

1 **Protecting half the planet could directly affect over one billion people**

2 Judith Schleicher<sup>a,\*</sup>, Julie G. Zaehring<sup>a,b</sup>, Constance Fastre<sup>c</sup>, Bhaskar Vira<sup>a</sup>, Piero Visconti<sup>d</sup> and

3 Chris Sandbrook<sup>a</sup>

4 <sup>a</sup> Department of Geography, University of Cambridge, Cambridge CB2 3EN, UK.

5 <sup>b</sup> Centre for Development and Environment, University of Bern, Bern, Switzerland.

6 <sup>c</sup> Institute of Zoology, Zoological Society of London, Regent's Park, London, NW1 4RY, UK.

7 <sup>d</sup> International Institute for Applied Systems Analysis (IIASA), Schlossplatz 1, 2361 Laxenburg, Austria.

8 \* Corresponding author: [Judith.Schleicher@cantab.net](mailto:Judith.Schleicher@cantab.net);

9 **Abstract**

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

16

17 **Main text**

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

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

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

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

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

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

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

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

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

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

101 Based on our findings we make three recommendations. Firstly, Half Earth  
102 proponents should be explicit about the types, and location, of conserved areas they are  
103 calling for, to allow for more in-depth assessments of their social, economic and  
104 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<sup>14,20</sup>. 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<sup>10,14,21</sup>.

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<sup>8</sup>, human footprint<sup>16</sup>, the World Database of PAs  
118 (WDPA, version July 2018<sup>17</sup>) and LandScan 2017 global population distribution<sup>18</sup>. We focused  
119 on ecoregions because (a) Half Earth targets have been judged achievable, or already  
120 reached, in ~49% of all ecoregions<sup>8</sup>, (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<sup>7</sup> and  
122 for assessing Half Earth's impacts on food production<sup>9</sup>. We grouped ecoregions into  
123 Dinerstein et al.'s<sup>8</sup> 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<sup>22</sup> with the World Bank's (WB) income classification<sup>23</sup> 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<sup>8</sup>. 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<sup>24</sup>. 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<sup>17</sup>. 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<sup>18</sup>. 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<sup>23</sup>.

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

157

## 158 **References**

- 159 1. *The Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets* (CBD,  
160 2010).
- 161 2. Tittensor, D.P. et al. *Science* **346**, 241–245 (2014).
- 162 3. *Global Assessment Preview* (IPBES, 2019).
- 163 4. Locke, H. *George Wright Forum* **31**, 359–371 (2014).
- 164 5. Wilson, E.O. (Liveright, New York, 2016).
- 165 6. Dinerstein, E. et al. *Sci. Adv.* **5**, eaaw2869 (2019).
- 166 7. *Synthesis of Views of Parties and Observers on the Scope and Content of the Post-2020*  
167 *Global Biodiversity Framework* (CBD, 2019).
- 168 8. Dinerstein, E. et al. *Bioscience* **67**, 534–545 (2017).
- 169 9. Mehrabi, Z., Ellis, E.C. & Ramankutty, N. *Nat. Sustain.* **1**, 409–412 (2018).
- 170 10. Ellis, E.C., Pascual, U. & Mertz, O. *Curr. Opin. Environ. Sustain.* **38**, 86–94 (2019).
- 171 11. Brockington, D. & Wilkie, D. *Philos. Trans. R. Soc. B Biol. Sci.* **370**, 20140271 (2015).
- 172 12. Oldekop, J.A., Holmes, G., Harris, W.E. & Evans, K.L. *Conserv. Biol.* **30**, 133–141 (2016).
- 173 13. West, P., Igoe, J. & Brockington, D. *Annu. Rev. Anthropol.* **35**, 251–277 (2006).
- 174 14. Büscher, B. et al. *Oryx* **51**, 407–410 (2017).
- 175 15. Kopnina, H. *Biol. Conserv.* **203**, 176–185 (2016).
- 176 16. Venter, O. et al. *Nat. Commun.* **7**, 12558 (2016).

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

188

189 **Corresponding Author.** Correspondence to Judith Schleicher.

190

### 191 **Acknowledgements**

192 J.G.Z. undertook this work whilst a Visiting Scholar in the Department of Geography,  
193 University of Cambridge (May 2018–April 2019), and was supported by the Swiss Programme  
194 for Research on Global Issues for Development (r4d programme), which is funded by the  
195 Swiss National Science Foundation (SNSF) and the Swiss Agency for Development and  
196 Cooperation (SDC), under grant number 400440 152167. This product was made utilizing the  
197 LandScan (2017)<sup>™</sup> High Resolution global Population Data Set copyrighted by UT-Battelle,  
198 LLC, operator of Oak Ridge National Laboratory under Contract No. DE-AC05-00OR22725  
199 with the United States Department of Energy.

200 **Author contributions**

201 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  
202 and conducted the analyses. J.S. wrote the paper with input from J.G.Z., C.F., B.V., P.V., and  
203 C.S.

204 **Competing interests.** The authors declare no competing interests.

205

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

208

209 **Figure captions:**

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

215

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

**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.

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

