Protecting half the planet could directly affect over one billion people

Judith Schleicher[a,*], Julie G. Zaehringer[a,b], Constance Fastre[c], Bhaskar Vira[a], Piero Visconti[d] and Chris Sandbrook[a]

[a] Department of Geography, University of Cambridge, Cambridge CB2 3EN, UK.

[b] Centre for Development and Environment, University of Bern, Bern, Switzerland.

[c] Institute of Zoology, Zoological Society of London, Regent's Park, London, NW1 4RY, UK.

[d] International Institute for Applied Systems Analysis (IIASA), Schlossplatz 1, 2361 Laxenburg, Austria.

[*] Corresponding author: Judith.Schleicher@cantab.net;

Abstract

In light of continuing biodiversity loss globally, one ambitious proposal has gained considerable traction amongst conservationists: the goal to protect half the Earth. Our analysis suggests that at least 1 billion people live in places that would be protected if the Half Earth proposal were implemented within all ecoregions. Considering the social and economic impacts of such proposals is central to addressing social and environmental justice concerns, and assessing their acceptability and feasibility.

Main text

To halt the rapid loss of biodiversity globally, numerous conservation strategies have been implemented. Member states of the Convention on Biological Diversity (CBD) have committed to placing 17% and 10% of the world's terrestrial and marine areas, respectively, within protected areas (PAs) by 2020 (Aichi Biodiversity Target 11[1]). Although meeting this target is within reach in many countries[2], rapid biodiversity loss continues[3]. As a result, conservationists have responded with alternative and more ambitious goals. One prominent proposal calls for the expansion of the global conservation estate to cover half the Earth[4,5]. This Half Earth, or Nature Needs Half, proposal has gained strong momentum, and has the potential to influence the post-2020 biodiversity targets and related processes[6]. Indeed, the Global Deal for Nature (GDN), which aims for 30% protection by 2030 and 50% by 2050, has been endorsed by a broad coalition of environmental organisations[7].

Achieving the Half Earth objective could involve radical changes in land and sea use across the planet. So far, the proposal has received some scrutiny with regards to environmental considerations[8] and its potential impacts on food production[9]. However, there has been no empirical analysis of other social and economic impacts of Half Earth, and the

proposal itself has been ambiguous about the exact forms and location of new conserved areas being called for. This is despite the fact that the proposal's social and economic impacts will influence its ability to deliver its conservation objectives and that there are frequently trade-offs involved in meeting environmental, social and economic goals of conservation and development interventions[10,11]. The reported impacts of existing PAs vary widely from physical and economic displacement to positive socio-economic outcomes for well-being or industry[12]. These impacts depend in part on the type of PAs, their governance arrangements, and the restrictions they place on resource use. Where the impacts are negative, they tend to disproportionally affect marginalised communities[13]. In light of this evidence on existing PAs, the increase in conserved areas to 50% could have large implications for the lives of those living inside these areas or in their vicinity[14,15].

We investigated the human implications of Half Earth by assessing the number and distribution of people that would be directly affected if half of Earth's land mass was protected. Since there is no consensus among those calling for a 50% protection target regarding which additional areas to protect, we based our analysis on the ecoregion approach proposed by Dinerstein and colleagues[78]. This approach is based on 846 ecoregions, to ensure protection of the full range of ecosystems and their associated species, to adequately conserve all elements of biodiversity. Dinerstein et al.[8] classify the ecoregions into four categories: those that already have 50% protection, those that could achieve 50% protection as sufficient natural habitat remains, those where 50% could be possible with substantial restoration efforts, and those with at most 20% of their natural habitat remaining and where achieving 50% protection of habitat is therefore unrealistic. To calculate the minimum number of people who would live in the conserved areas, and hence, would be directly affected by Half Earth, we selected areas (~5x5 km pixels) to be added to the existing

PA network within each ecoregion from lowest to highest human footprint value[16] until 50% coverage was achieved under two scenarios: (a) within all ecoregions and (b) only in ecoregions where Dinerstein and colleagues consider Half Earth reachable[8]. To achieve this we combined the global data layers of ecoregions, PAs (from the World Database of Protected Areas[17]) and human footprint with a global human population layer for 2017[18].

Our approach assumes a protection strategy designed to minimise key impacts on society, including avoiding areas with high population density and agricultural land. It ignores effects of conserved areas on people living beyond their boundaries, such as constrained access to resources. For these reasons our approach generates a conservative (lower bound) estimate of the potential number of people affected. Indeed, areas with higher human footprint values, and higher population density, would have to be protected if additional ecological criteria were applied to design the protection strategy, such as ensuring connectivity between conserved areas, setting minimum size thresholds of conserved areas, or seeking to protect land with highest biodiversity regardless of ecoregion. Hence, the number of people affected would likely be higher, especially in poorer countries which tend to have higher concentrations of biodiversity[19].

We find that over 1 billion people currently live in areas that would be protected under Half Earth if the proposal were applied to all ecoregions (Fig. 1). This is four times the number of people estimated by our approach to be living in PAs today (247 million) and includes 760 million people living in additional areas to be protected beyond existing PAs to meet the 50% target. If we only consider the ecoregions where Dinerstein et al. suggest 50% protection is feasible[8], 28% of the ecoregions' area (Supplementary Figure 2), currently home to 170 million people, must be newly protected. This is roughly equivalent to the population of the UK, Thailand and Morocco combined. The majority of people living in new areas to be

protected live in middle-income countries and ~10% in low income countries, regardless of whether we include all, or only less impacted, ecoregions (Table 1).

The majority of the additional conserved areas have human footprint values within the lowest 20% (Supplementary Figure 3). However, the global network of conserved areas necessary to achieve Half Earth would comprise areas with human footprint values within the top 20% under both scenarios, covering all ecoregions or only less impacted ones. At the upper end of this spectrum, these include highly developed areas, such as London, UK (Fig. 1 and Supplementary Figure 2). Implementing Half Earth at the ecoregion level in this way would clearly be in conflict with human use, raising questions about the feasibility and diverse social implications of this strategy.

We recognise the importance of conserved areas for the future of life on Earth, and the fundamental need for radical action in the face of unfolding environmental crises. However, our findings highlight the crucial importance of taking into account the human impacts of Half Earth, GDN, or other ambitious (area-based) conservation targets. Even with our conservative approach a very large number of people would be affected by implementing Half Earth. Therefore, any such proposals need to explicitly consider and seriously engage with their social and economic consequences. Considering these implications is not only central to concerns about social and environmental justice, but will also determine how realistic their implementation is in terms of achieving their intended conservation outcomes.

Based on our findings we make three recommendations. Firstly, Half Earth proponents should be explicit about the types, and location, of conserved areas they are calling for, to allow for more in-depth assessments of their social, economic and environmental impacts in the future. Secondly, the advocates of all area-based conservation

105 measures should recognise and take seriously the human consequences, both negative and
106 positive, of their proposals. Thirdly, the Parties to the CBD, tasked with negotiating and
107 implementing the post-2020 conservation framework, should apply more holistic,
108 interdisciplinary approaches that take into account social and economic implications across
109 scales[14,20]. Such approaches should consider important broader issues such as environmental
110 justice, the plural values people attribute to nature, and the need for action to tackle the
111 ultimate economic consumption and production drivers of biodiversity loss[10,14,21].
112
113 **Methods**
114 To determine the number and distribution of people living in areas that would be protected
115 under two Half Earth scenarios (50% protection within all ecoregions, and 50% protection of
116 those ecoregions with more than 20% natural habitat remaining), we combined the following
117 global datasets: terrestrial ecoregions[8], human footprint[16], the World Database of PAs
118 (WDPA, version July 2018[17]) and LandScan 2017 global population distribution[18]. We focused
119 on ecoregions because (a) Half Earth targets have been judged achievable, or already
120 reached, in ~49% of all ecoregions[8], (b) they have been widely used as a proxy to capture
121 biodiversity for conservation planning, and (c) they are the basis for the GDN proposal[7] and
122 for assessing Half Earth's impacts on food production[9]. We grouped ecoregions into
123 Dinerstein et al.'s[8] four categories according to their percentage protection and the amount
124 of natural habitat remaining. We selected new areas for protection (here referred to as
125 'conserved areas') based on the human footprint, which combines a diversity of human
126 impacts, including human population density, agricultural land, infrastructure and transport
127 routes. While it does not capture some less intensive human influences, it is the most
128 comprehensive global index of its kind. To determine the distribution of people within

129 countries of different income-status, we joined a Global Administrative Areas (GADM) layer
130 at country level[22] with the World Bank's (WB) income classification[23] of low, low-middle,
131 upper-middle and high income countries. Disputed territories and countries without WB
132 income codes were excluded from the analysis (n=6).

133 We pre-processed datasets in ArcGIS version 10.4.1. We rasterized all datasets, projected
134 them to Mollweide equal area at a spatial resolution of ~5x5 km, and set them to a common
135 extent. Through this pre-processing very small ecoregions, covering less than 50% of any
136 pixel, were removed, resulting in 818 remaining ecoregions. We excluded Antarctica because
137 it is not included in the human footprint dataset nor in the analysis conducted by Dinerstein
138 and colleagues[8]. As Antarctica is not permanently settled, excluding it does not affect our
139 population count results.

140 We imported, stacked and analysed the raster datasets in R version 3.5.1[24]. To determine the
141 area to be protected in each ecoregion to meet the 50% target, we divided the total area of
142 each ecoregion by two and subtracted the area currently protected per ecoregion according
143 to WDPA[17]. Under the first scenario, we then ordered pixels in each ecoregion according to
144 ascending human footprint values and selected the number of pixels with the lowest human
145 footprint values to meet the 50% target within each ecoregion from pixels not under
146 protection. We calculated the number of people living in the selected areas by summing up
147 the population count value[18]. Additionally, we calculated the number of people living within
148 existing PAs by combining the WDPA with the population distribution data layer. Under the
149 second scenario, we repeated this analysis while only selecting pixels to be protected from
150 ecoregions where over 20% of natural habitat remains. Finally, we calculated the number of
151 people living inside the conserved areas under each of these two scenarios per country,
152 according to the WB income classification[23].

Data availability. The R Code to reproduce the results is provided in the Supplementary Information. The datasets used in this study are all publically available or available to educational institutions for non-commercial purposes, but not distributable by the authors. Details of each dataset and download links are provided in the Supplementary Information.

References

1. *The Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets* (CBD, 2010).
2. Tittensor, D.P. et al. *Science* **346**, 241–245 (2014).
3. *Global Assessment Preview* (IPBES, 2019).
4. Locke, H. *George Wright Forum* **31**, 359–371 (2014).
5. Wilson, E.O. (Liveright, New York, 2016).
6. Dinerstein, E. et al. *Sci. Adv.* **5**, eaaw2869 (2019).
7. *Synthesis of Views of Parties and Observers on the Scope and Content of the Post-2020 Global Biodiversity Framework* (CBD, 2019).
8. Dinerstein, E. et al. *Bioscience* **67**, 534–545 (2017).
9. Mehrabi, Z., Ellis, E.C. & Ramankutty, N. *Nat. Sustain.* **1**, 409–412 (2018).
10. Ellis, E.C., Pascual, U. & Mertz, O. *Curr. Opin. Environ. Sustain.* **38**, 86–94 (2019).
11. Brockington, D. & Wilkie, D. *Philos. Trans. R. Soc. B Biol. Sci.* **370**, 20140271 (2015).
12. Oldekop, J.A., Holmes, G., Harris, W.E. & Evans, K.L. *Conserv. Biol.* **30**, 133–141 (2016).
13. West, P., Igoe, J. & Brockington, D. *Annu. Rev. Anthropol.* **35**, 251–277 (2006).
14. Büscher, B. et al. *Oryx* **51**, 407–410 (2017).
15. Kopnina, H. *Biol. Conserv.* **203**, 176–185 (2016).
16. Venter, O. et al. *Nat. Commun.* **7**, 12558 (2016).

17. *World Database on Protected Areas* (UNEP-WCMC & IUCN, 2018). www.protectedplanet.net
18. Rose, A.N., McKee, J.J., Urban, M.L. & Bright, E.A. *Landscan 2017* (2018).
19. Balmford, A. et al. *Science* **291**, 2616–2619 (2001).
20. Visconti, P., Bakkenes, M., Smith, R.J., Joppa, L. & Sykes, R.E. *Philos. Trans. R. Soc. B Biol. Sci.* **370**, 20140284 (2015).
21. Ten Brink, B. et al. (Netherlands Environmental Assessment Agency, 2010).
22. *Database of Global Administrative Areas* (GADM, 2018). www.gadm.org
23. *Country Classification* (World Bank, 2018).
24. R Core Team *R: A language and environment for statistical computing* (2018).
25. Google Earth (2019).

Corresponding Author. Correspondence to Judith Schleicher.

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Author contributions

J.S., J.G.Z., C.F., B.V., P.V., and C.S. designed the analyses. J.S. and J.G.Z. compiled the data and conducted the analyses. J.S. wrote the paper with input from J.G.Z., C.F., B.V., P.V., and C.S.

Competing interests. The authors declare no competing interests.

Supplementary Information. The Supplementary Information contains Supplementary Notes, Methods and Figures, including the full R Code to reproduce the results.

Figure captions:

Table 1: Number of people (million) living in additional areas protected to meet Half Earth targets within each ecoregion, according to the World Bank classification of low, lower-middle, upper-middle and high income countries and according to whether (a) all ecoregions are included, or (b) only less impacted ecoregions, where more than 20% of natural habitat remains. Percentage values of the total population are given for these two scenarios.

Fig. 1: Additional areas to be protected to meet Half Earth 50% protection targets within each ecoregion, on a colour scale of increasing human footprint value. A to D illustrate additional conserved areas (~5x5 km) with the highest human footprint within each World Bank income class: (A) High: London, UK; (B) Upper-middle: St Lucia; (C) Lower-middle: Egypt; (D) Low: Nepal[25].

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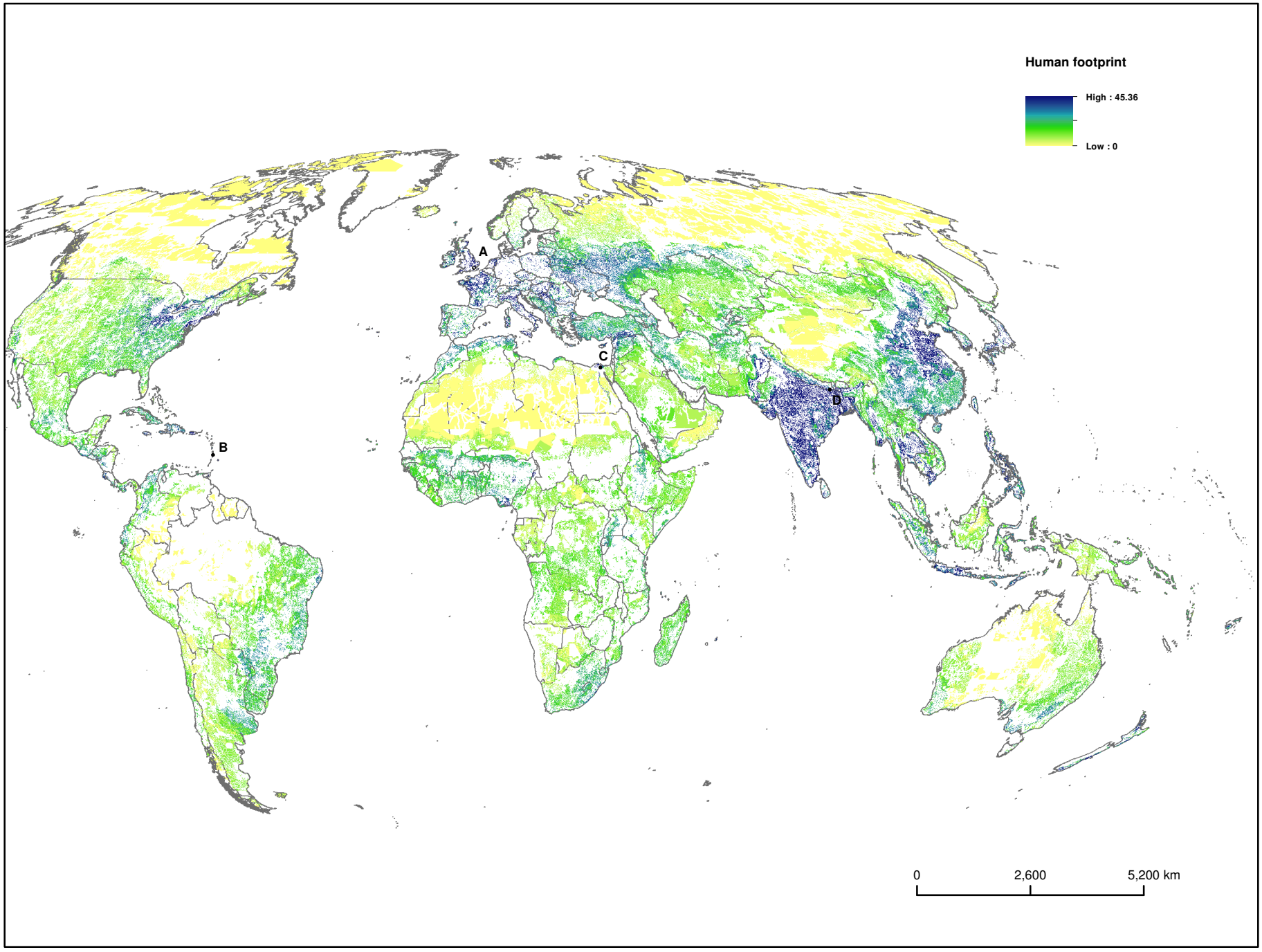
	All ecoregions	**Less impacted ecoregions**
Low	75 (10%)	16 (9%)
Lower-middle	403 (53%)	64 (37%)
Upper-middle	234 (31%)	65 (38%)
High	47 (6%)	25 (15%)


Human footprint
High : 45.36
Low : 0
A
B
C
D
0
2,600
5,200 km


A


B


C


D