An Ecoregion-Based Approach to Protecting Half the Terrestrial Realm

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We assess progress toward the protection of 50% of the terrestrial biosphere to address the species-extinction crisis and conserve a global ecological heritage for future generations. Using a map of Earth's 846 terrestrial ecoregions, we show that 98 ecoregions (12%) exceed Half Protected; 313 ecoregions (37%) fall short of Half Protected but have sufficient unaltered habitat remaining to reach the target; and 207 ecoregions (24%) are in peril, where an average of only 4% of natural habitat remains. We propose a Global Deal for Nature—a companion to the Paris Climate Deal—to promote increased habitat protection and restoration, national- and ecoregion-scale conservation strategies, and the empowerment of indigenous peoples to protect their sovereign lands. The goal of such an accord would be to protect half the terrestrial realm by 2050 to halt the extinction crisis while sustaining human livelihoods.

Keywords: Nature Needs Half, Aichi target 11, ecoregions, protected areas, global biodiversity conservation strategies

Protected areas are the cornerstone of biodiversity conservation (Coetzee et al. 2014, Wuerthner et al. 2015). Where networks of protected areas are large, connected, well managed, and distributed across diverse habitats, they sustain populations of threatened and functionally important species and ecosystems more effectively than other land uses (Noss and Cooperrider 1994, Gray et al. 2016). Protected areas also play an important role in climate-change mitigation (Baker et al. 2015, Melillo et al. 2015). Recognizing the importance of protected areas for conserving nature and its services, the Convention on Biological Diversity (CBD) established a goal to protect 17% of terrestrial land and inland water areas by 2020 through Aichi target 11. To date, approximately 15% of global land is protected (UNEP-WCMC and IUCN 2016).

Aichi target 11 is achievable but insufficient. Seventeen percent is not a science-based level of protection that will achieve representation of all species or ecosystems in protected areas and the conservation of global biodiversity, as are required by the CBD (Noss et al. 2012, Butchart et al. 2015, Wilson 2016). In contrast, reviews of conservation plans by Pressey and colleagues (2003) and Noss and colleagues (2012) demonstrated the scientific basis for a 50% protection target to achieve comprehensive biodiversity conservation. Authors of ecoregion-scale conservation plans from a variety of habitats who empirically evaluated what is required to represent and protect habitat and ecosystems (including marine) have agreed on the need to conserve about half of a given region (Noss and Cooperrider 1994, Pressey et al. 2003, Noss et al. 2012, O'Leary et al. 2016).

More recently, the scientific basis for protecting half the terrestrial realm was strengthened by Wilson's (2016) analysis of extinction in relation to area of natural habitat loss, of greatest concern in habitats rich in endemic species.

Even before these biodiversity-based analyses of the land area required for conservation, Odum and Odum (1972) pointed to the need to conserve half of the land to maintain ecosystem function for the benefit of humans. On the question of how much to conserve, a species-conservation approach derived the same answer as an ecosystem-services paradigm—a striking example of convergence. Therefore, the aspirational goal of 50% protected has emerged and the science codified in several advocacy and policy papers under the name *Nature Needs Half* (NNH; e.g., Locke 2013).

Nature Needs Half addresses the spatial dimensions of conservation biology, which comprises four goals: (1) represent all native ecosystem types and successional stages across their natural range of variation, (2) maintain viable populations of all native species in natural patterns of abundance and distribution, (3) maintain ecological and evolutionary processes, and (4) address environmental change to maintain the evolutionary potential of lineages (Noss and Cooperrider 1994). Here, we evaluate progress toward Nature Needs Half within the framework of ecoregions, protected areas, and habitats. We answer two basic questions that must be addressed: (1) Is the aspirational goal of protecting half of nature in the terrestrial realm possible? (2) Which half should be protected, and how much of it has already been conserved?

To address these questions and enhance systematic planning for terrestrial biodiversity conservation, we revised the 2001 map of terrestrial ecoregions of the world (supplemental appendix S1; Olson et al. 2001). We then determined the extent of both protected areas and remaining natural habitat within each ecoregion. To designate the protected area network, we used the World Database of Protected Areas (UNEP-WCMC 2016), which is inclusive of International Union of Conservation of Nature (IUCN) categories I to VI (Dudley 2008), as well as many community conservancies, aboriginal ownership, and private lands without an IUCN category. To assess habitat, we used tree-cover maps in forested ecoregions (Hansen et al. 2013) and excluded globally significant patterns of human land use and populations (anthropogenic biomes, or "Anthromes") in nonforested ecoregions (Ellis et al. 2010; detailed methods in supplemental appendix S2).

We conducted this analysis across all 846 terrestrial ecoregions distributed among the Earth's 14 terrestrial biomes (supplemental appendix S1). We then sorted ecoregions into four categories defined by the extent of both remaining natural habitat and protected land:

(1) *Half Protected*: More than 50% of the total ecoregion area is protected. (2) *Nature Could Reach Half*: Less than 50% of the total ecoregion area is protected but the sum of total ecoregion protected and unprotected natural habitat remaining is more than 50%. Ecoregions in this category have enough remaining natural habitat to reach Half Protected if additional protected areas or other types of conservation areas are added to the system. (3) *Nature Could Recover*: The sum of the amount of natural habitat remaining and the amount of the total ecoregion that is protected is less

than 50% but more than 20%. Ecoregions in this category would require restoration to reach Half Protected because the amount of available habitat outside protected areas plus the existing protected areas is below 50%. (4) *Nature Imperiled*: The sum of the amount of natural habitat remaining and the amount of the total ecoregion that is protected is less than or equal to 20%.

In many Nature Imperiled ecoregions, the remaining habitat exists as a mosaic of isolated fragments insufficient in size and orientation to adequately conserve biodiversity (Wilson 2016). We recognize that in the most heavily altered ecoregions, achieving Half Protected is inconceivable because of extreme rates of conversion. For example, in the tall grass prairie ecoregions of the United States and Canada, 99% of the land area is devoted to agriculture—an active land use that is unlikely to transition back to natural habitat.

To determine the shortcomings in conservation even where protected areas exist, we conducted a global survey of terrestrial ecoregions for which strategies to achieve long-term conservation goals have been developed. For each strategy, we assessed the extent to which all four goals of biodiversity conservation are addressed (appendix S3).

Evaluating protected area networks using ecoregions

The 2001 map of the terrestrial ecoregions of the world (Olson et al. 2001) facilitated the design of representative networks of protected areas. It has also been used to depict species distributions, to model the ecological impacts of climate change, to develop landscape-scale conservation plans, and to report on progress toward international targets. The revised map, named Ecoregions2017[©Resolve], that is the basis for this scheme is unchanged for large sections of the seven biogeographical realms but differs from the original map in four regions: the Arabian Peninsula, some of the desert and drier ecoregions of the African continent, Antarctica, and the southeastern United States (figure 1). Further details and justification for changes are presented in supplemental appendix S1.

Calculating the extent of protection by ecoregion and biome provides a scorecard to measure progress toward Half Protected (table 1, figure 2). Summing across all 14 biomes and their constituent 846 ecoregions, 98 ecoregions (12%) have already achieved Half Protected. The largest category is Nature Could Reach Half, with 313 ecoregions (37%), followed by the 228 ecoregions classified as Nature Could Recover (27%). Half Protected remains a reasonable goal in these regions. Within Nature Could Reach Half, 119 (38%) ecoregions have greater than 20% of their land area protected; the remaining 194 ecoregions (62%) have limited coverage of protected areas but retain considerable intact natural habitat. To achieve Half Protected, these 313 regions require only an expansion of their protected area network. The remaining 207 ecoregions (24%) classified as Nature Imperiled have little natural habitat and will require intensive efforts to achieve Half Protected or even to conserve the fraction that remains.
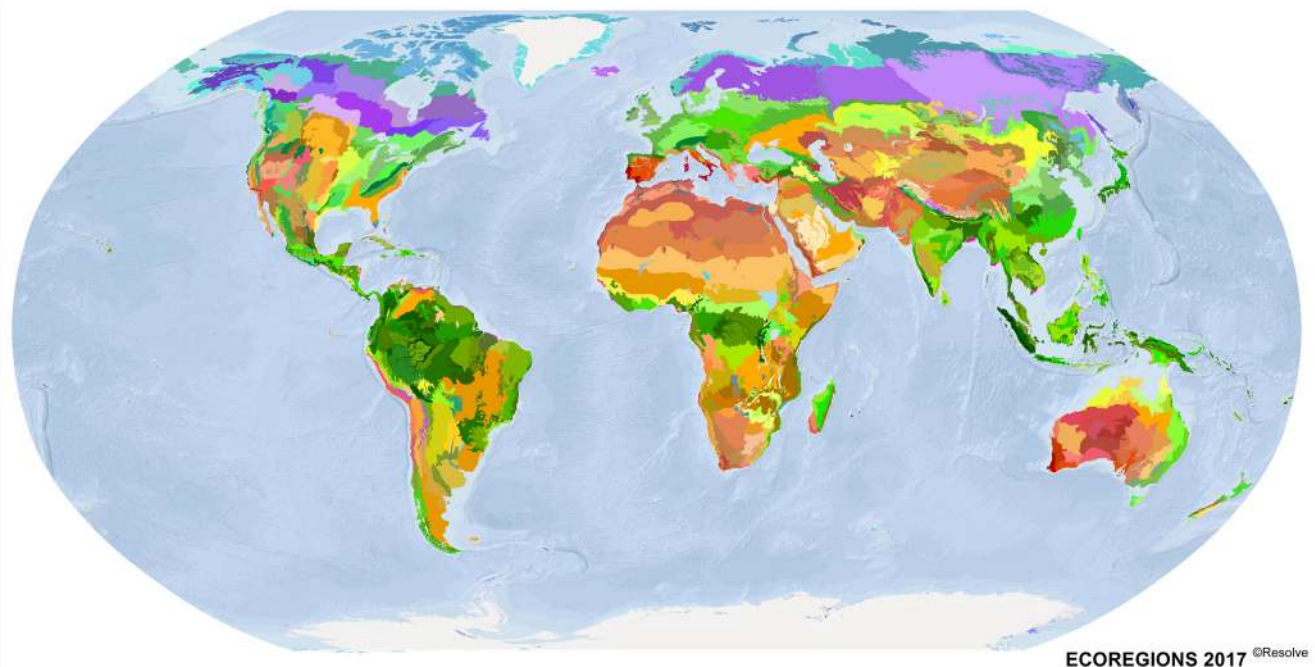
Figure 1. The 846 global ecoregions that comprise Ecoregions2017©Resolve nested within 14 terrestrial biomes. An interactive map is available at ecoregions2017.appspot.com. (A companion biome map is presented in supplemental appendix S1, supplemental figure S1).

Analyses conducted at a global scale inevitably involve error. Here, we were unable to differentiate "paper parks"—designated protected areas that remain unprotected because of lack of enforcement—from those that are well managed. Protected areas subjected to severe bushmeat-hunting pressures or overgrazing by domestic livestock are also ignored at this scale, although these are major threats. There are also protected areas where activities (e.g., industrial extraction) have been expressly allowed by governments even though these activities are plainly inconsistent with conservation objectives. We elucidate the major sources of error, including the assessments of tree-cover change and land-cover classes, in supplemental appendix S2.

Forested ecoregions and biomes. The 476 forested ecoregions are distributed unevenly among each of the four categories of protection: 40 (8%) achieve Half Protected; 198 and 130 fall into Nature Could Have Half and Nature Could Recover categories, respectively; and 108 are classified as Nature Imperiled.

The tropical and subtropical moist broadleaf forests biome has more species and ecoregions than any other on Earth. Covering only 14% of the Earth's land area, this biome supports at least 50% of the world's species (table 1), many of which have likely yet to be discovered (Mora et al. 2011). Fortunately, over half (61%; 140) of the ecoregions within this species-rich biome (*n* = 230) fall into the Half Protected or Nature Could Reach Half category: 24 (10%) ecoregions have achieved Half Protected (table 1, supplemental appendix S2), and 116 (50%) have achieved

Nature Could Reach Half (many of which already exceed Aichi target 11). Of the best-protected ecoregions, the majority (15) occur in the Neotropics, followed by the Indomalayan realm (11; figure 2).

In contrast to the moist forests, the tropical and subtropical dry broadleaf forest is the most endangered biome on Earth; only 2 ecoregions (among 56) are Half Protected, 20 are Nature Could Recover, and 26 are Nature Imperiled. The temperate broadleaf and mixed forests biome has the second largest number of ecoregions (83) but shows a distribution of protection categories skewed toward those needing restoration: Nature Could Recover and Nature Imperiled. The boreal forest ecoregions are among the largest and have the greatest potential to reach Half Protected because of their vast remaining intact forest blocks.

The majority of mangrove ecoregions fall into the categories of Half Protected or Nature Could Reach Half. The remaining mangrove ecoregions are degraded but can recover through restoration (table 1, supplemental appendix S2).

The Nature Imperiled category includes 108 (23%) forest ecoregions (*n* = 476; table 1; supplemental appendix S2, supplemental table S1a, S1b). Assessing recent trends in tree cover, of the 16 forest ecoregions with the greatest extent of tree loss between 2000 and 2014 (ranging from 20% to 86%), 9 are in the Afrotropics, and 4 are in the Indo-Malayan realm of India. Deforestation was greatest in the Nigerian lowland forests and the Cross-Niger transition forests.

Nonforested ecoregions and biomes. The protected area network is far less extensive in nonforested biomes. The

Table 1. Progress toward Nature Needs Half by biome, showing the number of ecoregions in each category, based on habitat protected and habitat remaining.

Biome name and number	Percentage of Earth's terrestrial area	Mean percentage of protected within biome	(1) Half Protected	(2) Nature Could Reach Half	(3) Nature Could Recover	(4) Nature Imperiled	Total
Forested biomes							
1. Tropical and subtropical moist broadleaf forests	14.4	12	24	116	46	44	230
2. Tropical and subtropical dry broadleaf forests	2.9	8	2	8	20	26	56
3. Tropical and subtropical coniferous forests	0.5	12	1	6	7	1	15
4. Temperate broadleaf and mixed forests	9.3	10	7	21	30	25	83
5. Temperate conifer forests	2.8	17	2	16	19	10	47
6. Boreal forests or taiga	11.4	9	1	23	2	0	26
14. Mangroves	0.2	26	3	8	6	2	19
Forested biome subtotal	*41.5*	*13*	*40*	*198*	*130*	*108*	*476*
Nonforested biomes							
7. Tropical and subtropical grasslands, savannas, and shrublands	15.8	15	5	14	18	20	57
8. Temperate grasslands, savannas, and shrublands	7.8	4	0	11	13	24	48
9. Flooded Grasslands and Savannas	0.9	32	8	4	9	4	25
10. Montane grasslands and shrublands	3.6	25	9	11	14	12	46
11. Tundra	8.7	8	26	24	0	1	51
12. Mediterranean forests, woodlands, and scrub	2.4	18	2	5	25	8	40
13. Deserts and xeric shrublands	19.3	6	8	46	19	30	103
Nonforested biome subtotal	*58.5*	*10*	*58*	*115*	*98*	*99*	*370*
Total	100	12	98	313	228	207	846

Note: The ecoregion data can be found in supplemental tables S1 and S2. (1) Half Protected: 50% or more of the total ecoregion area is protected. (2) Nature Could Reach Half: Less than 50% of the total ecoregion area is protected, but the sum of the total ecoregion protected and unprotected natural habitat remaining is 50% or more. (3) Nature Could Recover: The sum of the amount of natural habitat remaining and the amount of the ecoregion that is protected is less than 50% but more than 20%. (4) Nature Imperiled: The sum of the amount of natural habitat remaining and the amount of the ecoregion that is protected is less than or equal to 20%.

tundra biome is best protected among the seven nonforested biomes: 26 of the 51 tundra ecoregions (51%) fall under Half Protected, and another 24 ecoregions (47%) are in Nature Could Reach Half. Desert and xeric shrubland ecoregions also have expansive networks of protected areas and large swaths of natural habitat remaining: over half fall into Half Protected or Nature Could Reach Half (figure 2). Ecoregions in the remaining nonforested biomes have been more heavily degraded: 99 (27%) nonforested ecoregions were categorized as Nature Imperiled.

Human impact and revisiting the most endangered biomes on Earth. Land-use change as a result of human activities is

a dominant feature in the large majority of ecoregions, as has also been shown by Venter and colleagues (2016). In the 207 Nature Imperiled ecoregions, an average of 96% of natural habitat has been converted to an anthropogenic land use. Many of the fragments in these ecoregions are of disproportionately high biodiversity value. Here, protecting Key Biodiversity Areas (KBAs) will be crucial, and the goal of NNH remains aspirational and of secondary concern to protecting what remains (Eken et al. 2004).

Forested and nonforested biomes are evenly represented in the Nature Imperiled category (table 1). Hoekstra and colleagues (2005) described the temperate grasslands, savannas, and shrublands biome as the most endangered in the world. However, our results show that the most critically

Legend

- Half Protected (98)
- Nature Could Reach Half Protected (313)
- Nature Could Recover (228)
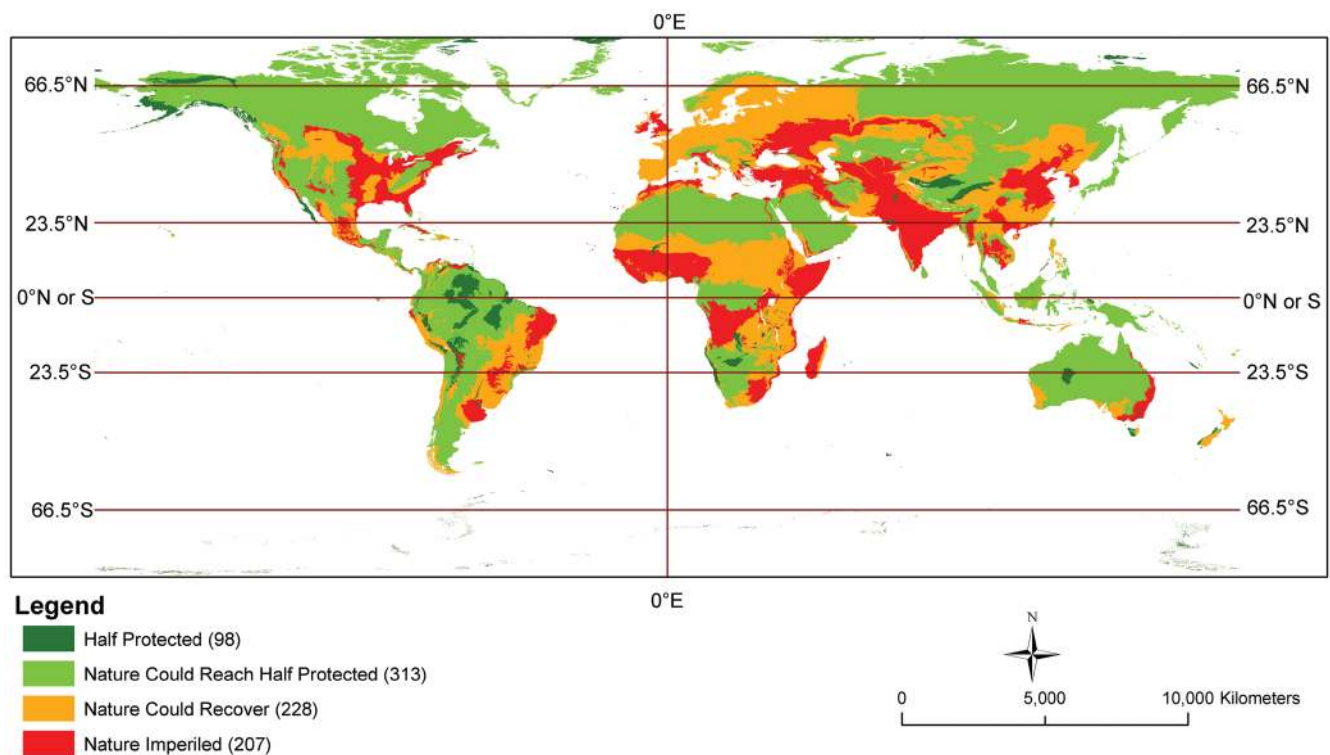- Nature Imperiled (207)

Figure 2. The protection statuses of ecoregions of the world. This map shows the high levels of habitat remaining in some of the most species-rich areas on Earth, including the Brazilian Amazon, the Congo basin, and the islands of Indonesia. Although enough habitat remains for nearly half of the ecoregions to exceed 50% protected in the coming decades, much of this forest is still unprotected, and just under 50% of ecoregions have adequate conservation plans in place to keep remaining forests intact (supplemental appendix S3). The numbers in parentheses for each category represent the entire number of ecoregions found in each category. The ecoregion protection categories are defined as the following: Half Protected, more than 50% protected; Nature Could Reach Half, less than 50% of the total ecoregion area is protected, but the sum of the total ecoregion protected and unprotected natural habitat remaining is more than 50%; Nature Could Recover, the sum of the amount of natural habitat remaining and the amount of the total ecoregion that is protected is less than 50% but more than 20%; Nature Imperiled, the sum of the amount of natural habitat remaining and the amount of the total ecoregion that is protected is less than or equal to 20%.

endangered biome—as is determined by the proportion of Nature Imperiled ecoregions that constitute each—is the tropical dry forests, whereas two nonforested biomes are nearly as endangered: (1) tropical and subtropical grasslands, savannas, and shrublands and (2) Mediterranean forests, woodlands, and scrub.

Without considering fine-scale endemism and beta-diversity (turnover of species with distance or along gradients), simple metrics of habitat loss and percent protection may underestimate the conservation crisis among biomes. Biodiversity loss would therefore be much greater and more sensitive to habitat conversion in tropical and subtropical grasslands, savannas, and shrublands; in Mediterranean forests, woodlands, and scrub; and in tropical moist and tropical dry forests. These four biomes support higher endemism and greater beta-diversity levels than those found in other biomes.

Beyond Aichi targets: Toward Half Protected

The need to go beyond Aichi protection targets was approved by delegates at the 2014 IUCN World Parks Congress. They further decided that the total area of protected areas and connectivity lands needs to be far higher than current conceptions and agreed on the importance of setting ambitious targets (IUCN 2014). Results from our global assessment suggest that the ambitious target of protecting half of terrestrial nature is attainable for many of the Earth's more intact ecoregions. Among the 846 ecoregions, 98 (12%) occupy the Half Protected category. Although these ecoregions are largely concentrated in two biomes—tropical and subtropical moist forest and tundra—there is at least one ecoregion achieving this status in 12 of the 14 biomes. Within Nature Could Reach Half ($n = 313$), 26 ecoregions (8%) are at least 40% protected and therefore require modest additional protection to reach Half Protected in each. These and the other 287 ecoregions constituting the Nature Could Reach Half category provide
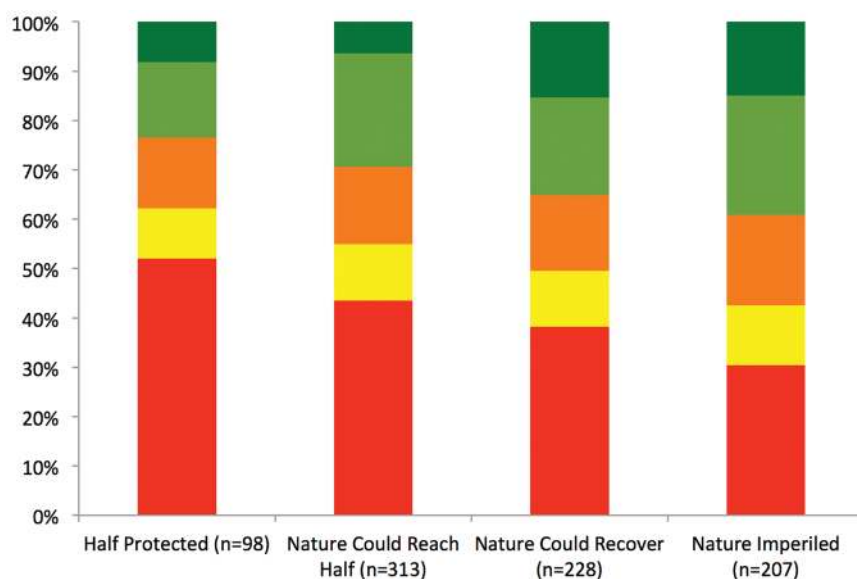
Figure 3. The proportion of biodiversity goals addressed within available conservation plans for all 846 ecoregions, distributed across the four protection-status categories. The colors represent the percentage of conservation strategies addressed within each protection-status category: 0 goals addressed, red; 1 goal addressed, yellow; 2 goals addressed, orange; 3 goals addressed, light green; 4 goals addressed, dark green. For a detailed list of conservation strategies and sources, see supplemental appendix S3.

the greatest conservation opportunity, because adequate habitat remains to reach Half Protected. These ecoregions are found within every biome and should rank high in the formulation of the next Aichi target 11 post-2020.

Because Aichi target 11 requires protected area networks to be ecologically representative, an ecoregion assessment provides an indispensable tool for meeting the new targets to be set in 2020. Greater effort is needed to complete these ecoregion strategies. For example, only 94 of the 846 terrestrial ecoregions (11%) have published plans that address all four biodiversity conservation goals (figure 3; see supplemental appendix S3 for methods). Formal conservation strategies that address three-fourths of the biodiversity conservation goals were published for 22% of ecoregions globally. Most of these strategies focus on identifying priority areas for protection and on conserving species of conservation concern (figure 3). Notably, a high percentage of ecoregions in the Nature Imperiled category have plans that address all four conservation goals. This is because biodiversity hotspots—biologically rich areas containing less than 30% of the original habitat—are explicitly targeted by Critical Ecosystem Partnership Fund (CEPF) profiles (Myers et al. 2000, Olson 2010). Of great concern are the 337 ecoregions that lack biodiversity plans (supplemental appendix S3).

Robust ecoregion strategies must be followed by effective implementation to realize biodiversity conservation goals formulated at a national scale. Three countries advancing to or already surpassing Half Protected—Namibia, Nepal,

and Bhutan—are worth singling out as compelling examples of where effective implementation embodies key principles of biodiversity conservation. They also refute some of the criticisms raised over the NNH approach that (a) it could displace rather than empower indigenous communities, (b) it is a paradigm only suitable for wealthy countries, and (c) it can only succeed in sparsely populated, remote ecoregions.

Namibia's conservation strategy includes conservation areas managed by local communities alongside government-run strict nature reserves across all its ecoregions. These communities are awarded autonomy to manage vast tracts of land for wildlife conservation and income generation, in large part by allowing communities to own the wildlife. Now widely touted as a success story in global conservation, these lands were largely defaunated through poaching only 25 years ago. Community-managed lands, called *communal conservancies*, now contribute to Namibia's national protected area network, which covers 47% of the country. Communal conservancies range in size from 43 square kilometers (km²) to 9120 km² (the mean being 1953 km²). In fact, many conservancies function as vital corridors connecting other protected areas and allowing dispersal, movement, and range recovery of large mammals, including elephants, lions, and others that are in steep decline elsewhere in sub-Saharan Africa (figure 4a; Naidoo et al. 2016).

In Nepal, ecoregion conservation strategies that involve local communities are the rule and complement the country's strictly protected areas. In the lowlands and midlands, community forestry and agroforestry in designated landscapes yield economic returns while strategically extending habitat and connectivity among reserves (figure 4b, table 2; Wikramanayake et al. 2010). Community-managed forest parcels are small—some are as little as 20 hectares in size—but abundant and interspersed among larger protected areas, often facilitating population recovery of endangered large mammals (Wikramanayake et al. 2010). Community forests, linked together to form corridors, play a pivotal role in landscape conservation. Handing over forest management to communities, which then receive 50% of the revenue generated by wildlife parks in designated buffer zones, led to a 61% increase in tigers and a 31% increase in rhinos over a 5-year period (2008–2013). No rhinos, tigers, or elephants have been poached in Nepal in several years (Dhakal et al. 2014).

In the Himalayan and trans-Himalayan ecoregions overlapping Nepal, conservation areas managed by local
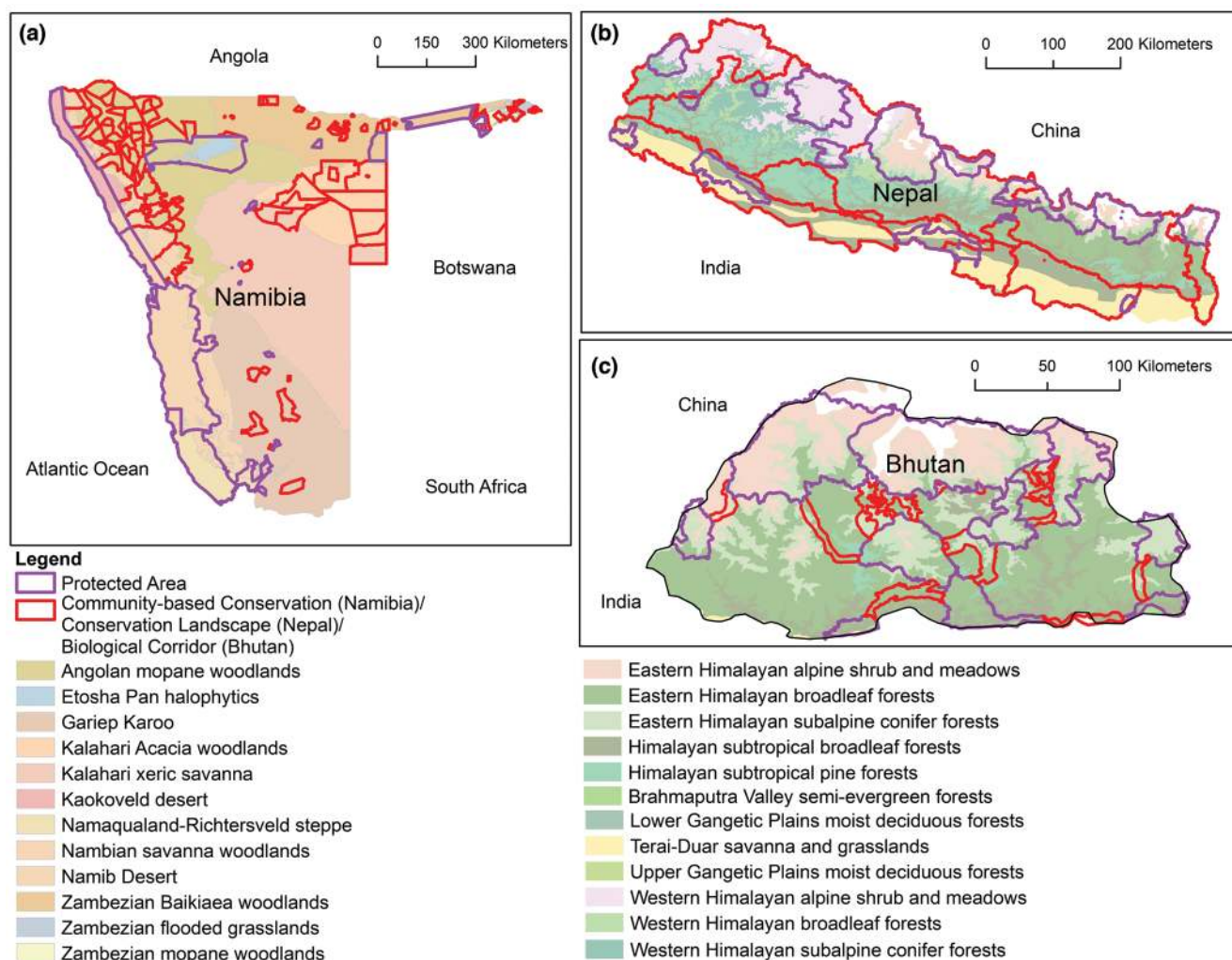
Figure 4a–c. Ecoregion conservation planning in three developing countries: (a) Namibia uses communal conservation areas to extend protection beyond protected areas and cover a diverse set of ecoregions, (b) Nepal uses a mixture of protected areas and conservation landscapes to protect along north–south and east–west gradients, and (c) Bhutan uses protected areas combined with biological corridors to provide connectivity between protected areas and across ecoregions.

communities exceed in area the land under national-park status and some, such as the Annapurna Conservation Area, return large sums of tourism-generated revenues annually to local funds. These are sparsely populated ecoregions. In contrast, the protected areas and community forests of the Terai-Duar savannas ecoregion in Nepal are intermingled with some of the highest rural population densities on Earth. In this densely settled, productive ecoregion situated on alluvial soils, there is room for intensive rice production and park protection (Dinerstein et al. 1999), the latter of which returns more than $1 million annually to local development funds in demarcated buffer zones.

Bhutan protects 51% of its land through national parks and corridors connecting reserves (figure 4c, table 2). In a novel policy framework, Bhutan's constitution requires that at least 60% of the country remains forested (currently, forest cover is estimated at 72%). Mid-elevation

temperate broadleaf forests, which are so heavily converted elsewhere, are particularly well protected. Bhutan, as with Nepal, ranks among the nations with the lowest *per capita* GDP but protects enough habitat to conserve biodiversity (Dinerstein 2013).

All three examples stress core protected areas, buffer zones, and connectivity—all key components of ecoregion conservation strategies and securing biodiversity. The first two examples illustrate how extensive areas can be put under conservation management by engaging local communities. The example of Bhutan offers a different mechanism through constitutional decree. Both approaches work.

Strengths and weaknesses of the Nature Needs Half approach to conserving half the terrestrial realm

NNH, like any paradigm, has strengths and weaknesses. NNH offers a simple, inspirational, and science-based

Table 2. The conservation status of ecoregions within the countries of Namibia, Nepal, and Bhutan.

Ecoregion number	Ecoregion	Global ecoregion area (km^2)	Ecoregion area within country (km^2)	Percentage of global ecoregion area	Country's area protected in IUCN cateogry I–VI (km^2)	Percentage of country's ecoregions protected	Global ecoregion protection status
Country of Namibia							
34	Angolan mopane woodlands	191,639	151,443	79	66,620	44	2
47	Kalahari Acacia woodlands	106,411	68,004	64	46,214	68	1
64	Zambezian Baikiaea woodlands	358,546	86,277	24	20,469	24	2
65	Zambezian mopane woodlands	387,596	4,724	1	2,569	54	2
70	Etosha Pan halophytics	7,691	7,688	100	7,457	97	1
76	Zambezian flooded grasslands	201,936	4,239	2	2,137	50	1
94	Gariep Karoo	251,666	142,553	57	10,729	8	2
97	Kalahari xeric savanna	685,551	183,555	27	12,277	7	2
98	Kaokoveld desert	33,039	20,806	63	20,767	100	1
102	Namaqualand-Richtersveld steppe	52,727	20,044	38	18,065	90	2
103	Namib Desert	79,116	79,118	100	72,427	92	1
104	Nambian savanna woodlands	102,712	56,391	55	31,704	56	3
Namibia Total		*1,406,746*	*506,706*	*36*	*168,106*	*33*	
Country of Nepal							
233	Himalayan subtropical broadleaf forests	38,124	28,447	75	2,766	10	3
238	Lower Gangetic Plains moist deciduous forests	253,213	250	0	0	0	4
287	Upper Gangetic Plains moist deciduous forests	262,642	25	0	0	0	4
302	Himalayan subtropical pine forests	76,126	22,811	30	836	4	3
306	Eastern Himalayan broadleaf forests	82,915	15,418	19	2,180	14	2
308	Western Himalayan broadleaf forests	55,825	4,809	9	913	19	3
309	Eastern Himalayan subalpine conifer forests	27,436	4,928	18	2,778	56	2
310	Western Himalayan subalpine conifer forests	39,650	12,080	30	1,753	15	4
311	Terai-Duar savanna and grasslands	34,517	22,732	66	3,265	14	4
751	Eastern Himalayan alpine shrub and meadows	121,014	8,212	7	6,725	82	2
769	Western Himalayan alpine shrub and meadows	70,090	21,243	30	7,593	36	3
Nepal Total		*1,061,552*	*140,954*	*13*	*28,810*	*20*	
Country of Bhutan							
222	Brahmaputra Valley semi-evergreen forests	56,613	274	0	125	46	4
233	Himalayan subtropical broadleaf forests	38,124	4,143	11	1,090	26	3
302	Himalayan subtropical pine forests	76,126	671	1	244	36	3
306	Eastern Himalayan broadleaf forests	82,915	16,198	20	4,079	25	2
309	Eastern Himalayan subalpine conifer forests	27,436	9,232	34	6,031	65	2
311	Terai-Duar savanna and grasslands	34,517	139	0	33	24	4
751	Eastern Himalayan alpine shrub and meadows	121,014	7,463	6	6,102	82	2
Bhutan Total		*436,745*	*38,119*	*9*	*17,704*	*46*	

Note: The protected status of many of these ecoregions is ahead of the global average because of ecoregional planning and the use of communal reserves and corridors in addition to strict protected areas. A map of these three countries and their protected areas can be found in figure 4. Global ecoregion protection status' refers to 1 = Half Protected, 2 = Nature Could Reach Half, 3 = Nature Could Recover, 4 = Nature Imperiled.

Box 1. Protecting half in a policy context.

Nature Needs Half finds support in the United Nation's Sustainable Development Goals (SDGs). Among other items, the SDGs call on humanity to "take urgent and significant action to reduce degradation of natural habitats [and] … protect and prevent the extinction of threatened species" and to "halt deforestation" and "halt loss of biodiversity" by 2020. These internationally agreed-on conservation goals will be challenging to achieve without protecting in the realm of half. As such, we call on advocates and leaders around the world to set new global protected area targets accordingly: 50% of the terrestrial realm by 2050.

Calls to increase the global area under protection should be considered in the context of other political mechanisms, such as international development funding (e.g., G20) and The Bonn Challenge. The Bonn Challenge, a global effort to restore millions of hectares of deforested and degraded land by 2020 or 2030, can be a critical mechanism in ecoregions falling under Nature Could Recover and Nature Imperiled. There are other opportunities to weave the 50% goal into the global economic and development fabric. For example, the "G20," the world's 20 largest economies, have called for as much as $60 trillion–$70 trillion in investment for large infrastructure projects (Foundation Earth 2015). Holistic ecoregional planning must be included to ensure that future infrastructure and cities are built in harmony with a world where nature receives half.

A Paris-like deal that addresses biodiversity conservation at the highest political level—a Global Deal for Nature under the auspices of the CBD—is needed for nature conservation (for further details see www.resolv.org/blog/2017/global-deal-for-nature). An initiative of this scale would mobilize unprecedented financial resources to support countries to implement the goal of Half Protected. The estimated cost to add terrestrial protected areas, better protect existing reserves, and restore habitat varies by country, region, and ecoregion, ranging between $8 billion and $80 billion per year for the terrestrial realm (Balmford et al. 2003, McCarthy et al. 2012) and between $5 billion and $19 billion per year for the marine realm (Balmford et al. 2004). Implementing a Global Deal for Nature would employ a large number of currently unemployed or underemployed workers in rural communities.

At the current rate, the amount of land under formal protection increases by about 4% per decade. If the rate of increase doubled to 8% or achieved 10% per decade, the global goal, supported by a Global Deal for Nature, could be within reach.

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message that can be easily understood by the general public. It also provides the conservation movement with a unifying goal. Incremental gains in global protection targets have proved insufficient in response to the magnitude of the biodiversity crisis. Conservation efforts have often been mired in process or targets that do not track onto an ultimate conservation goal or vision statement (Wilson 2016). NNH provides an endgame: Achieving Half Protected will help realize the outcomes and objectives of maintaining a living biosphere, avoiding mass extinction, and preserving ecological processes that benefit all human societies. NNH also provides a goal and a planning framework under which all conservation efforts can fit.

Importantly, 50% avoids setting targets too low and being surpassed by the synergistic effect of threats to nature from climate change and mass extinction. The recent Paris Agreement under the United Nations Framework Convention on Climate Change provides targets for stabilizing atmospheric greenhouse gas concentrations at a level that prevents "dangerous anthropogenic interference with the climate system." We contend that for the climate deal to succeed, we need a Global Deal for Nature (box 1). NNH provides a baseline from which we can monitor progress as the environmental data sets are increasingly dynamic, annually updated, and freely available and serve as a scorecard to underpin a Global Deal for Nature and assist the CBD in measuring progress. Finally, NNH could help provide government, lenders, citizens, and industry guidance about

where to site extractive industries and develop large infrastructure projects.

Providing clear implementation guidelines can help address weaknesses associated with NNH. For example, insisting that NNH be empirically derived for each of the world's ecoregions is important. However, in trying to erect a simple, science-based target that nonscientists can understand—50% protected by 2050—the approach runs the risk of giving the misimpression that 50% is the "right" target for each ecoregion. In fact, the amount of habitat that needs to be conserved in each region will vary. This guideline will help avoid pitfalls, such as a case in which governments could assign large areas to be protected just to reach the 50% target (e.g., high-elevation rock and ice, barren desert, contaminated areas, unproductive soils, or lands of low economic value) without consideration of the design, through ecoregion strategies, of representative networks to capture unique patterns of biodiversity. One clear guideline is that site selection is as important as total area protected in achieving conservation objectives (Margules and Pressey 2000). Tools such as ecoregion conservation planning, CEPF hotspot profiles, Key Biodiversity Areas, and systematic conservation planning that focus on the quality or irreplaceability of areas considered for protection will be most useful to avoid this danger (Margules and Pressey 2000, Myers et al. 2000, Eken et al. 2004, IUCN 2016).

A potential pitfall is that policymakers not well versed in ecosystem function might view NNH as license to clear the other 50%. This would be a disaster in some ecoregions,

such as those in the Amazon and Congo Basins, that perform vital ecological roles only if contiguous forest cover is maintained. Conservation planning will need to underpin the implementation of NNH to avoid these abuses.

Another concern is that the NNH approach risks overlooking, however unintentionally, those 207 ecoregions determined by our analysis to average only 4% of remaining natural habitat outside protected areas that fall into the Nature Imperiled category. Where ecoregions contain global centers of endemism but with only fragments of natural habitat remaining replete with irreplaceable sites, a concern is that the global importance of these sites of rarity could be downplayed. Donors and agencies might concentrate on those less biodiverse ecoregions but those likely to come closer to achieving the 50% target. In most of these ecoregions, Key Biodiversity Areas, if properly conserved will protect the biodiversity that remains (Eken et al. 2004). CEPF profiles should include all possible options for restoration (Butchart et al. 2015).

A possible concern expressed by critics of Wilson (2016) and of the NNH approach is that protecting half the terrestrial realm adversely affects humans in remote regions (e.g., Büscher et al. 2016). In contrast, implementing NNH is an opportunity to empower indigenous peoples and local communities. Many indigenous reserves in Latin America, Asia, Africa, and Australasia are an essential part of the formal protection network, but the decisionmaking is in the hands of those within the reserves. Several indigenous communities are also advocating for half their lands to be protected. The Dehcho Dene in northern Canada, for example, has articulated an explicit 50% protected goal for their own territory (Norwegian 2005). For many groups, such as the Dehcho Dene, protecting half is an approach derived from their traditional ecological knowledge. Conservation should be achieved through careful planning while respecting rights, improving livelihoods, and sharing decisionmaking.

Achieving Half Protected hinges on a reduction of human disturbance, sparing nature

Fortunately, two schools of thinking—how to save half for nature and how to feed and fuel advancing societies— are in growing concordance. As societies urbanize and develop, there is a well-documented trend toward "decoupling": an increasingly efficient use of land and resources that reduces environmental degradation (Ausubel 2000, Fischer-Kowalski and Swilling 2011, Tilman et al. 2011, Ausubel et al. 2012). These trends have already produced major recoveries of woodland and other vegetation in many regions (Ellis et al. 2013, Blomqvist et al. 2015). The prospects for feeding growing human populations while recovering natural habitat are not only aspirational but also achievable as long as these aspirations are put to work guiding land-use policy and commodity-chain interventions (box 1; Lambin et al. 2014).

The global phenomenon of growing urbanization, accentuated in some ecoregions, sets the stage for reaching Half Protected. In remote areas in many parts of the world,

depopulation due to socioeconomic changes such as increasing wages and career opportunities have resulted in rural populations moving to population centers; by 2050, 70% of people will live in cities. This phenomenon, driven by economics, could lead to expansion of the protected area network and restoration of disturbed or abandoned lands (Ellis et al. 2013).

Nature Needs Half is an ambitious goal that will allow humanity to maintain a world with space for all life and the continuance of critical ecosystem services. Our findings show that a large number of ecoregions are Half Protected and that NNH is achievable in the vast majority of remaining ecoregions. However, achieving NNH requires further research into the desirability, feasibility, and progress toward the goal at ecoregional and national scales. Here, we provide tools and information to chart progress toward NNH and call on advocates and leaders around the world to set new global protected area targets: 50% of the terrestrial realm by 2050. Doing so through carefully balanced ecoregion plans that promote economic development while sustaining nature will also make the planet more livable for humanity (Mulligan 2014, 2015).

Supplemental material
Supplementary data are available at *BIOSCI* online.

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