

LJMU Research Online

Plumptre, AJ, Baisero, D, Benítez-López, A, Faurby, S, Gallego-Zamorano, J, Köhl, HS, Luna-Aranguré, C, Vázquez-Domínguez, E, Voigt, M, Wich, S and Wint, GRW

Response: Where Might We Find Ecologically Intact Communities?

<https://researchonline.ljmu.ac.uk/id/eprint/18105/>

Article

Citation (please note it is advisable to refer to the publisher's version if you intend to cite from this work)

**Plumptre, AJ, Baisero, D, Benítez-López, A, Faurby, S, Gallego-Zamorano, J, Köhl, HS, Luna-Aranguré, C, Vázquez-Domínguez, E, Voigt, M, Wich, S
ORCID logoORCID: <https://orcid.org/0000-0003-3954-5174> and Wint, GRW
(2022) Response: Where Might We Find Ecologically Intact Communities?**

LJMU has developed **LJMU Research Online** for users to access the research output of the University more effectively. Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Users may download and/or print one copy of any article(s) in LJMU Research Online to facilitate their private study or for non-commercial research. You may not engage in further distribution of the material or use it for any profit-making activities or any commercial gain.

The version presented here may differ from the published version or from the version of the record. Please see the repository URL above for details on accessing the published version and note that access may require a subscription.

For more information please contact researchonline@ljmu.ac.uk



Response: Where Might We Find Ecologically Intact Communities?

Andrew J. Plumptre^{1*}, Daniele Baisero¹, Ana Benítez-López², Søren Faurby^{3,4}, Juan Gallego-Zamorano⁵, Hjalmar S. Kühl⁶, Carlos Luna-Aranguré⁷, Ella Vázquez-Domínguez⁷, Maria Voigt⁸, Serge Wich^{9,10} and Geoffrey R. William Wint¹¹

¹ KBA Secretariat, c/o BirdLife International, Cambridge, United Kingdom, ² Doñana Biological Station, Spanish National Research Council, Seville, Spain, ³ Department of Biological and Environmental Sciences, University of Gothenburg, Gothenburg, Sweden, ⁴ Gothenburg Global Biodiversity Centre (GGBC), University of Gothenburg, Gothenburg, Sweden, ⁵ Department of Environmental Science, Faculty of Science, Radboud University Nijmegen, Nijmegen, Netherlands, ⁶ German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, Germany, ⁷ Instituto de Ecología, Universidad Nacional Autónoma de México, Ciudad Universitaria, Mexico City, Mexico, ⁸ Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, Canterbury, United Kingdom, ⁹ School of Biological and Environmental Sciences, Liverpool John Moores University, Liverpool, United Kingdom, ¹⁰ Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Amsterdam, Netherlands, ¹¹ Environmental Research Group Oxford Ltd., Department of Zoology, Oxford University, Oxford, United Kingdom

OPEN ACCESS

Edited by:

Barry Alan Gardiner,
Institut Européen De La Forêt Cultivée
(IEFC), France

Reviewed by:

Iain James Gordon,
Australian National
University, Australia

*Correspondence:

Andrew J. Plumptre
aplumptre@keybiodiversityareas.org

Specialty section:

This article was submitted to
Forest Disturbance,
a section of the journal
Frontiers in Forests and Global
Change

Received: 21 February 2022

Accepted: 11 March 2022

Published: 05 April 2022

Citation:

Plumptre AJ, Baisero D, Benítez-López A, Faurby S, Gallego-Zamorano J, Kühl HS, Luna-Aranguré C, Vázquez-Domínguez E, Voigt M, Wich S and Wint GRW (2022) Response: Where Might We Find Ecologically Intact Communities? *Front. For. Glob. Change* 5:880353. doi: 10.3389/ffgc.2022.880353

Keywords: ecological integrity assessment, Key Biodiversity Areas (KBA), intactness, restoration of integrity, biodiversity

A Commentary on

Where Might We Find Ecologically Intact Communities?

by Plumptre, A. J., Baisero, D., Belote, R. T., Vázquez-Domínguez, E., Faurby, S., Jędrzejewski, W., Kiara, H., K, H., Benítez-López, A., Luna-Aranguré, C., Voigt, M., Wich, S., Wint, W., Gallego-Zamorano, J., and Boyd, C. (2021). *Front. For. Glob. Change* 4:626635. doi: 10.3389/ffgc.2021.626635

We thank the authors of the commentary of our paper “Where might we find ecologically intact communities” (Grantham et al., 2022) for their interest in our paper (Plumptre et al., 2021) and their critique of some of the methods and conclusions. We here respond to their commentary, where many of their points have been well-made, with the aim of advancing discussion of what is meant by ecological integrity or intactness.

Part of the reason for undertaking our study was to provide a scoping of potential Key Biodiversity Areas (KBAs) that might meet Criterion C status defined as sites of “outstanding ecological integrity.” We were interested in assessing what we might obtain if we use a strict interpretation of “wholly intact ecological communities” to mean that no species had been lost since a baseline date of 1,500. Another reason was to encourage the assessment of species composition as part of any assessment of ecological integrity. Our results clearly showed that very few areas would likely contain KBAs with this interpretation and baseline and as a result, we believe that a broader interpretation of intactness will be required, but that still identifies sites of “outstanding ecological integrity.”

There are three main points of criticism by Grantham et al. (2022) of Plumptre et al. (2021): (1) the definition of ecological integrity and that it does not follow the main paradigm of structure-composition-function that has been applied to assessment of ecological integrity; (2) the appropriateness of the methods applied; and (3) the issue of the usefulness of the results for policy and application for real-world conservation.

DEFINITION OF ECOLOGICAL INTEGRITY

We recognize there have been a recent series of papers that have suggested that “ecological integrity” is not a useful concept (Karr et al., 2021; Rohwer and Marris, 2021; Marris and Rohwer, 2022). The main argument by Rohwer and Marris is that integrity is defined in many different ways and that it is clearer to utilize the specific definitions rather than use the term integrity. While we would not necessarily agree that the term integrity should be abandoned, as it facilitates capturing complex ideas, we do believe that there is a value in being clear what we are measuring when we estimate ecological integrity.

Here the main critique appears to be that our paper does not follow the well-established paradigm that ecological integrity should include an assessment of structure, composition and function (Hansen et al., 2021). The authors list a set of studies, which they consider good examples of the measurement of ecological integrity in their first paragraph. We have therefore analyzed these and added one other commonly used measure of Intact Forest Landscapes (Potapov et al., 2017) to assess which ones specifically address Structure, Composition and Function, and summarize our results in **Table 1**. What is clear is that the majority of studies have used remotely-sensed products to derive impacts on ecosystem structure (human modification of habitat or proxies, like the presence of roads, settlements, human population density, and/or measures of canopy cover, height, or forest extent). A few have addressed composition directly (i.e., compiling species data) using the Biotic Integrity Index which measures changes in species richness and abundance (Scholes and Biggs, 2005) or the BILBI framework that uses species turnover (Mokany et al., 2020). None of the methods specifically targeted measures of ecosystem function. We would argue that only our study has explicitly tried to address aspects of structure, composition and function, in our assessment of global ecological integrity and this is why we identify a much smaller area of the world as “ecologically intact.” We accept that our methods are coarse and could clearly be improved with more accurate local data applied at site scales (e.g., Faber-Langendoen et al., 2016). However, it is still not technologically and logistically possible to derive such accurate data at global scales, particularly for assessing ecosystem function (see Table 1 in Hansen et al., 2021). We would encourage more assessments at this local scale that do include species composition data and measures of ecosystem function where it is possible to obtain data (e.g., Tierney et al., 2009), to advance our knowledge on what is “ecologically intact.”

A point is made that we identify a site as intact or not in a binary fashion, however, our investigation of these papers shows they all use specific thresholds (listed in **Table 1**) to separate intact areas from non-intact areas. While we agree with them that intactness is a spectrum, the definition of what is outstanding is necessarily tied to a threshold, with defined “intact areas” representing a binary decision.

Finally, there is the concern that the documented loss of one species in our paper excludes a site as having full ecological integrity. Our methods identified where varying numbers of species had been extirpated but our definition of full ecological integrity was sites with no loss of species. This definition of

“outstanding ecological integrity” is admittedly of an extremely high standard but our analysis was dominated by mammal species that have been extirpated. We looked at loss of range across mammals and 39.9% of the range loss is seen in species from 10 to 100 kg, 33.3% in species between 100 and 1,000 kg, and 4.1% in species weighing >1,000 kg. Therefore, 77.3% of the loss encompasses large-bodied species, which regularly serve as ecosystem engineers. The functional roles of large bodied mammals such as elephants (*Loxodonta africana* and *L. cyclotis*) have been well-documented (e.g., Laws et al., 1970; Blake et al., 2009; Campos-Arceiz and Blake, 2011; Ripple et al., 2015) as have those of large predators (Smith et al., 2003; Johnson et al., 2007; Ripple et al., 2014). However, scientific evidence also shows that medium and small mammals can also have significant impacts on ecological function, like seed predation and dispersal, with knock-on effects on vegetation dynamics and the carbon cycle (Colman et al., 2014; Mills and Letnic, 2018; Schmitz et al., 2018; Gardner et al., 2019). We therefore believe that loss of such species, in many instances even the loss of one species, may have led to ecological changes at sites and loss of ecological integrity as a result. Sometimes these roles can be replaced by other species but with large mammals, we would maintain that this is harder to achieve.

APPROPRIATENESS OF METHODS

The commentary criticized the use of a threshold value of Human Footprint of ≤ 4 . While the focus of the paper was not on measurements of intact structure, we used this threshold because we wanted to scope areas of outstanding ecological integrity and were interested in the combined effects of structure, composition and function. We selected the threshold value based on several of these authors own work because it has been used elsewhere as a threshold for good habitat quality (Beyer et al., 2020) and ecological integrity (Williams et al., 2020). For example, Williams et al. (2020), published 6 months before our paper, states “We used a human footprint threshold of <4 (on a 0–50 scale) to identify where land is considered ecologically intact (below the threshold) or highly modified and thus ecologically degraded (equal to or above the threshold).”

The second criticism was that the reference date of 1,500 CE was arbitrary and not based in science. We selected to use a single date for consistency but note that the KBA Standard (IUCN, 2016) allows for regionally appropriate baseline dates. This date is used as the baseline date by the IUCN Red List of Threatened species for the following reasons: It is a date before the expansion of Europeans into the Americas and also a date before the widespread use of firearms. Extinction rates have also increased substantially since this time (Barnosky et al., 2011; Cowie et al., 2022), although for mammals (and likely many other groups) elevated rates above background extinction rates as a result of human activities were also seen before this time (Andermann et al., 2020). Hence, using 1,500 CE as a baseline reference date falls within a period, which allows for assessment of the current condition of ecosystems relative to their pre-industrial baseline states. We note, however, that this baseline does not mean we

TABLE 1 | Review of global assessments of ecological integrity and the approaches, thresholds, and results obtained in relation to the structure-composition-function paradigm.

Study	Structure	Composition	Function
Newbold et al. (2016) PREDICTS data on changes in species composition—Biotic Intactness index (BII)	Land use, land-use intensity, human population density, and proximity to the nearest road used as fixed effects in models to predict BII	Approach: Used BII to assess where species or abundance of individuals is lost. Threshold: “biotically compromised” where there is 10% loss of abundance of species or 20% loss of species. Result: 62.4% of land is biotically compromised using loss of species composition.	
Watson et al. (2016) Last wilderness areas—using Last of the Wild method (Sanderson et al., 2002) based on Human footprint (HFP)	Approach: Used same methods as “Last of the Wild.” Threshold: 10 largest areas where 10% lowest HFP scores occur in biomes within realms. Result: 23.2% of land is wilderness (Last of the Wild).		
Potapov et al. (2017) Intact Forest Landscape (IFL) changes from 2000 to 2013	Approach: Forest with >20% tree canopy and not altered by man. Threshold: $\geq 500 \text{ km}^2$ patch size and minimum width of 10 km. Results: IFLs covered 22% of forest zone.		
De Palma et al. (2021) Changes in Biodiversity Intactness index (BII) in tropical and sub-tropical forests	Human pressures—population density, agriculture and density of roads built into predictions of BII	Approach: Assessed changes in BII in relation to human population density, road density, and landcover. Threshold: BII $\geq 90\%$ is considered intact for biosphere integrity. Result: Only three countries with BII $\geq 90\%$.	
Beyer et al. (2020) Intactness metric based on habitat area, fragmentation and Human Footprint (HFP). Applied metric to ecoregions	Approach: Identified intactness as influenced by habitat area, habitat fragmentation and weighted by habitat quality. Habitat quality was defined as Human Footprint score. Threshold: Quality defined as HFP score ≤ 4 . Greater than this was non-habitat. Result: Only 14.8% of ecoregions in good condition.		
Grantham et al. (2020) Forest Landscape Integrity Index (FLII)	Approach: FLII—combination of forest extent, pressure from man (infrastructure, agriculture, and forest loss), inferred edge effects (up to 12 km) and loss of connectivity. Threshold: High Integrity: FLII ≥ 9.6 . Result: Estimated 40% of world's forests as relatively intact.	Estimated that the inferred actions from edges will have implications for species composition but no species data used.	
Hansen et al. (2020) Forest Structural Integrity Index (FSII) applied to tropical and sub-tropical moist forests	Approach: Generated Structural Condition Index (SCI—Canopy cover and height) combined with Human Footprint (HFP). Selected for areas with high structural integrity and low HFP. Thresholds: High SCI: $\geq 75\%$ canopy cover and $> 15 \text{ m}$ tall; High FSII = high SCI and HFP ≤ 4 .		

(Continued)

TABLE 1 | Continued

Study	Structure	Composition	Function
Mokany et al. (2020) Contextual intactness (CI)	<p>Approach: Mapped habitat condition based on Human Footprint (HFP).</p> <p>Threshold: Wilderness HFP = 0; Low disturbance: HFP \leq 3.</p> <p>Result: No estimates of percentage area at low HFP given in paper.</p>	<p>Approach: Expected similarity of species assemblages (BILBI framework).</p> <p>Threshold: CI > 0.5.</p> <p>Result: 50% of planet has high value biodiversity habitat—where CI is defined with threshold of 0.5.</p>	
Riggio et al. (2020) Global Human influence maps comparison	<p>Approach: Compared results obtained from Anthromes (A), Global Human Modification (HM), Human Footprint (HFP), and Low Impact Areas (LIA)—all use data on human population density, land cover and other remotely sensed data of human impact.</p> <p>Thresholds: <i>very low impact:</i> A—wild woodlands, wild treeless and barren lands, and wild ice classes; HM < 1%; HFP = 0; LIA, human population and livestock density thresholds to <1 per 1 km² and no roads; and <i>low impact:</i> A—added remote rangeland, semi-natural remote woodlands, and semi-natural treeless and barren lands; HM < 10%; HFP \leq 3; LIA, landscapes that currently have low human density and are not primarily managed for human needs.</p> <p>Results: 48–56% classed as low influence; 20–34% very low influence.</p>		
Williams et al. (2020) Assessed changes in human footprint	<p>Approach: Changes in Human Footprint (HFP) between 2000 and 2013.</p> <p>Threshold: HFP \leq 4 (intact) and \leq 1 (wilderness).</p> <p>Result: In 2013, 42% of earth was relatively free of anthropogenic disturbance (HFP \leq 4) and 25% was wilderness (HFP < 1).</p>		
Plumptre et al. (2021) Assessed three measures of intactness: habitat, faunal, and functional intactness	<p>Approach: Habitat integrity defined using Human Footprint (HFP).</p> <p>Threshold: HFP \leq 4.</p> <p>Result: 43.4% of land has HFP \leq 4. Only 25.3% of ecoregions have sites where area \geq 10,000 km².</p>	<p>Approach: Faunal integrity defined numbers of species lost (mostly terrestrial vertebrates).</p> <p>Threshold: None lost for complete integrity; Up to 5 extirpated for reintroduction.</p> <p>Result: 2.9% for sites where area is \geq 10,000 km² or 3.4% where \geq 1,000 km².</p>	<p>Approach: Functional intactness—where a set of large mammals were at functional density; and modeled hunting pressures in forests to identify areas where species abundance was high.</p> <p>Threshold: Set for each species separately and for the defaunation index derived from hunting pressure models as <0.9 (> 10% average decline in abundance across mammal species).</p> <p>Result: 2.8% for sites where area is \geq 10,000 km² or 3.3% where \geq 1,000 km².</p>

necessarily consider the state at 1,500 CE entirely pristine but rather see it as a pragmatic baseline since effectively all changes since this time and some of the changes pre 1,500 CE will be anthropogenic in nature.

We agree that the use of range maps for the species are an approximation but these are the best data available at a global scale that have been validated by experts. They have also been used in many other analyses (e.g., Harfoot et al., 2021 and

many others). We would also argue that all global datasets are inaccurate whether these are the range maps we used, the layers that were used to derive the human footprint map, the predicted hunting pressure maps as well as the modeled ranges we used to assess functional intactness. One of the key drivers of the human footprint map is land use change and it is recognized that comparison of land cover maps derived using different methods should not be made (Herold et al., 2008; Sexton et al., 2016; Venter et al., 2016; Estes et al., 2018; Williams et al., 2020). Yet many of the approaches used (**Table 1**) apply different land cover products when calculating the areas of intactness and as a result are not easily comparable. As we argued in the paper, none of these global datasets are really useful for site identification but can help guide where more detailed investigations should take place to compile local data to develop a more accurate measure of ecological integrity as recommended by Chaplin-Kramer et al. (2022).

Our estimates of functional intactness were based on estimates of reduced species populations from the hunting pressure models in tropical forests, jointly with estimates of low density and less suitable habitat for 16 species/subspecies models considered to have important functional roles. These layers were primarily included as a demonstration of how functional integrity due to species densities might be assessed, but recognize that this can be better assessed at a local scale. We selected wide-ranging species for which species distribution models are available, but for many species these types of models do not exist across their entire range. However, the principle of identifying functional densities of species when selecting sites of ecological integrity, such as Criterion C sites for Key Biodiversity Areas (KBAs), should be strongly considered as part of an assessment of functional integrity. We would argue that again this is easier to apply at a local scale where more will be known or can be measured.

POLICY IMPLICATIONS

As we stated, the reason for undertaking our study was to provide a scoping of potential Criterion C KBAs, to assess what we might obtain if we use a strict interpretation of “wholly intact ecological communities.” We therefore agree with Grantham et al. (2022) that such a strict definition is of concern for policy makers who are pushing for ambitious conservation targets under the Global Biodiversity Framework, given how few areas we found were considered ecologically intact. While we think that highlighting the extent of still existing ecologically intact habitat has value in itself, in particular to avoid overly optimistic perceptions caused by the shifting baseline syndrome (Soga and Gaston, 2018), Grantham et al. (2022) mainly see a value when applicable to identifying specific areas for conservation. Clearly, there is a value in conserving large areas of relatively intact habitat, which have been identified by the various approaches used in **Table 1** and cover between 22 and 58% of land. Indeed, our paper ended with a statement that we recognized these places should be targets of conservation under the Global Biodiversity

Framework. However, we also believe that where we have intact habitat as well as intact fauna since 1,500 CE that these sites are particularly special and are worthy of recognition and protection. The findings of our paper, and the reactions to it, triggered a set of webinars and meetings in the second half of 2021 to reconsider how KBA Criterion C could be interpreted, and in which some of the authors of Grantham et al. (2022) participated. Participants in these events investigated ways in which we might broaden the interpretation to focus on all aspects of structure, composition, and function. Suggestions for how to proceed in relation to species composition advised that some allowance is needed for species turnover, particularly in the face of climate change, and having instead a target of maintaining all trophic levels at a site rather than a species-focused approach. Revised guidance for the application of Criterion C are being developed resulting from what was agreed in these meetings. This will likely identify more Criterion C sites that fall under this broader definition of ecological intactness.

We also showed in our paper that in many of these intact habitats there are opportunities to restore species that undoubtedly have important functional roles. A recent analysis, using similar data to ours, likewise argues that we should be considering the reintroduction of mammals to regain integrity and ecological function (Vynne et al., 2022). Large mammals are frequently the first to disappear and their successful reintroduction not only requires the effective removal of relevant threats, but also supports the re-establishment of associated ecological processes. Due to their spatial and habitat requirements they serve as extremely important indicators. The rewilding movement is growing and having successes in Europe (Fernández et al., 2020), USA (Smith et al., 2003), and Australia (Sweeney et al., 2019); it can be used to improve areas of intact habitat where we know of functional species that have been extirpated. We conceptually disagree with Grantham et al. (2022) that the re-wilding approach is species rather than process focussed. The goal of rewilding is the restoration of ecological processes, which is most easily achieved by reintroduction of extirpated species (Perino et al., 2019). This focus is, for example, seen in the frequent discussion of using functional analogs when the species that used to live at a given site are globally extinct (e.g., Louys et al., 2014; Falcón and Hansen, 2018). In the UN decade of restoration we believe it is more ambitious to not only consider conserving remaining areas of intact habitat but also consider rewilding areas with large mammals and other species that have been extirpated. We agree with Grantham et al. (2022) that conserving the relatively intact areas needed for their introduction is important but that we can achieve more than this and that we should be working together to accomplish both objectives.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

REFERENCES

- Andermann, T., Faurby, S., Turvey, S. T., Antonelli, A., and Silvestro, D. (2020). The past and future human impact on mammalian diversity. *Sci. Adv.* 6, eabb2313. doi: 10.1126/sciadv.abb2313
- Barnosky, A. D., Matzke, N., Tomiya, S., Wogan, G. O. U., Swartz, B., Quental, T. B., et al. (2011). Has the Earth's sixth mass extinction already arrived? *Nature* 471, 51–57. doi: 10.1038/nature09678
- Beyer, H. L., Venter, O., Grantham, H. S., and Watson, J. E. M. (2020). Substantial losses in ecoregion intactness highlights urgency of globally coordinated action. *Conserv. Lett.* 13, e12692. doi: 10.1111/conl.12692
- Blake, S., Deem, S. L., Mossimbo, E., Maisels, F., and Walsh, P. (2009). Forest elephants: tree planters of the Congo. *Biotropica* 41, 459–468. doi: 10.1111/j.1744-7429.2009.00512.x
- Campos-Arceiz, A., and Blake, S. (2011). Megagardeners of the forest—the role of elephants in seed dispersal. *Acta Oecol.* 37, 542–553. doi: 10.1016/j.actao.2011.01.014
- Chaplin-Kramer, R., Brauman, K. A., Cavender-Bares, J., Díaz, S., Duarte, G. T., Enquist, B. J., et al. (2022). Conservation needs to integrate knowledge across scales. *Nat. Ecol. Evol.* 6, 118–119. doi: 10.1038/s41559-021-01605-x
- Colman, N. J., Gordon, C. E., Crowther, M. S., and Letnic, M. (2014). Lethal control of an apex predator has unintended cascading effects on forest mammal assemblages. *Proc. R. Soc. B Biol. Sci.* 281, 20133094. doi: 10.1098/rspb.2013.3094
- Cowie, R. H., Bouchet, P., and Fontaine, B. (2022). The Sixth Mass Extinction: fact, fiction or speculation? *Biol. Rev.* 97, 640–663. doi: 10.1111/brev.12816
- De Palma, A. D., Hoskins, A., Gonzalez, R. E., Börger, L., Newbold, T., Sanchez-Ortiz, K., et al. (2021). Annual changes in the Biodiversity Intactness Index in tropical and subtropical forest biomes, 2001962012. *Sci. Rep.* 11, 20249. doi: 10.1038/s41598-021-98811-1
- Estes, L., Chen, P., Debats, S., Evans, T., Ferreira, S., Kuemmerle, T., et al. (2018). A large-area, spatially continuous assessment of land cover map error and its impact on downstream analyses. *Glob. Change Biol.* 24, 322–337. doi: 10.1111/gcb.13904
- Faber-Langendoen, D., Nichols, W., Rocchio, J., Walz, K., and Lemly, J. (2016). *An Introduction to NatureServe's Ecological Integrity Assessment Method*. Arlington, VA: NatureServe.
- Falcón, W., and Hansen, D. M. (2018). Island rewilding with giant tortoises in an era of climate change. *Philos. Trans. R. Soc. B Biol. Sci.* 373, 20170442. doi: 10.1098/rstb.2017.0442
- Fernández, N., Torres, A., Wolf, F., Quintero, L., and Pereira, H. M. (2020). *Boosting Ecological Restoration for a Wilder Europe*. Halle-Wittenberg: German Centre for Integrative Biodiversity Research (iDiv) and Martin-Luther-Universität.
- Gardner, C. J., Bicknell, J. E., Baldwin-Cantello, W., Struebig, M. J., and Davies, Z. G. (2019). Quantifying the impacts of defaunation on natural forest regeneration in a global meta-analysis. *Nat. Commun.* 10, 1–7. doi: 10.1038/s41467-019-12539-1
- Grantham, H. S., Duncan, A., Evans, T. D., Jones, K. R., Beyer, H. L., Schuster, R., et al. (2020). Anthropogenic modification of forests means only 40% of remaining forests have high ecosystem integrity. *Nat. Commun.* 11, 5978. doi: 10.1038/s41467-020-19493-3
- Grantham, H. S., Evans, T., Lieberman, S., Robinson, J. G., Elsen, P. R., Ferrier, S., et al. (2022). Response: where might we find ecologically intact communities? *Front. For. Glob. Change* 5, 730546. doi: 10.3389/ffgc.2022.730546
- Hansen, A. J., Burns, P., Ervin, J., Goetz, S. J., Hansen, M., Venter, O., et al. (2020). A policy-driven framework for conserving the best of Earth's remaining moist tropical forests. *Nat. Ecol. Evol.* 4, 1377–1384. doi: 10.1038/s41559-020-1274-7
- Hansen, A. J., Noble, B. P., Veneros, J., East, A., Goetz, S. J., Supples, C., et al. (2021). Toward monitoring forest ecosystem integrity within the post-2020 Global Biodiversity Framework. *Conserv. Lett.* 14, e12822. doi: 10.1111/conl.12822
- Harfoot, M. B. J., Johnston, A., Balmford, A., Burgess, N. D., Butchart, S. H. M., Dias, M. P., et al. (2021). Using the IUCN Red List to map threats to terrestrial vertebrates at global scale. *Nat. Ecol. Evol.* 5, 1510–1519. doi: 10.1038/s41559-021-01542-9
- Herold, M., Mayaux, P., Woodcock, C. E., Baccini, A., and Schmullius, C. (2008). Some challenges in global land cover mapping: an assessment of agreement and accuracy in existing 1 km datasets. *Remote Sens. Environ.* 112, 2538–2556. doi: 10.1016/j.rse.2007.11.013
- IUCN (2016). *A Global Standard for the Identification of Key Biodiversity Areas, Version 1.0, 1st Edn*. Gland: IUCN. Available online at: <https://portals.iucn.org/library/node/46259>
- Johnson, C. N., Isaac, J. L., and Fisher, D. O. (2007). Rarity of a top predator triggers continent-wide collapse of mammal prey: dingoes and marsupials in Australia. *Proc. R. Soc. B Biol. Sci.* 274, 341–346. doi: 10.1098/rspb.2006.3711
- Karr, J. R., Larsen, E. R., and Chu, E. W. (2021). Ecological integrity is both real and valuable. *Conserv. Sci. Pract.* (2021) 4, e583. doi: 10.1111/csp.2.583
- Laws, R. M., Parker, I. S. C., and Johnstone, R. C. B. (1970). Elephants and habitats in north Bunyoro, Uganda. *East Afr. Wildl. J.* 8, 163–180. doi: 10.1111/j.1365-2028.1970.tb00838.x
- Louys, J., Corlett, R. T., Price, G. J., Hawkins, S., and Piper, P. J. (2014). Rewilding the tropics, and other conservation translocations strategies in the tropical Asia-Pacific region. *Ecol. Evol.* 4, 4380–4398. doi: 10.1002/ecs3.1287
- Marris, E., and Rohwer, Y. (2022). The concept of ecological integrity may have been useful, but that does not make it real or morally valuable. *Conserv. Sci. Pract.* 4, e586. doi: 10.1111/csp.2.586
- Mills, C. H., and Letnic, M. (2018). Reversing functional extinction of mammals prompts a rethink of paradigms about seed fate in arid Australia. *R. Soc. Open Sci.* 5, 171977. doi: 10.1098/rsos.171977
- Mokany, K., Ferrier, S., Harwood, T. D., Ware, C., Di Marco, M., Grantham, H. S., et al. (2020). Reconciling global priorities for conserving biodiversity habitat. *Proc. Natl. Acad. Sci.* 117, 9906–9911. doi: 10.1073/pnas.1918373117
- Newbold, T., Hudson, L. N., Arnell, A. P., Contu, S., De Palma, A., Ferrier, S., et al. (2016). Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. *Science* 353, 288–291. doi: 10.1126/science.aaf2201
- Perino, A., Pereira, H. M., Navarro, L. M., Fernández, N., Bullock, J. M., Ceaușu, S., et al. (2019). Rewilding complex ecosystems. *Science* 364, eaav5570. doi: 10.1126/science.aav5570
- Plumptre, A. J., Baisero, D., Belote, R. T., Vázquez-Domínguez, E., Faurby, S., Jdrzejewski, W., et al. (2021). Where might we find ecologically intact communities? *Front. For. Glob. Change* 4, 626635. doi: 10.3389/ffgc.2021.626635
- Potapov, P., Hansen, M. C., Laestadius, L., Turubanova, S., Yaroshenko, A., Thies, C., et al. (2017). The last frontiers of wilderness: tracking loss of intact forest landscapes from 2000 to 2013. *Sci. Adv.* 3, e1600821. doi: 10.1126/sciadv.1600821
- Riggio, J., Baillie, J. E. M., Brumby, S., Ellis, E., Kennedy, C. M., Oakleaf, J. R., et al. (2020). Global human influence maps reveal clear opportunities in conserving Earth's remaining intact terrestrial ecosystems. *Glob. Change Biol.* 26, 4344–4356. doi: 10.1111/gcb.15109
- Ripple, W. J., Estes, J. A., Beschta, R. L., Wilmers, C. C., Ritchie, E. G., Hebblewhite, M., et al. (2014). Status and ecological effects of the world's largest carnivores. *Science* 343, 1241484. doi: 10.1126/science.1241484
- Ripple, W. J., Newsome, T. M., Wolf, C., Dirzo, R., Everatt, K. T., Galetti, M., et al. (2015). Collapse of the world's largest herbivores. *Sci. Adv.* 1, e1400103. doi: 10.1126/sciadv.1400103
- Rohwer, Y., and Marris, E. (2021). Ecosystem integrity is neither real nor valuable. *Conserv. Sci. Pract.* 3, e411. doi: 10.1111/csp.2.411
- Sanderson, E. W., Jaiteh, M., Levy, M. A., Redford, K. H., Wannebo, A. V., and Woolmer, G. (2002). The human footprint and the last of the wild. *Bioscience* 52, 891–904. doi: 10.1641/0006-3568(2002)052[0891:THFATL]2.0.CO;2
- Schmitz, O. J., Wilmers, C. C., Leroux, S. J., Doughty, C. E., Atwood, T. B., Galetti, M., et al. (2018). Animals and the biogeochemistry of the carbon cycle. *Science* 362, eaar3213. doi: 10.1126/science.aar3213
- Scholes, R., and Biggs, R. (2005). A biodiversity intactness index. *Nature* 434, 45–49. doi: 10.1038/nature03289
- Sexton, J. O., Noojipady, P., Song, X.-P., Feng, M., Song, D.-X., Kim, D.-H., et al. (2016). Conservation policy and the measurement of forests. *Nat. Clim. Change* 6, 192–196. doi: 10.1038/nclimate2816
- Smith, D. W., Peterson, R. O., and Houston, D. B. (2003). Yellowstone after Wolves. *Bioscience* 53, 330–340. doi: 10.1641/0006-3568(2003)053[0330:YAW]2.0.CO;2

- Soga, M., and Gaston, K. J. (2018). Shifting baseline syndrome: causes, consequences, and implications. *Front. Ecol. Environ.* 16, 222–230. doi: 10.1002/fee.1794
- Sweeney, O. F., Turnbull, J., Jones, M., Letnic, M., Newsome, T. M., and Sharp, A. (2019). An Australian perspective on rewilding. *Conserv. Biol.* 33, 812–820. doi: 10.1111/cobi.13280
- Tierney, G. L., Faber-Langendoen, D., Mitchell, B. R., Shriver, W. G., and Gibbs, J. P. (2009). Monitoring and evaluating the ecological integrity of forest ecosystems. *Front. Ecol. Environ.* 7, 308–316. doi: 10.1890/070176
- Venter, O., Sanderson, E., Magrath, A. Allan, J. R., Beher, J., Jones K. R., et al. (2016) Sixteen years of change in the global terrestrial human footprint and implications for biodiversity conservation. *Nat. Commun.* 7, 12558. doi: 10.1038/ncomms12558
- Vynne, C., Gosling, J., Maney, C., Dinerstein, E., Lee, A. T. L., Burgess, N. D., et al. (2022). An ecoregion-based approach to restoring the world's intact large mammal assemblages. *Ecography*. doi: 10.1111/ecog.06098. Available online at: <https://onlinelibrary.wiley.com/action/showCitFormats?doi=10.1111%2Fecog.06098>
- Watson, J. E. M., Shanahan, D. F., Di Marco, M., Allan, J., Laurance, W. F., Sanderson, E. W., et al. (2016). Catastrophic declines in wilderness areas undermine global environment targets. *Curr. Biol.* 26, 2929–2934. doi: 10.1016/j.cub.2016.08.049
- Williams, B. A., Venter, O., Allan, J. R., Atkinson, S. C., Rehbein, J. A., Ward, M., et al. (2020). Change in terrestrial human footprint drives continued loss of intact ecosystems. *One Earth* 3, 371382. doi: 10.1016/j.oneear.2020.08.009

Conflict of Interest: GW was employed by Environmental Research Group Oxford Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Copyright © 2022 Plumptre, Baisero, Benítez-López, Faurby, Gallego-Zamorano, Kühl, Luna-Arangurú, Vázquez-Domínguez, Voigt, Wich and Wint. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.