

The State of Tropical Bird Biodiversity

Overview: Tropical areas contain the largest proportion of imperiled bird species. Of 1227 bird species threatened worldwide, 79% occur in lowland and montane tropical forests. Many of the world's most threatened bird species also occur within the tropics. Tropical bird species are endangered by drivers such as habitat loss and degradation, hunting, pollution, invasive species, and disease. These drivers may act singly or in combination. Tropical bird species, especially the threatened ones, remain relatively poorly studied. Poor ornithological knowledge may hinder the design of effective conservation measures for threatened tropical birds. More ornithological research is urgently needed on tropical birds.

Lying between the Tropics of Cancer and Capricorn (i.e. 23.5° north and south of the equator), the tropics harbor two-thirds of the biodiversity in a region that is currently suffering a massive loss of native habitats (Dirzo and Raven 2003). Both mega-rich biodiversity and rapid loss of native habitats have made the tropics of high interest to conservation ornithologists. In this chapter, we highlight the state of tropical bird biodiversity by focusing on threatened bird species in the tropics. We also discuss some of the drivers of bird endangerment and highlight that tropical birds, particularly the threatened ones, need more and urgent scientific attention.

1.1 Imperiled bird biodiversity

The tropical region is at the forefront of bird extinction and endangerment. All three bird species suspected to have gone extinct since 2000 are tropical – Spix's Macaw (*Cyanopsitta spixii*), Hawaiian Crow (*Corvus hawaiiensis*), and Po'ouli

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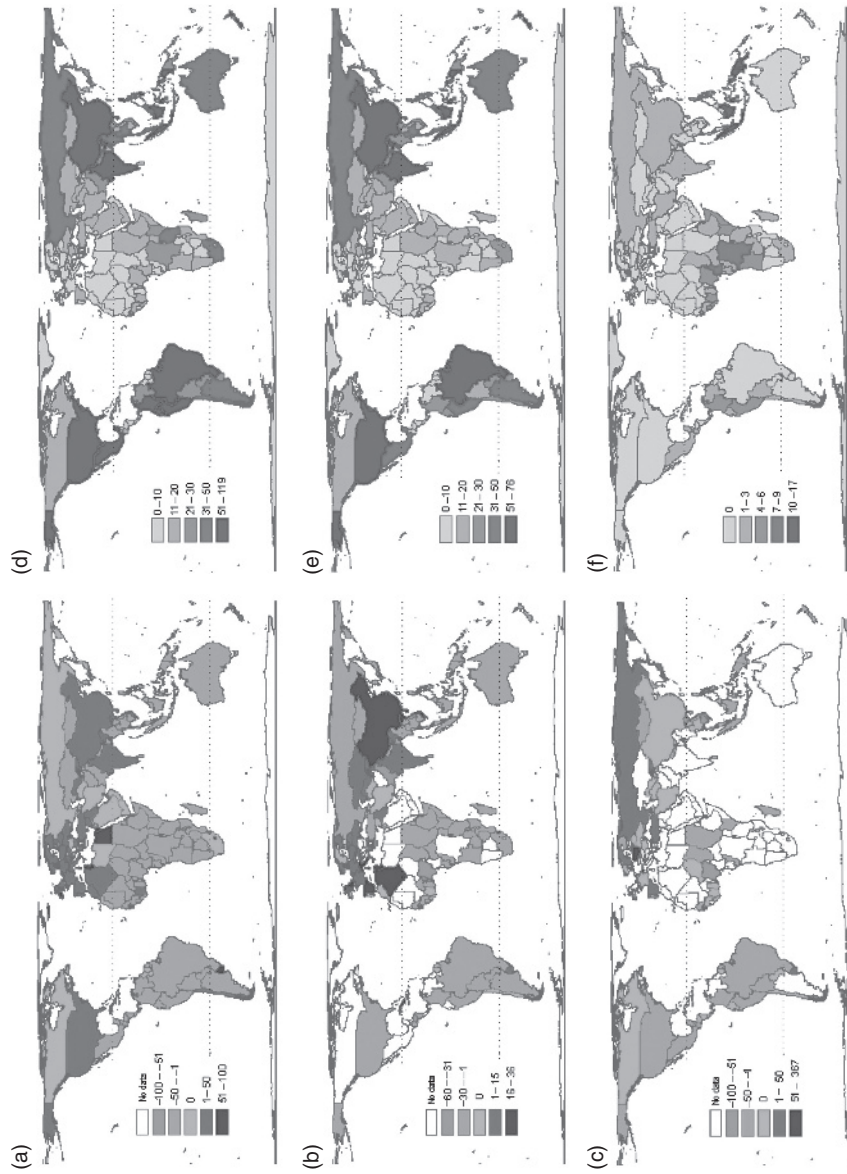


Figure 1.1 Global distribution of average annual forest cover percent change (1990–2005) and richness of threatened and data-deficient terrestrial birds among countries. Data sources for rate of forest cover change and terrestrial birds were obtained from Global Forest Resources Assessment (Food and Agriculture Organization [FAO] 2005) and IUCN Red List of Threatened Species (International Union for the Conservation of Nature and Natural Resources 2007), respectively. Definitions of (a) total, (b) natural, and (c) primary forest areas follow those of FAO (2005). (d) Globally threatened species (i.e. those classified on the IUCN Red List as “critically endangered,” “endangered,” or “vulnerable”). (e) Globally threatened species as defined for (d), but excluding those species listed under the Red List criteria A1c, B1b(iii), and B2b(iii) (i.e. criteria related to decline of the habitat area, in extent, quality, or both). (f) Data-deficient species (i.e. those classified on the Red List as “data-deficient”). Tropical countries are those in which all the land area is situated within ~23.5°N and ~23.5°S (indicated by the dotted lines). (After Sodhi *et al.* 2008.) (Please see Plate 1.1 for the color version of this figure.)

(*Melamposops phaeosoma*) (BirdLife International 2010a; see Chapter 3). Based on the most recent assessment in 2010, 1227 bird species (12.3%) worldwide are threatened with extinction (BirdLife International 2010a). Most of these threatened bird species occur within the tropics (Figure 1.1; Sodhi *et al.* 2008). For example, 79% of all threatened bird species are found in lowland and montane tropical forests (BirdLife International 2010a).

Overall, the endangerment of birds has been increasing steadily since 1988 (Figure 1.2; BirdLife International 2010a). In fact, birds are becoming more dramatically endangered, especially in the Indomalayan region (Figure 1.3; Butchart *et al.* 2004). The primary reason for this is massive habitat loss in this region (Sodhi *et al.* 2004a; see Section 1.2). The cause for concern is that within Indomalaya some areas such as Southeast Asia harbor not only the highest number of endemic species, but also threatened species as well (Figure 1.4; Sodhi *et al.* 2006a). Therefore, if extinctions are to happen in this region, they will represent global rather than population extinctions (see also Chapter 3). Similarly, far more threatened endemic bird species occur in tropical than in non-tropical biodiversity hotspots (Sodhi *et al.* 2007). Biodiversity hotspots are areas that contain 42% of all terrestrial vertebrates on 2% of Earth's land surface, but have lost 70% of their original vegetation due to heavy impact of human activities (Myers *et al.* 2000). Therefore, to prevent global extinctions, these areas should be immediately preserved – there are 34 biodiversity hotspots across the globe (www.biodiversityhotspots.org).

The importance of tropics for conservation is further attested by the fact that four out of five top countries housing the highest number of critically endangered bird species are tropical – Brazil, Indonesia, India, and Philippines (Figure 1.5; BirdLife International 2008a). It is not surprising that many of the world's most threatened bird species (< 60 individuals in the wild) are found in the tropics; for example, Caerulean Paradise-flycatcher (*Eutrichomyias rowleyi*; Indonesia), Bali Starling (*Leucopsar rothschildi*; Indonesia), Puerto Rican Amazon (*Amazona vittata*; Puerto Rico), Sulu Hornbill (*Anthracoceros montani*; Philippines), Tahiti Monarch (*Pomarea nigra*; French Polynesia), and Floreana Mockingbird (*Mimus trifasciatus*; Ecuador) (BirdLife International 2008a).

Birds may not be the most threatened taxonomic group – 32% and 22% of the known amphibian and mammal species are currently threatened with extinction, respectively (www.iucnredlist.org; see Chapter 3). It is unclear however if the number of threatened bird species correlates well with those of other taxonomic groups. At least one other taxonomic group shows congruence with bird endangerment: the proportion of threatened bird and mammal species correlate strongly for tropical countries (Figure 1.6; Kerr and Burkey 2002). Additionally, forests protected just for birds may also adequately protect other groups such as woody plants, moths, butterflies, and small mammals, at least in Uganda (Howard *et al.* 1998). However, there may be regional and site differences in such a complementarity (Moore *et al.* 2003).

Overall, it is clear that the tropics is the most critical region for bird biodiversity and conserving birds, and also for the conservation of other organisms.

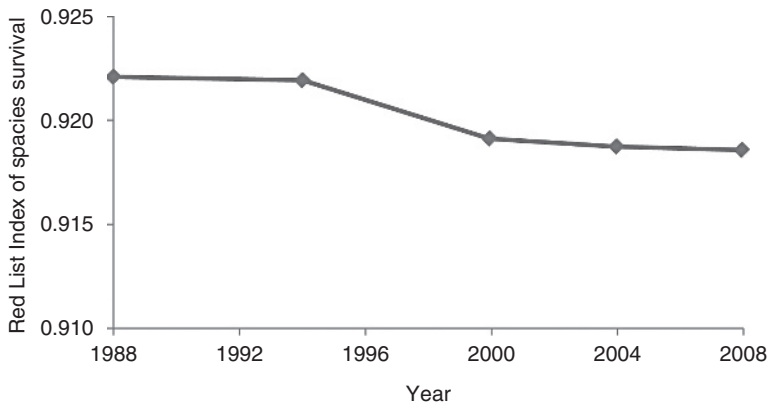


Figure 1.2 Red List Index for the world's birds. Red List Index indicates the change in birds in their threat status. (After www.birdlife.org/action/science/species/global_species_programme/red_list.html)

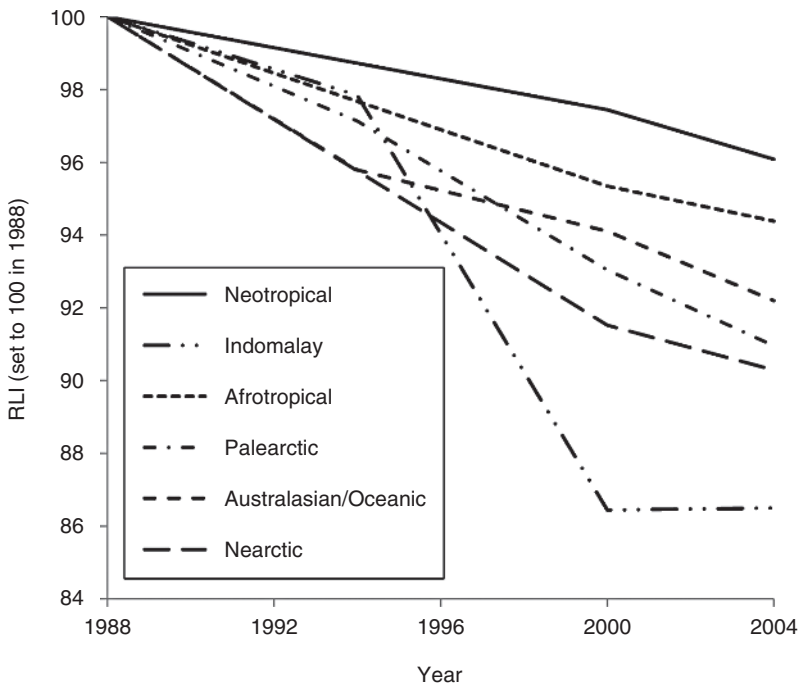


Figure 1.3 Red List Index (RLI) for birds in different biogeographic realms over time. For the definition of RLI see Figure 1.2. (After Butchart *et al.* 2004.)

1.2 Drivers of endangerment

Major causes of bird endangerment include the loss, fragmentation and degradation of native habitats (for 95% of threatened species; see Chapter 3), human use (~71%; see Chapter 7), and invasive species (~33%; see Chapter 6) (Figure 1.7;

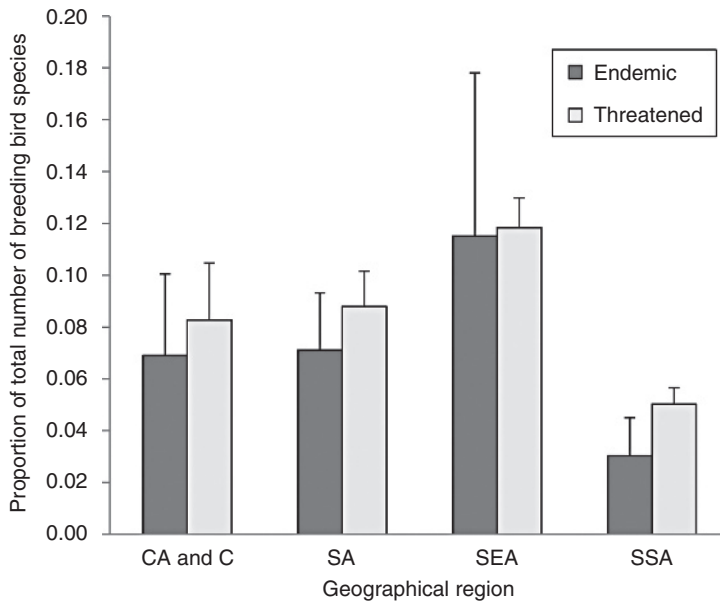


Figure 1.4 Comparison of proportion of total number of breeding bird species that are endemic and threatened among tropical regions. Data on number of breeding, endemic and threatened bird species were obtained from World Resources Institute; threatened status was obtained using IUCN Red Listing criteria. Error bars represent standard errors of mean proportion of total number of breeding bird species that are endemic or threatened. Abbreviations: SEA = Southeast Asia; SSA = Sub-Saharan Africa; CA and C = Central America and Caribbean; SA = South America. (After Sodhi *et al.* 2006a.)

BirdLife International 2008b, 2010a). Additional drivers of bird endangerment include environmental pollution, fire (see Chapter 5), disease (see Chapter 3), climate change (see Chapter 8), and indirect mortality (e.g. drowning of seabirds in longline fisheries). These noxious drivers impact species singly or in combination (Figure 1.8; Brook *et al.* 2008). Here we briefly review some of the drivers of bird decline that will not be detailed in subsequent chapters.

1.2.1 Habitat loss

Deforestation epitomizes habitat loss within the tropical region. Using the United Nations Food and Agricultural Organization's (FAO) data on forest cover change from 1980 to 1990, Laurance (1999) estimated that 15.4 million ha (hectares) of tropical forest is destroyed annually, with an additional 5.6 million ha being degraded through activities such as selective logging. According to the FAO, between 2000 and 2005, Africa and South America lost 4 million ha of tropical forests annually (FAO 2005). During the same period, Southeast Asia was deforested at one of the highest rates of 1% per year (FAO 2005). There is controversy as to whether the FAO values are accurate, as they may fail to include catastrophic events such as the vast 1997–98 forest fires in Indonesia and Amazon, and perhaps erroneously include plantations as forest cover (Achard *et al.* 2002;

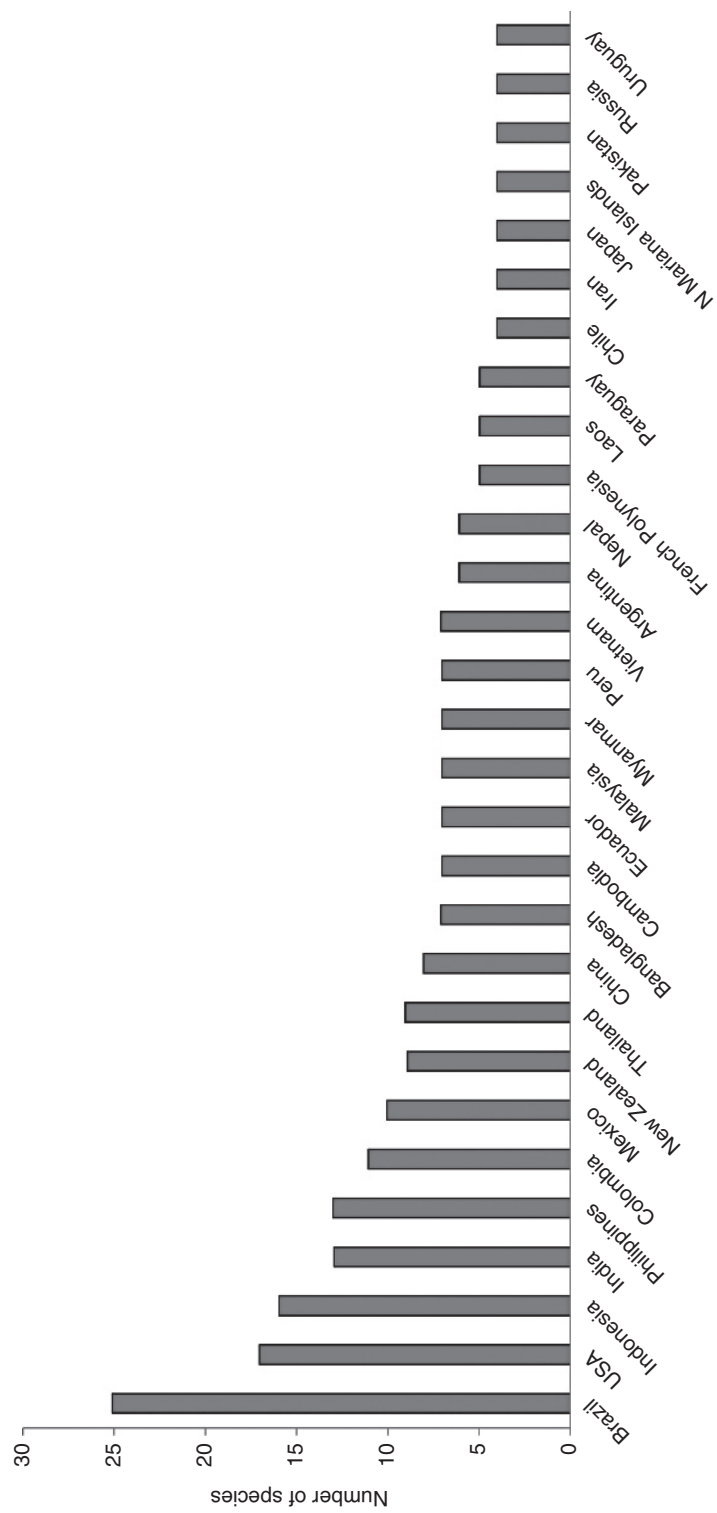


Figure 1.5 Critically endangered bird species in various countries. N = North. (After BirdLife International 2008a.)

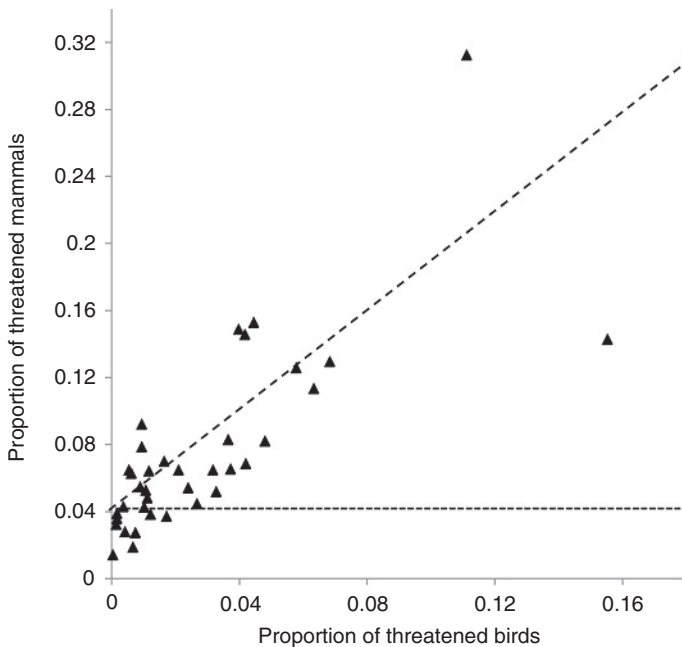


Figure 1.6 Proportions of threatened bird and mammal species per tropical country are strongly correlated. The horizontal dotted line shows the location of the x-intercept, located at 0.04. It indicates that in general 4% of a tropical forested country's mammal fauna is threatened with extinction before any birds. (After Kerr and Burkey 2002.)

Grainger 2008). Deploying remotely sensed satellite imagery, Hansen *et al.* (2008) reported that humid tropical forest loss was 27.2 million ha from 2000 to 2005, with the highest losses in the Americas and Asia (Figure 1.9). The two countries with the highest absolute rate of deforestation were Brazil and Indonesia (Hansen *et al.* 2008). Despite the debate about the exact levels of tropical deforestation, most would agree that the current rate is massive.

Although native forest loss seems to be decelerating over time in tropical Latin America, it continues to accelerate in tropical Asia (Matthews 2001). This trend is corroborated by a satellite imagery study conducted by Hansen and DeFries (2004). Deforestation continues at an alarming rate not only in humid but also in seasonal and montane tropical forests as well (Sodhi *et al.* 2007).

The direct causes of deforestation in rainforests (and loss of other habitats) are numerous, including agricultural expansion, logging, and urbanization. These drivers can act singly, or most likely, synergistically. The ultimate underpinnings of these causes of deforestation are complex, however, involving both socio-political and economic imperatives (Sodhi *et al.* 2004a). Devastating losses are not restricted to the tropical forests – other habitat types in the tropics such as mangroves, swamp forests, dry forests, and savannas face similar predicaments (Sodhi *et al.* 2007). For example, mangroves covered more than 200,000 km² of the tropical and subtropical coastlines, but are now disappearing at the rate of 1–2% annually, and may be soon wiped out from 26 of 120 countries containing

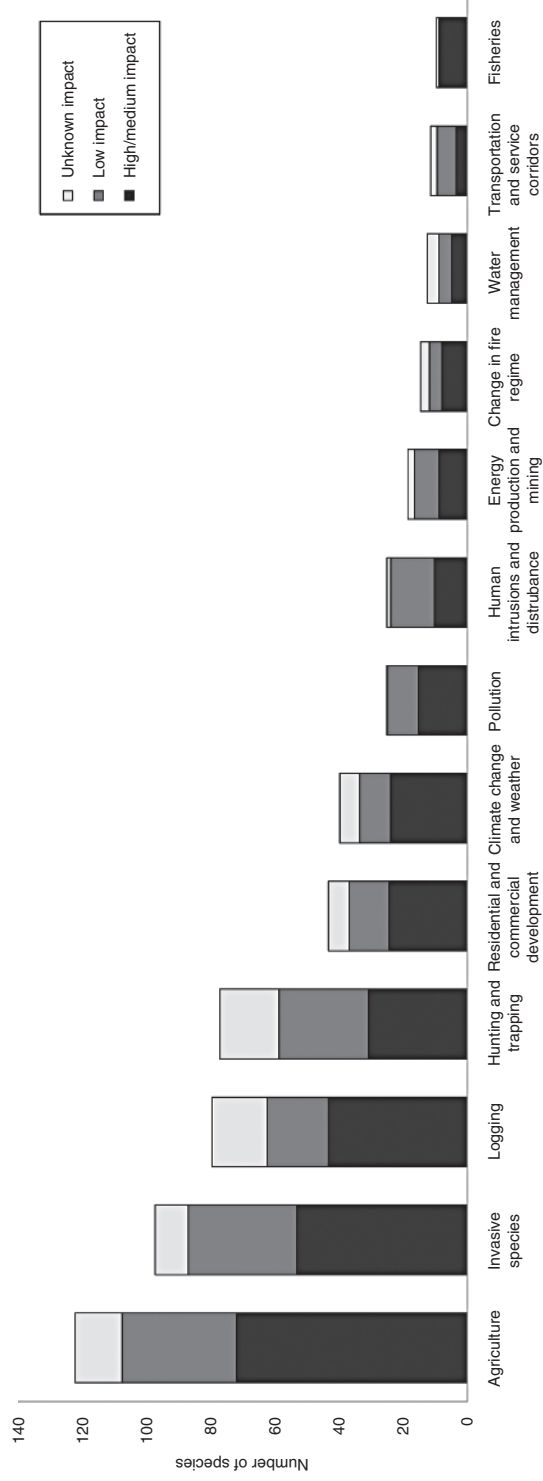


Figure 1.7 The main threats to globally threatened species. (After BirdLife International 2008b.)

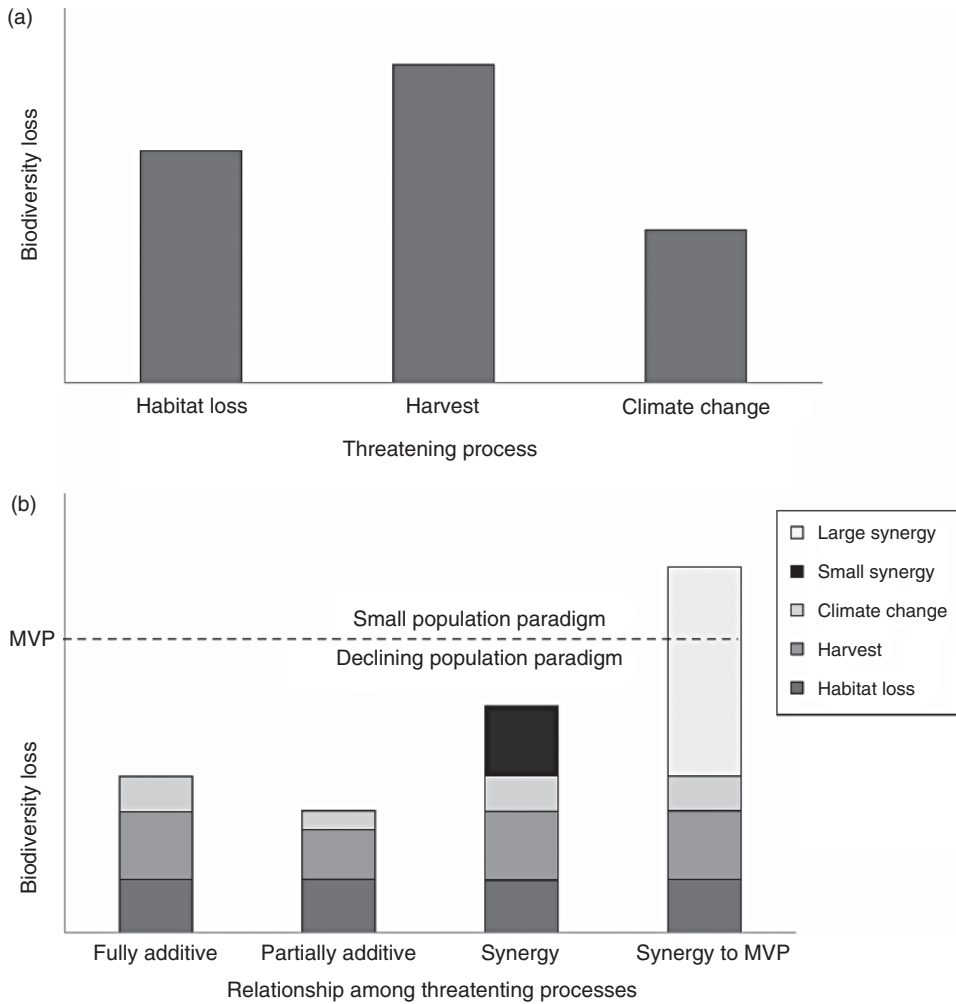


Figure 1.8 Threatening processes can cause biodiversity loss (either through declines in species' abundance or loss of species from communities), and they can act alone or in combination. The schematic shows three examples of threatening processes: habitat loss, harvest, and climate change. (a) Acting singularly, each process has varying negative effects on biodiversity such as a reduction in carrying capacity (habitat loss), direct decline in abundance (harvest), or reduction in range size (climate change). (b) Many systems show multiple threatening processes acting together. A fully additive model predicts that the combined negative effects are simply the sum of each process's individual effects, whereas combinations might result in only partial additivity (e.g. further range restrictions from habitat loss encompass those predicted from climate change). A synergy among processes implies a positive interaction (feedback) whereby the total negative effect on biodiversity is greater than the sum of each threatening process's individual contribution. Small synergistic interactions will result in population decline (i.e. the declining population paradigm); however, only when large synergies occur that push populations below their minimum viable population (MVP) size does extinction risk become non-negligible (i.e. the small population paradigm). (After Brook *et al.* 2008.)

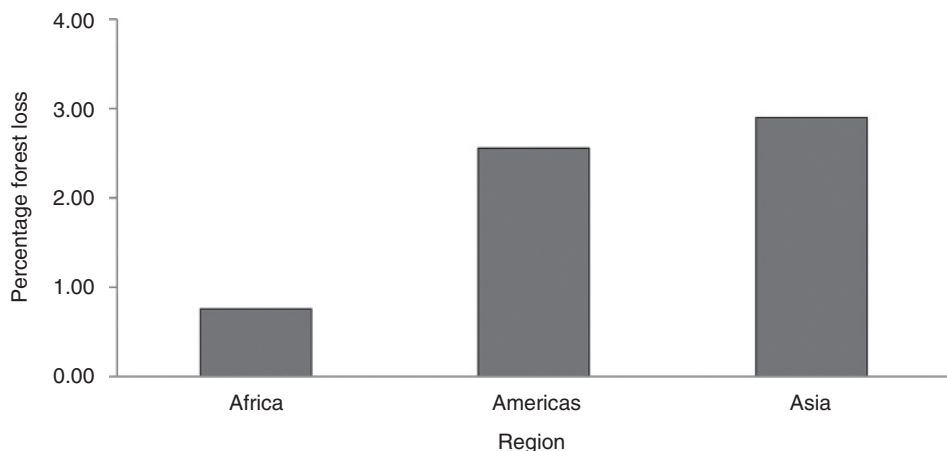


Figure 1.9 The percentage of humid tropical forests cleared in different regions. (Data derived from Hansen *et al.* 2008.)

mangroves (Duke *et al.* 2007). There has been a loss of 3.6 million ha of mangroves since 1980s, with the steepest declines in Asia (Figure 1.10; FAO 2007). Mangroves are important for bird biodiversity, with 48 bird species or subspecies restricted to mangroves (Luther and Greenberg 2009). Of these, five species are currently endangered – Madagascar Teal (*Anas bernieri*; Madagascar), Plain-flanked Rail (*Rallus wetmorei*; Venezuela), Mangrove Hummingbird (*Amazilia boucardi*; Costa Rica), Sapphire-bellied Hummingbird (*Lepidopyga lilliae*; Colombia), and Mangrove Finch (*Camarhynchus heliobates*; Galápagos Islands, Ecuador). Mangroves also provide refuge for bird species such as the Philippine Cockatoo (*Cacatua haematuropygia*) that have lost their primary habitat – inland forests (Luther and Greenberg 2009). Additionally, mangroves are enormously useful to humanity – they are important for carbon sequestration, fisheries, timber, medicines, and protection from storms, tsunamis, and sea-level rise. Therefore, numerous human communities also suffer from the loss of mangroves (Duke *et al.* 2007).

Massive habitat loss and conversion in the tropics has already heavily impacted birds and will continue to do so. Gaston *et al.* (2003) estimated that habitat conversion thus far may have reduced tropical forest bird densities at least by 15% since the pre-agricultural times, approximately 300 years ago (Ellis *et al.* 2010). Because they are apex predators, raptors are thought to be good indicators of the consequences of environmental change (see below). Habitat loss threatens 46% of diurnal tropical raptors, the highest percentage being threatened in the Austral tropics (Figure 1.11; Bildstein *et al.* 1998). The raptor decline may be caused by the high habitat loss in this region, but might also be a result of relatively better biological understanding of raptors there (Bildstein *et al.* 1998). Overall, “ecological health” (estimated as using species richness and demographic variables) of all birds declined by 18% in human-modified habitats compared with pristine forests in Southeast Asia (Sodhi *et al.* 2009b). As mentioned, habitat loss not only harms biodiversity, but also human well-being via the damaged delivery of key

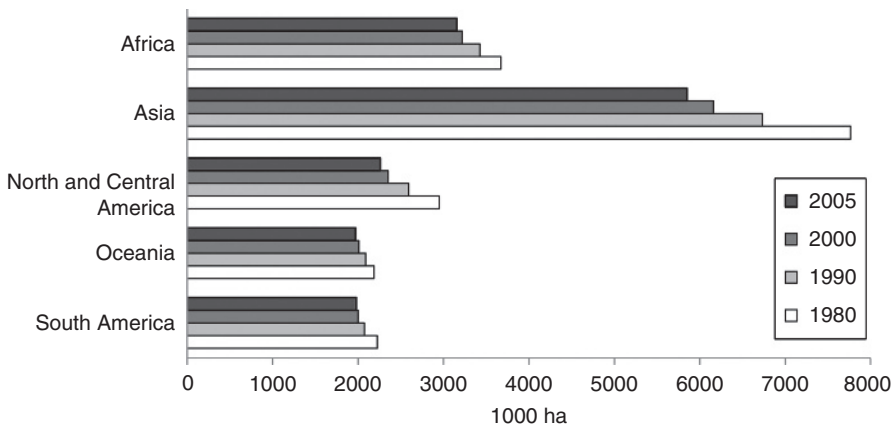


Figure 1.10 Changes in world mangrove area, 1980–2005. (After FAO 2007.)

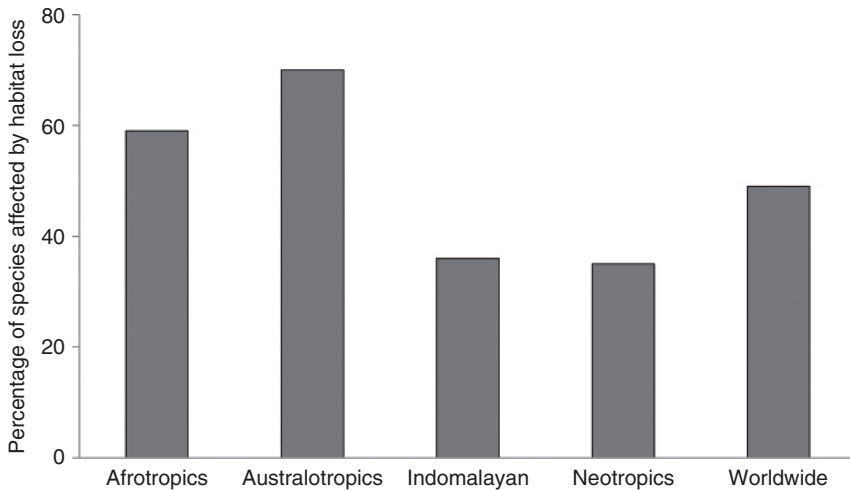


Figure 1.11 The percentage of tropical raptor species affected by habitat loss in different regions. (Data derived from Bildstein *et al.* 1998.)

ecosystem services such as pollination and flood protection (Balmford *et al.* 2002). We will further examine the consequences of habitat loss and degradation on birds in Chapters 2, 3, and 5.

1.2.2 Agricultural expansion and intensification

Agricultural areas remain the most ecologically degraded human-modified habitats (Sodhi *et al.* 2009b). However, a burgeoning human population means more mouths to feed, and agriculture remains the main factor in land conversion in the tropics. It is estimated that agricultural expansion is responsible for as much as 90% of tropical deforestation (Hardtör *et al.* 1997; Achard *et al.* 2002), 55% of which may be at the expense of intact forests (Gibbs *et al.* 2010). Globally, over

the last three decades, croplands have doubled from 50 million ha to 1.4 billion ha (Niesten *et al.* 2004; Smith *et al.* 2010), and they now cover a quarter of Earth's land surface (Millennium Ecosystem Assessment 2005). By 2030, it is predicted that an additional 120 million ha of agricultural land will be needed by developing countries to support their increased populations (Jenkins 2003). Therefore, land clearing for agriculture is almost certain to continue at a rapid pace. In addition, due to factors such as low soil fertility and high levels of erosion, land conditions in many tropical areas are not particularly conducive to sustainable agriculture, thus promoting a cycle of forest destruction (Sodhi *et al.* 2007). Further, increased demands for meat production may increase the grazing by at least 10% by 2050 (Smith *et al.* 2010), further increasing competition for the land.

There are a number of quintessential examples of crop expansion in the tropics. For example, the production of soybean (*Glycine max*) has increased 100-fold since 1961 in Argentina and Brazil largely for import to China (Donald 2004). This has resulted in a severe shrinking of *Cerrado* grasslands (Donald 2004). These grasslands are home to 837 bird species, of which 3% are endemic (Klink and Machado 2005). Similar to soybean expansion, oil palm (*Elaeis guineensis*) cultivation has been expanding in the past few decades in the tropics, particularly in Southeast Asia (Koh and Wilcove 2008). In addition to cooking oil, palm oil is used in soaps, candles, cosmetics, and biodiesel. More than half of oil palm expansion in Malaysia and Indonesia has occurred at the expense of forests (Koh and Wilcove 2008). This expansion reduces the habitat for most forest birds, and studies conducted in Peninsular Malaysia and Thailand report a reduction in forest bird species richness in oil palms (Figure 1.12; Peh *et al.* 2005, 2006; Aratrakorn *et al.* 2006).

For immediate conservation, BirdLife International has identified 218 Endemic Bird Areas (EBAs) that contain the breeding ranges of at least two of 2623 restricted-range species (Stattersfield *et al.* 1998). EBAs cover about 14,500,000 km², mostly in the tropics and subtropics (Stattersfield *et al.* 1998). Since the 1700s, more land for crops and pastures has been used in EBAs than in the other areas (Figure 1.13; Scharlemann *et al.* 2004), suggesting that these regions remain vulnerable to future agricultural development.

Due to the expanding human footprint on the planet, conservation efforts in human-dominated landscapes or “countryside habitats” that encompass the diverse array of active agriculture, plantation or managed forests, fallow land, gardens, and small remnants of native vegetation are also needed (Daily *et al.* 2001; Gardner *et al.* 2009). About 37% of global land, some containing natural habitats, is embedded in countryside landscapes (Ellis *et al.* 2010). Surveys in these landscapes have indicated that they can harbor a substantial proportion of the regional avifauna, forest species included (Estrada *et al.* 1997; Daily *et al.* 2001; Hughes *et al.* 2002; Sodhi *et al.* 2005a; Ranganathan *et al.* 2008; see Chapter 2). For example, production forests (native forests undergoing extraction of non-timber products such as leaf litter) and areca nut plantations (*Areca catechu*; used for chewing purposes) had similar forest bird species richness, second only to intact forests in the Western Ghats (a global biodiversity hotspot) in India (Figure 1.14; Ranganathan *et al.* 2008). However, the value of the different anthropogenic land uses for maintaining bird biodiversity can vary (Peh *et al.*

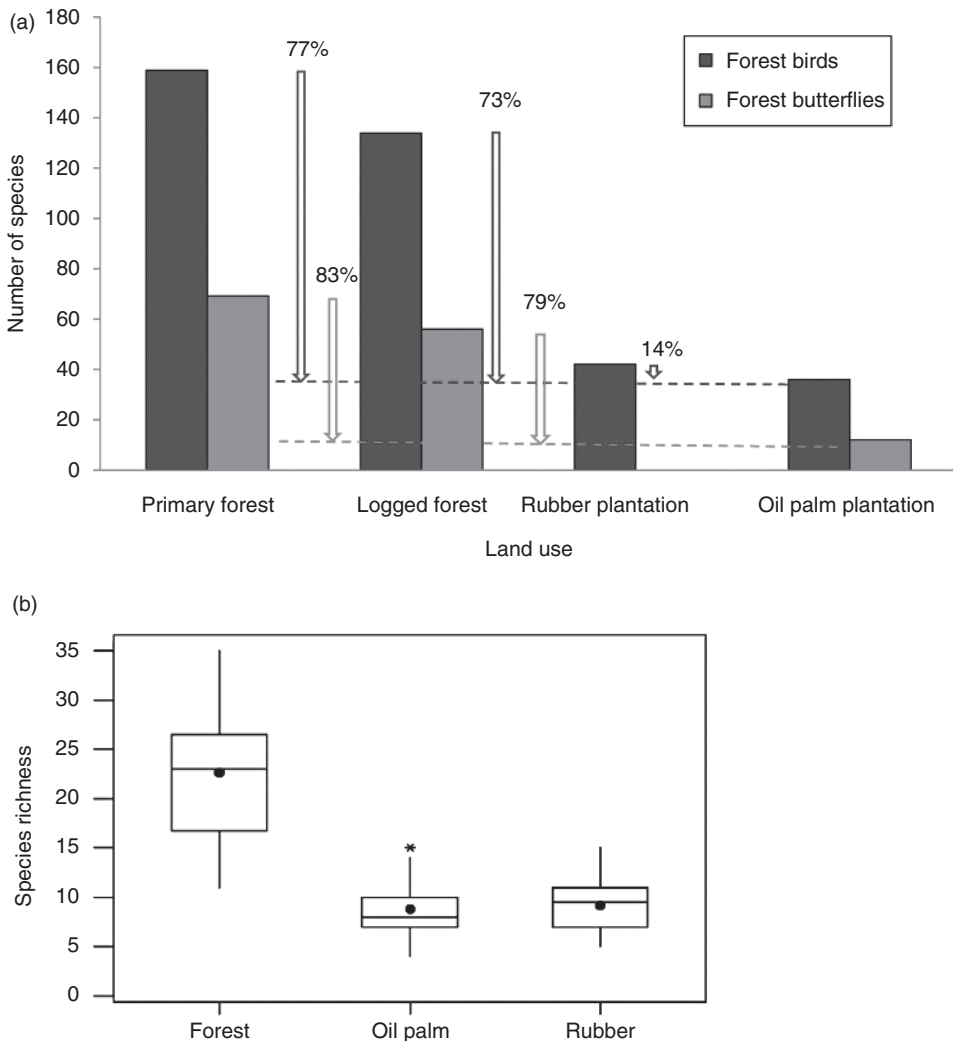


Figure 1.12 (a) Total number of species of forest birds and butterflies recorded from different land-use types in southern Malaysia and Borneo. (After Koh and Wilcove 2008.) (b) Bird species richness in forest, oil palm, and rubber in southern Thailand. The horizontal line shows the median and the box the interquartile range. Vertical lines represent the range of values between the interquartile and 1.5 times the interquartile range. Outlier is represented by asterisk. (After Aratrakorn *et al.* 2006.)

2005; Posa and Sodhi 2006; Soh *et al.* 2006). In some disturbed areas, as much as 80% of canopy cover is need to retain all forest species (Figure 1.15).

Low bird species richness is also observed in intensively managed plantations, especially in monocultures of non-arboreal annual crops (Estrada *et al.* 1997; Matlock *et al.* 2002; Waltert *et al.* 2004). Open country species dominate these habitats, as forest birds may be sensitive to the extreme climatic conditions present. Crops such as coffee, cacao and cardamom support a greater number of

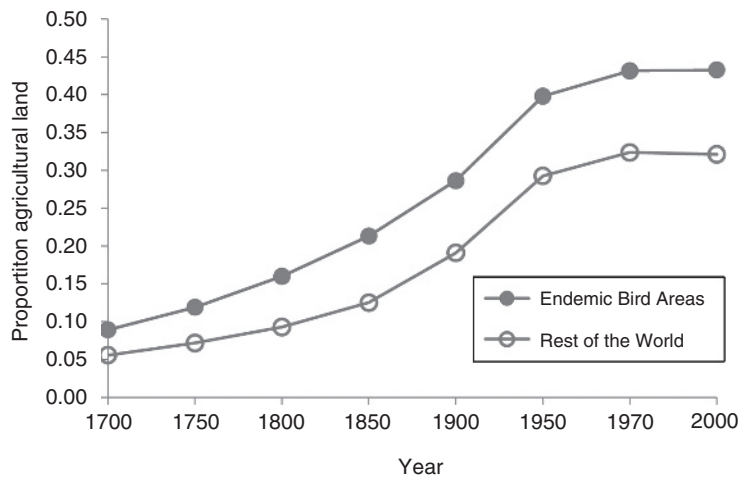


Figure 1.13 Historical changes in the proportion of land under crops and pastures in 139 Endemic Bird Areas and in the rest of the world. (After Scharlemann *et al.* 2004.)

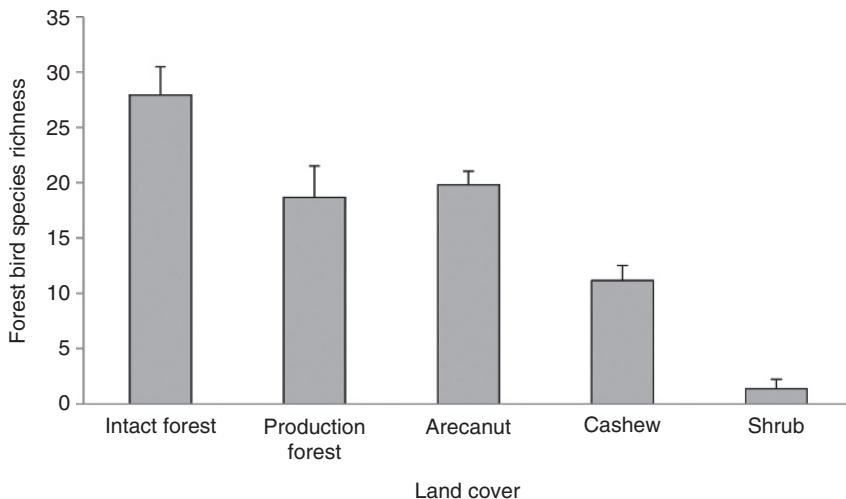


Figure 1.14 Forest bird species richness in each land cover in southwestern India. Error bars represent standard errors. (After Ranganathan *et al.* 2008, copyright National Academy of Sciences, USA.)

forest bird species, particularly if natural vegetation (i.e. “shade cultivation”) is allowed to grow within cropfields (Shahabuddin 1997; Greenberg *et al.* 1997a,b; Estrada *et al.* 1997; Petit *et al.* 1999; but see Waltert *et al.* 2004). Remnant forest trees and riparian strips can be critical for the persistence of forest birds in tropical countryside (Sekercioglu *et al.* 2007; Hawes *et al.* 2008; Lees and Peres 2008a; see Chapter 2). Some primary forest birds can use older plantations of exotic trees that allow secondary growth (Mitra and Sheldon 1993) or traditional agroforests that are diverse and structurally complex (Thiollay 1995). However, species richness and diversity in these are still lower compared to primary forest

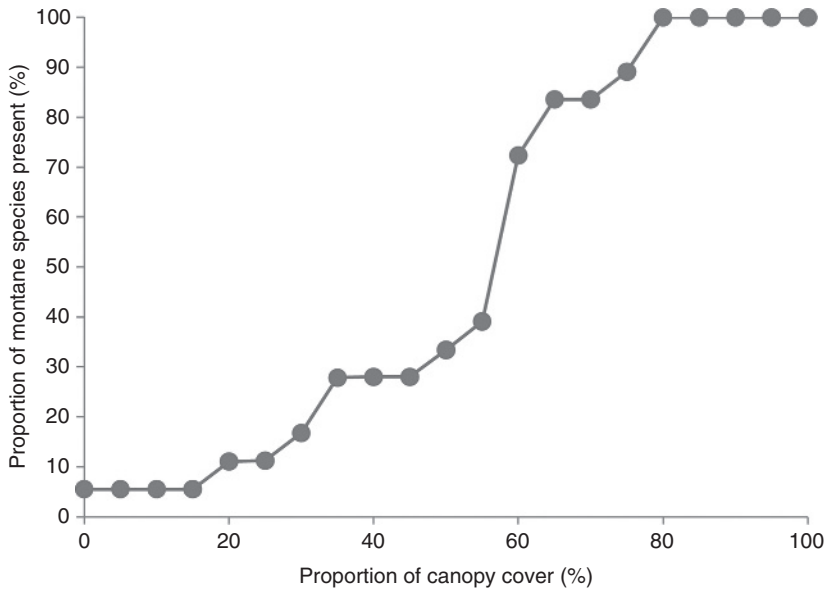


Figure 1.15 Graph showing proportion of montane species present for simulated proportions of canopy cover. (After Soh *et al.* 2006.)

(Tschardtke *et al.* 2008). Successional vegetation resulting from practices such as shifting cultivation (i.e. slash and burn) or from the abandonment of “permanent” agriculture can similarly be colonized by some forest birds. Species richness and abundance has been found to parallel vegetation recovery (Bowman *et al.* 1990, Blankespoor 1991; Andrade and Rubio-Torgler 1994; Raman *et al.* 1998). Secondary forest regrowth from agricultural fallows can contain a significant proportion of forest avifauna, as well as secondary-growth specialists (Blankespoor 1991; Raman *et al.* 1998). However these habitats are still suboptimal for forest-dependent species (Raman 2001), and over 40% of primary forest species birds are not found in biodiversity friendly matrix (areas surrounding remnant forests) habitats such as secondary forests and plantations (Barlow *et al.* 2007, 2010).

While large-scale agriculture and silviculture are generally detrimental to tropical forest birds, traditional systems of shifting agriculture practiced on small scales, with long intervals between burning and recropping, may have minimal impact on bird fauna (Zhijun and Young 2003). Nonetheless, the species richness of large forest frugivores and insectivores generally decline in agricultural areas and agroforests (Figure 1.16; Tschardtke *et al.* 2008). In contrast, nectivorous, granivorous, omnivorous, small insectivorous, and frugivorous species survive and sometimes flourish in such areas probably because of their superior abilities to track seasonal food resources. The sensitivity of insectivorous birds in agroforests may reduce crop yields as they play an important role in pest removal (Koh 2008; Van Bael *et al.* 2008). Therefore, for economic reasons alone, forest remnants should be preserved near or within agroforests (Koh 2008).

The degree of similarity between species assemblages in countryside habitats and pristine forest appear to be dependent on land-use patterns and landscape

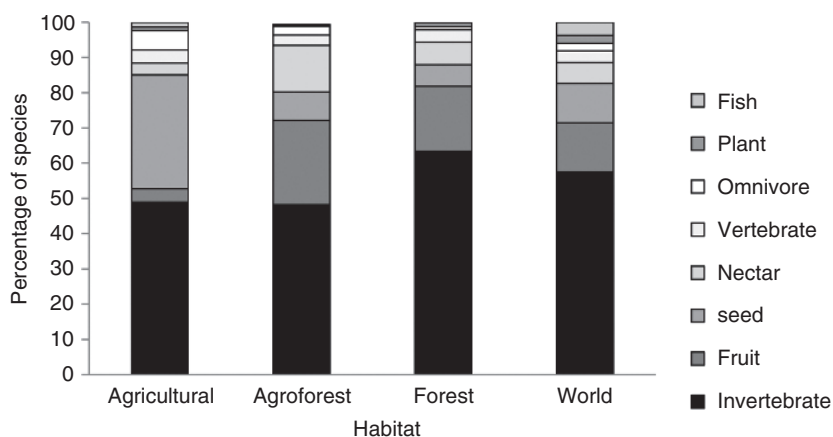


Figure 1.16 Relative bird species richness (percentage of all bird species) per habitat type based on primary diet, which is a proxy for ecological function. (After Tschardt *et al.* 2008.)

context (Luck and Daily 2003). Pesticides adversely affect insectivores, as does the lack of leaf litter and low vegetational diversity in agricultural areas (Shahabuddin 1997), but these birds appear to benefit from insect pests in timber plantations (Mittra and Sheldon 1993). Although large frugivores generally do not benefit from the dominating crop trees of agroforests and are absent from plantations in some areas (Thiollay 1995; Shahabuddin 1997; Barlow *et al.* 2007), they have been observed in other mixed-rural habitats (Sodhi *et al.* 2005a). However, such an occurrence may be due to the close proximity of pristine forests to study areas (Figure 1.17; Barlow *et al.* 2007; Tschardt *et al.* 2008). Overall, agricultural expansion remains a threat to tropical birds and better management of these areas is certainly needed to ameliorate this threat.

1.2.3 Selective logging

As mentioned, forests are being selective logging in many tropical countries. In selectively logged areas, forests are usually allowed to regenerate in gaps created by timber harvests, resulting in a forest structure with a mix of tree sizes and ages. Some species vacate an area when logging begins but return to it after it has been logged, but this pattern is not universal (Thiollay 1992; Dranzoa 1998). Studies indicate that many tropical forest species continue to survive in, or use, selectively logged forest. Studies from Borneo show up to 17% decline in bird species richness in logged compared to unlogged forests (Figure 1.18; Lambert 1992; Edwards *et al.* 2009; Berry *et al.* 2010). Some avian communities remain distinct from the original for periods of up to 10–15 years (Johns 1996; Thiollay 1997a, 1999). Logging can also result in significant changes in the relative abundance and composition of the avifauna, with an increase of widespread generalists or forest-edge species, compared with pristine forests (Johns 1996; Thiollay 1997a; Dranzoa 1998; Aleixo 1999). The influx of these types of species can sometimes results in high avian richness in logged areas.

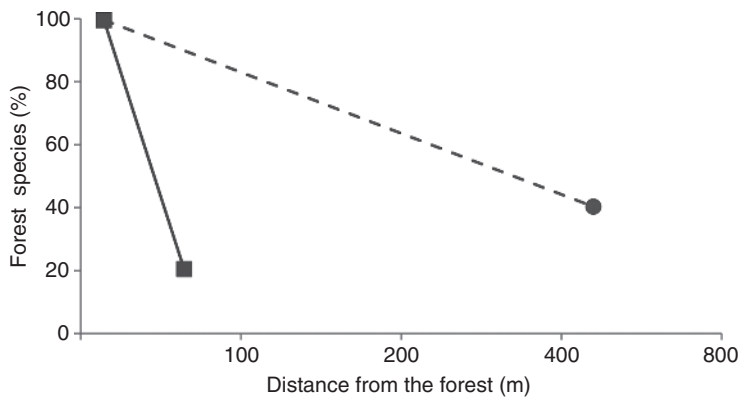


Figure 1.17 The percentage of forest species in agricultural areas decreases with increased distance from a nearby forest. (After Tschardt *et al.* 2008.)

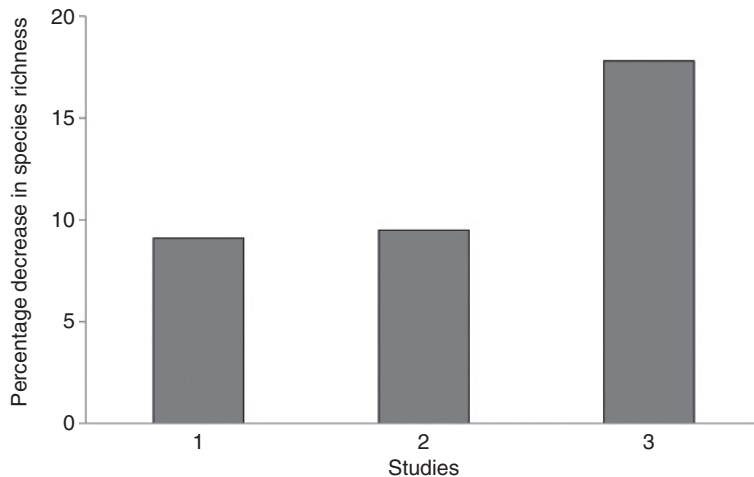


Figure 1.18 Species richness decline in selectively logged forests when compared with unlogged forests in Borneo. Figures based on three studies that are cited in the text. (Data derived from Berry *et al.* 2010.)

Selective logging affects various avian guilds differently. Some understory insectivores, as well as mixed-species flock members, are intolerant of the changes in microclimate and vegetation that occur after logging, because of their physiology and foraging-habitat specializations (Johns 1986; Mason 1996; Dranzoa 1998; Marsden 1998; Thiollay 1999). Guilds such as bark-associated insectivores and large-canopy frugivores (e.g. hornbills) also decline after large trees are lost (Johns 1989; Cleary *et al.* 2007). However, some studies report that nectarivores, generalist frugivores, omnivores, and gap or edge specialists seem to benefit from logging-related changes in vegetation (Lambert 1992; Owunji and Plumptre 1998; Dranzoa 1998; Thiollay 1999). There is little evidence that logging disproportionately threatens rare species or those with restricted ranges (Thiollay 1997b; Marsden 1998). However, the richness and abundance of

threatened bird species can be lower in logged than in unlogged forests (Edwards *et al.* 2010).

Many logging concessions are in proximity to primary forests from which birds can disperse, which may account for the minimal species loss and occurrence of some forest-dependent species in logged areas. For instance, when contiguous with unlogged forests, 75% of forest birds can persist even in forests that are repeatedly logged (Edwards *et al.* 2010). The magnitude of impact of logging on the avifauna can also depend on the management regime adopted by timber companies (Frumhoff 1995; Mason 1996; Sekercioglu 2002a). If harvest regimes do not either allow logged forests to regenerate or isolate them from unlogged areas, bird communities are unlikely to fully recover. However, one of the serious consequences of logging is increased access through roads, which can elevate hunting and further forest clearance (Laurance *et al.* 2009).

1.2.4 Infrastructure development and urbanization

Cities are expanding worldwide, with expectations that more than half of the world's total human population will be living in them by 2030 (Palmer *et al.* 2004). It is postulated that 70% of Earth's land surface will be impacted by infrastructure development in the next 30 years (UNEP 2002). Some regions are likely to be more affected than others, with more than 75% of all land area affected by such developments in the Caribbean and Asia-Pacific (UNEP 2002).

Many threatened bird species are projected to be negatively impacted by infrastructure development in the Asia-Pacific region (Figure 1.19). Unlike other land-uses, it is difficult, if not impossible, for vegetation to recover via natural succession in urban areas. Thus, impacts on biodiversity are likely to be long term (Pautasso *et al.* 2010). Urbanization increases biological homogenization, causing the extirpation of native species and promoting the establishment of non-native, urban-adaptable species that are becoming increasingly widespread and locally abundant across the planet (McKinney 2006). There is a near-complete absence of forest species in many tropical urban areas with human commensals such as Rock Doves (*Columba livia*) and House Crows (*Corvus splendens*) flourishing (Sodhi *et al.* 1999; Lim and Sodhi 2004; Pauchard *et al.* 2006; Posa and Sodhi 2006). However, some frugivorous species that can feed on fruit-bearing ornamental plants are able to persist in city parks and low-density housing areas (Petit *et al.* 1999; Lim and Sodhi 2004; Posa and Sodhi 2006). The presence of remnant forests may be the most important determinant of forest bird diversity in tropical cities (Sodhi *et al.* 1999; Lim and Sodhi 2004). Therefore, it is unfortunate that cities in developing tropical countries typically do not maintain natural forests in the urban environment (Pauchard *et al.* 2006; Posa and Sodhi 2006). Our understanding of the effects of urbanization in regions of high avian diversity, such as the tropics, is still rudimentary (Chace and Walsh 2006), and measures for urban conservation will be crucial in the coming decades as urban sprawl is set to replace native and rural habitats.

Infrastructure does not need be massive to affect birds. Linear infrastructure such as roads, power lines, gas and oil pipelines are common features of human

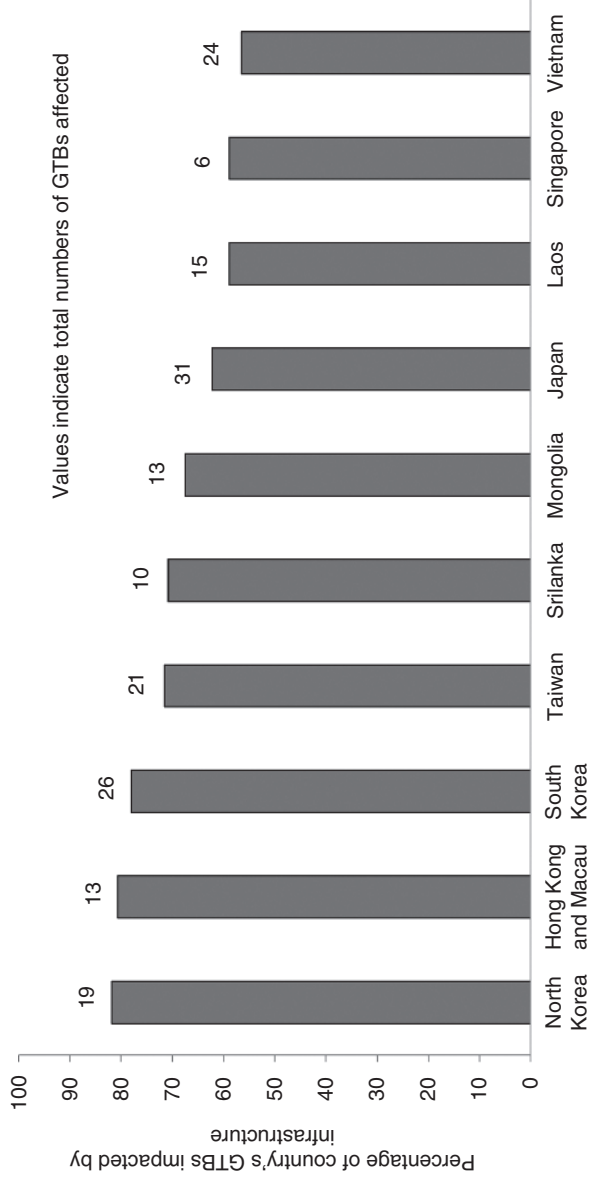


Figure 1.19 The ten countries in Asia with the highest percentage of their GTBs (Globally Threatened Birds) impacted by infrastructure development. (After http://www.birdlife.org/action/science/sowb/case_studies/p38-39.pdf)



Figure 1.20 Road-killed vulture in Panama. (After Laurance *et al.* 2009.)

activity. These are becoming ubiquitous in many tropical areas due to logging, mining, agriculture, and oil and gas development activities (Laurance *et al.* 2009). Tropical bird species become susceptible to hunting, road kill, elevated predation and invasions near these linear disturbances. Slower-flying bird species, and those whose activities coincide with heavy traffic (e.g. crepuscular species), remain vulnerable while crossing roads (Figure 1.20; Laurance *et al.* 2009). Movements of forest-dependent insectivorous bird species (e.g. those following army-ants or formed mixed-species flocks) were interrupted by road clearing in Amazon (Laurance *et al.* 2004). Generally, species avoiding the forest edges also avoided the road clearings.

In addition to linear infrastructure, hydroelectric projects also threaten terrestrial and aquatic tropical birds. Increasing energy prices and shrinking stocks of oil will facilitate more dams, and it is likely that large dams will eventually affect almost all major tropical rivers (Junk 2002). Dams lead to: (i) deforestation, especially of highly productive floodplain habitats and the loss of disturbance-dependent species of river edges; (ii) reduction in aquatic biodiversity; (iii) degradation of downstream habitats such as forests, estuaries, and deltas; and (iv) reduction in water quantity and quality (Junk 2002; www.birdlife.org/action/science/sowb/case_studies/p38-39.pdf). In Asia, existing or planned dam projects

will endanger threatened bird species such as Masked Finfoot (*Heliopais personata*) and Indian Skimmer (*Rynchops albicollis*) (www.birdlife.org/action/science/sowb/case_studies/p38-39.pdf).

1.2.5 Environmental pollution

Pollution remains a threat to about 9% of globally threatened bird species, mainly by causing either elevated mortality or reduced reproductive success (BirdLife International 2008b). However, effluents released through agriculture, forestry, and industry further degrades habitats of 11% of globally threatened species (BirdLife International 2008b). Tropical ecotoxicology is still in its infancy and thus impacts of pesticides on tropical biotas are poorly understood (Lacher and Goldstein 1997). Nonetheless, fertilizers and pesticides (i.e. herbicides, insecticides, and fungicides) used in agricultural areas adjacent to tropical forests can take a toll on tropical forest biotas. Because chemicals tend to accumulate up the food chain, top predators are likely to be the most affected by toxic substances used in pesticides and fertilizers. For instance, severe reduction in the range of Mauritius Kestrels (*Falco punctatus*) in the 1970s may have been brought about due to heavy DDT (dichlorodiphenyltrichloroethane; an organochlorine) usage on the island to control malaria-spreading mosquitoes (Safford and Jones 1997). Raptors have been among the most prominent victims of organochlorine insecticide use because they are at the top of their food web and accumulate organochlorines through the food chain.

Environmental pollutants, for example, have been implicated in the dramatic declines of the breeding populations of various raptors in the 1970s and 1980s in North America and Europe. Impacted species included the Peregrine Falcon (*F. peregrinus*), Bald Eagle (*Haliaeetus leucocephalus*), Golden Eagle (*Aquila chrysaetos*), and Osprey (*Pandion haliaetus*) (Wiemeyer *et al.* 1984, 1988; Ratcliffe 1993; Nygård and Gjershaug 2004). These species were exposed to a “cocktail” of organochlorines that included DDT, aldrin, dieldrin, and heptachlor, as well as PCBs (polychlorinated biphenyls; non-insecticides with many uses, such as coolant) (Fry 1995). Negative effects included severe declines in reproductive success (Newton 1979). Reproductive success was compromised because of the production of thin egg-shells, which could break under the weight of an incubating parent (Newton 1979). These effects were exacerbated by high embryo and nesting mortality. Declining reproductive success eventually resulted in epic population declines in some raptors in Europe and North America (Newton 1979). DDT was banned in various countries in the 1970s and 1980s but it is still being used for malaria control in tropical countries such as India (www.who.int/malaria/en/). Since the ban of DDT in North America, populations of many raptors have recovered, aided by aggressive captive breeding and release programs, such as the one for Peregrine Falcons (Ratcliffe 1993).

In most countries, DDT and related organochlorine insecticides have been usually replaced by organophosphate and carbamate chemicals. However, sadly these chemicals also remain a threat to birds. In 1995, 700 Swainson’s Hawks (*Buteo swainsoni*) perished in Argentina, presumably because of an insecticide

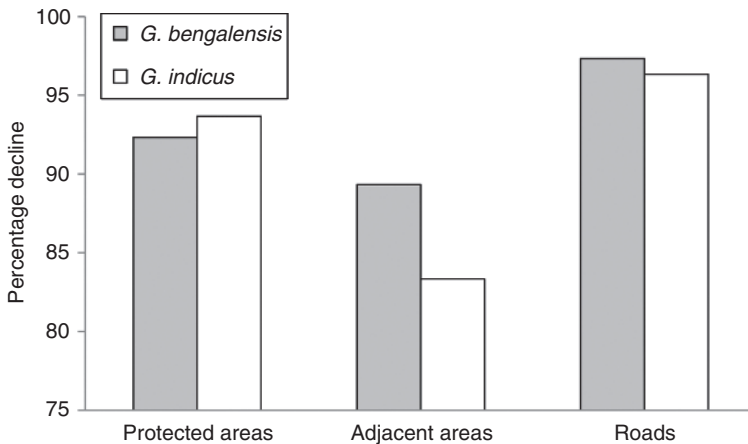


Figure 1.21 The percentage of decline in the number of two vulture species in India. Declines are based on surveys conducted in 1991–1993 and 2000. (Data derived from Prakash *et al.* 2003.)

(organophosphate monocrotophos) extensively used to eliminate grasshoppers (Woodbridge *et al.* 1995). As a result of pesticide-mediated mortality in wintering grounds, Swainson's Hawks have been suffering population declines in parts of its breeding range in North America (Sarasola *et al.* 2008). As in northern areas, raptors such as Grey Falcon (*F. hypoleucos*) and Eastern Grass-owl (*Tyto longimembris*) in tropical Australia (Mooney 1998) remain vulnerable to pesticides. Environmental contaminants threaten 11% of diurnal tropical raptors, with the highest risk in the Austral tropics (Figure 1.11; Bildstein *et al.* 1998). Raptors in other tropical regions also remain susceptible. For example, fenthion used to eradicate Red-billed Quelea (*Quelea quelea*) causes the mortality of raptors when they feed on treated individuals (Keith and Bruggers 1998).

The quintessential example of the effects of environmental contaminants on birds comes from tropical vultures. Since 1990s, there has been over 92% decline in vulture populations in India (Figure 1.21; Prakash *et al.* 2003). Veterinary use of the anti-inflammatory drug diclofenac appears to be behind these declines (Oaks *et al.* 2004; Green *et al.* 2006). Vultures are likely exposed to diclofenac when they feed on the carcasses of livestock that were treated with this drug. Diclofenac residues in vultures result in renal failure and visceral gout (build up of uric acid in internal organs) (Oaks *et al.* 2004). Possibly because of diclofenac-related effects, breeding populations of the White-backed Vulture (*Gyps bengalensis*) have been obliterated from the Keoladeo National Park (India) (Figure 1.22; Prakash *et al.* 2003). To reverse the decline of vultures, the Indian government banned diclofenac in 2006 (www.birdlife.org/news/news/2006/05/vulture_update.html). Pharmaceutical companies in the Indian subcontinent are now promoting meloxicam as an alternative to diclofenac, which is considered to be safe for vultures (Swarup *et al.* 2007). However, it is unclear if measures taken have reversed the vulture declines.

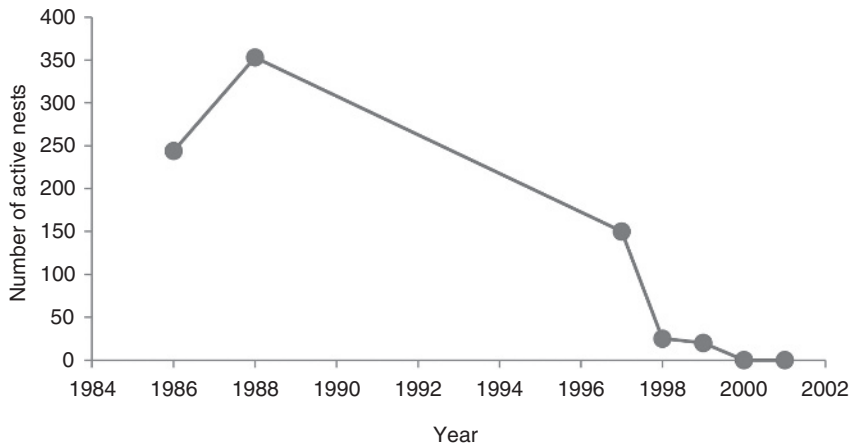


Figure 1.22 The decline in the number of active nests of the White-backed Vulture at Keoladeo National Park (India). (Data derived from Prakash *et al.* 2003.)

Noxious chemicals used by humanity also wash into local waterways, affecting aquatic birds (Junk 2002). Despite the negative effects of pesticides, their exports to tropical countries have been steadily increasing. For example, in 2006, US\$73–100 million worth of these chemicals were exported to these countries (www.fao-statistics.org). International pesticide companies facilitate pesticide use in tropical developing countries by selling cheap pesticides with expired patents (Wanger *et al.* 2010).

1.2.6 Other drivers that threaten tropical birds

In addition to the drivers described above, and those that will be discussed in the following chapters, tropical birds remain vulnerable to factors such as drought, hurricanes, and longline fisheries. Fisheries bycatch remains a formidable threat to tropical birds: an estimated 200,000 birds perish annually in fishing nets (Zydels *et al.* 2009). Long-lived seabirds such as albatrosses remain particularly vulnerable to mortality through fishing nets because the chances of population recovery are low due to delayed and slow reproduction (Veran *et al.* 2007). For example, annual adult survival of the Galapagos Waved Albatross (*Phoebastria irrorata*) declined between 1999 and 2005, likely due to high mortality caused by fisheries (Awkerman *et al.* 2006). It is now endangered with extinction (BirdLife International 2010a). Significant longline fishing operations are currently being conducted in tropical waters (see Huang 2009), so the fishing industry should be required to devise and employ seabird avoidance methods. Tori lines (streamer lines) and establishing protected areas near seabird colonies may be effective measures to reduce seabird mortality through fisheries (Gilman *et al.* 2005; Mancini *et al.* 2009). In addition to fisheries, tropical seabirds remain susceptible to oil-spills (Gonzalez-Solis *et al.* 2007).

Other disasters such as hurricanes, cyclones, and typhoons can also be catastrophic for tropical birds. Soon after a hurricane, there can be heavy mortality

of forest birds (Will 1991). Nectivorous and frugivorous bird species (e.g. toucans, tinamous, parrots, and hummingbirds) seem to be severely impacted by hurricanes (Lynch 1991; Tanner *et al.* 1991; Wunderle 1991), probably because of factors such as lack of fruits and flowers in hurricane-damaged forests (Askins and Ewert 1991). However, generalist foragers usually become more numerous in hurricane-damaged forests (Tejeda-Cruz and Sutherland 2005). Migratory birds also remain vulnerable to hurricanes. Two neotropical migrant species, the Black-and-white Warbler (*Mniotilta varia*) and Northern Parula (*Parula americana*), had lower numbers on St John (US Virgin Islands) four months after than in the two years before Hurricane Hugo (Askins and Ewert 1991). Even two years after the hurricane, hurricane-damaged forests lack typical lowland rainforest birds such as woodcreepers, forest antbirds, and furnaiids (ovenbirds) (Will 1991). Therefore, hurricane-damaged forests may require active management (e.g. reforestation) to attract and retain forest bird species.

1.3 The enigmatic

Ornithological knowledge in the tropics remains limited. In every tropical region, birds remain poorly studied compared to non-tropical birds (Figure 1.23; Sodhi *et al.* 2007). This is attested by the fact that there are high numbers of

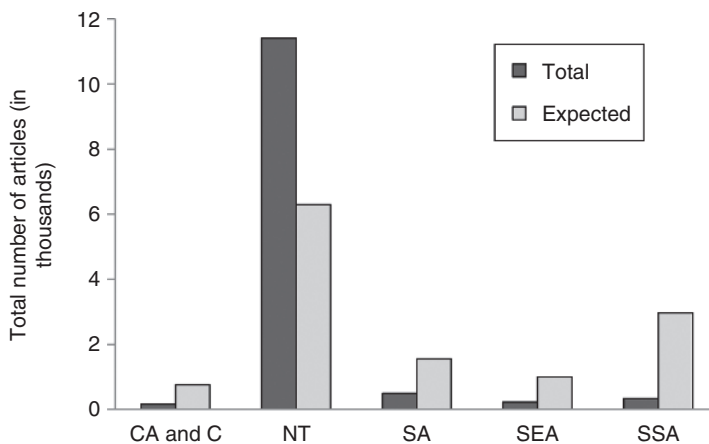


Figure 1.23 Total number of published (dark bars) and expected (light bars) articles on biodiversity-related issues of birds among tropical regions and non-tropical regions. All comparisons were based on the number of internationally peer reviewed research articles (excluding marine studies) published between 1986 and 2005 extracted from the database BIOSIS Previews. For each taxonomic group, the expected number of publications for each geographical region was calculated by dividing the number of publications evenly among geographical regions, weighted by the total number of recorded species per region for that particular taxonomic group. Abbreviations: SEA = Southeast Asia; SSA = Sub-Saharan Africa; SA = South America; CA and C = Central America and Caribbean; NT = non-tropical regions.

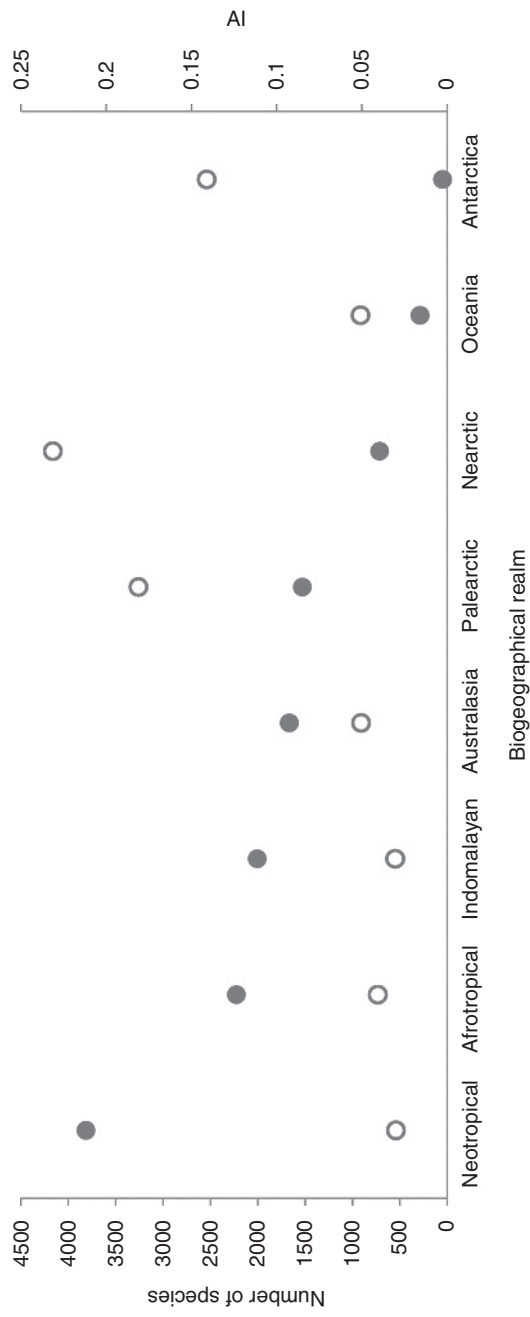


Figure 1.24 Biogeographical attention index (open dots) and total number of bird species (filled dots) for each biogeographical realm. AI = attention index was obtained by dividing the number of papers by the number of species. (After Brito and Oprea 2009.)

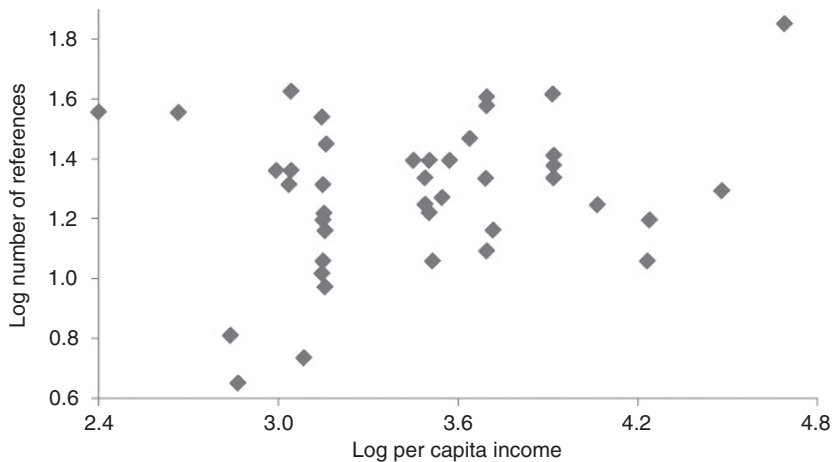


Figure 1.25 The relationship between numbers of references for a random sample of 50 threatened bird species and per capita income in their range countries. (After Brooks *et al.* 2008.)

data-deficient birds in the tropics than other regions (Figure 1.1; Sodhi *et al.* 2008). Despite higher species richness and endangerment in tropical areas, the highest number of conservation-related scientific articles on birds comes from the Nearctic and Palearctic regions (Figure 1.24; Brito and Oprea 2009). Lack of adequate research funds and personnel may hinder research in the tropics. In fact, more studies on threatened bird species are conducted in richer than in poorer countries (Figure 1.25; Brooks *et al.* 2008), suggesting that there is a greater need to develop ornithological research in poor developing tropical countries. It is disconcerting that 600 threatened bird species do not have a single scientific article published on their biology (Brooks *et al.* 2008). Another problem is that the academic establishment tends to value and fund global meta-analyses and modeling papers based on existing data more than field-based papers on the biology of individual species, which results in a disincentive for young scientists to do long-term field research under difficult conditions. Patently, more research on tropical birds, especially the threatened species, is urgently needed.