How to resolve conflicting conservation objectives: A decision support tool for the global selection of multi-purpose protected areas

Running title: Global priorities for conservation

Keywords: conservation funding, strategic site selection, decision support tool, conservation planning, biodiversity protection

Abstract

The establishment and maintenance of protected areas(PAs) is viewed as a key action in delivering post-2020 biodiversity targets. PAs often need to meet a multitude of objectives, ranging from biodiversity protection to ecosystem service provision and climate change mitigation. As available land and conservation funding are limited, optimizing resources by selecting the most beneficial PAs is vital. Here we present a decision support tool that enables a flexible approach to PA selection on a global scale, allowing different conservation objectives to be weighted and prioritized according to user-specified preferences. We apply the tool across 1347 terrestrial PAs and highlight frequent trade-offs among different objectives, e.g., between biodiversity protection and ecosystem integrity. These results indicate that decision makers must usually decide among conflicting objectives. To assist this our decision support tool provides an explicitly value-based approach that can help resolve such conflicts by considering divergent societal and political demands and values.

Introduction

Halting biodiversity loss is one of the major global challenges faced by humanity in the 21st century (Pereira et al. 2010; IPBES 2019). Human wellbeing, livelihoods and economics all rely on biodiversity, and an international collaborative effort is needed to conserve it (IPBES 2019; Dasgupta 2021a). A cornerstone of biodiversity conservation are protected areas (PAs). Aichi Target 11 of the Convention on Biological Diversity (CBD) called for an increase in PA coverage to 17% by 2020 for the terrestrial realm, and asked that these PAs should be of particular importance for biodiversity and ecosystem services, ecologically representative and well connected (Convention on Biological Diversity 2010); this goal has only partly been reached (Secretariat of the Convention on Biological Diversity 2020). PAs must be both sustainably funded and effectively managed if they are to protect biological resources, yet only about 20% of all PAs are considered to meet these criteria (Dasgupta 2021b). Meanwhile, many PAs have experienced downgrading, downsizing or degazettement (Golden Kroner et al. 2019) or are threatened by downsizing in the future (Kuempel et al. 2021).

Both the allocation of sparse conservation funding for the maintenance of current PAs and the identification of additional sites to expand PA networks frequently require the application of prioritization approaches, and a wealth of methods have been developed. These range from using complex algorithms to optimize conservation networks towards specific conservation goals (e.g. by considering complementarity, connectivity, or cost efficiency (Margules & Pressey 2000; Moilanen et al. 2005, 2009) to identifying global hotspot areas for certain conservation objectives. By focusing on these global hotspots, priority areas for biodiversity conservation have been identified. Initial approaches considered various aspects of biodiversity to be captured such as species richness, endemism, habitat loss, or evolutionary history (Satterfield et al. 1998; Myers et al. 2000; Sechrest et al. 2002). Other approaches highlight the protection of areas that will limit further impacts of global change on biodiversity, for example, by identifying remaining wilderness areas (Watson et al. 2018) or those of irrecoverable carbon storage (Goldstein et al. 2020; Noon et al. 2021). All of these hotspot selection approaches have one aspect in common: they result in the identification of global priority areas for one or more specific conservation objectives.

Although it has become increasingly important to align different conservation objectives, e.g. climate and biodiversity protection (Dinerstein et al. 2020; Pörtner et al. 2021), it is often unclear whether different conservation objectives will imply prioritizing the same sites. To date, efforts have compared the spatial alignment of conservation objectives such as terrestrial biodiversity, carbon storage and water quality regulation, and have identified areas with the highest synergies between these objectives (“Nature Map Earth” 2021; Jung et al. 2021). However, there is also evidence for trade-offs between different conservation objectives, e.g. between biodiversity and ecosystem integrity, in a species- vs. ecosystem-based selection approach (Ceauşu et al. 2015). The weaker the alignment is among different conservation objectives, the greater the influence of priority setting (i.e., favoring certain conservation objectives) on the outcome of site selection approaches. If trade-offs are prevalent, explicit value-based decision making is necessary. The relative priority of different conservation objectives varies among different societal groups, which differ in their demands and values (Peter et al. 2021). Therefore, decisions as to which areas should be prioritized are strongly value based. All of this substantiates the need for a flexible approach to site selection, where different conservation objectives can be explicitly considered and weighed against each other, to facilitate deliberative societal and political decision making.

Here, we introduce a transparent site selection approach that allows users to implement area prioritization among existing PAs based on various self-specified conservation objectives. By exclusively using biogeographic information that is publicly available at a global scale, we aimed to identify areas with the highest potential for a range of biodiversity and climate protection objectives. In our approach, we defined six different conservation objectives. We collated a broad set of conservation indicators that reflect these objectives. As a case study to explore the potential and limitations of this approach, we assembled a global dataset of 1347 sites in the context of the Legacy Landscapes Fund (LLF), a recently established foundation that provides long-term funding for protected areas (Legacy Landscapes Fund 2021). We assessed synergies and trade-offs among areas according to the different objectives at a global scale, as well as within biogeographic realms. Finally, we aimed to investigate how priority setting by different societal actors affects site selection by combining the multiple conservation objectives into broader conservation scenarios that weigh each objective according to user-specified priorities. A key aspect in this work was to make our results accessible to a broader audience, including decision makers. We therefore developed an open-source spatial decision support tool to facilitate the priority-based area selection process.

Methods

To identify sites with a high potential for both biodiversity and climate protection, we defined six overarching conservation objectives (Fig. 1), that address biodiversity conservation, climate protection, and their present and projected future status: 1) high current biodiversity, focusing on overall species richness, species endemism and evolutionary diversity, 2) high current ecosystem integrity, which focuses on pristine areas that have experienced few anthropogenic impacts, 3) high climate protection, which selects for sites that have large, irreplaceable carbon stocks, 4) large size, which prioritizes large sites, 5) high land-use stability, which focuses on the future likelihood of land-use change in the immediate surroundings of sites, and 6) high climatic stability, which highlights sites in which climate change is projected to have low impacts on current biodiversity. These conservation objectives were represented by one or multiple indicators. The biodiversity objective considered as indicators the total species richness of four vertebrate taxa (birds, mammals, amphibians and reptiles) as well as species endemism and evolutionary diversity to capture the amount of biodiversity as well as its irreplaceability; the ecosystem integrity objective considered biodiversity intactness, recent land-use change and the human footprint within the site; the climate protection objective considered the average amount of carbon per hectare that is stored in the vegetation and soil (up to 1 meter below ground) of the site and its vulnerability to typical land conversion; the size objective covers the extent of the site in km^2; the land-use stability objective considered the projected change in land-use in a buffer zone around the site, and the climatic stability objective considered the biodiversity change based on the projected future turnover of the four vertebrate taxa and the projected change in tree cover within the site (see supplementary material for a detailed description of all indicators and citations of data sources).

These objectives were developed in a discussion process among the broader conservation community. We introduced our approach at a two-day webinar which was attended by 35 experts with a strong conservation background. These included 1) conservation scientists, 2) international conservation NGOs, 3) the financial sector, and 4) policy sectors, in particular the German Federal Ministry for Economic Cooperation and Development (BMZ). These experts provided feedback on the objectives and indicators using a questionnaire (see supplementary material). They were asked to: 1) report any missing objectives, 2) report any missing indicators that should be included in the objectives and 3) rank the suggested objectives by their personal preferences. To translate personal preferences into site selection, the resulting ranks for each individual indicator were scaled from zero to one. Each objective consists of several underlying indicators (datasets), so by taking the mean across all indicators per objective these were weighted equally. These mean scores were then taken as input to weigh the different objectives against each other.

To assess synergies and trade-offs among the conservation objectives, we used the LLF as a case study to assemble a global dataset of sites. The LLF is a recently established foundation that provides long-term funding of one million U.S. dollars per "legacy landscape" per year. Funding stems from public and private sources. It aims to protect areas of outstanding biodiversity over initially 15 years – but with a vision to ensure funding in perpetuity (BMZ Division 102 & KfW Centre of Competence for Infrastructure Water Natural Resources 2020). The LLF is based on a strategic global site-selection approach and the strong long-term commitment of local NGOs, protected area authorities and local communities 'on the ground' (Legacy Landscapes Fund 2021). The initial requirements for sites to be considered by the LLF, are outstanding biodiversity, a minimum size of 2,000km^2 and a protection status as IUCN protected area category I or II for at least 1,000 km^2 (BMZ Division 102 & KfW Centre of Competence for Infrastructure Water Natural Resources 2020). Based loosely on these guidelines, we assembled a dataset and extracted site-specific values for each objective (Fig. 1) (see supplementary material for the datasets accessed, and the processing of the individual variables). We then investigated global synergies and trade-offs among the final set of conservation objectives using a principal component analysis (PCA) across sites. To further explore if synergies and trade-offs between the objectives were different in biogeographic regions of the world, we repeated the PCA separately for each of the six terrestrial biogeographic realms (Olson et al. 2001).

To investigate how priority setting by different societal groups can affect site selection, we compared three different conservation scenarios. We used two extreme and one combined scenario, to explore a broad range of values (Fig. 1). The first scenario was a biodiversity scenario where we weighted the biodiversity objective by 100% and the other five objectives by 0%. The second was an ecosystem integrity scenario where we weighted ecosystem integrity by 100% and all others by 0%. The third scenario was a stakeholder-driven scenario that resulted from joint discussion at the expert workshop (LLF scenario). This reflects the main selection criteria for potential LLF sites (high biodiversity, ecosystem integrity and size) but considers also the other objectives weighted according to lower priorities. We therefore weighted biodiversity, ecosystem integrity and size with 25% each, climatic stability and land-use stability with 10% each and climate protection with 5%. The code to replicate the presented analysis is available from GitHub under (https://github.com/Legacy-Landscapes/LL_analysis).

Finally, to make the analysis accessible to the broader conservation community and to enable a rapid comparison of sites based on the user-specified prioritization of the different conservation objectives, we designed an interactive spatial decision support tool in which weightings can be modified (see supplementary material, available at: https://ll-evaluation-support-tool.shinyapps.io/legacy_landscapes_dst/). The user interface for the tool was developed using R Shiny version 1.5.0 (Chang et al. 2020).

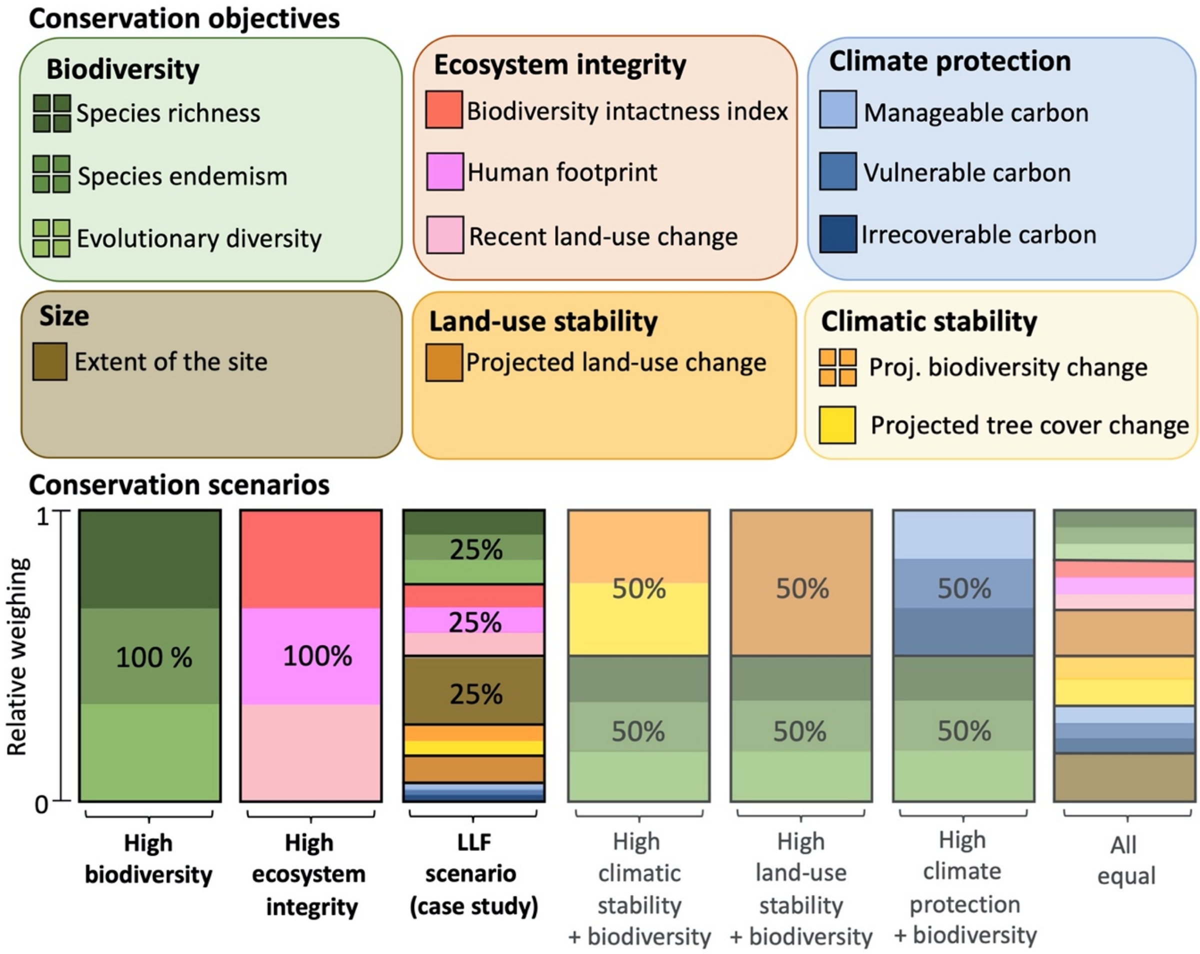

Fig. 1: The six conservation objectives defined to set priorities for the site selection, the indicators considered for each objective (note that Biodiversity and Climatic stability (of biodiversity) include indicators for four different vertebrate taxa), and examples for conservation scenarios based on these objectives. By applying a weighting approach, user-specified objectives can be combined into different conservation scenarios, which are therefore customized for specific conservation goals. The High biodiversity, High ecosystem integrity and LLF scenarios are used in the case study.

Results

The case study dataset for the analysis contained 1347 sites globally. The principal component analysis (PCA) applied to this dataset (Fig. 2; see also supplementary material) showed that the indicators belonging to each conservation objective tended to be closely aligned both at the global and the realm level, with the only exception being the two climatic stability indicators across the Australian realm (Fig. 3). For example, within the biodiversity objective, species richness (SR), species endemism (SE) and evolutionary diversity (ED) were closely aligned at the global scale, as well as at the biogeographic realm level, though the alignment between SR and the other two indicators was slightly less tight in the tropical realms (Fig. 3).

Looking at the trade-offs and synergies among the objectives, we found that at the global scale the first and second PCA axes explained 31.4 and 14.2 percent of the variation in the data respectively. These axes showed clear trade-offs and synergies among the six different conservation objectives (Fig. 3). The strongest global trade-off was found between current biodiversity and future land-use stability (Pearson's correlation coefficient r (n=1346) = -.30, p<0.01). These two objectives are negatively correlated, as increasing land-use pressure is often projected to occur around sites with exceptionally high current biodiversity (e.g. deforestation of tropical forests for agriculture). The strongest global synergies were found between current biodiversity and future climatic stability (r (n=1346) = .41, p<0.01) and current biodiversity and high climate protection potential based on the amount of manageable carbon stored in the site (r (n=1346) = .58, p<0.01). This suggests that sites with exceptionally high biodiversity are projected to often coincide with areas of lower projected impacts of climate change on vertebrate communities and tree cover and with a high potential for climate protection through carbon storage. The identified global synergies and trade-offs between the different objectives were only partially consistent within realms, with very similar patterns for the Afrotropical realm but notably different alignment of the conservation objectives in the Palearctic and Nearctic.

Finally, despite synergy between some objectives we found that when comparing the top five sites selected for each of the three conservation scenarios, within each biogeographic realm, there is little congruence among these "hotspots" (Fig. 4). This implies that selecting sites based on their biodiversity will in most cases result in the protection of different sites compared to a selection based on high ecosystem integrity, or the LLF scenario. Australasia has the highest overlap of top sites for the three different scenarios, with four sites being in the top five for both the biodiversity and the combined scenario (Fig. 1). The Nearctic, Neotropic and Afrotropic realms have the least overlap among the top sites for the investigated scenarios with only one shared site in the top five of all scenarios.

These results demonstrate how our decision support tool facilitates the flexible evaluation of potential priority sites for conservation. The tool enables users to rank sites globally as well as for each biogeographic realm, based on the six conservation objectives. Using sliders to allocate weights to the six conservation objectives, the user is able to design their own conservation scenarios. Therefore, the tool allows to compare a far wider range of different conservation scenarios than the examples we give here, to evaluate synergies and trade-offs among these, and select sites for a more detailed investigation. The current version is publicly available and restricted to the LLF case study dataset and the objectives and indicators presented in the paper, but the flexible approach we use can be implemented easily to other datasets, objectives, and goals (R code available from GitHub under (https://github.com/Legacy-Landscapes/LL_Decision_Tool).

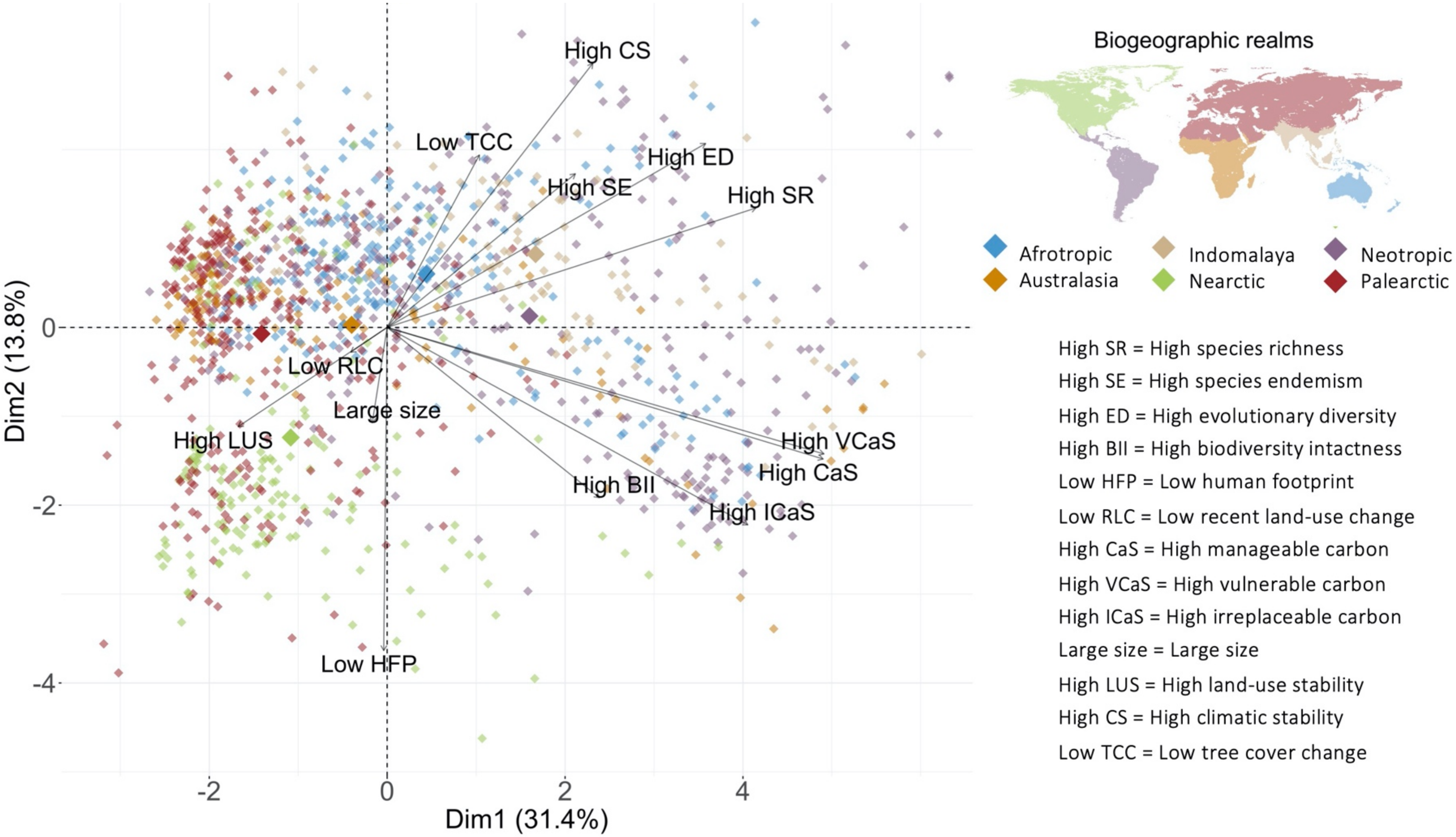

Fig. 2: Trade-offs and synergies between the conservation indicators of individual sites. Shown are the first and second dimensions of a principal component analysis (PCA) that was performed across 1347 sites and their variation in 13 indicator variables aggregated into six conservation objectives. The first and second PCA dimensions together explain 45.3% of the variation in the data. Each dot represents one site. The arrows represent the indicators and the arrow length indicates the loading of each indicator onto the PCA dimensions (i.e. their correlation with the PCA dimension). Opposite loadings indicate trade-offs between the variables (i.e., a site that has a high value in one of these variables, has a low value in the other variable and vice versa). The individual sites (points) are colored by the biogeographic realm they are located in (Olson et al. 2001).

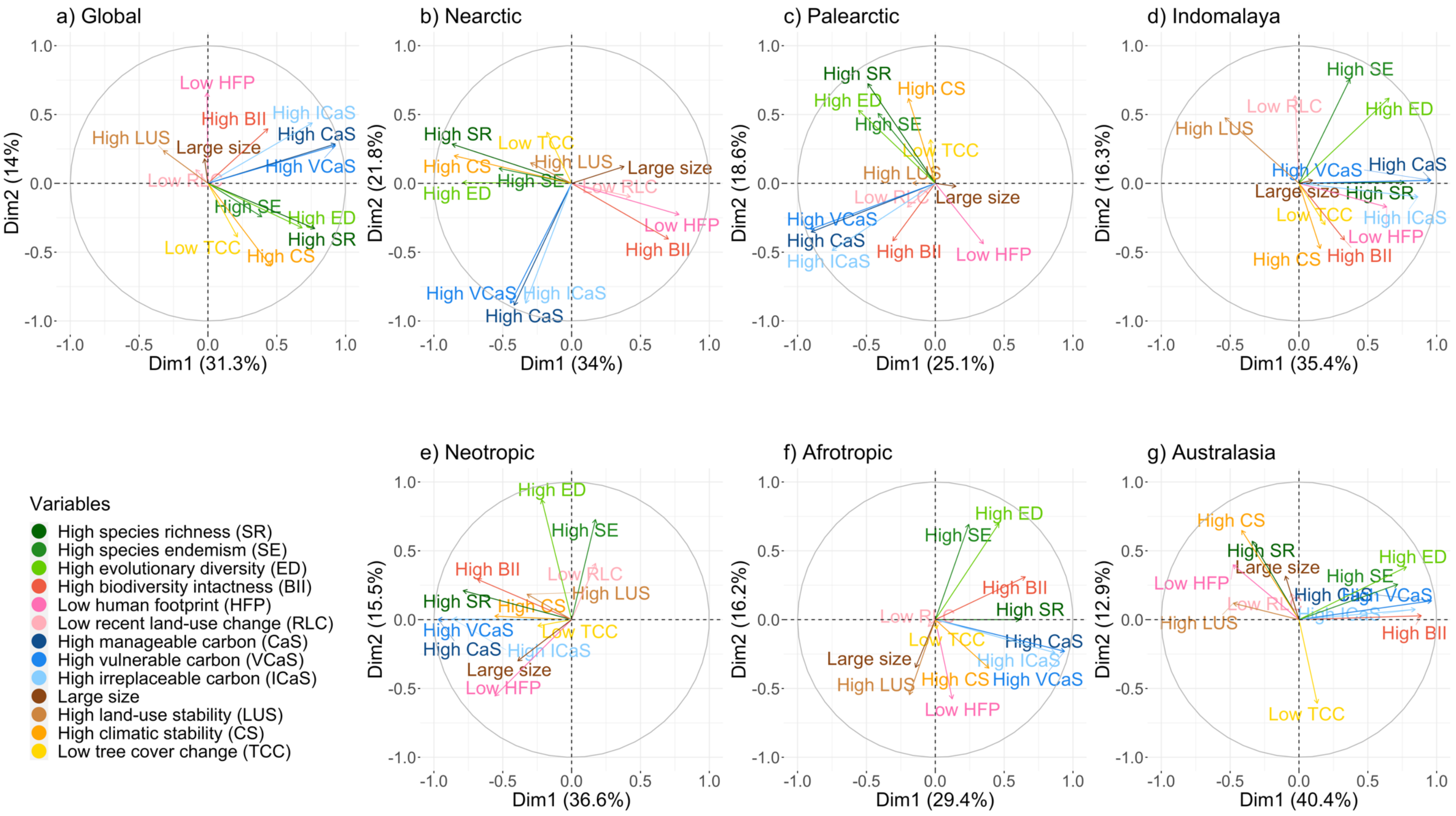

Fig. 3: Trade-offs and synergies between the conservation indicators of individual sites at the global and realm levels. Shown are the first two axes of the principal component analysis (PCA) for all 1347 sites included in the Legacy Landscapes case study globally and for each individual realm. These analyses reveal trade-offs between the conservation objectives, indicated by variables mapping onto opposing ends of a principal component axis. Variable colours

indicate conservation objectives as in Fig. 1: biodiversity (green), ecosystem integrity (red), climate protection (blue), size (dark brown), land-use stability (orange) and climatic stability (yellow). PCA plots show the respective first two axes identified and the percentage of variation explained by each of the axes.

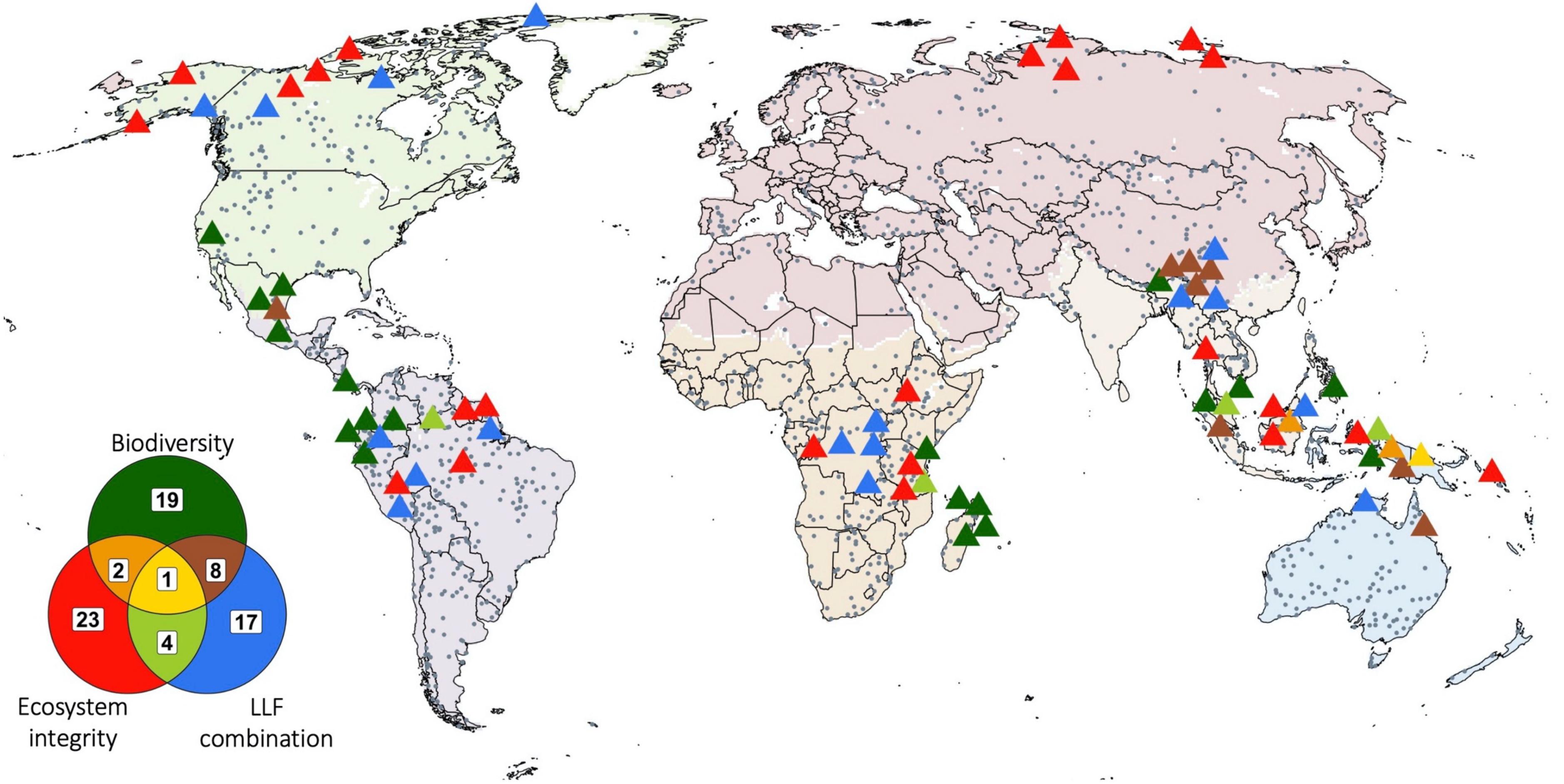

Fig. 4: **Spatial distribution of sites highlighting the top 5 priority sites for each of the 3 example conservation scenarios.** Those shown are: prioritizing biodiversity (dark green), prioritizing ecosystem integrity (red) and the LLF scenario (prioritizing a combination of all objectives that stresses high biodiversity, high ecosystem integrity and large size; blue). The top 5 sites for all three scenarios (large triangles) are shown per biogeographic realm (i.e., 30 top sites per conservation strategy in total). The colours correspond to the three different conservation scenarios and their overlap (if a site is in the top five for

more than one objective), as shown in the Venn diagram. Only 13 of the top sites were selected under two scenarios (light green, brown and orange) and 2 sites were selected under all 3 scenarios (yellow). Grey points indicate sites included in the analysis but not selected under the top 5. Top sites in close geographic proximity are spaced out for visualization and deviate from their exact spatial position. Map colours indicate the different biogeographic realms.

Discussion

Our analysis demonstrates that the selection of 'best' sites for nature conservation depends largely on the relative weighting of different conservation priorities and is therefore heavily influenced by stakeholder values. This is supported by the clear trade-offs between the six conservation objectives (Fig. 3) at the realm and global scale, as well as the limited congruence among the top sites selected under the three different conservation scenarios (Fig. 4). These results illustrate the opportunities and challenges decision makers face when selecting priority areas for nature conservation, for example, when allocating nature conservation funds. Furthermore, they demonstrate the need for a global approach to nature conservation that involves multiple stakeholder groups and perspectives and a transparent decision-making process.

Here, we introduce an approach to select priority areas for biodiversity conservation at the global scale that separates 1. global biogeographic information on biodiversity, ecosystem services, etc., from 2. a value-based prioritization of different conservation objectives in the decision-making process. This allows the trade-offs between conservation objectives to be understood and acknowledged explicitly and quantitatively. It thereby enables a first transparent evaluation of sites that reflects the varying priorities among different societal or conservation actors. Furthermore, the approach allows to optimize site selection towards more than one objective, which can significantly increase the efficiency of a PA network (Sala et al. 2021). Additionally, the transient nature of conservation goals (Mace 2014) or new drivers of biodiversity loss, such as climate change, might result in the need to adjust prioritization in the future. Both arguments highlight the advantages of a flexible site selection approach over the static selection of hotspots based on a small number of fixed objectives and indicators.

Applying the tool to a specific conservation problem

For the Legacy Landscapes Fund, three conservation objectives, size, biodiversity and ecosystem integrity are of high priority (BMZ Division 102 & KfW Centre of Competence for Infrastructure Water Natural Resources 2020). Applying the decision support tool to the assembled dataset revealed a trade off between high biodiversity and high ecosystem integrity, clearly demonstrated in the comparison between the three conservation scenarios, high biodiversity, high ecosystem integrity and the LLF scenario, which considers multiple conservation objectives. For the LLF, the decision support tool enabled an initial screening of potential sites globally, to evaluate the performance of individual sites under the desired conservation objectives and to compare different weightings before proceeding with the selection of the pilot sites. Here the decision support tool was used in an integrative decision-making process amongst other very important criteria like stakeholder consent, political commitment, and experience of the implementing NGO.

Study limitations

It is important to keep in mind that the tool is meant to allow the comparison of sites and different conservation objectives based on biogeographic variables, which are available at a global scale. This necessitates the use of relatively coarse-grained datasets (resolution here is dependent on the biodiversity data). The tool allows an initial screening of a large number of potential sites globally and can be extremely useful in creating prioritizations of PAs based on different objectives and indicators that can be applied flexibly. This tool, however, is only useful as a first step that allows a range of options to be explored, as part of a much broader decision-making process. This decision-making process should include on-site assessments of additional parameters at a higher resolution (e.g. more detailed biological data acquired through surveys and observations) as well as non-biological characteristics. These include, for example, socio-economic factors, the political situation in the country, the participatory involvement of local communities and the presence of an NGO that supports the national authorities. In case of the LLF these factors were considered in the next step that followed using the site evaluation tool, to select a first set of pilot sites.

Implications for conservation

The presented framework has several potential implications for conservation. Firstly, it can be easily extended to include a broader range of biogeographic datasets, additional conservation objectives, or additional sites into the analysis, making the tool widely applicable to a variety of site selection tasks. The ambition of the Aichi Biodiversity Targets has been increasingly criticized as being too modest to safeguard biodiversity (Noss et al. 2012; Larsen et al. 2015). To halt biodiversity loss and ensure climate goals, it has been proposed that 50% of all land areas should be under some form of protection (Dinerstein et al. 2020). Accordingly, more recent calls aim for a milestone of 30% coverage by 2030 and 50% coverage by 2050 (Wilson 2016; Dinerstein et al. 2017; Baillie & Zhang 2018; “High Ambition Coalition (HAC)” 2021). Also, with respect to the post-2020 biodiversity goals, which potentially aim to extend protected area coverage to 30 percent by 2030 on land and in the oceans, it becomes increasingly important to identify new sites for conservation outside of the already delineated areas.

The presented decision support tool could be extended to aid these efforts, either by adapting it to identify new sites or by expanding the presented dataset of state-designated PAs and Key Biodiversity Areas. A first possible extension would be the inclusion of the not yet formerly recognized Indigenous and Community Conservation Areas (ICCAs) and of Other Effective Conservation Measures (OECMs) which are increasingly being recognized as effective and potentially more inclusive conservation tools (Gurney et al. 2021). Secondly the tool could be used at the national or sub-national level to help prioritizing conservation decisions and support implementing the post-2020 global biodiversity framework of the Convention on Biological Diversity at this scale (Perino et al. 2021). Overall, the proposed approach is a valuable tool to accomplish a transparent initial screening of potential priority sites, considering various stakeholder positions, views and preferences, and facilitate discourse and decision-making whilst working towards the overarching conservation goals.

Acknowledgements

We thank all participants of the expert workshop for valuable discussions and input to the development of the decision support tool and the FZS staff in the project areas who tested the tool and helped to evaluate its use for conservation. We gratefully acknowledge the use of the Goethe-HLR HPC at the Centre for Scientific Computing at Goethe University Frankfurt for some of the computationally heavy aspects of this work. We also thank BirdLife International for making the KBA data available as well as the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) and ISIpedia - the open climate-impacts encyclopedia for their support and making the data available.

Funding statement

We thank the Temperatio Foundation for their financial support. SF was supported by the German Research Foundation DFG (FR 3246/2-2) and the Leibniz Competition of the Leibniz Association (P52/2017); AN was supported by European Union's Horizon 2020 research and innovation program under grant agreement No. 689443.

References

Baillie, J. & Zhang, Y.-P. (2018). Space for nature. *Science.*, 361, 1051–1051.

BMZ Division 102 & KfW Centre of Competence for Infrastructure Water Natural Resources. (2020). *The Legacy Landscapes Fund Safeguarding outstanding biodiversity for humanity - the next level of conservation*. Federal Ministry for Economic Cooperation and Development (BMZ), Berlin.

Ceauşu, S., Gomes, I. & Pereira, H.M. (2015). Conservation planning for biodiversity and wilderness: a real-world example. *Environ. Manage.*, 55, 1168–1180.

Chang, W., Cheng, J., Allaire, J., Xie, Y. & McPherson, J. (2020). shiny: Web Application Framework for R. R package.

Convention on Biological Diversity. (2010). “Strategic Plan for Biodiversity 2011 - 2020, including Aichi Biodiversity Targets” [WWW Document]. URL https://www.cbd.int/sp/

Dasgupta, P. (2021a). *The Economics of Biodiversity: The Dasgupta Review*. London.

Dasgupta, P. (2021b). *The Economics of Biodiversity: The Dasgupta Review, Abridged Version, Chapter 19 Natures Supply and Our Demands*. London, UK.

Dinerstein, E., Joshi, A.R., Vynne, C., Lee, A.T.L., Pharand-Deschênes, F., França, M., Fernando, S., Birch, T., Burkart, K., Asner, G.P. & Olson, D. (2020). A “Global Safety Net” to reverse biodiversity loss and stabilize Earth’s climate. *Sci. Adv.*, 6, eabb2824.

Dinerstein, E., Olson, D., Anup, J., Vynne, C., Burgess, N.D., Wikramanayake, E.D., Hahn, N., Palminteri, S., Hedao, P., Noss, R.F., Hansen, M., Locke, H., Ellis, E.C., Jones, B., Barber, C.V., Hayes, R., Kormos, C., Martin, V., Crist, E., Sechrest, W., Price, L., Baillie, J.E.M., Weeden, D., Suckling, K., Davies, C., Sizer, N., Moore, R., Thau, D., Birch, T., Potapov, P. V, Turubanova, S., Tyukavina, A., de Souza, N., Lilian, P., Brito, J.C., Llewellyn, O.A., Miller, A.G., Patzelt, A., Ghazanfar, S.A., Timberlake, J., Kloeser, H., Shennan-Farpon, Y., Kindt, R., Barnekow Lillesø, J.-P., van Breugel, P., Graudal, L., Voge, M., Al-Shammari, K.F. & Saleem, M. (2017). An Ecorerion Based Approach to Protecting Half the Terrestrial Realm. *Bioscience*, 67, 534–545.

Golden Kroner, R.E., Qin, S., Cook, C.N., Roopa, K., Pack, S.M., Bonilla, O.D., Cort-Kansinally, K.A., Coutinho, B., Feng, M., Martínez Garcia, M.I., He, Y., Kennedy, C.J., Lebreton, C., Ledezma, J.C., Lovejoy, T.E., Luther, D.A., Parmanand, Y., Ruíz-Agudelo, C.A., Yerena, E., Morón Zambrano, V. & Mascia, M.B. (2019). The uncertain future of protected lands and waters. *Science.*, 364, 881–886.

Goldstein, A., Turner, W.R., Spawn, S.A., Anderson-Teixeira, K.J., Cook-Patton, S., Fargione, J., Gibbs, H.K., Griscom, B., Hewson, J.H., Howard, J.F., Ledezma, J.C., Page, S., Koh, L.P., Rockström, J., Sanderman, J. & Hole, D.G. (2020). Protecting irrecoverable carbon in Earth’s ecosystems. *Nat. Clim. Chang.*, 10, 287–295.

Gurney, G.G., Darling, E.S., Ahmadia, G.N., Agostini, V.N., Ban, N.C., Blythe, J., Claudet, J., Epstein, G., Estradivari, Himes-Cornell, A., Jonas, H.D., Armitage, D., Campbell, S.J., Cox, C., Friedman, W.R., Gill, D., Lestari, P., Mangubhai, S., McLeod, E., Muthiga, N.A., Naggea, J., Ranaivoson, R., Wenger, A., Yulianto, I. & Jupiter, S.D. (2021). Biodiversity needs every tool in the box: use OECMs. *Nature*, 595, 646–649.

High Ambition Coalition (HAC) [WWW Document]. (2021). . URL https://www.hacfornatureandpeople.org

IPBES. (2019). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. IPBES secretariat, IPBES secretariat, Bonn, Germany.

Jung, M., Arnell, A., de Lamo, X., García-Rangel, S., Lewis, M., Mark, J., Merow, C., Miles, L., Ondo, I., Pironon, S., Ravilious, C., Rivers, M., Schepaschenko, D., Tallowin, O., van Soesbergen, A., Govaerts, R., Boyle, B.L., Enquist, B.J., Feng, X., Gallagher, R., Maitner, B., Meiri, S., Mulligan, M., Ofer, G., Roll, U., Hanson, J.O., Jetz, W., Di Marco, M., McGowan, J., Rinnan, D.S., Sachs, J.D., Lesiv, M., Adams, V.M., Andrew, S.C., Burger, J.R., Hannah, L., Marquet, P.A., McCarthy, J.K., Morueta-Holme, N., Newman, E.A., Park, D.S., Roehrdanz, P.R., Svenning, J.-C., Violle, C., Wieringa, J.J., Wynne, G., Fritz, S., Strassburg, B.B.N., Obersteiner, M., Kapos, V., Burgess, N., Schmidt-Traub, G. & Visconti, P. (2021). Areas of global importance for conserving terrestrial biodiversity, carbon and water. *Nat. Ecol. Evol.*

Kuempel, C.D., Chauvenet, A.L.M., Symes, W.S. & Possingham, H.P. (2021). Predicted protected area downsizing impedes conservation progress across terrestrial ecoregions in the tropics and subtropics. *Conserv. Sci. Pract.*

Larsen, F.W., Turner, W.R. & Mittermeier, R.A. (2015). Will protection of 17% of land by 2020 be enough to safeguard biodiversity and critical ecosystem services? *Oryx*, 49, 74–79.

Legacy Landscapes Fund. (2021). *Charter Internationaler Naturerbe Fonds - Legacy Landscapes Fund*. Frankfurt am Main, Germany.

Mace, G.M. (2014). Whose conservation? *Science.*, 345, 1558 LP – 1560.

Margules, C.R. & Pressey, R.L. (2000). Systematic conservation planning. *Nature*, 405, 243–253.

Moilanen, A., Franco, A.M.A., Early, R.I., Fox, R., Wintle, B. & Thomas, C.D. (2005). Prioritizing multiple-use landscapes for conservation: methods for large multi-species planning problems. *Proc. R. Soc. B Biol. Sci.*, 272, 1885–1891.

Moilanen, A., Wilson, K. & Possingham, H. (2009). *Spatial conservation prioritization: quantitative methods and computational tools*. Oxford University Press.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, 403, 853–858.

Nature Map Earth. (2021). .

Noon, M.L., Goldstein, A., Ledezma, J.C., Roehrdanz, P.R., Cook-Patton, S.C., Spawn-Lee, S.A., Wright, T.M., Gonzalez-Roglich, M., Hole, D.G., Rockström, J. & Turner, W.R. (2021). Mapping the irrecoverable carbon in Earth's ecosystems. *Nat. Sustain.*

Noss, R.F., Dobson, A.P., Baldwin, R., Beier, P., Davis, C.R., Dellasala, D.A., FRANCIS, J., Locke, H., Nowak, K., Lopez, R., Reining, C., Trombulak, S.C. & Tabor, G. (2012). Bolder Thinking for Conservation. *Conserv. Biol.*, 26, 1–4.

Olson, D.M., Dinerstein, E., Wikramanayake, E.D., Burgess, N.D., Powell, G.V.N., Underwood, E.C., D'Amico, J.A., Itoua, I., Strand, H.E., Morrison, J.C., Loucks, C.J., Allnutt, T.F., Ricketts, T.H., Kura, Y., Lamoreux, J.F., Wettengel, W.W., Hedao, P. & Kassem, K.R. (2001). Terrestrial ecoregions of the world: A new map of life on earth. *Bioscience*, 51, 933–938.

Perino, A., Pereira, H.M., Felipe-Lucia, M., Kim, H., Kühl, H.S., Marselle, M.R., Meya, J.N., Meyer, C., Navarro, L.M., van Klink, R., Albert, G., Barratt, C.D., Bruelheide, H., Cao, Y., Chamoin, A., Darbi, M., Dornelas, M., Eisenhauer, N., Essl, F., Farwig, N., Förster, J., Freyhof, J., Geschke, J., Gottschall, F., Guerra, C., Haase, P., Hickler, T., Jacob, U., Kastner, T., Korell, L., Kühn, I., Lehmann, G.U.C., Lenzner, B., Marques, A., Motivans Švara, E., Quintero, L.C., Pacheco, A., Popp, A., Rouet-Leduc, J., Schnabel, F., Siebert, J., Staude, I.R., Trogisch, S., Švara, V., Svenning, J.-C., Pe'er, G., Raab, K., Rakosy, D., Vandewalle, M., Werner, A.S., Wirth, C., Xu, H., Yu, D., Zinngrebe, Y. & Bonn, A. (2021). Biodiversity post-2020: Closing the gap between global targets and national-level implementation. *Conserv. Lett.*, n/a, e12848.

Peter, S., Le Provost, G., Mehring, M., Müller, T. & Manning, P. (2021). Cultural worldviews consistently explain bundles of ecosystem service prioritisation across rural Germany. *People Nat.*, n/a.

Pörtner, H.O., Scholes, R.J., Agard, J., Archer, E., Arneth, A., Bai, X., Barnes, D., Burrows, M., Chan, L., Cheung, W.L., Diamond, S., Donatti, C., Duarte, C., Eisenhauer, N., Foden, W., Gasalla, M.A., Handa, C., Hickler, T., Hoegh-Guldberg, O., Ichii, K., Jacob, U., Insarov, G., Kiessling, W., Leadley, P., Leemans, R., Levin, L., Lim, M., Maharaj, S., Managi, S., Marquet, P.A., McElwee, P., Midgley, G., Oberdorff, T., Obura, D., Osman, E., Pandit, R., Pascual, U., Pires, A.P.F., Popp, A., Reyes-García, V., Sankaran, M., Settele, J., Shin, Y.J., Sintayehu, D.W., Smith, P., Steiner, N., Strassburg, B., Sukumar, R., Trisos, C., Val, A.L., Wu, J., Aldrian, E., Parmesan, C., Pichs-Madruga, R., Roberts, D.C., Rogers, A.D., Díaz, S., Fischer, M., Hashimoto, S., Lavorel, S., Wu, N. & Ngo, H.T. (2021). *Scientific outcome of the IPBES-IPCC co-sponsored workshop on biodiversity and climate change*. Bonn, Gernmany.

Sala, E., Mayorga, J., Bradley, D., Cabral, R.B., Atwood, T.B., Auber, A., Cheung, W., Costello, C., Ferretti, F., Friedlander, A.M., Gaines, S.D., Garilao, C., Goodell, W., Halpern, B.S., Hinson, A., Kaschner, K., Kesner-Reyes, K., Leprieur, F., McGowan, J., Morgan, L.E., Mouillot, D., Palacios-Abrantes, J., Possingham, H.P., Rechberger, K.D., Worm, B. & Lubchenco, J. (2021). Protecting the global ocean for biodiversity, food and climate. *Nature*, 592, 397–402.

Satterfield, A.J., Crosby, M.J., Long, A.J. & Wege, D.C. (1998). *Endemic Bird Areas of the World: Priorities for Biodiversity Conservation* . Birdlife International.

Sechrest, W., Brooks, T.M., da Fonseca, G.A.B., Konstant, W.R., Mittermeier, R.A., Purvis, A., Rylands, A.B. & Gittleman, J.L. (2002). Hotspots and the conservation of evolutionary history. *Proc. Natl. Acad. Sci.*, 99, 2067–2071.

Secretariat of the Convention on Biological Diversity. (2020). *Global Biodiversity Outlook 5*. Montreal, Canada.

Watson, J.E.M., Venter, O., Lee, J., Jones, K.R., Robinson, J.G., Possingham, H.P. & Allan, J.R. (2018). Protect the last of the wild. *Nature*, 563, 27–30.

Wilson, E.O. (2016). *Half Earth Our Planets fight for Life*. Liveright, New York.