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Martine Maron[1,2*], Jeremy S. Simmonds[1,2], James E.M. Watson[1,2,3], Laura J. Sonter[1,2], Leon Bennun[4,5], Victoria F. Griffiths[6], Fabien Quétier[7], Amrei von Hase[8], Stephen Edwards[9], Hugo Rainey[3], Joseph W. Bull[10], Conrad E. Savy[11], Ray Victurine[3], Joseph Kiesecker[12], Philippe Puydarrieux[9], Todd Stevens[3], Naïg Cozannet[13], Julia P.G. Jones[14s]

1. Centre for Biodiversity and Conservation Science, The University of Queensland, St Lucia 4072, Australia.

2. School of Earth and Environmental Sciences, The University of Queensland, St Lucia 4072, Australia.

3. Wildlife Conservation Society, Global Conservation Program, New York 10460, United States of America.

4. The Biodiversity Consultancy, Cambridge CB2 1SJ, United Kingdom.

5. Conservation Science Group, Department of Zoology, University of Cambridge, Cambridge CB2 3EJ, United Kingdom.

6. Department of Zoology, University of Oxford, Oxford OX1 3SZ, United Kingdom.

7. Biotope, 34140 Mèze, France.

8. Forest Trends, Washington, DC 20036, United States of America and Bo-Kaap 8001, South Africa.

9. International Union for Conservation of Nature (IUCN), CH-1196 Gland, Switzerland.

10. Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, United Kingdom.

11. International Finance Corporation, Nairobi, Kenya.

12. The Nature Conservancy, Global Conservation Lands Program, Colorado 80524, United States of America.

13. Agence Française de Développement, Paris, France.

14. College of Environmental Sciences and Engineering, Bangor University, Bangor LL57 2UW, United Kingdom.

Corresponding author: Martine Maron (m.maron@uq.edu.au)

Abstract

A global goal of No Net Loss (GNNL) of natural ecosystems or better has recently been proposed, but such a goal would require equitable translation to country-level contributions. Given the wide variation in ecosystem depletion, these could vary from Net Gain (for countries where restoration is needed), to Managed Net Loss (in rare circumstances where natural ecosystems remain extensive and human development imperative is greatest). National contributions and international support for implementation also must consider non-area targets (e.g. for threatened species) and socioeconomic factors such as the capacity to conserve and the imperative for human development.

Main text

Momentum is building for an ambitious new commitment to be signed at the Conference of the Parties to the Convention on Biological Diversity (CBD) in 2020 as a global framework for nature conservation[1-4]. Notable are calls for retention of half the Earth's natural ecosystems[5,6], to be enshrined by 2030 as a target under the deal. Yet this leaves little 'room to move'—approximately half the Earth's terrestrial ecosystems have already been lost[7]. Nevertheless, complete cessation of anthropogenic impacts on natural ecosystems is infeasible, given the imperative for socioeconomic development where current levels of human development are low[8]. Conservation that ignores such differences among nations is likely to be unjust[9].

In this context, a goal of global No *Net* Loss (GNNL) of natural ecosystems is likely the most ambitious target that society can realistically achieve[10,11], at least by 2030. Such a goal allows for losses in some places and gains in others, which, taken together, ensure no further net decline of natural ecosystems, benefitting the species and people which rely upon them[12]. GNNL implies an absolute cessation of decline in net terms—a key distinction from the relative 'NNL' that characterises biodiversity offset policies[13].

It is far from trivial to translate a GNNL goal to effective policy mechanisms and mitigation approaches at the national level; indeed, the problem is akin to dividing humanity's 'carbon budget' equitably[14,15]. Here, we examine how different countries might set goals for retention and restoration as part of a contribution to achieving GNNL of natural ecosystems, using terrestrial ecosystems as an example.

Translating a GNNL goal to a blanket requirement for each nation to achieve NNL would clearly be inappropriately coarse. Instead, a GNNL target would act as an umbrella for a range of minimum net outcome goals adopted by each country as their respective contributions to GNNL (Fig. 1). Some countries support natural ecosystems across almost their entire extent—10 have more than 75% of original natural ecosystems according to the latest published human footprint[16] (e.g. Suriname and Canada Fig. 1; see Methods for more detail), while others retain close to none of their original natural ecosystems in reasonable condition (68 countries including France, Italy and India have <5% remaining; Fig. 1). Countries also vary tremendously in the imperative to convert or degrade those ecosystems in the pursuit of needed economic development, and in their capacity to protect and restore ecosystems. So, under a GNNL commitment, some countries might focus on restoring earlier losses, while others might further deplete their remaining ecosystems. Thus, some countries might commit to Net Gain, some to NNL, and in some circumstances, controlled loss, or drawdown, of ecosystems (here termed Managed Net Loss).

Information about depletion of natural ecosystems can help frame both country-level conservation goals, and policy mechanisms for achieving those goals. For example, even NNL is likely to be inadequate to conserve threatened species and functioning ecosystems for countries whose natural ecosystems are most severely depleted. Therefore, for such countries, Net *Gain* in the extent of their natural ecosystems is likely to be essential. For example, the UK has only 6% of ecosystems with a Human Footprint of <4 remaining (a threshold used as a proxy for ecosystem intactness[7]). The UK government recently proposed biodiversity Net Gain as a requirement for new development projects[17]. Similarly, France has committed to zero net conversion of natural land[18]. On the other hand, those countries with largely intact remaining ecosystems (e.g. Suriname, Gabon) may, in some circumstances, be able to accept further limited and controlled depletion ('Managed Net Loss') (Fig. 1). However, even if all countries with less than 25% of natural ecosystems remaining adopt Net Gain and seek to double the extent of those ecosystems through restoration, this would only contribute 4% to global ecosystem extent. Conversely, even a small percentage of net loss from countries with extensive remaining natural ecosystems, such as Australia and Brazil (5,535,401 km^2 and 4,643,615 km^2, respectively), would shift a very substantial restoration burden to other countries, if GNNL is to be achieved.

Even within countries that retain similar amounts of natural ecosystems, variation in depletion among different ecosystems can be lower (e.g. Norway, where retention of all its different ecosystem types is similarly high) or higher (e.g. Chad, where some ecosystems are much more depleted than others). In such cases, approvals for unavoidable losses of less-depleted ecosystem types might be tied to requirements to restore other, more-depleted ecosystems, using compensatory policy mechanisms like biodiversity offsetting[19,20]. Further complexity is introduced by the fact that some ecosystems may be extensive within a country, but globally rare; conversely, others are highly-depleted at a country level, yet globally common. Therefore, both country-level goal-setting, and trading losses for gains among different ecosystems within a country, must reflect this variation to ensure all ecosystem types can be adequately conserved.

We use the retention of terrestrial natural ecosystems to illustrate the complexity of translating GNNL to country-level goals, and propose that a similar exercise could consider the translation of the concept to the marine realm, or indeed to non-political units such as ecoregions. However, area-based retention is only one type of target that must be set for biodiversity to be adequately conserved. For example, the number of species listed as threatened with extinction does not correlate strongly with the depletion of natural ecosystems within a country (Pearson's $R = 0.17$; Figure 1a), though species decline often lags behind habitat loss[21]. Therefore, further ecosystem losses even from countries with relatively extensive natural systems could have a disproportionately negative impact in the most diverse but imperilled places (e.g., Brazil; 55% ecosystems remaining but 290 globally-threatened species of birds, mammals and amphibians).

A purely biophysical basis for conservation goal-setting in a country ignores important socioeconomic realities, which may further modify appropriate relative contributions of countries to a GNNL goal. Countries vary enormously in their levels of human development; people's basic needs in many countries are not currently being met[12]. Rapid economic growth for those at the bottom of the global wealth rankings is the most important goal for governments in many such countries and is essential from a human rights perspective. The countries with the most severe ecosystem depletion (and therefore requiring, in principle, biodiversity Net Gain) include many countries with the lowest Human Development Index (HDI) values (e.g. numerous African countries) (Fig. 2). Given that converting ecosystems can contribute to much needed development, and significant amounts of ecosystem degradation in poorer countries has contributed to fuelling economic growth in richer countries[22], it is unrealistic as well as unjust for goals to be set without socio-economic circumstances being considered. Addressing these equity implications, while also recognising the fundamental role of nature in supporting achievement of the Sustainable Development Goals[12], will also be essential to secure support for a GNNL commitment.

Given that globally, biodiversity loss already exceeds safe levels[23], NNL at the country level might be the minimum acceptable standard for wealthy, developed countries where standards of living are already high (e.g. Australia, Canada; Fig. 2). We suggest their conservation goals should be set such that further degradation and loss of ecosystems is halted—at least in net terms. This may require radical solutions including moving away from the paradigm that economic growth is always desirable[9].

Countries with low HDI are more likely to face further pressure on their natural ecosystems to facilitate urgently-needed economic development. Therefore, even where the level of depletion of natural ecosystems implies a NNL goal, Managed Net Loss may be unavoidable for such countries (Fig. 2), at least temporarily[24]. Countries with a low HDI may reasonably expect support from the international community to deliver on their contribution to a GNNL goal. Unfortunately, weak governance in some low HDI countries discourages such investment[25] and can limit the effectiveness of any development support[26] or of any in-country mechanisms to compensate for biodiversity losses. For example, many of the countries to which assistance may need to be provided score poorly on the Corruption Perceptions Index (Fig. 2). Achievement of global biodiversity conservation arguably is most sensitive not to the global goals and targets that are agreed, but to how well such complex challenges to their implementation are addressed[27].

Our framework provides guidance on the principles through which different countries could identify appropriate respective contributions toward a global goal of NNL of biodiversity. Any agreed set of contributions must tackle the reality of both biodiversity depletion, its causes, and global inequity in both ongoing pressures and capacity to respond to them. Goals must be transparently managed to avoid the task falling inequitably upon the world's poorest countries, while recognising that development at the expense of biodiversity is unsustainable[28].

Loss without limit is the paradigm under which natural ecosystems are currently being destroyed[3]. The need to clarify the overarching goal of the CBD and sharpen our commitments to retain, restore, and protect natural ecosystems was underscored resoundingly by the recent release of the IPBES global assessement[29]. So, as the focus turns to setting post-2020 conservation targets under the CBD, calls to dramatically increase their ambition[1,30] and to set explicit nature retention targets[3] must be heeded—and a pathway to translate them to country-level contributions laid out. A GNNL goal sets a limit to the loss we—and biodiversity—can tolerate, while allowing for human development where it is most urgently needed. Any basis for country-level commitments to a GNNL goal must reflect the substantial variation among countries in the level of depletion of their natural ecosystems—but also the degree to which capacity to conserve and the imperative for human development varies globally.

Methods

We used the depletion of natural ecosystems as one proxy for biodiversity loss, and the global Human Footprint 2009 dataset[31] as an indicator of this depletion. The Human Footprint is a comprehensive representation of anthropogenic threats to biodiversity, which cumulatively accounts for eight human pressures—built environments, crop lands, pasture lands, human population density, night lights, railways, major roadways, and navigable waterways[31]. It is mapped across the terrestrial surface of the globe at a 1 km^2 resolution, on a scale of 0 (lowest Human Footprint) to 50 (highest Human Footprint). Human Footprint values of 0-3 are representative of land that is largely devoid of infrastructure and development (although may support sparse human populations)[7,32]. We therefore considered areas with a Human Footprint value of ≥4 to be transformed – in other words, no longer supporting a natural ecosystem (as per Watson, et al.[7]).

For 170 countries (for which data were also available for all measures), we calculated the area of the country that is mapped with Human Footprint values of 0-3, as a proportion of the area of the country (for which Human Footprint mapping was available). This represented our measure of the proportion of the original natural ecosystems remaining in each country. We also calculated the variance in depletion of specific natural ecosystem types in each country. To do this, we used the map of global terrestrial ecoregions[33], to represent the broad ecosystem types that do or would have naturally occurred in each country. We calculated the loss of each ecoregion type per country, by overlaying the Human Footprint map (value ≥4). To calculate the variation in depletion among ecoregion types within each country, we used the Gini coefficient – a metric frequently used to indicate dispersion within a frequency distribution. Although most commonly used as an index of income inequality, it can be used as an index of inequality for disparate datasets; a value of 0 indicates all values are identical and 1 indicates extreme disparity among values. All GIS analysis was undertaken using ArcMap6.1, with spatial datasets projected to a Mollweide coordinate system.

To explore the extent to which countries differ in their biophysical context, we plotted the proportion of the original natural ecosystems remaining in each country against the variance in depletion of natural ecosystems. We also considered two other measures of the status of a country's biodiversity: the number of species listed as threatened under the IUCN Red List of Threatened Species (restricted to fully assessed taxa only, as of November 2018: mammals, birds, amphibians; note that most taxa are poorly known, so this too is a partial measure); and the total area (km^2) of natural ecosystems remaining in each country.

To examine how countries varied in environmental *and* socioeconomic contexts, we incorporated two further datasets into our analysis. We used the 2017 Human Development Index (HDI)[34] as a representation of key elements of human development at the national level. This composite metric subsumes indices relating to life expectancy, education and per capita income. We also considered the 2017 Corruption Perceptions Index (CPI)[35], which represents relative public sector corruption levels of nations as perceived by experts and businesspeople, and has been linked with the strength of a nation's democratic institutions[36]. We plotted these variables as they relate to a nation's level of depletion of ecosystems, to examine how variation in a country's socioeconomic factors potentially affect its capacity to contribute to a goal of GNNL.

Author contributions

MM, JPGJ, JEMW and JSS led the writing. JSS led the data analysis. All authors developed the central concepts collaboratively, and wrote and edited parts of the manuscript.

Data availability

All datasets used in this analysis are available via the citations identified in the Methods section. The raw data used to create Figure 1 and Figure 2 are available in Supplementary Table 1.

Code availability

No custom code was used.

Competing interests statement

LB, FQ and AvH receive income from commercial contracts for consultancy services related to the development and implementation of biodiversity offset policies.

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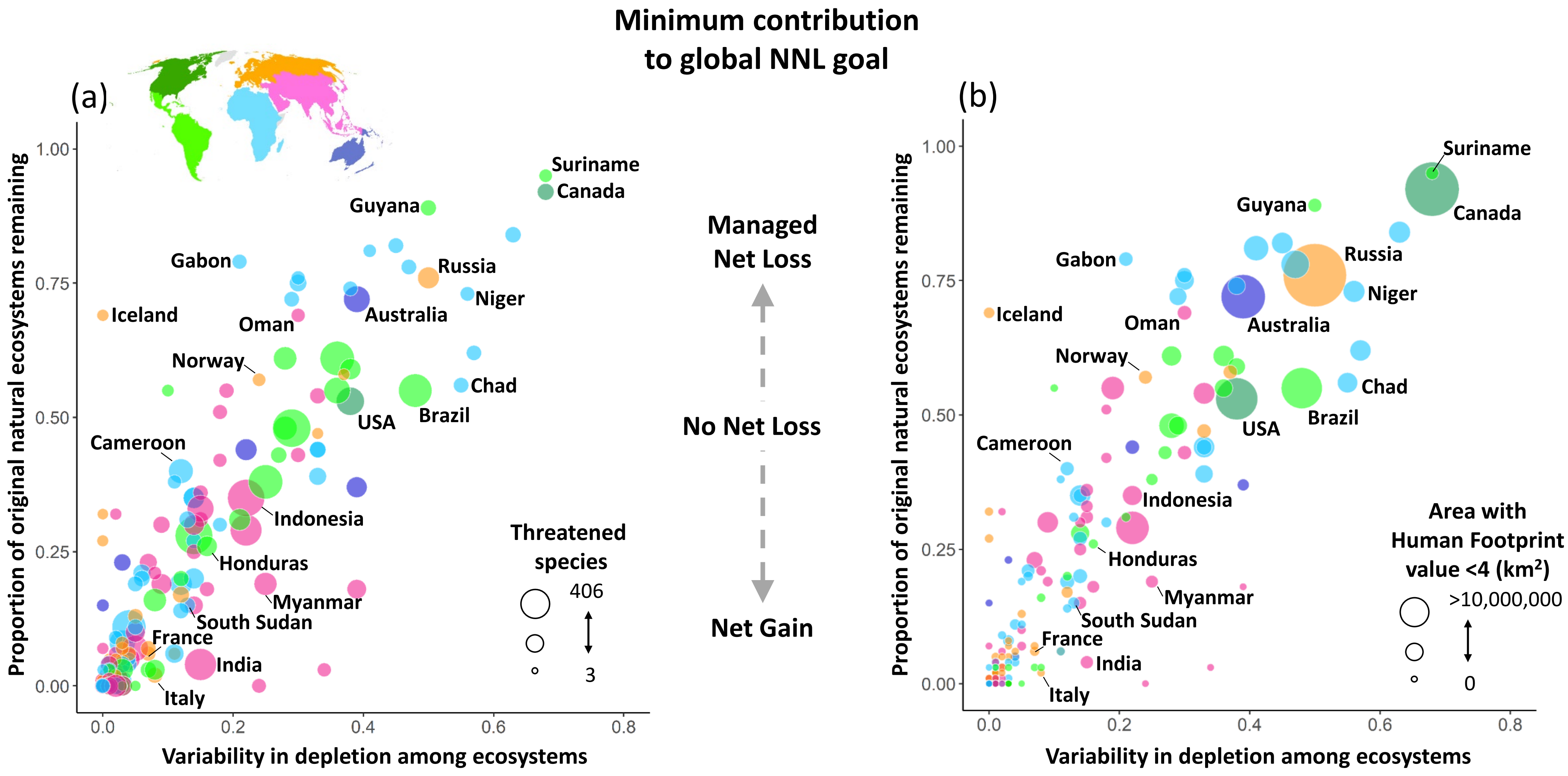
Figure legends

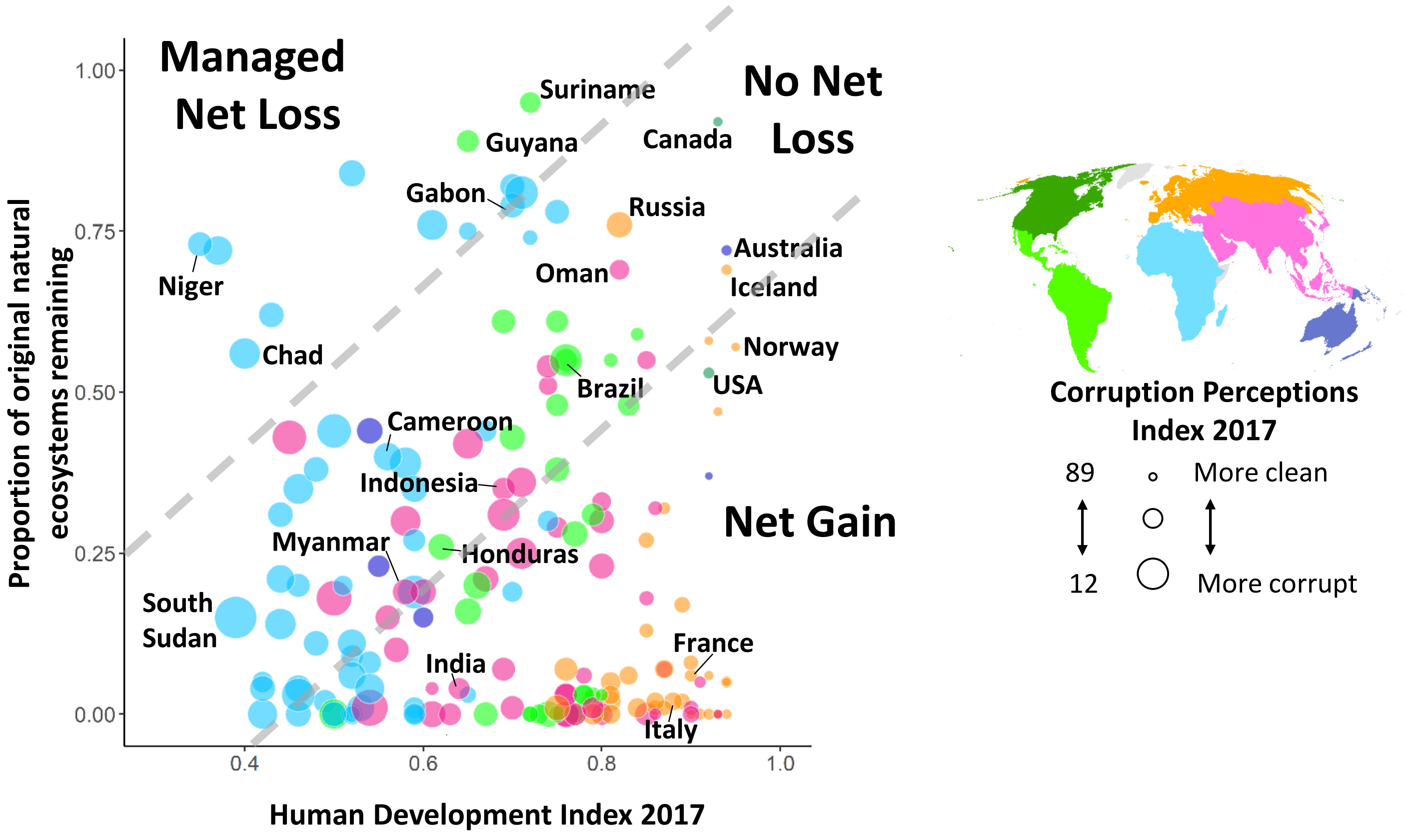
Fig. 1. Potential contributions of countries to GNNL. The proportion of natural ecosystems (Human Footprint value <4) remaining per country varies enormously, as does variation in the depletion among different ecosystems (Gini coefficient; see Methods). The minimum country-level contribution to a GNNL goal must reflect this, as well as the absolute area of natural ecosystems remaining (Fig. 1b). Ecosystem depletion must be considered alongside other factors in setting targets; e.g., the number of threatened species according to the IUCN

Red List of Threatened Species (for fully-assessed taxa only - mammals, birds and amphibians) relates only weakly to retention of ecosystems ($R = 0.17$; d.f. 169; $P = 0.0279$; R version 3.5.1; Fig. 1a).

Fig. 2. The degree of human development should affect minimum country-level contributions to achievement of GNNL, such that high HDI countries commit to at least country-level NNL. Bubble size reflects the Corruption Perceptions Index (2017) for each country; see Methods.



Minimum contribution
to global NNL goal
(a)
(b)
Proportion of original natural ecosystems remaining
Variability in depletion among ecosystems
1.00
0.75
0.50
0.25
0.00
0.0
0.2
0.4
0.6
0.8
Suriname
Canada
Guyana
Gabon
Russia
Niger
Iceland
Oman
Australia
Norway
Chad
USA
Brazil
Cameroon
Indonesia
Honduras
Myanmar
South Sudan
France
India
Italy
Threatened
species
406
3
Managed
Net Loss
No Net Loss
Net Gain
Area with
Human Footprint
value <4 (km²)
>10,000,000
0



Managed Net Loss
No Net Loss
Net Gain
Suriname
Guyana
Canada
Gabon
Russia
Niger
Oman
Australia
Iceland
Chad
Norway
Brazil
USA
Cameroon
Indonesia
Myanmar
Honduras
South Sudan
India
France
Italy
1.00
0.75
0.50
0.25
0.00
0.4
0.6
0.8
1.0
Proportion of original natural ecosystems remaining
Human Development Index 2017
Corruption Perceptions Index 2017
89
More clean
12
More corrupt