

Conservation successes at micro-, meso- and macroscales

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Although large-scale biodiversity declines are ongoing, certain conservation actions have made a positive difference. Rates of extinction and endangerment of vertebrate species, for instance, have probably been reduced via conservation interventions. Such conservation actions operate at different spatial scales. Habitat preservation and endangered species recovery are examples of conservation successes at microscales. Mesoscale conservation includes regional cooperation among neighboring countries that has arrested population declines of endangered species, such as mountain gorillas. At macroscales, public pressure on multinational corporations has sometimes resulted in their abandoning environmentally damaging practices or suppliers with poor environmental records. Overall, conservation projects such as these need more long-term funding and greater political and popular support, and must also include provisions to evaluate and document their outcomes. As we discuss here, a focus on conservation successes achieved at different scales can help to promote these aims and guide future conservation victories.

The scales of conservation intervention

Human actions have been directly or indirectly responsible for biodiversity endangerment on a large scale [1,2]. A recent review suggests that conservation actions have largely failed to arrest the ongoing global collapse in biodiversity [3]; as a consequence, widespread pessimism prevails in the conservation community. What successes have been won are rarely highlighted or fail to attract wide attention [4,5]. Furthermore, conservation projects rarely have clear provisions to evaluate their outcomes [6,7]. However, many conservation efforts have been beneficial for biodiversity. For instance, rates of extinction and endangerment of vertebrates have probably been reduced because of conservation interventions [8]. There is a clear need to synthesize such information to guide future projects and provide much-needed hope for the conservation community.

An important factor that might be crucial to guiding future conservation actions is the scale at which such actions should occur. Here, we highlight successful conservation initiatives at micro-, meso- and macroscales, which we define to include both the geographic extent and type of

conservation action (Figure 1). Microscale conservation encompasses direct efforts to protect species or habitats, including the creation of protected areas (PAs) and the control of illegal hunting. A regional focus defines mesoscale conservation, which includes transboundary agreements and the regulation of international wildlife trade. Macroscale conservation is targeted at global phenomena, and includes changing consumer demands and passing legislation to limit the impact of unsustainable business practices. Conservation actions at these scales might differ or overlap; in fact, some conservation efforts must be advanced simultaneously at multiple scales.

We focus here on conservation successes that we feel are inadequately highlighted and merit further attention. Our definition of ‘success’ is admittedly loose and based on any evidence of positive conservation outcomes, such as population increases of endangered species following targeted interventions. We are aware that some conservation efforts, such as ‘paper parks’ that suffer severe encroachment [9–12], have failed dismally. Furthermore, some conservation successes are exaggerated [13] and many of those we highlight are imperiled by future threats. As such, it is crucial not to interpret this article as portraying all conservation measures as success stories; we paint here only part of the picture, and arguably a smaller part compared with the grim portrayals in myriad scientific and news articles suggesting widespread conservation failures. Yet, to highlight successes that do exist and thereby provide a more balanced view, we provide a broad-brush assessment of conservation achievements spanning more than three decades.

Microscale conservation

Habitat and species preservation epitomize microscale conservation projects (Figure 1). PAs are key local conservation initiatives that are considered essential for preserving remnant habitats and endangered species [14], and several studies from wide geographic locations show that protection confers tangible benefits to biodiversity [15] (but note the limited effectiveness of some PAs, especially in the tropics [9–12]). Thanks to PAs, some megafauna species are flourishing in the Indian subcontinent [16]. Following the establishment of Bardia National Park in Nepal, for example, the density of wild ungulates increased fourfold in just 22 years [17]. This spike in prey base triggered increases in both endangered tiger (*Panthera tigris*) and

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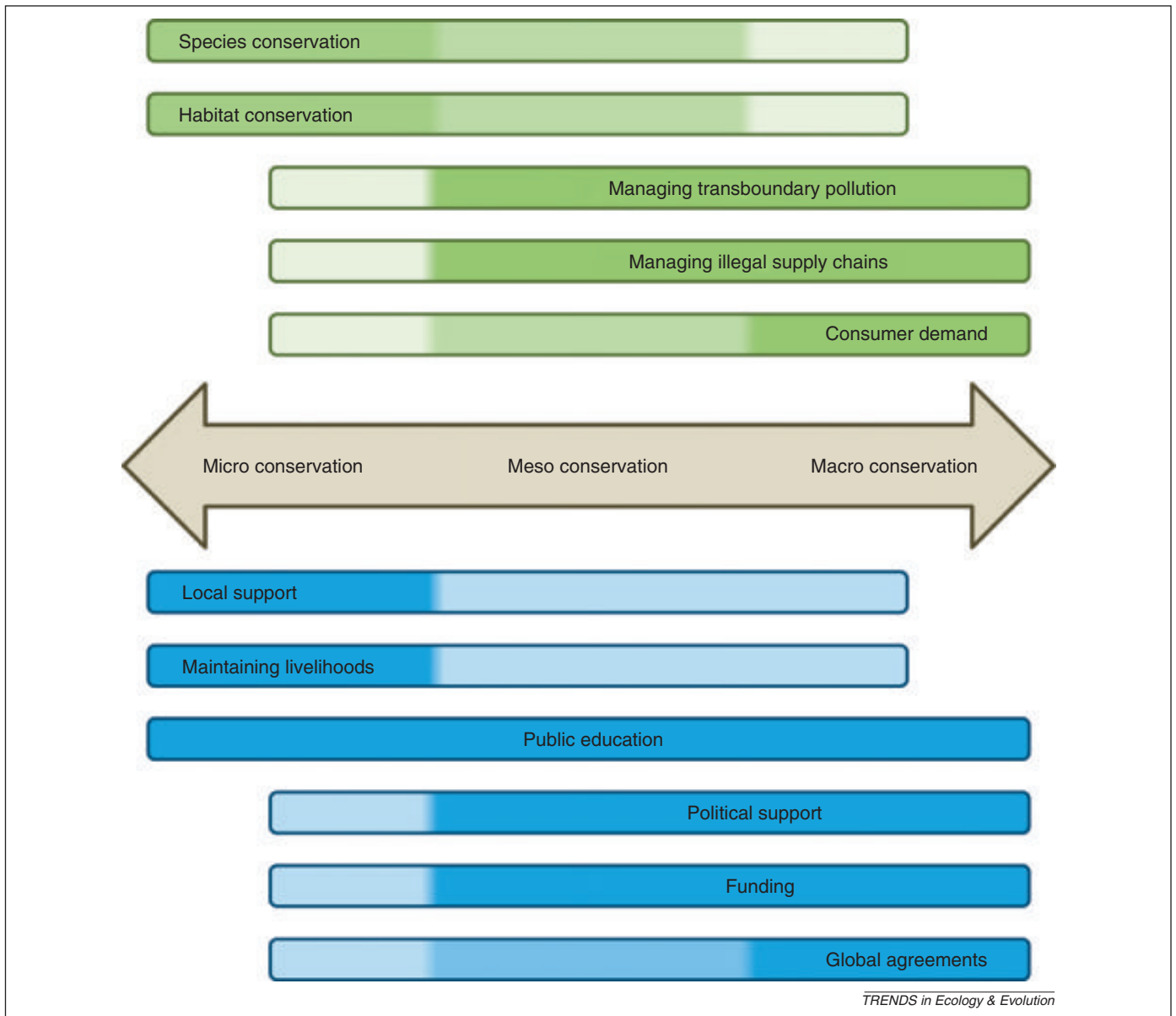


Figure 1. The scale of conservation interventions (thick bar, middle), showing the conservation actions that epitomize each scale (green bars, above) and the essential components of success at each scale (blue bars, below). These actions and essential components are not mutually exclusive, but we illustrate the scale at which each is most important with shading and placement of text.

threatened leopard (*Panthera pardus*) densities, to 20 and five animals 100 km^{-2} , respectively [17]. Similarly, the creation of PAs in the Gir forests of India enabled the recovery of wild ungulate populations and their endangered predator, the Asiatic lion (*Panthera leo persica*) [18].

In the largest remaining tract of tropical rainforest in the world, in Brazilian Amazonia, PAs have helped to reduce deforestation rates [19]: an estimated 37% of the decline in annual deforestation rates in Brazil between 2002 and 2009 can be attributed to the preservation of 709 000 km^2 of forest in newly established PAs (Figure 2) [19]. The Brazilian Government has an ambitious plan to maintain these lower rates of deforestation [19], and has communicated this intent by arresting prominent politicians and others involved in illegal logging* and economically embargoing

townships championing deforestation†. Current and planned PAs in Brazilian Amazonia will reduce global annual anthropogenic carbon emissions by approximately 16% [19] and will also provide other ecosystem services, such as limiting floods and fires, maintaining stable rainfall regimes and improving food security for rural people [20,21]. Other countries have followed the impressive example of Brazil by expanding their own protected lands. For example, Canada recently protected 72 million ha of boreal forests via an agreement between forestry companies and environmentalists‡. Protecting forests and other natural habitats represents a fundamental step towards conservation that is achieved first and foremost at the microscale

* Neme, L. (2010) Top officials busted in Amazon logging raids, but political patronage may set them free. 8 July, 2010. http://news.mongabay.com/2010/0708-neme_operation_jurupari.html (accessed 18 July, 2011).

† Fanzeres, A. (2010) A down-to-earth attitude. <http://www.oecoamazonia.com/en/news/brazil/31-com-os-pes-no-chao> (accessed 18 July, 2011).

‡ Hance, J. (2010) Big compromise reached on Canada's boreal by environmental groups and forestry industry. 19 May, 2010. http://news.mongabay.com/2010/0519-hance_boreal_agreement.html (accessed 18 July, 2011).

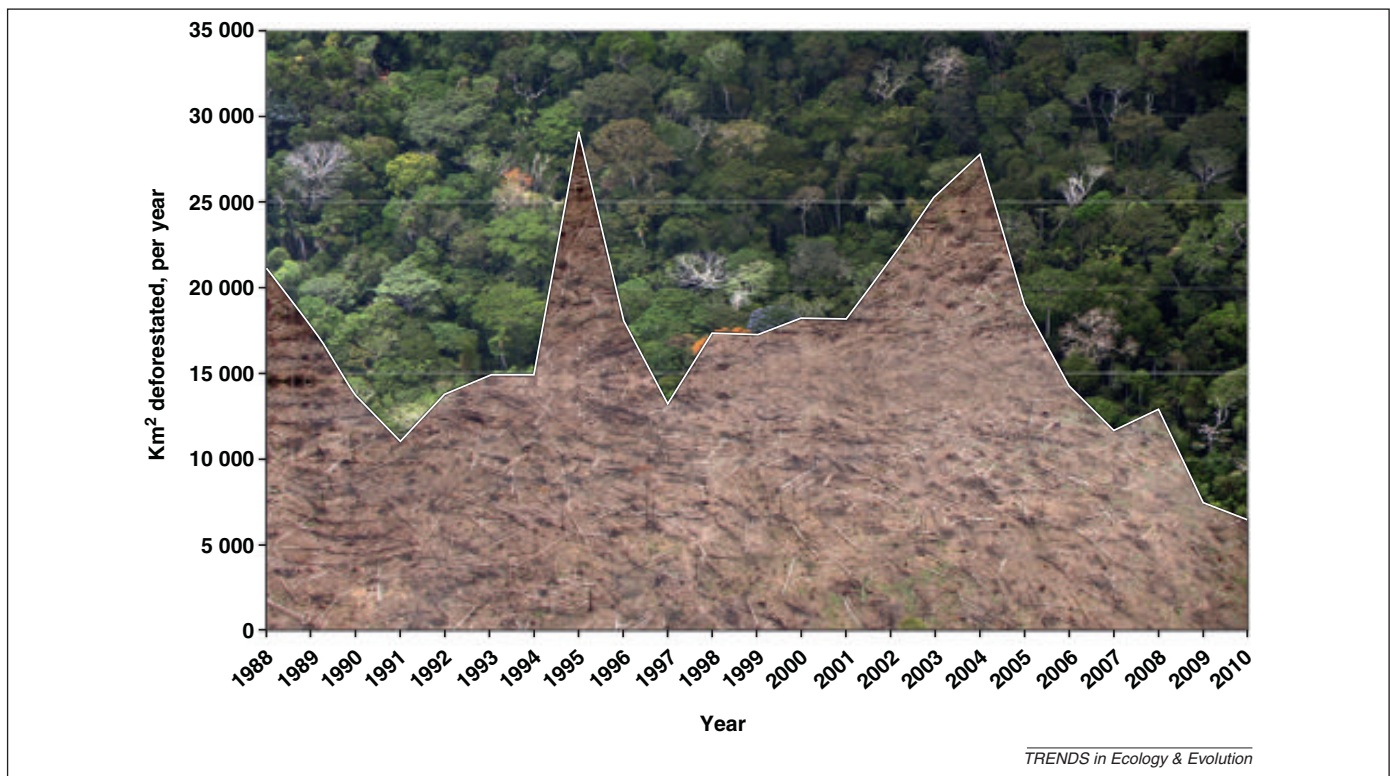


Figure 2. Annual deforestation rates in the Brazilian Amazon from 1988 to 2010. Crackdowns on illegal logging and forest clearing and the establishment of new protected areas have helped to slow deforestation in recent years [19]. Images reproduced, with permission, from Rhett A. Butler/<http://www.mongabay.com>.

(Figure 1). Despite these achievements, deforestation continues at high rates elsewhere, particularly in tropical Asia [22].

In addition to habitat conversion, hunting and the wildlife trade represent major threats to biodiversity at the microscale [23]. The trade of tropical parrots epitomizes unsustainable harvesting. Parrot populations are especially vulnerable to overexploitation because of low reproductive rates [24]. As a result, 36% of parrot species worldwide are threatened, with trade impacting 55% of these [25]. High demand for parrots makes their nests vulnerable to poaching; in some areas, all parrot nests are poached [25]. Reflecting the importance of PAs, nest poaching was higher in unprotected than protected sites for four species of Neotropical parrot [24], with habitat protection increasing nesting success threefold for African, Asian and Australasian parrots [25]. Similarly, habitat protection and better enforcement of whaling regulations have resulted in the population recovery of Pacific gray whales (*Eschrichtius robustus*; Box 1) [6].

Sometimes, habitat protection alone does not benefit imperiled biota. Interventions such as rehabilitation, reforestation, reintroduction, population augmentation and invasive species eradication might then become necessary. The effort to conserve the large blue butterfly (*Maculinea arion*) is an example of a multipronged conservation approach to species recovery [26]. In 1979, this species was declared extinct in the UK; its recovery was achieved via reintroduction, habitat restoration and management. Similarly, a combined approach involving food supplementation, provision of nest boxes, translocations, the ban of insecticide and the eradication of invasive species (cats and brown rats)

reversed the decline of one of the rarest birds in the world, the Seychelles magpie robin (*Copsychus sechellarum*) [27,28]. Several other multifaceted conservation approaches have rescued species from the brink of extinction (Box 1). However, these approaches are not always successful. More than US\$15 million in eradication efforts failed to remove the invasive brown tree snake (*Boiga irregularis*) from Guam, which has caused several bird and bat extinctions and continues to threaten the resident birds [29,30]. In addition, despite mounting efforts to control its spread, the chytrid fungus (*Batrachochytrium dendrobatidis*) continues to threaten amphibian populations worldwide and has already caused the extinction of at least 200 species [31].

Habitat restoration both within and outside PAs is becoming an increasingly common conservation approach [4]. To combat high deforestation rates, the Rwandan Government planted 116 million trees, doubling its net forest cover[§], and plans to add 44 million more trees by the end of 2011. In addition to protecting expanses of its existing native forest, the Brazilian Government provides low-interest loans to farmers to reforest agricultural land[¶]. These restoration projects will promote the existence of forests and other habitats that might serve as refuges for animal communities.

Nature provides invaluable ecosystem services to humanity [32]. In many instances, maintenance of these

[§] Hance, J. (2010) Rwanda government: one third forest cover coming seven years ahead of schedule. 1 December, 2010. http://news.mongabay.com/2010/1201-hance_rwanda_trees.html (accessed 18 July, 2011).

[¶] Anon. (2010) Brazil's development bank announces \$588m fund to reduce agricultural emissions. 10 November, 2010. http://news.mongabay.com/2010/1110-bndes_abc.html (accessed 18 July, 2011).

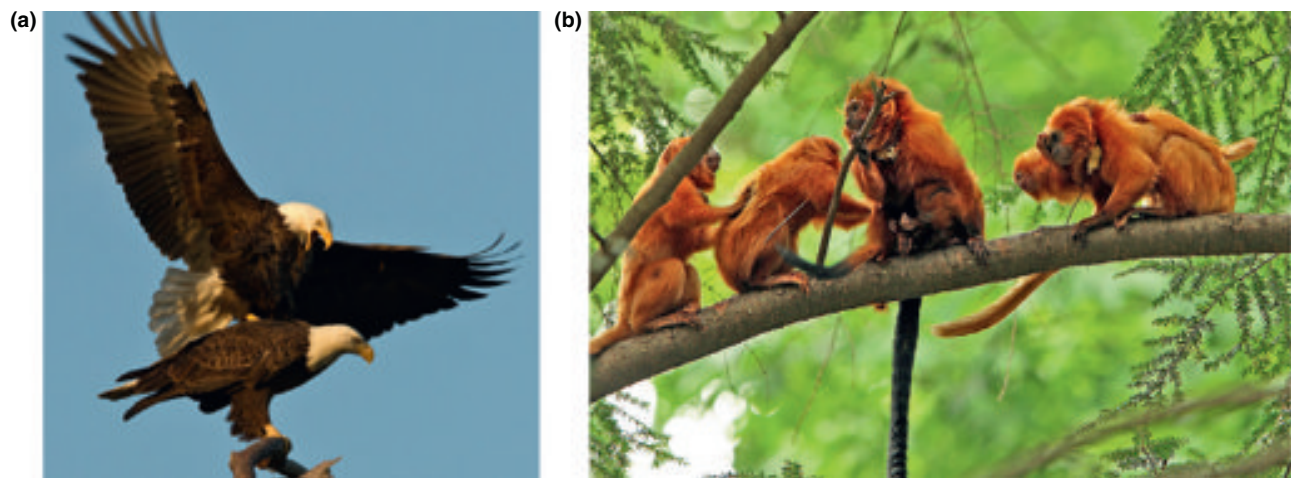
Box 1. Iconic species returning from the brink

Several flagship species have recovered from the brink of extinction following conservation efforts at micro-, meso- and macroscales. In the continental USA, bald eagles (*Haliaeetus leucocephalus*; Figure 1a) were decimated by widespread hunting, poisoning and use of DDT insecticides, which collectively reduced the population to just 417 breeding pairs in 1963 [73]. At that time, they were listed as an endangered species. Targeted efforts at their protection, including the ban of DDT in 1972, led to an impressive recovery, and there are now nearly 10 000 breeding pairs [73].

In the Atlantic forest region of Brazil, severe habitat loss and fragmentation reduced the golden lion tamarin (*Leontopithecus rosalia*; Figure 1b) to just 562 individuals during the early 1990s [74]. Successful reintroductions from zoos boosted their population to approximately 1500 individuals today, and education campaigns have reduced threats from hunting and illegal wildlife trade [75].

Reintroductions also helped to save the endangered Arabian oryx (*Oryx leucoryx*), which vanished in the wild in 1972 from overhunting [76]. Captive breeding and reintroduction programs have boosted its population in parts of its historic range on and around the Arabian Peninsula [76], with the population in Oman surpassing 400 individuals by the mid-1990s [77]. However, this species requires further attention because of resumed poaching [77].

Finally, the recovery of the eastern Pacific gray whale (*Eschrichtius robustus*) population is a successful example of marine conservation implemented across international borders. Driven to near extinction by whaling during the 19th century, the eastern Pacific population now numbers between 18 000 and 29 000 individuals [78]. These four examples highlight targeted campaigns to save iconic endangered species using conservation efforts at various scales.



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Figure 1. Iconic species returning from the brink. (a) Bald eagles and (b) golden lion tamarins. Reproduced, with permission, from Dan Pancamo (a) and Steve (b).

services has provided local residents and governments with a good justification to conserve. Awareness is growing that the livelihoods and welfare of local peoples are often strongly tied to conservation success [33]. For example, pressure by traditional landowners caused the Papua New Guinea Government to change its plan to deforest 70% of Woodlark Island for oil palm plantations^{**}. The plan would have threatened local culture and endemic species, such as the woodlark cuscus (*Phalanger lullulae*), an endemic arboreal marsupial. In Madagascar, severe upland deforestation caused stream siltation and reduced water yields needed by lowland farmers [34]. The potential loss of natural hydrological benefits provided ample reason for locals to conserve the remaining forest [35] and, combined with economic benefits from ecotourism, helped encourage the Malagasy Government in 2003 to commit to tripling the area of protected forests [36]. A similar example comes from the hyperbiodiverse cloud forests in western Ecuador. Collaboration between non-governmental organizations (NGOs) and villagers resulted in joint data collection that revealed the importance of cloud forests for fog interception, a vital process bringing moisture to an area otherwise devoid of major water inputs. Loss of these forests would

cost each household an estimated US\$640 annually, approximately half their annual income, which convinced locals to preserve approximately 3000 ha of cloud forest as an ecological reserve [37,38]. Similarly, preserving the Catskill Watershed protected a clean water supply used by New York City residents and saved billions of dollars by eliminating the need for a water-filtration plant [39]. Habitat preservation in the Catskill Mountains was also a boon for native biodiversity.

Clearly, garnering support from locals is vital for protecting biodiversity, particularly at the microscale (Figure 1), and providing economic alternatives to development is one way to encourage their support. For example, in Thailand, Poonswad *et al.* [40] enlisted 28 known hornbill poachers into hornbill-monitoring programs using mostly locally generated funds. After three years, the number of nests with fledglings rose by 38%. This ongoing project demonstrates that local biologists can generate funding within their countries to employ local people to protect, rather than imperil, biodiversity (for an additional example, see Box 2). Likewise, programs in South America are providing alternative livelihoods, such as ecotourism-related employment, which replace detrimental jobs in the wildlife trade [41,42].

Yet other examples reveal how economic initiatives can promote nature conservation. By 1996, the rarest giraffe

^{**} Anon. (2008) Palm oil developer abandons plan to log 70% of Woodlark Island. 14 January, 2008. <http://news.mongabay.com/2007/0114-woodlark.html> (accessed 18 July, 2011).

Box 2. Hope from the hopeless: the Philippines

Encompassing more than 7000 tropical islands, the Philippines has exceptionally high levels of biological diversity and endemism, with nearly half of all vertebrate species found nowhere else [79]. However, ongoing destruction of the forests and surrounding reefs threatens this biodiversity. Today, just 6–8% of primary forests remains, and only 5% of reefs retain at least 75% live coral cover, prompting some to question whether the Philippines is worth any conservation attention [80].

Despite such pessimism, conservation efforts have proved vital in several instances. The critically endangered Philippine cockatoo (*Cacatua haematuropygia*; Figure 1a) has benefited from education campaigns, nest protection and monitoring, and even hiring and training former poachers to work as game wardens. As a result, the population has grown, increasing on one island from 20 to 100 individuals between 1998 and 2004 [80]. The Philippine Endemic

Species Conservation Program used similar tactics to protect the critically endangered Visayan wrinkled hornbill (*Aceros waldeni*; Figure 1b). From a population of just 60–80 breeding pairs during the late 1990s, this endemic hornbill recovered and successfully fledged 502 broods in 2006 [81,82].

Community-based marine protected areas (MPAs) are particularly important in the Philippines, where coastal communities derive much of their subsistence from fish. Coastal communities have established and manage more than 600 MPAs, leading to increases in fish populations throughout the country [80,83]. Finally, increased ecological research in the Philippines has led to the discovery of new species and the rediscovery of species previously believed extinct, reviving local interest in conservation [80]. These successful examples demonstrate that, even in the Philippines, local and regional efforts can lead to the recovery of critically endangered species and habitats.

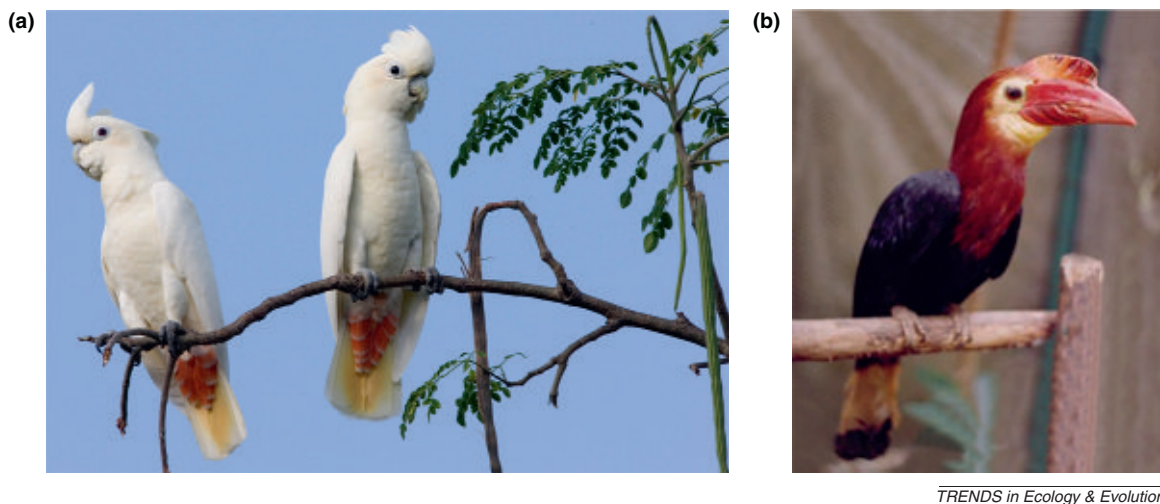


Figure 1. Examples of conservation success in the Philippines. (a) Philippine cockatoos and (b) the Visayan wrinkled hornbill. Reproduced, with permission, from Benedict De Laender (a) and Callan Bentley (b).

subspecies, the West African giraffe (*Giraffa camelopardalis peralta*), was reduced to 50 animals in Niger by heavy poaching and habitat loss [43]. This giraffe population has increased to over 200 individuals as a result of not only strict antipoaching enforcement, but also by sustaining local economies through ecotourism and microloans to buy lambs as an alternative source of meat. Other examples include the sustainable harvest of edible-nest swiftlets (*Aerodramus* sp.) in Vietnam [44], and the sustainable harvest of fynbos flowers to subsidize conservation costs in South Africa [4]. Some conservation effort are truly ingenious; for example, in Gunung Palung National Park in Borneo, locals are provided affordable healthcare paid for by conservation-oriented programs, such as reforestation, aimed at protecting the threatened rainforest (<http://www.healthinharmony.org/mission.html>). In summary, gaining the support of local residents (often by identifying valuable ecosystem services and maintaining lasting livelihoods) can help to promote habitat preservation and species conservation at the microscale (Figure 1).

Mesoscale conservation

Regional efforts, including transboundary conservation agreements and the international regulation of illegal wildlife trade, can boost conservation outcomes at the mesoscale

(Figure 1). Species ranges, particularly for large-bodied animals most in need of conservation, often extend beyond the border of a single country, and transboundary collaborations between neighboring countries can help to protect their populations. In this manner, adjoining national parks established in the Virunga landscape of the Democratic Republic of the Congo, Uganda and Rwanda have led to population increases of elephants and gorillas [45]: the population of mountain gorillas (*Gorilla beringei beringei*) has increased from 250 to 480 animals over the past 30 years^{††}. Other prominent transboundary conservation areas include the Limpopo Transfrontier Park in Mozambique, South Africa and Zimbabwe; and the Heart of Borneo in Brunei, Indonesia and Malaysia. The latter aims to protect endangered orangutans (*Pongo pygmaeus*) and threatened clouded leopards (*Neofelis nebulosa*). Such regional cooperation can also focus on marine biodiversity, as in the case of 16 Pacific nations working together to better protect and manage reef habitats and fisheries^{‡‡}. These regional efforts

^{††} Anon. (2010) Mountain gorilla numbers have increased, census reveals. 7 December, 2010. http://news.bbc.co.uk/earth/hi/earth_news/newsid_9265000/9265917.stm (accessed 18 July, 2011).

^{‡‡} Butler, R.A. (2010) As a tiny island nation makes a big sacrifice, will the rest of the world follow suit? 15 September, 2010. http://news.mongabay.com/2010/0915-kiribati_interview_anote_tong.html (accessed 18 July, 2011).

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to reduce forest loss might also be crucial for limiting harmful climate change, by ensuring that the efforts of one country to reduce its greenhouse gas emissions is not countered by the increased emissions of another [46].

Regional cooperation can also aid the reintroduction of endangered species. Following the extinction of the Arabian oryx (*Oryx leucoryx*) in Jordan, a conservation agreement with Abu Dhabi led to the transfer of 20 oryx from Abu Dhabi to Jordan, spurring the reintroduction program of the latter (Box 1) [47,48]. This release appears to be succeeding because some females were already pregnant. However, such reintroductions are often expensive and, even when limited to the best-funded conservation programs, not all succeed. For instance, despite over US\$10 million spent towards the recovery of the Hawaiian crow (*Corvus hawaiiensis*), reintroduction efforts failed to prevent its extinction from the wild [49].

A leading threat to biodiversity is the burgeoning international trade in wildlife, but mesoscale conservation efforts can help to control illegal trade. In Indochina, tigers are threatened by habitat loss and degradation, poaching and encroachment from expanding human populations [50]. Fewer than 3500 tigers remain in the wild and they are mostly hunted for use in Asian medicine [51]. However, a regional agreement by the Association of Southeast Asian Nations (ASEAN) Wildlife Enforcement Network for sharing information on wildlife crime is reducing the crossborder smuggling of tigers [50]. Similarly, a recent international meeting among countries with tigers has aimed to double tiger numbers in the wild by 2020 [50,51], a praiseworthy goal that will only be achieved via mesoscale conservation involving many tiger-host countries.

Macroscale conservation

Global efforts to limit unsustainable business practices illustrate macroscale conservation (Figure 1). Multinational corporations are now major drivers of habitat loss and overharvesting in many developing tropical countries [52], and public pressure by consumers in developed countries is sometimes needed to make a conservation difference thousands of miles away. This pressure, often in the form of boycotts of products obtained via deforestation, is transforming supply chains. For example, following the revelation from Greenpeace that prominent Western brands were promoting deforestation by purchasing beef and leather from ranchers in the Amazon, major companies, including Nike and Walmart, pressured slaughterhouses to implement sourcing safeguards to ensure cattle products would no longer be produced at the expense of rainforests^{§§}. As a result, ear tags and genetic testing are now used in Brazil to track cattle from ranches to slaughterhouses^{§§}. Similar targeting of the Brazilian soy industry in 2006 led to a moratorium that reduced forest conversion for soy production^{¶¶}. Meanwhile, campaigns against French

shipping companies complicit in timber smuggling from Madagascar led to a ban of rosewood exports from that country. Complaints about chronic environmental transgressions by Asia Pulp and Paper led several major buyers, including Staples, Office Max and Unisource, to abandon the firm as a supplier of paper products^{***}. Golden Agri Resources, the largest palm oil producer in Indonesia, recently adopted stricter forest and social policies following large-scale customer defections over its conversion of high conservation value forests and peatlands in Borneo. Encouragingly, at the recent UN Climate Change Summit in Cancún, Mexico, the Board of Consumer Goods announced a goal to achieve zero deforestation in products such as beef, palm oil, paper and soya by 2020^{†††}. These and many other claims of improved environmental practices by companies and their suppliers can be independently verified using Google Earth Engine, which tracks changes in land use based on satellite imagery^{‡‡‡}. Thus, global changes in consumer demands in concert with new technology to monitor global forest cover can help to curtail deforestation in countries that consumers might never visit.

One prime target of the Google Earth Engine is oil palm (*Elaeis guineensis*), which has helped to drive the rapid loss of tropical forests. Used in a variety of products, such as foodstuffs, soaps, cosmetics and biodiesel, the toll of this crop on tropical biodiversity will largely depend on changes in international demand. Southeast Asia has experienced a blitzkrieg of oil palm expansion during the past few decades, with more than half of expansion in Malaysia and Indonesia occurring at the expense of rainforests [53]. This has reduced the habitat for many forest species (e.g. [54,55]). In response to growing consumer pressures, Walmart recently announced that it will only use sustainably produced oil palm by 2015^{§§§}. This laudable decision, hopefully followed by others, such as Nestlé, might help to curb the expansion of oil palm at the expense of old-growth tropical forests.

In another example of macroscale conservation, laws thousands of miles away can sometimes benefit biodiversity. After decades of petitions and lawsuits, the US Fish and Wildlife Service in 2010 designated 25 foreign bird species endangered under the US Endangered Species Act^{¶¶¶}. These include seven Brazilian bird species, such as the black-hooded antwren (*Formicivora erythronotos*) and Brazilian merganser (*Mergus octosetaceus*). Although applying only in the USA, this legal protection will increase the chance of survival for these endangered birds in Brazil by restricting wildlife trade, enhancing conservation funding and attention, and protecting habitat during developmental

^{§§} Butler, R.A. (2009) Concerns over deforestation may drive new approach to cattle ranching in the Amazon. 9 September, 2009. <http://news.mongabay.com/2009/0909-amazon-cattle-ranching.html> (accessed 18 July, 2011).

^{¶¶} Butler, R.A. (2010) How Greenpeace changes big business. 22 July, 2010. http://news.mongabay.com/2010/0722-greenpeace_skar_interview.html (accessed 18 July, 2011).

^{***} Butler, R.A. (2010) Asia Pulp & Paper fumbles response to deforestation allegations by Greenpeace. 28 September, 2010. http://news.mongabay.com/2010/0928-app_vs_greenpeace.html (accessed 18 July, 2011).

^{†††} Hance, J. (2010) Consumer goods industry announces goal of zero deforestation in Cancun. 30 November, 2010. http://news.mongabay.com/2010/1130-hance_bcgf.html (accessed 18 July, 2011).

^{‡‡‡} Anon. (2010) Google lends its massive computing cloud in fight against deforestation. 3 December, 2010. http://news.mongabay.com/2010/1203-google_earth_engine.html (accessed 18 July, 2011).

^{§§§} Butler, R.A. (2010) Walmart takes on Amazon deforestation. 18 October, 2010. http://news.mongabay.com/2010/1018-walmart_deforestation.html (accessed 18 July, 2011).

^{¶¶¶} Augustine, J. (2010) Seven imperiled Brazilian bird species gain endangered status. 28 December, 2010. http://www.biologicaldiversity.org/news/press_releases/2010/brazilian-birds-12-28-2010.html (accessed 18 July, 2011).

projects by the US Government and organizations such as the World Bank. Similarly, the decision by multinational banks, such as Citigroup, not to sanction loans to unscrupulous forestry projects and to require rigorous verification of eco-certification will benefit biodiversity [52].

Finally, governments are beginning to enact regulatory safeguards to exclude unsustainably sourced products. The USA and Europe have strengthened legislation prohibiting the import of illegally logged timber products, whereas California and the EU are evaluating biofuel standards that would ban fuels produced via the conversion of carbon-dense ecosystems. Furthermore, the Netherlands will require all palm oil imports to be certified by the Roundtable on Sustainable Palm Oil by 2015. In summary, these macroscale conservation approaches can help to preserve forests and sustain biodiversity in distant nations. Increased consumer education and awareness can help to effect such changes and limit environmental abuses at the macroscale (Figure 1).

Linked conservation scales

Some of the examples discussed above transcend conservation scales (Figure 1). Nonetheless, the International Union for the Conservation of Nature and Natural Resources (IUCN) listing of threatened species is an example of how different conservation scales can be effectively linked. The listing attracts global attention and thereby promotes efforts at local levels, such as habitat preservation, that can alleviate threats to imperiled species. Between 1994 and 2004, conservation actions, including habitat protection and management, control of invasive species, and captive breeding and release, probably prevented the extinction of 16 imperiled bird species (Figure 3) [56]. Conservation actions reduced extinction and endangerment of many vertebrates between 1988 and 2008 [8], and several high-profile endangered species have recovered as a result (Box 1). Buying and protecting expanses of crucial habitat is a common strategy used by international organizations to preserve endangered animals (<http://savingspecies.org>). Zoos can help via the reintroduction of native species that have vanished in the wild. For instance, the Bronx and Toledo Zoos in the USA supplied Kihansi spray toads (*Nectophrynoides asperginis*) for release in their former native range in Tanzania [57].

In concert with the IUCN, the Convention on International Trade in Endangered Species (CITES) attempts to regulate the international trade of 34 000 species and also can spur conservation successes across scales (<http://www.cites.org>). Despite its deficiencies, such as poor monitoring, CITES has made positive differences in some instances [58]. Trading of rhinoceros horns was banned by CITES in 1976, with 175 countries eventually agreeing to this ban, including major rhino-horn importers, such as China, Japan, Vietnam and Yemen. This ban shifted some of the trade to the black markets, but better protection and law enforcement have enabled populations of both the black (*Diceros bicornis*) and white (*Ceratotherium simum*) rhinos to recover in dozens of countries in sub-Saharan Africa [59]. Breeding of rhinos in private ranches in Africa has also contributed to population growth [60]. Rhinos remain vulnerable to poaching, given the high prices their horns fetch,

but this nevertheless represents a success story triggered by decisive CITES action. International trade bans have also reduced unsustainable harvesting. In 1992, the US enacted the Wild Bird Conservation Act, prohibiting the import of CITES-listed birds (except from licensed captive-breeding or sustainable-harvesting programs; [24]). Nest poaching of parrots in the Neotropics declined by 28% as a probable result [24]. Similarly, the trade of CITES-listed Asian birds came to a complete halt, possibly because of the ban by the EU on import of wild-caught species in response to the avian influenza outbreak in 2005 [61].

Efforts by international NGOs can also assist species recovery at local and regional scales. Under pressure from international NGOs, federal and international protections during the 1960s and 1970s enabled the recovery of humpback whale populations from 1400 to approximately 20 000 individuals today [62]. International NGOs are also helping to protect orangutans and tree kangaroos in Borneo and Papua New Guinea, respectively [63]. Similarly, an international effort succeeded in restoring habitat for the critically endangered greater bamboo lemur (*Prolemur simus*) in Madagascar (<http://savingspecies.org>).

In other instances, cooperation among countries can enhance local-scale habitat protection. Clearing and burning of peatlands in Southeast Asia alone produces approximately 3% of annual anthropogenic carbon emissions [64]. In 2010, the Indonesian and Norwegian Governments signed a 2-year agreement to reduce conversion of peatlands and native forests [65], stemming from the UN Reducing Emissions from Deforestation and forest Degradation (REDD) program (<http://www.un-redd.org>). REDD and its various spin-offs offer funds to developing countries for preserving or managing their forests as carbon stores. If Indonesia meets its deforestation reduction targets, it could be paid up to US\$1 billion [65]. If carefully targeted, REDD investments could help to preserve biodiversity 'hotspots' with many endangered species [66].

Many conservation actions at multiple scales can aid conservation (Figure 1). Since 2006, the UN Environment Programme to reforest the planet has resulted in the planting of 7.3 billion trees in 167 countries^{****}. Although this effort might not restore native forests, it will create benefits, such as wood production, carbon storage, soil stabilization and flood alleviation. Similarly, since 2007 the Royal Society for the Protection of Birds (UK), BirdLife International and Burung Indonesia have been restoring Harapan Forest in Sumatra, with the assistance of the Indonesian Government [4]. This forest presently spans 100 000 ha and plans are afoot to expand it to 2 million ha by 2020. Multiscale efforts are also underway to manage and eradicate invasive species to protect island biotas (<http://www.islandconservation.org>).

The way forward

Conservation successes can span differing scales (Figure 1) and they have sometimes reversed endangered species declines in even the most desperate situations. However, better connections among different scales of conservation

**** Anon. (2009) Global campaign has planted 7 billion trees. 23 September, 2009. <http://news.mongabay.com/2009/0925-reforestation.html> (accessed 18 July, 2011).



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Figure 3. Bird species whose extinctions were prevented by conservation interventions from 1994 to 2004. (a) Tahiti monarch (*Pomarea nigra*); (b) California condor (*Gymnogyps californianus*); (c) Puerto Rican parrot (*Amazona vittata*); (d) Zino's petrel (*Pterodroma madeira*); (e) northern bald ibis (*Geronticus eremita*); (f) Seychelles magpie robin (*Copsychus sechellarum*); (g) crested ibis (*Nipponia nippon*); (h) Bali starling (*Leucopsar rothschildi*); (i) Chatham Island taiko (*Pterodroma magentae*); (j) pale-headed brush-finch (*Atlappetes pallidiceps*); (k) Junin grebe (*Podiceps taczanowskii*); (l) Lear's macaw (*Anodorhynchus leari*); (m) pink pigeon (*Nesoenas mayeri*); (n) Mauritius parakeet (*Psittacula eques*); (o) Norfolk Island green parrot (*Cyanoramphus cookii*); and (p) black stilt (*Himantopus novaezelandiae*). Modified, with permission, from [56]. Images reproduced, with permission, from: Tun Pin Ong (a), Phil Armitage (b), P. Torres (c), Kjetil Schjølberg (d), Richard Bartz (e), Adrian Scotton (f), Mike Endres (g), C. Burnett (h), John Barkla (i), Niels K. Krabbe (j), Alejandro Tabini (k), Marcos Pereira (l), Trisha M. Shears (m), Gregory Guida/<http://www.naturalvisions.co.uk> (n), Paul Gear (o) and Yang Zhang (p).

are needed. Conservation goals in projects should be clearly stated from the onset, and provisions should be made to evaluate their progress. Because the effects of conservation interventions on target populations and species can manifest over a protracted period [67], long-term commitments by funders are needed to document such positive outcomes. Fortunately, an increasingly large array of tools now exists to evaluate conservation projects [68–71]. Results from both successful and unsuccessful conservation projects should be widely disseminated so that future successes can be repeated.

More conservation projects fail than succeed, and our highlighting of successes here should not be taken as a call to rest on our laurels. Instead, our aim is to engender hope and inspire others to continue their dedicated efforts. With the global population expected to surge past 10 billion people by the end of this century [72], conservationists will face increasing challenges and a need for more funding and political and popular support. Having achieved some

notable successes, conservationists should pat themselves on the back and then redouble their efforts at all conservation scales.

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