazettement of necessarily small and isolated forest reserves would reverse the trend in the long term. The successful recovery of the Mauritius Kestrel (*Falco punctatus*) is not a reason for hope. It was probably much helped by the relative adaptability of island species, but it could not be repeated in most continental situations.

2. Forest degradation

In the long term, at least locally, there is some hope of stopping or even reversing tropical deforestation. Yet almost inevitably, the habitat quality will remain, or be further, altered, e.g. the vegetation structure, the community composition and the abundance of some resources needed by food specialists will continue to shift away from the primary forest conditions because of isolation, edge effects or development-oriented management forms involving some human exploitation.

The most widespread and relatively benign tropical forest uses are often favoured by conservationists as the best incentives to promote forest preservation by an economically sustainable or traditional use for indigenous human populations. Unfortunately, they are likely, or are already known, to affect somewhat the maintenance of primary forest raptors. They are, in order of increasing severity for bird populations:

a) Hunting pressure. The traditional hunting by sparsely distributed primitive populations has almost vanished everywhere. Higher human densities, the use of guns or motorboats and some trade for cash have now severe impacts on some large mammals or game birds. Raptors are still only occasionally killed but the domino-like effect of natural community disturbance, probably through prey population decrease, may be detrimental to some raptor species (Thiollay 1985c).

b) Exploitation of minor forest products. Although the overall structure of the forest is little affected, this traditional activity is almost always associated with hunting.

c) Road building. The opening of forest tracts by new roads not only promotes the colonization of road verges by alien species but is always likely to bring disturbance and hunting unless it is strongly controlled.

d) Logging. Even the so-called selective logging, that affects most tropical forests, usually results in unacceptable damage to soil and forest structure, out of proportion with the volume of timber harvested. Commonly, when less than 10 % of the large trees are exploited, 50 % or more of the forest area is heavily damaged and slow to regenerate because of additional wind falls and the growth of a dense secondary vegetation in gaps (Thiollay in press), let alone increased hunting pressure and the settlement of shifting cultivators.

e) The silvicultural management of logged forest to promote a sustainable production of timber further aggravates the disturbance by removing additional, commercially not valuable, tree species and sometimes by introducing new species or by highly favouring a small number of natural species. A step further in the primary forest conversion is traditional agroforestry, most extensively carried out and currently studied in Indonesia (Thiollay in prep.). Although a relatively high variety of large trees are left in these planted and managed forests, the decrease in primary forest bird diversity is striking. At the extreme, industrial tree plantations (Hevea, oilpalm, coffee, cocoa, ...) are extremely poor and retain an insignificant proportion of the natural forest bird density.

The artificial timber plantations (pine, *Eucalyptus*, *Gmelina*, ...) also fall in this last category, although they are mistakenly called reafforestation.

f) Shifting cultivation is the major cause of deforestation throughout the tropical world, especially because of a break-down of the old agricultural methods. It is now performed intensively, by denser populations over larger continuous areas and with increasingly shorter fallow periods than formerly. It leads at best to a dense secondary forest that bears little resemblance to the primary forest and that retains only a part of its original bird community. Under economic or population pressure, this itinerant cultivation may also be converted into pasture (as in Amazonia, Browder 1988) or into more intensive permanent farming or tree plantation (mainly in Asia). There are an estimated 300 million people involved in shifting cultivation and they are converting the forest at a rate of 100,000 km² per year (Mabberley 1992).

Semi-wooded agricultural landscapes or partially open secondary forests resulting from human exploitation have not necessarily a markedly lower raptor species diversity. The problem is that some primary forest species, unable to withstand a high level of disturbance, soon disappear. Conversely other species show a wider range of adaptations, while still others, usually edge or gap specialists, patchily distributed in the primary forest tracts, are favoured by openings and actually increase in logged, secondary or fragmented forests. Additionally, on every continent there is an assemblage of species that readily invade roads or clearings newly opened in continuous undisturbed forest where they are naturally rare or absent. When deforestation creates much larger clearings, then a new set of species typical of open grasslands comes to replace the fast disappearing forest species, thus contributing to a relative maintenance of the overall species richness.

3. Fragmentation

Another serious concern is the increasing patchiness of the remaining forest cover. Even when, at best, patches are protected as primary forest reserves, they tend to be increasingly smaller and more isolated. Both shrinking area and isolation, often occurring simultaneously, are well known to threaten the survival of populations trapped in such reserves (Wilson & Pater 1988). The minimum viable size of isolated populations is still debated and the relative suitability of the surrounding habitats as well as the dispersal ability of the different species are critical parameters. The endless controversies over the inconvenience or benefits of edge effects, corridor design or single large vs several small reserves have still not been tested on raptors and, as usual, they probably depend to a large extent upon local conditions and species' biology.

Before only isolated fragments are left, the forest cover is often punched out into an irregular network of patches interconnected by corridors of variable width, usually on ridges, steep slopes, or in gullies. The effects of such a partial fragmentation are currently studied in Guiana and in the Western Ghats (Thiollay in prep.).

4. Island populations

Endemic species on oceanic islands are a special case. They are often considered as highly vulnerable. However, many of them exhibit life history traits typical of island populations that allow them to survive in conditions where similar species on continents would be in jeopardy. Very small populations may survive and breed successfully even in marginal conditions (e.g., *Chondrohierax uncinatus mirus* on Grenada). They may reach very high densities (e.g., *Buteo platypterus* on little hunted Caribbean islands) and primarily forest species may occupy a wide range of habitats including severely degraded woodlands (e.g., *Accipiter haplochrous* in New Caledonia). All examples above are from recent field studies (Thiollay in prep.). During a long evolution within a limited area, with no genetic exchanges, free from interspecific competition and periodically reduced by random catastrophes, island species seem to have evolved adaptations that facilitate their survival in the face of human-caused habitat destruction and population reduction.

CURRENT STATE OF KNOWLEDGE; RESEARCH AND FUTURE NEEDS

Since the picture I drew ten years ago (Thiollay 1985b), a lot of new information has been accumulated on the distribution and status of the raptors in some areas where they were previously little known, e.g., in Java, the Solomons or New Caledonia, just to name some projects initiated by the World Working Group on Birds of Prey. However relatively little has been added to our knowledge of the life history and ecology of rain forest raptors. Notable exceptions come from Guatemala, French Guiana, Central Amazonia and Madagascar. Only one species, the Red Goshawk in Australia (Baker-Gabb, pers. comm.) has been studied over most of its range. Many species remain virtually unknown and sometimes their current existence or taxonomic position is in doubt. Even more worrying is that we still know almost nothing on the demography and natural population dynamics of any species, except maybe the Crowned Eagle in its marginal habitat of Kenyan highlands. This prevents effective management measures and even the launching of actions.

Several current research programmes on conservation-oriented ecology of tropical forest raptors are in progress. They include most prominently the Maya Project in Guatemala and Belize, where habitat selection, home range use, food habits and breeding success of several species are carefully monitored. Similar studies have also begun in Madagascar. Raptor density and distribution in successive stages of forest degradation, adaptability to forest management (logging, hunting, silviculture, agroforestry, fragmentation) and sensitivity to disturbance are being studied in French Guiana, Sumatra, the Western Ghâts and Andaman Islands (Thiollay 1989a & in prep.). Other monitoring or conservation projects are also actively carried out in Mexico, India, Java and the Philippines, let alone the successful recovery programme of the Mauritius Kestrel.

New advances on the rain forest raptors' ecology will rely on the development and experimentation of specific techniques to ease time-consuming behavioural studies, surveys and monitoring of populations. Promising methods include mid-morning visual censuses from canopy emergent viewpoints, pre-dawn mapping of singing Neotropical forest falcons, broadcast of distressed prey vocalizations to attract some bird predators and indeed a development of radiotelemetry or even satellite tracking of large eagles. Standardization of results is also needed to compare abundance indexes or actual densities obtained by different observers. For instance, the minimum number of individuals recorded during a 4-hour point census above the canopy, beginning one hour after sunrise, in fine weather conditions and limited to 1 km² has proven to be a manageable and reliable index of abundance (Thiollay 1989b, Burnham *et al.* 1991). I also increasingly use 1 or 4 sq-km sample quadrats to assess raptor densities, focusing on the identification of territorial pairs and on the distribution of home ranges.

Several research priorities must be outlined. Indeed, classical data of conservation biology are essential, such as area requirements, minimum viable population size, demographic parameters and genetic variability. With the help of radiotracking, it will be possible to find more nests and to gather the first basic data on clutch size, nesting success and breeding intervals. More specifically, we need a detailed assessment of the adaptation, tolerance and vulnerability of every species to habitat changes and to different levels of deforestation or fragmentation. This would allow us to understand the species' adaptability to forest degradation, to predict the composition of raptor communities in new tropical landscapes and to design conservation measures that would reduce the loss of primary forest species. If it is easy to monitor the mere presence of a species in a modified habitat, it is far more difficult to measure its reproductive success or fitness, which is the only way to know the actual value of this new habitat for the long-term maintenance of the species.

Even more urgent is the need to survey the status and distribution of the many endemic raptors known to occur in species-rich, recently little surveyed and rapidly deforested areas including western Colombia and Ecuador, south-eastern Brazil, eastern Indonesia, Andaman and Nicobar, the Philippines, Bismarck and Solomon islands. Among the new projects to be undertaken, such areas should receive top priority.

CONSERVATION STRATEGIES

Time is running short and different objectives must be achieved with equal priority to successfully alleviate the declining trend of tropical forest raptors.

1. Surveys of priority areas

As all too often, it is necessary to focus first on the most threatened species and areas. This strategy was highlighted by Myers (1988 & 1990) who defined hot spots, i.e., areas that feature exceptional concentration of species with high levels of endemism and face the highest threats of destruction. Based only on plant diversity, he defined 14 rain forest hot spots that together cover 310,000 sq-km or 0.2 % of the land surface, with only 3.5 % of their area remaining in primary forest, but that harbour 15 % of the Earth's plant species. They are Madagascar, eastern Tanzania, south-western Ivory Coast, the Atlantic coast of Brazil, western Ecuador, Colombian Choco, uplands of western Amazonia, south-western Sri Lanka, the western Ghats, eastern Himalayas, peninsular Malaysia, northern Borneo, the Philippines and New Caledonia. Together, 92 forest raptor species are found in these areas, i.e., 68 % of all the world's tropical forest raptors.

In Table 1, I emphasize here 4 hot spot areas, including only 2 areas from the above list. They are the most heavily forested countries of Australasia and they have the highest number of endemics and the least known raptor species. They certainly deserve to be designated as priority areas for immediate surveys and conservation actions as far as the forest raptors are concerned.

2. Ecological studies

Again I stress the need to develop new and efficient techniques to survey, study and monitor threatened raptor populations and to accumulate much more life history data than are currently available on most species. This is a fundamental prerequisite to better assess their ecological requirements, demographic trends, sensitivity to habitat alteration and minimum size of viable populations.

3. Habitat management

Indeed the first strategy is to slow down deforestation rates, but the conservation of tropical forests is a far more general problem and we shall focus on measures more specifically directed at raptors.

The maintenance of species strictly associated with primary forest ideally requires the setting aside of large tracts of undisturbed forest. Today 669 areas, totalling 66 million hectares, are under some form of protection within the tropical forest belt (IUCN 1990). However maybe less than half of them are covered with truly primary humid forest and are completely protected. Together only 3.9 % of the world's rain forests are in parks or reserves, whereas the lowest target to prevent extinction of a significant number of species would be the preservation of 10 % of all the tropical moist forest remaining in 1990 (Sayer 1991). Few of these areas reach the minimum size for the long-term maintenance of an entire forest raptor community, estimated to be in the order of 1 million ha or more (Thiollay 1989a).

As options for new protected areas are disappearing almost daily under increasing human pressure, even this modest goal maybe unlikely to be achieved. Moreover legal protection does not always prevent illicit logging, settlement and poaching, let alone the increasing isolation of forest patches as a result of clearance of adjacent forested areas. Thus the importance of unprotected areas will remain critical for the conservation of many species. Education and training of local biologists and reserve managers, with some special focus on raptors, is also necessary.

A significant proportion of broadly-classified forest species are actually gap or edge species, while a number of others, although widespread in undisturbed mature forest, still maintain appreciable population levels in some stages of forest degradation or fragmentation. Hence it is important to devise appropriate land use policies, management techniques, silvicultural systems, logging methods, agroforestry rules, agricultural practices and landscape design in multiple use areas that are most compatible with the ecological requirements of this category of species tolerant to disturbance. This strategy must be applied not only in the necessary buffer zones around protected reserves but also in the much larger exploited, semi-deforested areas, to mitigate the destructive effect of intensive management and to ensure the conservation of a significant part of

Table 1. Important areas for the conservation of tropical forest raptor diversity. From the conservative taxonomic list of Howard and Moore (1991). Estimated area of moist forest from Collins *et al.* (1991).

Islands	Rain forest area (million ha)	Number of forest raptors		
		Species	Subspecies	Threatened endemic species
Philippines	6.5	15	20	2
Malaysia + Western Indonesia	75.9	19	36	2
Lesser Sundas + Celebes + Moluccas	18.3	21	42	2
New Guinea + Solomons	73.4	22	51	8
Proportion of the world tropical forest total	14.5 %	40 %	45 %	31 %

the original forest biodiversity. Currently, less than 1% of all tropical forest is considered to be sustainably managed (WRI 1990) and the goal of sustainability itself is usually one of timber production. This target of broad-minded conservationists involves silvicultural practices that lead to greatly impoverished forest avifaunas. Other options such as nonwood products or nature tourism must be favoured if most of the richness of tropical forests is to be maintained.

Among the numerous projects currently in progress throughout the world to conserve or sustainably manage tropical forests, only one is specifically aimed at the protection of a threatened raptor (the Philippine Eagle). In forthcoming large-scale programmes initiated by international bodies such as IUCN, WWF, ITTO, FAO, World Bank, etc ... and devoted to the conservation of tropical forests, it would make sense to promote the use of forest raptors as indicators of habitat quality at the landscape level or to assess the minimum size of reserves.

3. Additional guidelines

When dealing with habitat management, one should not forget to control and at least minimize *hunting pressure*. This widespread and traditional activity may have a significant impact, even on non target species such as raptors, through complex interspecific relationships within the tropical forest communities, and it is additive to other forms of disturbance. Education programmes and the development of other cheap protein sources may help to reduce shooting.

Captive breeding, however attractive it may be for some conservationists, must be considered only if enough quality rain forest remains to eventually release the captive-bred individuals. There is no example of a tropical forest raptor vanishing where its natural habitat is still extensive and little disturbed. Nevertheless, ex-situ conservation is also justified when sufficient areas of suitable habitat can be recovered. The readaptation of released, inexperienced raptors into the complex environment of tropical forests may be far more difficult than are similar operations in open temperate habitats.

My last words will be a plea for a renewed interest in the *conservation of subspecies*. This concept was abandoned under the pressure of the fast-growing number of threatened full species to which little or no effort could be devoted. However, subspecies are an integral part of

biodiversity. They often have well-differentiated life histories or physiological adaptations and singular interspecific relationships within their own community, whatever their level of morphological differentiation. In this respect also, Indonesia, the Philippines, New Guinea and the Solomons, with their many island forms so little known, should be priority areas.

REFERENCES

- AMADON, D. & J. BULL, 1988. Hawks and Owls of the World. An annotated list of species. *Proc. Western Found. Vert. Zool.* 3 (4): 295-357.
- BROWDER, J. O. 1988. Public policy and deforestation in the Brazilian Amazon. Pp. 247-297 in "Public policies and the misuse of forest resources". Repetto, R. & M., Gillis, eds. Cambridge University Press, Cambridge.
- BURNHAM, W.A. *et al.* 1988-91. Maya Project. Progress Reports I, II, III, IV. The Peregrine Fund, Boise.
- CLEMENTS, J.F. 1991. *Birds of the World*. A checklist, 4th ed. Ibis Publ. Co., Vista.
- COLLAR, N.J. & P. ANDREW 1988. *Birds to Watch*. The ICBP World Checklist of Threatened Birds. ICBP Tech. Publ. n° 8.
- COLLINS, N.M., J.A. SAYER & T.C. WHITMORE (eds) 1991. *The conservation atlas of tropical forests. Asia and the Pacific*. IUCN & MacMillan Press, London.
- FAO 1987. *Yearbook of forest products*. FAO, Rome.
- FEARNSIDE, P.M. 1989. Deforestation in Brazilian Amazonia: the rates and causes of forest destruction. *The Ecologist* 19: 214-218.
- HOWARD, R. & A. MOORE 1991. *A complete checklist of the birds of the world*. 2nd edition. Academic Press, London.
- IUCN (International Union for the Conservation of Nature) 1990. *United Nations list of national parks and protected areas*. IUCN, Gland.
- JOHNS, A.D. 1985. Selective logging and wildlife conservation in tropical rain forest: problems and recommendations. *Biological Conservation* 31: 355-375.
- LANLY, J.P. 1982. Tropical forest resources. FAO Forestry Paper 30.
- MABBERLEY, D.J. 1992. *Tropical rain forest ecology*. 2nd edition. Blackie, Glasgow.
- MATHER, A.S. 1990. *Global forest resources*. Belhaven Press, London.
- MYERS, N. 1988. Threatened biotas: hot spots in tropical forests. *The Environmentalist* 8: 187-208.
- MYERS, N. 1990. The biodiversity challenge: expanded hot-spots analysis. *The Environmentalist* 10: 243-256.
- SAYER, J. 1991. Conservation and protection of tropical rain forests; the perspective of the World Conservation Union. *Unasylva* 166, 42: 40-45.
- SIBLEY, Ch. G. & B.L. MONROE 1990. *Distribution and taxonomy of birds in the world*. Yale University Press, New Haven.
- SIMBERLOFF, D. 1986. Are we on the verge of a mass extinction in tropical rain forests? Pp. 165-182 in "Dynamics of extinction", Elliot, D.K. (ed.) J. Wiley, New York.
- TERBORGH, J. 1988. The big things that run the world. A sequel to E.O. Wilson. *Conservation Biology* 2: 402-403.
- THIOLLAY, J.M. 1985a. Falconiforms of tropical rain forests: a review. ICBP Tech. Publ. 5: 155-165.
- THIOLLAY, J.M. 1985b. The tropical rain forest raptors: state of knowledge, world situation and conservation strategy. ICBP Tech. Publ. 5: 223-225.
- THIOLLAY, J.M. 1985c. Raptor community structure of a primary rain forest in French Guiana and effect of hunting pressure. *Raptor Research* 18: 117-122.
- THIOLLAY, J.M. 1989a. Area requirements for the conservation of rain forest raptors and game birds in French Guiana. *Conservation Biology* 3: 128-137.
- THIOLLAY, J.M. 1989b. Censusing of diurnal raptors in a primary rain forest: comparative methods and species detectability. *Journal of Raptor Research* 23: 72-84.
- THIOLLAY, J.M. 1991. Tropical rain forest bird communities: emerging patterns and processes of organization. Acta XX Cong. Intern. Ornith., Christchurch.
- THIOLLAY, J.M. 1992. Influence of selective logging on birds species diversity in a Guianan rain forest. *Conservation Biology*.
- THIOLLAY, J.M. (in prep.). Effects of rain forest disturbance and fragmentation on the raptor community.

Comparative gradient analyzes in French Guiana.

UNEP (United Nations Environment Programme) 1991. *Environmental Data Report*. 3rd edition. Blackwell, Oxford.

WILSON, E.O. 1989. Threats to biodiversity. *Scientific American* 261: 60-69.

WILSON, E.O. & F.M. PETER (eds.) 1988. *Biodiversity*. National Academy Press, Washington.

WRI 1990. *World Resources 1990-91*. Oxford University Press, New-York.

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APPENDIX

List of tropical forest Falconiformes considered threatened, or at least rare and insufficiently known (?) according to Collar & Andrew 1988, personal experience and an extensive review of adequate literature. The systematic list follows Amadon & Bull 1988.

ACCIPITRIDAE

- Madagascar Cuckoo Hawk, *Aviceda madagascariensis* (Madagascar)
Black Honey Buzzard, *Henicopernis infuscata* (New Britain)
Solomon Sea Eagle, *Haliaeetus sanfordi* (Solomon Islands)
? East African Snake Eagle, *Circaetus fasciolatus* (East Africa)
Kinabalu Serpent Eagle, *Spilornis kinabaluensis* (North Borneo)
? Nicobar Serpent Eagle, *Spilornis minimus* (Nicobar Islands)
? Andaman Serpent Eagle, *Spilornis elgini* (Andaman Islands)
Madagascar Serpent Eagle, *Eutriorchis astur* (Madagascar)
Gray-bellied Hawk, *Accipiter poliogaster* (South America)
? Blue-and-Gray Sparrowhawk, *Accipiter luteoschistaceus* (New Britain)
Imitator Sparrowhawk, *Accipiter imitator* (Solomon Islands)
Gray-headed Goshawk, *Accipiter princeps* (New Britain)
Semicollared Hawk, *Accipiter collaris* (N. Andes)
Dwarf Sparrowhawk, *Accipiter nanus* (Sulawesi)
New Britain Collared Sparrowhawk, *Accipiter brachyurus* (New Britain)
? Madagascar Sparrowhawk, *Accipiter madagascariensis* (Madagascar)
Cuban Hawk, *Accipiter gundlachi* (Cuba)
Madagascar Goshawk, *Accipiter henstii* (Madagascar)
? Chestnut-mantled Goshawk, *Accipiter buergerii* (New Guinea)
Red Goshawk, *Accipiter radiatus* (N. Australia)
Plumbeous Hawk, *Leucopternis plumbea* (Choco)
? White-browed Hawk, *Leucopternis kuhli* (W. Amazonia)
White-necked Hawk, *Leucopternis lacernulata* (SE Brazil)
Gray-backed Hawk, *Leucopternis occidentalis* (W. Ecuador)
Mantled Hawk, *Leucopternis polionota* (SE Brazil)
Black Solitary Eagle, *Harpyhaliaetus solitarius* (Tropical America)
Ridgway's Hawk, *Buteo ridgwayi* (Hispaniola)
Hawaiian Hawk, *Buteo solitarius* (Hawaii)
Guiana Crested Eagle, *Morphnus guianensis* (Tropical America)
Harpy Eagle, *Harpia harpyja* (Tropical America)
New Guinea Eagle, *Harpyiopsis novaeguineae* (New Guinea)
Great Philippine Eagle, *Pithecophaga jefferyi* (Philippines)
? Black and White Hawk Eagle, *Spizaetus melanoleucus* (Tropical America)
Javan Hawk Eagle, *Spizaetus bartelsi* (Java)
? Celebes Hawk Eagle, *Spizaetus lanceolatus* (Sulawesi)
? Philippines Hawk Eagle, *Spizaetus philippensis* (Philippines)
Wallace's Hawk Eagle, *Spizaetus nanus* (Burma to Sumatra)
? Black and Chestnut Eagle, *Spizaetus isidori* (Andes)

FALCONIDAE

- Plumbeous Forest Falcon, *Micrastur plumbeus* (Choco)
Buckley's Forest Falcon, *Micrastur buckleyi* (W. Amazonia)
? Bornean Falconet, *Microhierax latifrons* (N. Borneo)
? Pied Falconet, *Microhierax melanoleucus* (SE Asia)
Mauritius Kestrel, *Falco punctatus* (Mauritius)
? Banded Kestrel, *Falco zoniventris* (Madagascar)
Orange-breasted Falcon, *Falco deiroleucus* (Tropical America)