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Global no net loss of natural ecosystems

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A global goal of no net loss 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 (for example, for threatened species) and socioeconomic factors such as the capacity to conserve and the imperative for human development.

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 probably 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 that rely upon them[12]. GNNL implies an absolute cessation of decline in net terms—a key distinction from the relative 'no net loss' that characterizes 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 no net loss would 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. Some countries support natural ecosystems across almost their entire extent—ten retain more than 75% of original natural ecosystems according to the latest published human footprint[16] (for example, Suriname and Canada; Fig. 1; see Methods for more detail), while others retain almost 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 no net loss, 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 no net loss 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 United Kingdom 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 (for example, Suriname and 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 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

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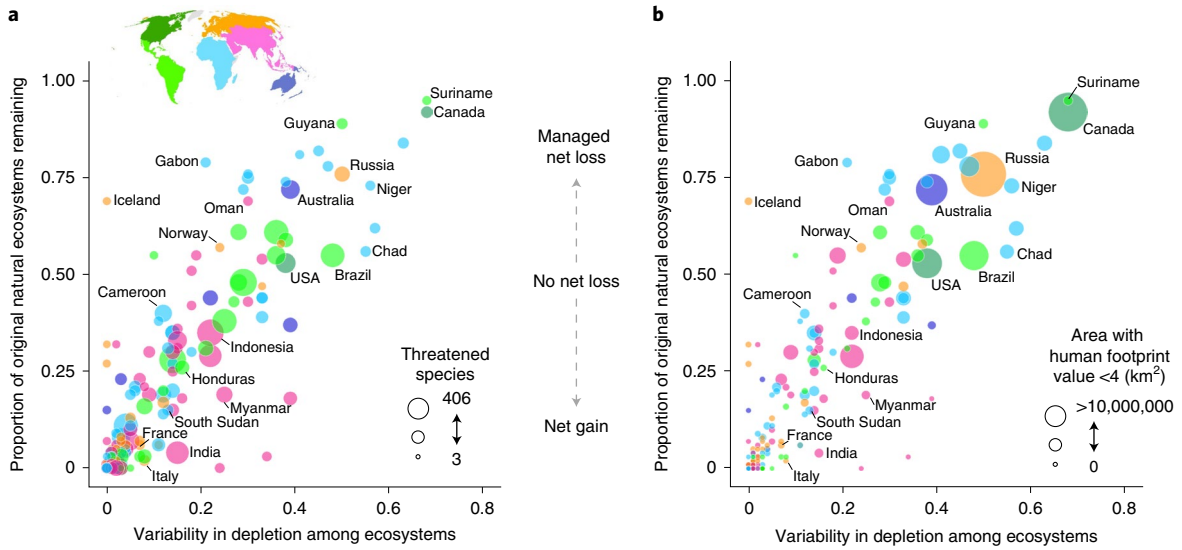

Fig. 1 | Variation in ecosystem depletion must be considered when setting country-level contributions to GNNL. The proportion of natural ecosystems (human footprint value <4) remaining per country varies enormously, as does variation in the depletion among different ecosystems (Gini coefficient; see Methods). The minimum country-level contribution to a GNNL goal must reflect this, alongside other factors. For example, **a**, 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 v.3.5.1). **b**, The absolute area of natural ecosystems remaining must also be considered in setting country-level contributions.

lower (for example, Norway, where retention of all its different ecosystem types is similarly high) or higher (for example, 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 and target-based ecological compensation[19–21]. 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 that 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. We 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 $R = 0.17$; Fig. 1a), though species decline often lags behind habitat loss[22]. 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 (for example, 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 (for example, numerous African countries; Fig. 2). Given that converting ecosystems can contribute to much-needed development and that notable amounts of ecosystem degradation in poorer countries has contributed to economic growth in richer countries[23], it is unrealistic as well as unjust for goals to be set without socioeconomic circumstances being considered. Addressing these equity implications, while also recognizing 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[24], no net loss at the country level might be the minimum acceptable standard for wealthy, developed countries where standards of living are already high (for example, Australia and 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 no net loss goal, managed net loss may be unavoidable for such countries (Fig. 2), at least temporarily[25]. 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[26] and can limit the effectiveness of any development support[27] 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 (CPI; 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[28].

Our framework provides guidance on the principles through which different countries could identify appropriate respective

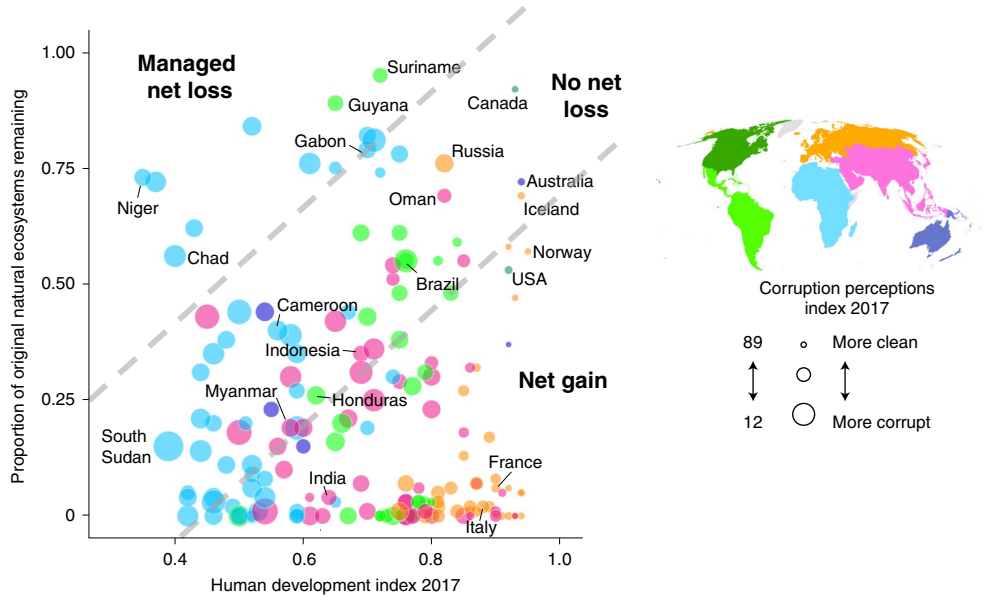

Fig. 2 | Minimum country-level contributions to achievement of GNNL should consider the degree of human development. Under a GNNL goal, managed net loss might be acceptable in countries where the imperative for human development is greatest, but high HDI countries should commit to at least no net loss to avoid shifting the burden of restoring ecosystems to countries with lower HDI. Bubble size reflects the CPI (2017) for each country; see Methods.

contributions toward a global goal of no net loss 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 recognizing that development at the expense of biodiversity is unsustainable[29].

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 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services global assessement[30]. So, as the focus turns to setting post-2020 conservation targets under the CBD, calls to dramatically increase their ambition[1,31] 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 vary globally.

Methods

We used the depletion of natural ecosystems as one proxy for biodiversity loss and the global human footprint 2009 dataset[32] 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[32]. 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)[7,33]. 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[34], 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 geographic information system 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 and 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 HDI[35] 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 CPI[36], 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[37]. 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.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

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

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Author contributions

M.M., J.P.G.J., J.E.M.W. and J.S.S. led the writing. J.S.S. led the data analysis. M.M., J.S.S., J.E.M.W., L.J.S., L.B., V.F.G., F.Q., A.v.H., S.E., H.R., J.W.B., C.E.S., R.V., J.K., P.P., T.S., N.C. and J.P.G.J. developed the central concepts collaboratively and wrote and edited parts of the manuscript.

Competing interests

L.B., F.Q. and A.v.H. receive income from commercial contracts for consultancy services related to the development and implementation of biodiversity offset policies. All other authors have no competing interests.

Additional information

Supplementary information is available for this paper at https://doi.org/10.1038/s41559-019-1067-z.

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Data collection	no software was used for data collection
Data analysis	The Pearson's correlation coefficient was calculated using R version 3.5.1

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Study description	We first assess the extent to which different ecosystems have been depleted among countries, and the variance in that depletion among ecosystem types, using the latest Human Footprint data, a relatively fine-scale metric that increasingly is used to reveal relatively intact ecosystems. We identify how these biophysical considerations can help inform decisions about NNL, Net Gain, and Managed Net Loss as country-level goals while ensuring an overall global goal of NNL can be achieved. We explore how factors such as a nation's need for human development, and capacity to deliver conservation, will affect both goal-setting and delivery strategies.
Research sample	All 170 countries as per Supplementary Table
Sampling strategy	Data from all countries was used
Data collection	Data from all countries was used
Timing and spatial scale	The Human Footprint data are from 2009; the Corruption Perceptions Index from 2017 and the threatened species data from 2018.
Data exclusions	No data were excluded.
Reproducibility	Not an experimental study
Randomization	Not an experimental study
Blinding	Not an experimental study

Did the study involve field work? ☐ Yes ☒ No

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Methods

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