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PHILIPPINE BIODIVERSITY CONSERVATION: GLOBAL PRIORITIES AND LOCAL TARGETS

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Abstract - Biodiversity is facing an extinction crisis, with rates of species loss three orders of magnitude higher than normal throughout geological history. However, neither biodiversity nor threats are randomly distributed around the planet, and so it is extremely important to target and prioritize conservation activities in order that they are as effective as possible. At a global scale, we can set priorities by considering a framework of irreplaceability and vulnerability, from which we can derive biodiversity "hotspots". The Philippines emerges as one of the most important of these. However, the hotspots concept does not inform conservation on the ground. For such establishment of conservation targets, we require a system that assesses biodiversity at multiple scales of ecological organization. The finest scale at which sufficiently comprehensive data are available is the level of the species, where we can use the IUCN Red List to determine targets for species conservation. However, most threatened species are best conserved through protecting areas, and so we can use information regarding species distributions to identify Key Biodiversity Areas as targets for site scale conservation. While the protection of areas is essential for biodiversity conservation, it will not be sufficient unless we can also maintain the ecological processes that allow these sites and species to persist, for which landscape interventions through biodiversity conservation "corridors" are necessary. The compilation of data on conservation targets at these three scales of organization by a number now allows consideration of prioritization among these conservation targets in the Philippines. An urgent research priority remains the compilation of such data for aquatic systems.

INTRODUCTION

Humanity's impact on our planet is approaching catastrophic proportions. Severe poverty in the tropics and overconsumption in the temperate zones are driving a suite of interconnected environmental changes, including the loss of natural habitats, pollution, global climate change, and species extinctions (Vitousek *et al.* 1997). Habitats can be restored, pollution cleaned, and even global climate change (given sufficient political will) can be reversed, but extinctions are irreversible, and hence the most serious of these crises. Species extinctions have direct economic and ecological costs; they also foreclose our future options for sustainable use and leave humanity with a deep moral and ethical scar (Ehrlich & Ehrlich 1981). While species loss is natural, anthropogenic impacts have now forced extinction rates up to around a thousand times those normal through the planet's history (Pimm *et al.* 1995). Extinctions are hard to measure because of the time lag between habitat loss and species loss, but can

be estimated based on the species-area relationship (Reid 1992) and calibrated using well-known taxonomic groups (Brooks *et al.* 1997). Contemporary extinction rates are approaching those that characterized the "Big Five" mass extinctions, such as that at the K-T boundary 65 million years ago, which killed the dinosaurs (Pimm & Brooks 1997).

Clearly, then, humanity would do well to conserve of the full, representative suite of the planet's biodiversity into the future. Currently, though, global investment in biodiversity conservation falls well short of that required to allow this, in spite of the fact that conservation's benefits exceed its costs by at least a hundred times (Balmford *et al.* 2002). Given this shortfall of responses in the face of the magnitude of the extinction crisis, where should such conservation focus most urgently in order to minimize biodiversity loss? To answer this, conservationists need to establish targets (what do we want to conserve?) and priorities (what should we conserve first?). To progress from the former to the latter, it is necessary to map conservation targets within a framework of vulnerability and irreplaceability (Margules & Pressey 2000). Vulnerability is a measure of the *temporal* options for the conservation of a given biodiversity feature, irreplaceability a measure of the *spatial* options. Those places that are characterized by both high vulnerability and high irreplaceability are the highest conservation priorities.

In this paper, we address how the establishment of conservation targets and priorities applies in the context of the Philippines. We begin by looking at conservation priorities at a global scale – biodiversity *hotspots*. Compared to similar regions worldwide by measuring both vulnerability and irreplaceability, the Philippine islands emerge as one of the planet's highest conservation priorities. The fact that the country is a global priority for conservation, however, does not inform action on the ground. This requires a process beginning with the establishment of targets for conservation *outcomes*, at multiple scales of ecological organization. Building from these targets, conservationists within the Philippines can then prioritize, implement, and monitor their interventions to ensure the safeguarding of the country's globally outstanding biodiversity.

THE PHILIPPINES HOTSPOT IN CONTEXT: GLOBAL CONSERVATION PRIORITIES

The identification of global conservation priorities requires the development of globally consistent metrics for vulnerability and irreplaceability. Myers (1988) was the first to suggest that the extent of habitat loss and of plant endemism as appropriate metrics for evaluating conservation priority. Based on this, he identified ten hotspots for biodiversity conservation – including the Philippines – in forests around the tropics. This verdict was reinforced by the work of Myers *et al.* (2000) who introduced quantitative thresholds for hotspot status for both vulnerability (at least 70% of historical habitat lost) and irreplaceability (at least 1,500 endemic vascular plants). Again, the Philippines figured as one of the highest priority hotspots (Heaney *et al.* 1999). Similarly, using bird endemism as a metric for irreplaceability, Stattersfield *et al.* (1998) defined Endemic Bird Areas (EBAs); prioritizing among these based on threat revealed six of the Philippines' seven EBAs to be 'critical', their highest priority rank.

Over the last few years, Conservation International has worked on several updates to the hotspots analysis (Mittermeier *et al.* 2004). First, data have now become available to allow the identification of seven new hotspots and the subdivision of two more, yielding a total of 34 hotspots. Second, the boundaries of all hotspots have now been adjusted to match those of amalgamations of ecoregions (www.worldwildlife.org/science/ecoregions.cfm; Olson *et al.* 2001), which, despite their arbitrary nature are nevertheless the most widely used global bioregional classification. Third, actual species lists enumerating occurrence, endemism, and threat to vertebrate species in each hotspot have now been made freely, publicly and electronically available over the World Wide Web

(www.biodiversityhotspots.org). Finally, a number of other supplementary datasets have now been added to the hotspots analysis, including data for freshwater fish, and for two invertebrate groups (tiger beetles and nasutitermites).

Considering these new datasets, the Philippine archipelago retains its position as one of the "hottest" of the hotspots. In terms of vulnerability, only 7% of the Philippines' natural forest cover remains – only four hotspots have lost a greater proportion of habitat. Other metrics also reveal the extreme threat faced by the islands, with the Philippines holding, for example, 273 people per km^2, the second highest of any hotspot (Cincotta *et al.* 2000).

In terms of irreplaceability, the Philippine islands rank among the most endemic-rich hotspots for all taxa (Table 1). The Philippines, being islands, have particularly high endemism among those taxonomic groups able to disperse over water – those with the power of flight, like birds and insects. Endemism is relatively slightly lower among poor dispersers like amphibians and freshwater fish, but is still exceptional. The "endemism density" of the Philippines, given the hotspot's relatively small area, is astounding for all taxa, although this is a rather misleading comparative measure because of the species-area relationship is a power function (not linear). As a result, simply dividing by area relatively underestimates the endemism of large hotspots. However, it is possible to factor out effects of area (by fitting a power function and taking residuals), which yields qualitatively similar results (Brooks *et al.* 2002).

Table 1. Rank of the Philippine hotspot (out of 34 hotspots in total) for endemism in various taxa (Mittermeier *et al.* 2004).

Taxon	Endemics	Rank
Plants	6,091	9th
Mammals	102	5th
Birds	185	4th
Reptiles	160	8th
Amphibians	74	11th
Freshwater fish	67	11th
Tiger beetles	113	3rd
Nasutitermites	16	4th

That the Philippine hotspot is such an important global priority is key information for decision-makers with the responsibility for investing globally flexible conservation resources. These include conservation NGOs, private philanthropists and foundations, enlightened corporations, and, crucially, bilateral and multilateral donors. It is also important that this information reaches all concerned with conservation in the Philippines to support fundraising and inspire pride. However, that the Philippines are a global priority does not provide information as to how conservation should proceed on the ground. For this, we need a much finer scale of analysis to determine specific conservation outcomes.

TARGETS FOR CONSERVATION OUTCOMES WITHIN THE PHILIPPINES

Conservation is complicated by the fact that there is no single measure of biodiversity – biodiversity is distributed along a continuum of scales of ecological organization from the genetic level up to the scale of the entire biosphere (Wilson 1992). At the moment, it is not possible to measure more than a miniscule fraction of biodiversity at the genetic level, and so the finest scale of ecological organization at which we can measure biodiversity to identify conservation targets with any kind of consistency is the level of the species. Building from the species scale, we can identify targets for the conservation of natural habitats – areas within which biodiversity should be safeguarded. Finally, the coarsest level at which conservation can be implemented on the ground is that of landscapes and seascapes, a scale at which our target is maintaining those processes which allow biodiversity to persist into the future. At each of these scales, conservation requires four stages within an overall cycle: i) the identification of quantitative, spatially explicit targets, ii) the scheduling of priorities for action among these, iii) the implementation of measures to safeguard this biodiversity, and iv) the continual monitoring of progress towards these

outcomes. Here, we focus on the framework for the first of these, while recognizing that all four stages are essential for conservation to succeed.

At the species scale, we are fortunate in that the Species Survival Commission of IUCN (the World Conservation Union) has, over the last four decades, invested intensive work in the assessment of those species in danger of extinction. Furthermore, these Red List assessments are increasingly comprehensive across taxonomic groups, and quantitative criteria for extinction risk now underlie them (IUCN 2001). BirdLife International (2004) has assessed all bird species four times, Baillie & Groombridge (1996) assessed all mammal species and an updated Global Mammal Assessment is underway, and a first Global Amphibian Assessment has recently been completed (Stuart *et al.* 2004). In addition, numerous plant and invertebrate species have been assessed, such that in total the status of nearly 30,000 species has been evaluated with ~10,000 species considered globally threatened (www.iucnredlist.org; IUCN 2004). While these assessments are clearly not comprehensive across all species – the latest estimates suggest that a total of six million species exist worldwide (Novotny *et al.* 2002), which would mean that only half a percent of all species have been evaluated – they are much the best available. They are also dynamic to the iterative incorporation of new information from field scientists: for example, Mindanao Gymnure *Podogymnura truei*, listed as Endangered on the 2004 Red List, will be down-listed by the Global Mammal Assessment on the basis of updated information. It is important to be clear about the differences between the global Red List and national lists (e.g., WSCP 1997) – the latter contribute important new data on national endemics not assessed globally (and can also be useful in informing national policy), but because they include species that are locally rare but globally common are much less useful in establishing conservation targets.

The Philippines hold a total of 466 globally threatened species, of which 367 are endemic (most of the non-endemics are trees or marine fish). Table 2 enumerates these numbers by taxonomic group. The totals for birds, mammals and amphibians represent comprehensive assessments of all species. In contrast, many species in the other groups have not yet been assessed, and so these may be found to hold many more threatened species, once evaluations are conducted. A few of the threatened species of the Philippines are threatened by idiosyncratic threats – examples include hunting of large mammal species like Tamaraw *Bubalus mindorensis*, Philippine Spotted Deer *Cervus alfredi*, and Visayan Warty Pig *Sus cebifrons*, trade in Philippine Cockatoo *Cacatua haematuropygia*, and the impacts of invasive species on the freshwater fish of Lake Lanao. The conservation of these species will require specific conservation actions to ameliorate these threats one at a time. Resources for such work are available from sources like the Haribon Threatened Species Program (www.haribon.org.ph) and also through collaborations with zoos, botanic gardens, and other species-focused institutions.

However, it will never be possible to conserve all of the threatened species of the Philippines one-by-one. Fortunately, however, this is not necessary, because the main threat to most of these is habitat destruction, and so the main conservation action necessary is the protection of the places where they live. How can we identify these site scale targets for biodiversity conservation? In 2000, the Protected Areas and Wildlife Bureau of the Department of the Environment and Natural Resources, along with numerous NGOs, universities, and other organizations, convened the Philippine Biodiversity Conservation Priority-setting Program (PBCPP) to forge consensus on where these sites might be. The program identified 170 priority sites (Ong *et al.* 2002). Simultaneously, the Haribon Foundation, the BirdLife International partner in the Philippines, implemented an Important Bird Areas (IBA) program across the country, to identify and conserve 117 sites of global ornithological importance based on quantitative data and criteria (Mallari *et al.* 2001). That the maps resulting from these exercises were very similar (Fig.1) is

Table 2. Endemic and total numbers of globally threatened species in the Philippines, by taxonomic group (www.iucnredlist.org; IUCN 2004).

Taxon	Globally threatened species	
	Endemics	**Occurring**
Plants	167	215
Mammals	50	52
Birds	56	72
Reptiles	3	8
Amphibians	48	48
Freshwater fish (Actinopterygii)	25	26
Marine fish (Actinopterygii)	0	9
Marine fish (Elasmobranchii)	1	17
Marine molluscs	0	2
Gastropod molluscs	1	1
Butterflies	14	14
Dragonflies	2	2
Total	**367**	**466**

unsurprising, given that there was much interchange between the two processes.

Given the advances in biodiversity assessment over the last couple of years, it is now possible to bring these two processes together, capitalizing on the strengths of each to combine the data-driven rigor of the IBA process with the cross-taxonomic breadth of the PBCPP. To enable this, numerous conservation organizations have been developing a concept of Key Biodiversity Areas (KBAs) as site scale targets for conservation. The assessment of KBAs is based on the same framework of irreplaceability and vulnerability as used globally for identifying hotspots, with the criteria directly matching those used for IBAs. Vulnerability triggers a single category of KBAs: the presence of globally threatened species at a given site. Irreplaceability, meanwhile, triggers three categories of KBAs: the presence of with global ranges of <50,000 km^2 (Stattersfield *et al.* 1998); of more than 1% of the global population of any individual species (Mittermeier *et al.* 2003); or of species assemblages restricted to individual biomes (Olson *et al.* 2001). "Sites" are delimited based on the needs of the species for which they are important, although in highly fragmented landscapes (as in the Philippines) they will generally approximate land use boundaries (for example, protected areas) as well. While various exercises have examined conservation priorities in the Philippines using similar frameworks (e.g. Hague *et al.* 1986, Peterson *et al.* 2000, Curio 2002, Heaney & Mallari 2002, Danielsen & Treadaway 2004) all but the latter two focused at the scale of islands rather than individual sites.

Simultaneous to the ongoing process of KBA assessment, an important international initiative is underway to identify and conserve the "tip of the iceberg" of site scale conservation targets – the Alliance for Zero Extinction (AZE, www.zeroextinction.org). The criteria for consideration of sites by AZE are extremely strict: they must hold effectively the entire global population of at least one species considered Critically Endangered or Endangered on the IUCN Red List. Thus, unless these sites are conserved soon, they will suffer species extinction. In total, 11 AZE sites have been identified for 15 species (Table 3) in the Philippines. These are the absolute highest priorities for the conservation of specific sites in the country.

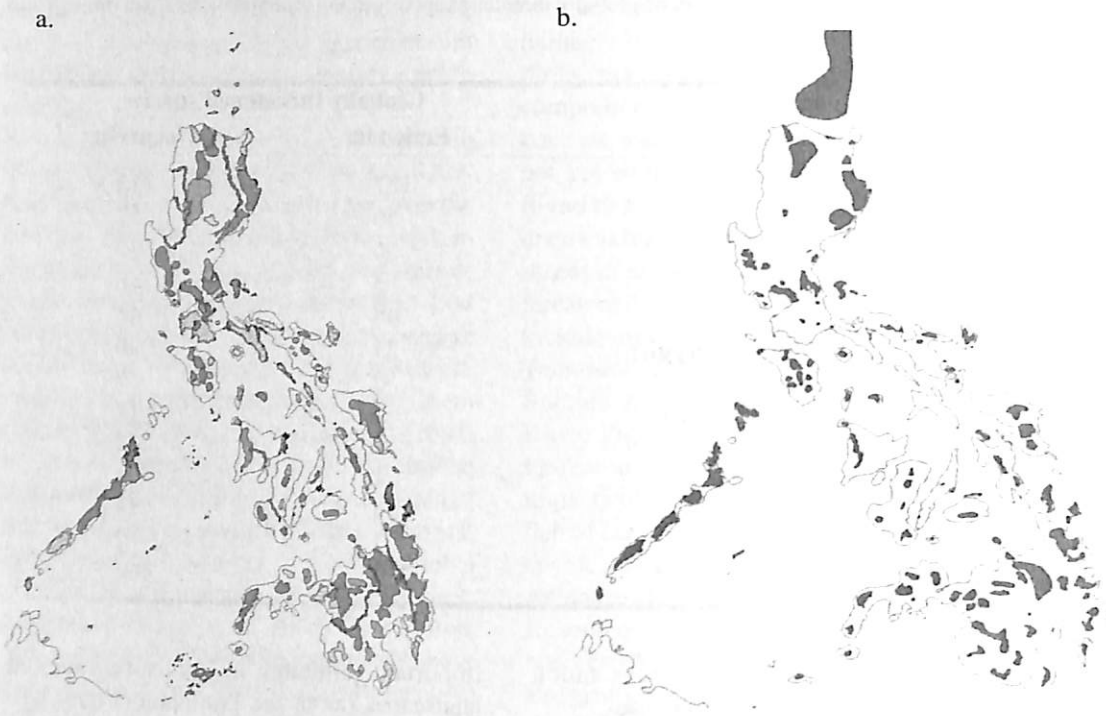

Figure 1. a) Results of the Philippines "conservation priority-setting workshop", showing expert-driven consensus on site scale conservation targets across the hotspot (Ong *et al.* 2002). Shading intensity denotes priority level. b) Important Bird Areas of the Philippines, showing data-driven site scale bird conservation targets across the hotspot (Mallari *et al.* 2001).

The implementation of conservation at KBAs requires protecting each site in a way suitable to ensure that the biodiversity for which it is important is safeguarded. This will often require some kind of national or provincial level formal protected area (under the management of the Department of the Environment and Natural Resources), but other safeguard mechanisms suitable in various situations include community conservation, indigenous territories, and private reserves. The Global Environment Facility -supported Conservation of Priority Protected Areas Project (CPPAP) is working on the management of protected areas at ten KBAs through the Philippines, while the European Union -funded National Integrated Protected Areas Project (NIPAP) is implementing conservation at another eight. A range of other sources is available to support the protection of KBAs, such as Conservation International's Global Conservation Fund (www.conservation.org/xp/gcf) and the Foundation for the Philippine Environment (www.fpe.ph).

While the protection of KBAs is essential for the conservation of biodiversity, in some cases this will not be sufficient. This is because a range of ecological processes operating at much broader scales than individual sites is often necessary to allow their persistence. While the science necessary to measure these ecological processes and hence provide quantitative criteria for landscape or seascape scale conservation is still in its infancy (Lens *et al.* 2002), the general characteristics for the consolidation of biodiversity conservation corridors are fairly clear. First, some threatened species range too widely (either as home ranges, or through migration) for their

Table 3. Alliance for Zero Extinction sites in the Philippines and corressponding Important Bird Areas (IBAs) and trigger threatened species.

AZE site	Island	IBA	Trigger species
Northern Sierra Madre Natural Park	Luzon	015	*Crunomys fallax* (CR)
Mt Isarog National Park	Luzon	031	*Archboldomys luzonensis* (EN)
			Chrotomys gonzalesi (CR)
Siburan	Mindoro	042	*Centropus steerii* (CR)
Ilin Island	Mindoro	-	*Crateromys paulus* (CR)
Mt Mantalingajan	Palawan	054	*Palawanomys furvus* (EN)
Central Panay Mountains	Panay	061	*Crateromys heaneyi* (EN)
Mt Canlaon National Park	Negros	063	*Ptilinopus arcanus* (CR)
Cuernos de Negros	Negros	066	*Crocidura negrina* (CR)
			Stachyris nigrorum (EN)
Mt Kambinlio and Mt Redondo	Dinagat	081	*Crateromys australis* (EN)
Mt Malindang National Park	Mindanao	107	*Crocidura grandis* (EN)
Tawi-Tawi Island	Tawi-Tawi	115	*Gallicolumba menagei* (CR)
			Phapitreron cinereiceps (CR)
			Anthrococeros montani (CR)

conservation to be possible at individual sites, and so these ranges and connections between KBAs must be incorporated into corridors. Second, it should be possible to identify, quantity and map the ecological processes on which KBAs depend: these could include predation, hydrological process, fire, and gradients necessary for resilience to climate change. Third, the consolidation of corridors is at a sufficient scale to counter landscape and seascape level threats from infrastructure development (e.g., roads, dams), and so these should inform corridor planning (although they do not provide targets for conservation in themselves). Finally, landscape conservation in the Philippines will ultimately have to incorporate some level of habitat restoration in the most degraded ecosystems.

In the Philippines, three major corridors have been identified to date, through the PBCPP. These span the mountains of the Sierra Madre in northeastern Luzon, the eastern portion of Mindanao, and the island of Palawan. These three corridors have attracted considerable investment in the hotspot from the Critical Ecosystem Partnership Fund (www.cepf.net) and various other sources. The area necessary for a single wide-ranging threatened species, the Philippine Eagle *Pithecophaga jefferyi* is debatable (Collar 1997, Bueser *et al.* 2003) but certainly large enough to be important in defining the Sierra Madre and eastern Mindanao corridors, although the maintenance of their watershed functions is clearly also essential. The Palawan corridor is particularly key for wide-ranging threatened species like Philippine Cockatoo *Cacatua haematuropygia* (Boussekey 2000). Another 16 potential corridors were identified by the PBCPP, although these have yet to be assessed. It is important to note that not all threatened species and KBAs need to be incorporated into corridors: for example, the Sierra Madre, eastern Mindanao, and Palawan corridors only represent 24 (21%) of the Philippines IBAs (and probably a similar proportion of KBAs).

CONCLUSIONS

Rigorous data and a transparent, iterative process must underlie conservation if it is to minimize species extinctions. In this paper, we have shown how this holds both at the global scale of the establishment of regional hotspots as conservation priorities, and at the local scale of the identification of targets for conservation

outcomes on the ground. Given the multi-scale nature of biodiversity, these targets must be defined at the species, site and corridor levels. We report on the importance of the Philippines hotspot as a global conservation priority, and on progress towards the identification of conservation targets within the hotspot. Encouraging evidence of the incorporation of new scientific data into conservation planning is provided by examples such as Sibuyan, which was listed as a NIPAP site after fieldwork in the early 1990s revealed its importance (Goodman & Ingle 1993), and Cebu, now the focus of outstanding conservation action by the Cebu Biodiversity Conservation Foundation, following the rediscovery of supposedly extinct species (Magsalay *et al.* 1995).

A glaring omission from these discussions is the issue of aquatic conservation. In the marine realm, the Philippines are recognized as the apex of the "coral triangle", holding some of the highest diversity coral reefs on the planet (Roberts *et al.* 2002). However, much of this diversity remains undiscovered, or at least un-assessed. The PBCPP did tentatively identify 36 site scale conservation targets for the Philippine seas, and ten marine corridors (Ong *et al.* 2002). While the level of freshwater diversity in the Philippines is likely to be lower, the threat is almost certainly much greater (Davies *et al.* 1995), given the water demands of the country's 81 million people. Evaluation and conservation of biodiversity in the waters of the Philippines is therefore an extremely urgent priority. A total of 34 of the 170 PBCPP sites comprise freshwater systems (Ong *et al.* 2002).

Two related and crucially important points should be made in conclusion. The first is that, while the establishment of global conservation priorities must necessarily be a top down one (to avoid parochial bias), the identification of targets for conservation outcomes must, in contrast, be institutionally bottom up. This is to ensure that the planning of conservation is inextricably tied to its implementation – which is essential if conservation is to address the most urgent priorities. A second point, following from this, is that if the scientific process outlined above for the establishment of targets for conservation outcomes is essential, it is doubly important to harness similar rigor to plan the conservation of a given target, to implement these safeguarding actions, and to monitor their success. Only through undertaking conservation as a locally driven cycle of establishing targets, planning, implementation and monitoring will it be possible to move towards a goal of the preservation of biodiversity.

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REFERENCES

Baillie, J. & Groombridge, B. 1996. *1996 IUCN Red List of Threatened Animals.* IUCN, Gland, Switzerland.

Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R.E., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., Munro, K., Myers, N., Naeem, S., Paavola, J., Rayment, M., Rosendo, S., Roughgarden, J., Trumper, K. & Turner, K.T. 2002. Economic reasons for conserving wild nature. *Science* 297: 950–953.

BirdLife International. 2004. *Threatened Birds of the World 2004.* CD-ROM. BirdLife International, Cambridge, UK.

Boussekey, M. 2000. An integrated approach to conservation of the Philippine or Red-vented Cockatoo. *International Zoo Yearbook* 37: 137–146.

Brooks, T.M., Pimm, S.L. & Collar, N.J. 1997. The extent of deforestation predicts the number of birds threatened with extinction in insular South-east Asia. *Conservation Biology* 11: 382–394.

Brooks, T.M., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B. da, Rylands, A.B., Konstant, W.R., Flick, P., Pilgrim, J., Oldfield, S., Magin, G. & Hilton-Taylor, C. 2002. Habitat loss and extinction in the hotspots of biodiversity. *Conservation Biology* 16: 909–923.

Bueser, G.L.L., Bueser, K.G., Afan, D.S., Salvador, D.I., Geier, J.W., Kennedy, R.S. & Miranda, Jr., H.C. 2003. Distribution and nesting density of the Philippine Eagle *Pithecophaga jefferyi* on Mindanao Island, Philippines: what do we know after 100 years? *Ibis* 145: 130–135.

Cincotta, R.P., Wisnewski, J. & Engelman, R. 2000. Human population in the biodiversity hotspots. *Nature* 404: 990–992.

Collar, N.J. 1997. Species survival versus perpetuation of myth – the case of the Philippine eagle. *Oryx* 31: 4–7.

Curio, E. 2002. Prioritisation of Philippine Island avifaunas for conservation: a new combinatorial measure. *Biological Conservation* 106: 373–380.

Danielsen, F. & Treadaway, C.G. 2004. Priority conservation areas for butterflies (Lepidoptera: Rhopalocera) in the Philippine islands. *Animal Conservation* 7: 79–92.

Davies, J. 1995. Diversity and endemism in Philippine inland waters: implications for conservation and management. *Silvatrop* 7: 55–70.

Ehrlich, P.R. & Ehrlich, A.H. 1981. *Extinction.* Random House, New York, USA.

Goodman, S.M. & Ingle, N.R. 1993. Sibuyan Island in the Philippines – threatened and in need of conservation. *Oryx* 27: 174–180.

Hauge, P., Terborgh, J., Winter, B. & Parkinson, J. 1986. Conservation priorities in the Philippine Archipelago. *Forktail* 2: 83–91.

Heaney, L.R. & Mallari, N.A.D. 2002. A preliminary analysis of current gaps in the protection of threatened Philippine terrestrial mammals. *Sylvatrop* 10: 28–39.

Heaney, L.R., Ong, P.S., Mittermeier, R.A. & Mittermeier, C.G. 1999. The Philippines. Pp. 308–317 in Mittermeier, R.A., Myers, N., Robles Gil, P. & Mittermeier, C.G. (eds.) *Hotspots.* CEMEX, Mexico City, Mexico.

IUCN. 2001. *IUCN Red List Categories and Criteria.* Version 3.1. IUCN, Cambridge, UK.

IUCN. 2004. 2004 *IUCN Red List of Threatened Species.* IUCN, Gland, Switzerland.

Lens, L., van Dongen, S., Norris, K., Githiru, M. & Matthysen, E. 2002. Avian persistence in fragmented rainforest. *Science* 298: 1236–1238.

Magsalay, P., Brooks, T., Dutson, G. & Timmins, R. 1995. Extinction and conservation on Cebu. *Nature* 373: 294.

Mallari, N.A.D., Tabaranza, Jr., B.R. & Crosby, M.J. 2001. *Key Conservation Sites in the Philippines.* Bookmark, Makati City, Philippines.

Margules, C.R. & Pressey, R.L. 2000. Systematic conservation planning. *Nature* 405: 243–253.

Mittermeier, R.A., Robles Gil., P., Mittermeier, C.G., Brooks, T., Hoffmann, M., Konstant, W.R., Fonseca, G.A.B. da & Mast, R.B. 2003. *Wildlife Spectacles.* CEMEX, Mexico.

Mittermeier, R.A., Robles Gil, P., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C.G., Lamoreux, J. & Fonseca, G.A.B. da. 2004. *Hotspots revisited.* CEMEX, Mexico.

Myers, N. 1983. *A Wealth of Wild Species.* Westview, Boulder, USA.

Myers, N. 1988. Threatened biotas: "hotspots" in tropical forests. *The Environmentalist* 8: 1–20.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B. da & Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858.

Novotny, V., Basset, Y., Miller, S.E., Weiblen, G.D., Bremer, B., Cizek, L. & Drozd, P. 2002. Low host specificity of herbivorous insects in a tropical forest. *Nature* 416: 841–844.

Olson, D.M., Dinerstein, E., Wikramanayake, E.D., Burgess, N.D., Powell, G.V.N., Underwood, E.C., D'Amico, J.A., Itoua, I., Strand, H.E., Morrison, J.C., Loucks, C.J., Allnutt, T.F., Ricketts, T.H., Kura, Y., Lamoreux, J.F., Wettengel, W.W., Hedao, P. & Kassem, K.R. 2001. Terrestrial ecoregions of the world: a new map of life on earth. *BioScience* 51: 933–938.

Ong, P.S., Afuang, L.E. & Rosell Ambal, R.G 2002. *Philippine Biodiversity Conservation Priorities: a Second Iteration of the National Biodiversity Strategy and Action Plan.* Department of the Environment and Natural Resources, Quezon City, Philippines.

Peterson, A.T., Ball, L.G. & Brady, K.M. 2000. Distribution of birds of the Philippines: biogeography and conservation priorities. *Bird Conservation International* 10: 149–167.

Pimm, S.L. & Brooks, T.M. 1997. The sixth extinction: how large, how soon, and where? Pp. 46–62 in Raven, P.H. & Williams, T. (eds.) *Nature and Human Society: the Quest for a Sustainable World.* National Academy Press, Washington, D.C., USA.

Pimm, S.L., Russell, G.J., Gittleman, J.L. & Brooks, T.M. 1995. The future of biodiversity. *Science* 269: 347–350.

Reid, W.V. 1992. How many species will there be? Pp. 55–73 in Whitmore, T.C. & Sayer, J.A. (eds.) *Tropical Deforestation and Species Extinction.* Chapman & Hall, London, UK.

Roberts, C.M., McClean, C.J., Veron, J.E.N., Hawkins, J.P., Allen, G.R., McAllister, D.E., Mittermeier, C.G., Schueler, F.W., Spalding, M., Wells, F., Vynne, C. & Werner, T.B. 2002. Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science* 295: 1280–1284.

Stattersfield, A.J., Crosby, M.J., Long, A.J. & Wege, D.C. 1998. *Endemic Bird Areas of the World: Priorities for Biodiversity Conservation.* BirdLife International, Cambridge, UK.

Stuart, S.N., Chanson, J.S., Cox, N.A., Young, B.E., Rodrihuez, A.S.L., Fischman, D.L. and Waller, R.W. 2004. Status and trends of amphibian declines and extinctions worldwide. Science 306:1783-1786.

Vitousek, P.M., Mooney, H.A., Lubchenco, J., & Melillo. J.M. 1997. Human domination of earth's ecosystems. *Science* 277: 494–499.

WSCP. 1997. *Philippine Red Data Book.* Bookmark, Makati City, Philippines.

Wilson, E.O. 1992. *The Diversity of Life.* Belknap Harvard, Boston, USA.