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Evaluating the Success of Conservation Actions in Safeguarding Tropical Forest Biodiversity

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Abstract: *We reviewed the evidence on the extent and efficacy of conservation of tropical forest biodiversity for each of the classes of conservation action defined by the new International Union for Conservation of Nature (IUCN) classification. Protected areas are the most tested conservation approach, and a number of studies show they are generally effective in slowing deforestation. There is some documentation of the extent of sustainable timber management in tropical forest, but little information on other landscape-conservation tactics. The extent and effectiveness of ex situ species conservation is quite well known. Forty-one tropical-forest species now survive only in captivity. Other single-species conservation actions are not as well documented. The potential of policy mechanisms, such as international conventions and provision of funds, to slow extinctions in tropical forests is considerable, but the effects of policy are difficult to measure. Finally, interventions to promote tropical conservation by supporting education and livelihoods, providing incentives, and furthering capacity building are all thought to be important, but their extent and effectiveness remain poorly known. For birds, the best studied taxon, the sum of such conservation actions has averted one-fifth of the extinctions that would otherwise have occurred over the last century. Clearly, tropical forest conservation works, but more is needed, as is critical assessment of what works in what circumstances, if mass extinction is to be averted.*

Keywords: conservation actions, extinction rates, landscape conservation, protected areas, species management, tropical forests

Evaluación del Éxito de Acciones de Conservación para Salvaguardar la Biodiversidad de Bosques Tropicales

Resumen: *Revisamos la evidencia de la extensión y eficacia de la conservación de la biodiversidad de bosques tropicales para cada una de las clases de acciones de conservación definidas por la nueva clasificación de la UICN (Unión Internacional para la Conservación de la Naturaleza). Las áreas protegidas son la estrategia de conservación más probada, y un número de estudios muestra que son generalmente efectivas para aminorar la deforestación. Hay alguna documentación sobre la extensión del manejo sustentable de madera en los bosques tropicales, pero la información sobre otras tácticas de conservación del paisaje es escasa. La extensión y efectividad de la conservación de especies ex situ es bastante bien conocida. Actualmente, cuarenta y un especies de bosques tropicales solo sobreviven en cautiverio. Otras acciones de conservación de especies individuales están tan bien documentadas. El potencial de los mecanismos políticos, como las convenciones internacionales y la donación de fondos, para aminorar las extinciones en los bosques tropicales es considerable, pero los efectos de las políticas son difíciles de medir. Finalmente, se piensa que las intervenciones para promover la conservación tropical mediante el soporte a la educación y a los medios de vida, el establecimiento de incentivos y la promoción de la capacitación son importantes, pero su extensión y efectividad permanecen poco conocidas. Para aves, el taxón más estudiado, la suma de tales acciones de conservación ha evitado la quinta parte de las extinciones que hubiesen ocurrido en último siglo. Claramente, la conservación de bosques tropicales funciona, pero se requiere más, así como una evaluación crítica de qué funciona bajo qué circunstancias, se quiere impedir una extinción masiva.*

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Palabras Clave: acciones de conservación, áreas protegidas, bosques tropicales, conservación del paisaje, manejo de especies, tasas de extinción

Introduction

Human activities have accelerated natural background extinction rates by as much as three orders of magnitude (Pimm et al. 1995). Nevertheless, the geographic extent, mechanisms, trends, and errors around the actual rates remain poorly known. Among the key uncertainties is the contribution that conservation actions may have played in reducing extinction rates. We explored this contribution with specific reference to tropical forest.

There is great interest in measuring conservation impact. The Convention on Biological Diversity's (CBD) target to achieve by 2010 a significant reduction of the current rate of biodiversity loss (CBD 2009) is one driver of this interest, and it has stimulated development and implementation of conservation indicators (Balmford et al. 2005). A related effort involves evidence-based conservation, which aims to document the effectiveness of conservation interventions (Sutherland et al. 2004), especially relative to costs (Ferraro & Pattanayak 2006). Thus, despite the competitive pressure for conservation agencies to publicize success and hide failure (Brechin et al. 2002), evaluations of the cost-effectiveness of conservation actions are gaining momentum. A new standard classification of conservation actions has been developed (Salafsky et al. 2008) and is in the process of being applied to the more than 40,000 species that have been assessed for the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2008). Nevertheless, these initiatives will take time to bear fruit.

In the meantime, the success of conservation efforts in reducing extinction rates in tropical forests needs to be determined. Thus, we explored the extent of such conservation activities and examined the documentation of their effectiveness. We structured our evaluations following the new IUCN classification of conservation actions (Salafsky et al. 2008).

Land and Water Protection

Most species of conservation concern are threatened by destruction of their habitats. Thus, establishing protected areas (PAs) to safeguard these habitats is the primary conservation response. The World Database on Protected Areas (WDPA 2009) provides data on the spatial coverage of PAs, and, through integration with data on species distributions, the degree to which they represent biodiversity.

Globally, the extent of PAs is impressive. Sustained growth since the 1960s has yielded more than 100,000 PAs, and they cover 12% of the Earth's land area (Chape et al. 2005). This coverage varies by latitude and by IUCN category. The IUCN categories describe management goals, and broadly speaking categories I–IV are strict nature reserves, whereas categories V and VI are managed to preserve cultural features and ecosystem services, respectively (Dudley 2008). (Fig. 1). The greatest absolute and percent coverage is in the tropics, although this includes >1 million km^2 that has not been assigned a category (e.g., large indigenous reserves in Amazonian Brazil [Schwartzman & Zimmerman 2005]). Coverage of tropical forest countries by PAs of categories I–IV is similar among all three tropical continents (approximately 6% of total land area), but coverage by categories V and VI and by uncategorized PAs, is much higher for Latin America (approximately 20%) than for Africa and Asia (approximately 6%).

There is a wide variation in coverage of PAs among biomes, even for tropical forests. Dry forests and tropical coniferous forests are underrepresented relative to moist forests (Hoekstra et al. 2005). Given the value of protecting tropical forests for climate-change mitigation through reduction of emissions from deforestation and degradation (REDD; Campbell et al. 2008), growth in PA coverage of tropical forest is likely to continue.

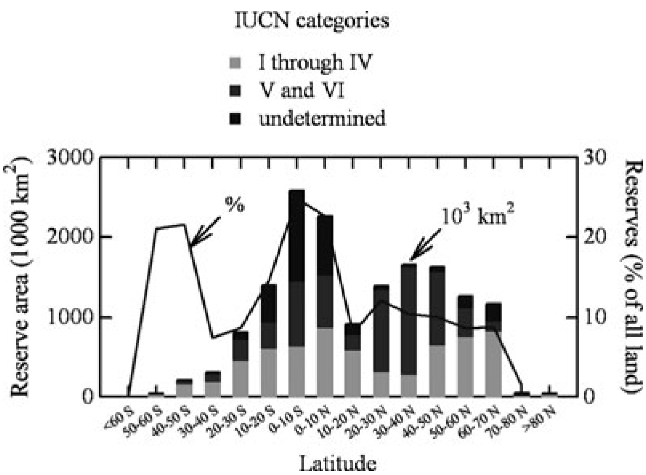

Figure 1. The latitudinal distribution of protected areas as a percentage of all land area (line) and as absolute area (histogram). Data are from the 2007 World Database on Protected Areas. The IUCN categories indicate management goals, wherein categories I–IV are strict nature reserves and categories V and VI are managed to preserve cultural features and ecosystem services.

Two approaches address how PA coverage translates into species coverage: gap analysis assesses which species occur within PAs (Scott et al. 1993) and systematic conservation planning identifies priority sites for PA expansion (Margules & Pressey 2000). Rodrigues et al. (2004*a,b*) applied both approaches to reveal that at least 12% of terrestrial vertebrates (1424 species) and 20% of threatened terrestrial vertebrates (408 species) are unrepresented in PAs and that tropical islands and mountains are priority regions in which to expand PA coverage. Similarly, only 290 of 595 sites containing the only remaining population of one or more highly threatened species of terrestrial vertebrates and conifers have even partial PA coverage (Ricketts et al. 2005). These analyses added robustness and urgency to the CBD Programme of Work on Protected Areas (CBD 2009), which was designed to support the establishment and maintenance of comprehensive, effectively managed, and ecologically representative terrestrial PAs. This in turn has stimulated dozens of gap analyses at national and regional scales, with broadly similar results. Overall, the task of representing the world's species in PAs is proceeding well, but gaps remain, and these gaps are greatest for the most threatened species, that is, those that most need protection.

Protected area effectiveness can be categorized for individual areas or for networks (Gaston et al. 2008). The former often focus on failures (e.g., Liu et al. 2001; Curran et al. 2004), which tend to be "newsworthy," although even within single PAs, effectiveness can be highly variable over time and space (Gaveau et al. 2009). Broader analyses are therefore necessary to draw general conclusions (Brooks et al. 2001). There have been two meta-analyses of PA networks. Naughton-Treves et al. (2005) reviewed 49 such studies and found that deforestation was slower inside than outside 32 of the 36 PAs for which comparisons were possible. Similarly, Nagendra (2008) found deforestation was slowed in PAs compared with adjacent areas in 32 of 35 cases and reduced relative to that occurring before PA establishment in 9 of 14 cases.

Results of recent studies on tropical PA networks generally confirm their overall effectiveness in slowing deforestation (Table 1). Bruner et al. (2001) surveyed 93 PAs in 22 countries and found that PAs decreased habitat loss and other threats significantly compared with land in the surrounding 10-km belt. In this study, assessments of effectiveness were provided by PA professionals, who might have had an interest in demonstrating success (Bhagwat et al. 2001). Nevertheless, remote-sensing-based studies confirmed the effectiveness of tropical PAs at reducing levels of deforestation and the frequency of fire inside their borders. Joppa et al. (2008) showed that forest cover approaches 100% inside and outside PAs in regions of low human pressure (the Amazon and Congo), but it is much greater inside than outside in regions of high pressure (Brazilian Atlantic forest and

Table 1. Key characteristics of studies of the effectiveness of protected-area networks.

Study	*Extent*	*Countries*	*Number of protected areas*	*Time*	*Data*	*Metrics*	*Control?*		
							control region	*for leakage**	*for bias**
Bruner et al. 2001	global	22	93	-2001	questionnaire	threats	10-km buffer	no	no
Deininger & Minten 2002	Chiapas/ Oaxaca,Mexico	1	not recorded	1980–1990	remote sensing	deforestation probability	Rest of region	no	no
Sánchez-Azofeifa et al. 2003	Costa Rica	1	27	1986–1997	remote sensing	deforestation rates	10-km buffer	no	no
DeFries et al. 2005	global	38	198	20 years	remote sensing	deforestation rates	50-km buffer	no	no
Hayes 2006	global	13	76	1993–2000	field survey	vegetation density	87 "Non-parks"	no	no
Wright et al. 2007	global	57	823	2002–2004	remote sensing	fire detection density	5-, 10-, and 15-km Buffers	no	no
Oliviera et al. 2007	Peruvian Amazon	1	18	1999–2005	remote sensing	deforestation rates	Rest of region	yes	no
Joppa et al. 2008	Amazon, Atlantic Forest, Congo, West Africa	27	1131	2000	remote sensing	habitat cover	Buffers of 2 km, up to 30 km	no	no
Andam et al. 2008	Costa Rica	1	>150	1960–1997	remote sensing	deforestation rates	Rest of region	yes	yes

*Protected areas suffer from "leakage" if they displace threats to elsewhere and from location bias if they are situated nonrandomly with respect to threats.

West Africa). Hayes (2006) compared vegetation density of parks with "non-parks" and found no differences; however, this study is difficult to interpret because controls (i.e.,"non-parks") were selected a priori as forested.

Results of all these studies show that tropical forest PAs reduce deforestation within a park. The net impact, however, could be confounded by "leakage" whereby effective protection of one location simply displaces threats elsewhere (Ewers & Rodrigues 2007) or by location bias, whereby PAs are placed in the most pristine and least accessible sites (Vanclay 2001). Thus, Sánchez-Azofeifa et al. (2003) and DeFries et al. (2005) found that PAs were becoming increasingly isolated due to deforestation outside their borders. Only two studies have tackled the leakage and location-bias problems. Oliviera et al. (2007) measured leakage for PAs in Peru by developing a regional deforestation baseline before PA establishment. Andam et al. (2008) used a similar approach in Costa Rica, but added the methodological embellishment of matching PAs with control areas with similar environmental characteristics (Mas 2005). Their results indicate PAs are effective, relative to their surroundings, but with some leakage apparent in Peru. Of course, PAs will still reduce extinction rates even with leakage if the area protected is more important for biodiversity than the areas that are cleared. Moreover, leakage will necessarily decline to zero as tropical forests are either cleared or protected.

Measures of deforestation and fire frequency are an incomplete reflection of PA success. Little is known about other drivers of biodiversity loss within PAs. Examples include disease, which caused the extinction of the golden toad (*Incilius periglenes*) in Costa Rica's Reserva Biológica Monteverde (Pounds et al. 2006), and infrastructure development, which threatens the cycad *Encephalartos whitelockii* in Uganda's Queen Elizabeth National Park (Roberts 2008). Despite the recognized decline of many species outside PAs (Hart & Hall 1996), no one has yet examined PA network effectiveness in terms of biodiversity outcomes, for example, by examining species populations and trends within PAs relative to those in comparable habitats outside PAs.

Land and Water Management

Although strict PAs are a cornerstone of conservation, they are inevitably too small and incomplete in coverage to be sufficient (Janzen 1986) because of society's other demands on land (Wilhere 2008). Meanwhile, biodiversity of conservation significance persists in human-dominated landscapes, where imposing complete protection is impractical (Robbins et al. 2006) or where land tenure systems render formal PAs difficult to implement (Osborne 1995). Furthermore, many threatened species (and the ecological processes on which they depend) require areas too large to be conserved in PAs alone (Boyd et al. 2008). Thus, biodiversity goals are advanced when PAs are supplemented with conservation-friendly landscape-management practices (Crooks & Sanjayan 2006). The scale of these opportunities is impressive. For example, the half of Borneo's remaining forests (approximately 200,000 km^2) that have active forestry concessions maintain significant wildlife conservation value and appear better staffed and controlled than PAs; some willingly incorporate conservation-friendly practices because they bring market benefits (Meijaard & Sheil 2007*a*).

Few measures exist for evaluating the effectiveness of landscape-level action (Dudley et al. 2005). There have been conceptual reviews of tropical forest restoration (Lamb et al. 2005; Chazdon 2008), but no comprehensive evaluation of the resulting conservation benefits. Similarly, although climate-change adaptation (Hannah et al. 2002) and control of invasive species (Veitch & Clout 2002) require landscape-level action, the extent to which tropical conservation practice has incorporated such responses to climate change and invasives is unclear. The same challenge exists for most other measurements of activities integrating conservation with other land uses.

Forest-management data by the International Tropical Timber Organization (ITTO 2005) and the Forest Stewardship Council (FSC 2009) provide some insights. The ITTO (2005) estimates that $<5\%$ of the world's tropical forests are sustainably managed. They also note extreme challenges in the compilation of such data, with large gaps in reporting, sparse monitoring of illegal activity, and wide variation around what is defined as forest in the first place. The FSC, the principal international body applying voluntary standards for sustainable forestry, shows that certification for tropical forestry has expanded from 3 million ha in 1995 to >10 million ha today. Nevertheless, this represents only 10% of the global forest area certified by FSC (Rametsteiner & Simula 2003).

Species Management

Single-species conservation is better documented than that for PAs. Good data exist for ex situ conservation of vertebrates because meticulous record keeping is part of captive breeding (Flesness 2003). Although only a small proportion of threatened species are maintained in captivity, most of which are large terrestrial vertebrates and plants (Balmford et al. 1996), the extent of ex situ conservation can be assessed in several ways. International studbooks are kept under the auspices of the World Association of Zoos and Aquariums (WAZA 2009) for 182 taxa. Comparison with the IUCN Red List (IUCN 2008) indicates that 126 of these 182 are tropical forest species of which 105 (83%) are threatened. Nearly two-thirds are mammals (Fig. 2a). The total number of threatened species in captivity is higher. There are 172 threatened bird species in 10 British zoos (Whitford & Young 2004). IUCN (2008) lists 65 extant species in total

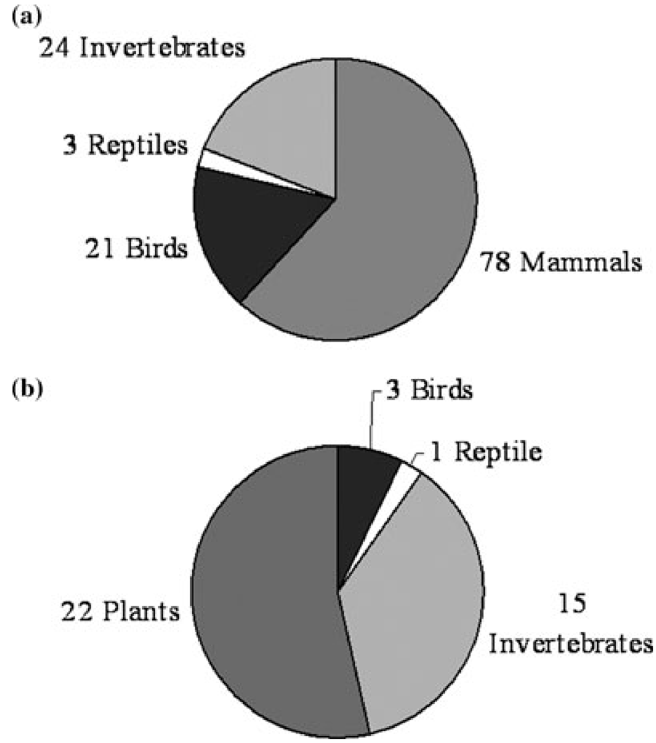

Figure 2. Distribution of ex situ conservation efforts by taxonomic group among tropical forest species: (a) taxa for which International Studbooks are maintained by the World Association of Zoos and Aquaria and (b) species listed as extinct in the wild (IUCN 2008).

as officially "extinct in the wild," of which 41 previously occurred in tropical forests and 35 are plants (Fig. 2b). Although ex situ conservation is preventing extinctions in the short term, these efforts need to be increased, for example, for declining amphibians (Griffiths & Pavajeau 2008). Such work will require even greater attention to address climate-change threats, such as the dislocation of species distributions from their original habitats (Wright et al. [this issue]), that have no possible in situ response.

The other major class of single-species conservation action is the sustainable management of hunting or harvesting regimes for food, artifacts, pets, or sport (Hutton & Leader-Williams 2003). The need for such management is clear, given the massive scale of hunting for bushmeat (Milner-Gulland et al. 2003). Many tropical countries have implemented measures to regulate the harvest of wild species (predominantly vertebrates and trees), but documentation of such action remains limited to case studies, for instance of incentives (Child 1996), partnerships (Steinmetz et al. 2006), and enforcement (Madhusudan & Karanth 2002).

Education and Awareness

Despite its central role in many programs, there are few data on the extent of education and awareness activities. Although conservation organizations explicitly focused on public outreach document their work (e.g., Butler 2000), these organizations represent only a small fraction of total outreach efforts. At the other end of the scale, nationwide surveys provide evidence of broad public support for biodiversity conservation. For example, two-thirds of U.S. citizens believe that they have the responsibility to protect all plant and animal life (Novacek 2008), but the impact of environmental education and other actions on such metrics has not yet been attempted. This overall lack of documentation frustrates attempts to measure success and thus improve conservation education efforts (Bride 2006).

In recent years local environmental movements have blossomed across the world, including in the tropics, where opinion polls often imply concerns similar in magnitude to wealthy western countries (Steinberg 2005). Even in remote regions, local people reveal a widespread desire for effective and democratically accountable conservation (Padmanaba & Sheil 2007). Although local people sometimes appear hostile to conservation projects, this attitude rarely reflects an actual anticonservation perspective (Sharpe 1998). For example, even those affected by loss of crops to elephants agree without reservation that elephants should be protected (Hill 1998). Nonetheless comprehensive data on such views and associated trends are lacking.

Law and Policy

Multilateral agreements are the broadest policy tools available for addressing biodiversity loss (Steiner et al. 2003). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2009) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS 2009) explicitly address tropical forest species. A measure of the large coverage of these agreements is the number of nations that are parties to each (173 and 84, respectively). A more sophisticated approach is to evaluate how well the species included under these conventions reflect those known to be threatened. Thus, for example, species listed on the CITES appendices should be compared with those listed on the IUCN Red List as being threatened by harvest, and those in the CMS Appendices should be compared with those listed on the IUCN Red List as threatened and migratory. Initial analyses are not encouraging. For example, less than half of amphibian species listed as threatened by overexploitation on the IUCN Red List are also listed on the CITES appendices (Baillie et al. 2004).

A number of other conventions are relevant. The World Heritage Convention (WHC 2009, 176 parties) has considerable potential to support tropical biodiversity conservation (Sayer et al. 2000), but currently provides highly uneven biodiversity coverage (Hazen & Anthamatten 2007), maybe because of ambiguities in the criteria (Pocock 1997). The broadest multilateral environmental agreement is the CBD (2009; 191 parties, but not the United States). The implementation of the CBD is difficult to measure because it coordinates activities among countries rather than implementing or enforcing action (Raustiala & Victor 1996; Swanson 1999; Müller 2000). Beyond these conventions, there are many regional treaties (e.g., CBFP 2006) and hundreds of national legal instruments that support conservation in countries with tropical forests. Little has been published in the way of synthetic assessment of these laws and policies, but simply knowing of their existence is a key step toward understanding their impact. The EcoLex database of environmental legislation (FAO et al. 2009) is an essential contribution to this understanding.

One direct manifestation of conservation policy is finance. James et al. (2001) surveyed PA funding (and estimated shortfalls) across all nations and found that total annual conservation investment was approximately \$6 billion, \$1 billion of which was invested in the tropics (equivalent to \$93/km^2/year). For example, Cambodia and Laos budgeted only approximately \$1/km^2/year on PAs in the 1990s (MacKinnon 2005). The total investments of five major conservation agencies was \$1.5 billion in 2002, half of which was spent in the United States (Halpern et al. (2006). The Global Environment Facility (GEF 2005) invested \$1.9 billion in biodiversity between 1991 and 2005. Finally, the new Project Level Aid Database (Hicks et al. 2008) details biodiversity project funding from bilateral and multilateral sources as totaling \$2.35 billion over 1980–1999. These figures need to be considered relative to the costs of effective conservation, which may be around \$13 billion annually for existing PAs in the tropics (Bruner et al. 2004) and \$30 billion for REDD to reduce deforestation by 95% (Strassburg et al. 2009). In this context, current investment in tropical conservation, although essential, is inadequate.

The impact of multilateral environmental agreements has been scrutinized. The CITES has had two well-publicized failures (tigers [*Panthera tigris*] and rhinoceros species) for which the closure of the legal trade has stimulated massive illegal markets (Hemley 1995). Such effects may be more general (Courchamp et al. 2006). Nonetheless, CITES is considered effective both in general (Reeve 2006; Gehring & Ruffing 2008) and for specific species such as spotted cats and crocodilians (Ginsberg 2002). The impacts of the CBD and the GEF are harder to measure (Vaessen & Todd 2008). Although the CBD has successfully garnered intergovernmental cooperation, it has been less successful with capacity building and knowledge dissemination (Siebenhüner 2007). The most recent evaluation of the GEF reports that GEF "has had a notable impact on slowing or reducing the loss of biodiversity," although these claims were not quantified (GEF 2005), and that resources available through the GEF still fall far short of those required to safeguard tropical biodiversity.

Livelihood, Economic, and Other Incentives

The implementation of PAs can affect local people negatively if the opportunity costs of foregoing extractive activities are not taken into account (Balmford & Whitten 2003) and if local aspirations, culture, and well-being are neglected (Posey 1999). Early integrated conservation and development projects attempted to reduce pressures on biodiversity through livelihood investment with mixed success at best (Wilshusen et al. 2002). Now many conservation programs incorporate mechanisms to pay the local opportunity costs of conservation through conservation concessions and easements, direct payments, allowances for bioprospecting, and similar mechanisms (Ferraro & Kiss 2002). Despite numerous case studies, few data are available on either the financial costs of such programs or their geographic distribution. There are two exceptions. The first is ecotourism. Although locally important (McNeilage 1996), it is unlikely ecotourism will have a large impact at extensive scales (Kiss 2004). The second is the incorporation of REDD into the voluntary carbon markets. Despite its omission from the Kyoto Protocol (Brown et al. 2002), REDD is expanding in the voluntary markets, increasing from 3% of a \$58.5 million market in 2006 to 5% of a \$258.4 million market in 2007 (Hamilton et al. 2008). More information on the effectiveness of payments for environmental services will certainly become available in coming years (Engel et al. 2008).

In addition to economic incentives for conservation, most cultures possess practices and social norms that contribute to the conservation of biodiversity, even though this is not necessarily their explicit objective (Vermeulen & Sheil 2007). One estimate suggests that community conservation efforts, both formal and informal, cover an area of 370 million ha globally—similar in magnitude to that under government-implemented PA systems. Including larger forest landscapes and agroforest mosaics might double or even triple this total (Molnar et al. 2004).

External and Internal Capacity Building

Few data are available on the extent of capacity building in tropical conservation, despite its importance (Hart et al. 1996). Some programs target early career conservationists (e.g., the Conservation Leadership Program; CLP 2009), whereas others invest in PhD programs (e.g., capacity-building program of the U.S. Fish and Wildlife Service [USFWS 2009]). Some proximate metrics of such programs have been developed (e.g., numbers of universities offering graduate programs in conservation; Rodríguez et al. 2005), but further compilation of data would be greatly beneficial (e.g., tracking program alumni).

Another notable class of action is conservation research. Whitten et al. (2001) inferred that conservation science was doing little to stem the biodiversity crisis. Meijaard and Sheil (2007*b*) tested this by reviewing 284 publications on wildlife in Borneo and found that, although the urgency of the tropical biodiversity crisis is a major justification for gaining research funds, few studies address threats to species and even fewer provide guidance on effective management. Conservation science should place more emphasis on addressing practical conservation needs and goals.

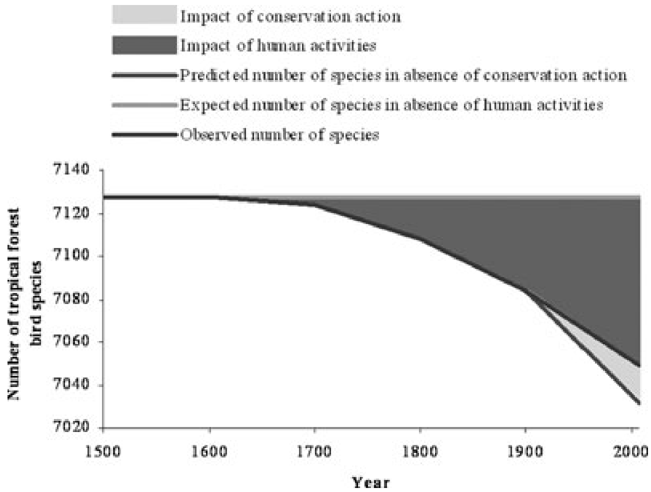

Figure 3. Estimated impact of conservation action to prevent extinctions of tropical forest birds compared with the impact of human activities on overall species richness of tropical forest birds (Rodrigues et al. 2006).

Conclusions

Great variation exists in the degree to which the extent and effectiveness of conservation actions have been documented. Given this, how much can be concluded about extinction rates? Birds are the only taxon for which any comprehensive assessment has been made. BirdLife International (2004) evaluated the extent of implementation and impact of 5500 actions for the conservation of 1186 threatened bird species (nearly three-quarters of which were tropical forest species). Over a 4-year period, some action had been implemented for at least 789 species and 280 species had benefitted. Similarly, of 54 projects proposed for game-bird conservation in 1995, 33 had been initiated by 2000 (Fuller et al. 2003).

The clearest evidence of the benefits of conservation actions is provided by Butchart et al. (2006), who identified 26 bird species, 14 of which are from tropical forests, which would likely have become extinct over the preceding century in the absence of interventions. More broadly, Rodrigues (2006) added species considered extinct in the wild to these 26 species to show that conservation actions have averted perhaps one-fifth of the bird extinctions that would otherwise have occurred since 1900. The time frame is important here. Significant conservation action did not occur until the last century, whereas substantial numbers of bird extinctions date back thousands of years (Steadman 1995). We restricted the analysis of Rodrigues (2006) to tropical forest species, with, unsurprisingly, near-identical results (Fig. 3). The general success we documented here may help explain that observed bird extinction rates are lower than predicted for critically endangered species (Brooke et al. 2008). Moreover, the total benefits of conservation action are greater than these analyses imply because conservation has also slowed declines for many other species.

Although there has been no comprehensive review of the impact of conservation on reducing extinctions among other higher taxa, there are a few good species-by-species examples of such successes. Perhaps the most famous example is the Golden Lion Tamarin (*Leontopithecus rosalia*), which was rescued from the brink of extinction (Kierulff & DeOliveira 1996). Although five mammals have been down listed from extinct in the wild into the threatened categories as a result of reintroduction, none are tropical forest species (IUCN 2008). Other species hang in the balance. For example, the installation of a sprinkler system failed to maintain the spray-zone habitat of the Kihansi spray-toad (*Nectophrynoides asperginis*) following the closure of the Kihansi Dam, so the only known surviving animals are now in captivity (Krajick 2006).

Overall our review provides grounds for cautious optimism. At least in the short term, conservation actions can and do prevent extinctions; thus, there is hope in even the most challenging conservation contexts (Posa et al. 2008). The coverage of PAs is extensive and expanding, even if it is still far from comprehensive. The extent of the success of other conservation actions requires further research, but these actions appear to be considerable if not necessarily well targeted. Conservation actions, notably PAs, help reduce habitat loss and other threats, although there may be leakage in deforestation from the protected site. Finally, the ultimate impact of such efforts on the extinction rate is real, at least for birds, with maybe one in five extinctions averted by conservation action over the last century. Although this is encouraging, more must be done; nobody passes an exam by getting just 20% right. Moreover, efforts to prevent further extinctions could be optimized (McCarthy et al. 2008). Given the threats to tropical forest species (Laurance & Peres 2006), we believe conservation of tropical forests must be targeted at the right places and themes to help stave off large-scale species extinctions.

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