**PERSPECTIVE**

Designing an ecologically representative global network of protected areas requires coordination between countries

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### 1. Protected areas (PAs) and their importance for conserving biodiversity

People are now impacting the natural environment at an unparalleled scale [1]. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services warns that up to 1 million species may be threatened with extinction [2]. PAs represent an essential conservation strategy for addressing human environmental impacts [3]. It is for that reason that in 2010 the Parties to the Convention on Biological Diversity (CBD) agreed to the following target—known also as Aichi Target 11:

By 2020, at least 17% of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Although the quantitative terrestrial coverage of 17% was achieved at a global scale [4], there has been less progress regarding the other key aspects of the target. Many of the world’s PAs remain ineffective [5], inequitably managed [6], poorly connected [7], and are not ecologically representative [4, 8].

Here, we focus on the representativeness aspect to demonstrate that transboundary coordination between countries is essential to achieve this objective. Yet, decisions regarding PAs and their placement continue to be made unilaterally at the national level, resulting in large differences among ecosystems and species in the degree of protection at the regional and global levels [4]. Recognizing and addressing this issue is critical for the successful implementation of the post-2020 global biodiversity targets—which are to be adopted during the second phase of the CBD’s 15th Conference of the Parties (COP 15) in Kunming, China in May 2022. According to the first detailed draft of the post-2020 global biodiversity framework (GBF) [9], the new quantitative coverage target for PAs and other effective area-based conservation measures (OECMs) will likely be set at 30% of the planet to be achieved by 2030 (Action Target 3). For this to happen, countries will have to expand their protected land significantly; for many, it would mean more than doubling their current network of PAs and OECMs. However, as we illustrate below, should these expansions continue to occur without transboundary coordination, countries risk creating a global network of PAs that is still not ecologically representative despite its greatly expanded coverage.

### 2. Ecological representativeness

PAs must be ecologically representative to successfully conserve our planet’s biodiversity and its key ecological and evolutionary processes [9]. At the global level, ecological representativeness is often interpreted to mean the even coverage of the world’s ecoregions [4, 10–12]. For example, this is how progress towards achieving the Aichi Target 11 has been
measured \cite{4, 10}. There are 846 terrestrial ecoregions worldwide \cite{13, 14}, each reflecting a unique biogeographical area with ‘distinct assemblages of natural communities and species’ \cite{13, 15}. Yet, the percentage of protected land within each ecoregion varies considerably \cite{3, 14}. According to the most recent ‘Protected Planet Report’ \cite{4}, 55.5\% of the world’s ecoregions have less than 17\% of their area protected, and 5.1\% lie entirely outside PAs \cite{4}.

This uneven representation of the world’s ecoregions is partly driven by differences in the percentage of protected land amongst countries and differences in the amount of habitat available for protection. However, it is also driven by the fact that PAs are designed at the national level with no coordination between countries sharing the same ecoregions. This practice produces suboptimum results at the regional and global levels because nearly half of the world’s ecoregions extend across national borders \cite{3, 11}, with a quarter of them found in three or more countries. What this means for the post-2020 GBF is that even if global conservation efforts are successful at protecting 30\% of the planet by 2030 \cite{9}, many of the world’s ecoregions will still have substantially less of their total area protected if countries do not coordinate their expansion of PAs.

To illustrate this and to quantify the potential consequences, we simulated three different scenarios under which countries expand their networks of PAs sequentially by adding a PA equal to the mean size of their current PAs until they reach 30\% of their land area (figure S1 \cite[available online at stacks.iop.org/ERL/16/121001/mmedia]). We calculated the amount of land available for conservation within each ecoregion in each country by omitting all land already protected, and all land modified extensively by humans \cite{16}. We then ran each simulation 100 times and compared the mean percentage of protected land within each ecoregion, to assess how many ecoregions would fail on average to reach the 30\% coverage target in the absence of transboundary coordination. The 30\% target mentioned in the first draft of the post-2020 GBF refers to the planet’s total area \cite{9}, and it does not necessarily mean it is an appropriate target for every country. In theory, this percentage could be reached with some countries protecting more than 30\% of their area while others protect less. However, since most national targets are not yet in place, and since countries are expected to establish ‘targets/indicators aligned with this (post-2020) framework’ \cite{9}, we believe it is a reasonable benchmark for this hypothetical exercise. Moreover, as the CBD’s Kunming Declaration mentions—which was released during the first phase of COP 15 in October 2021—many countries have already announced plans to protect 30\% of their land by 2030 through a combination of PAs and OECMS \cite{17}.

The first two scenarios are variations of the approach used currently by countries to designate PAs, i.e. independently of each other. The third scenario assumes coordination between countries by considering the amount of land protected in shared ecoregions as it increases over time (figure S1). Under the first scenario, the probability of placing a new PA in an ecoregion in a country is proportional to the ecoregion’s size in that country. The rationale is that larger ecoregions will have more land available and, therefore, a higher chance of being selected for a new PA. This scenario reflects also the fact that decisions regarding where to place PAs are frequently based on non-ecological criteria \cite{18}, such as the land’s suitability for other human uses, e.g. agriculture. The second scenario assumes a deliberate effort by countries to protect ecoregions within their borders as evenly as possible to maximize ecological representation within their territory. Therefore, the probability of a country placing a new PA in an ecoregion within its territory is inversely proportional to that ecoregion’s percentage of land already protected in the particular country. As that percentage increases (i.e. with the sequential addition of new PAs), this probability decreases. Once the ecoregion reaches \(\geq\)30\% of its land protected, the probability of being selected drops to nearly zero, meaning that the ecoregion is only selected if it is necessary for the country to achieve its national 30\% coverage target. The third scenario aims at maximizing ecological representation at the regional level and assumes that countries sharing ecoregions coordinate their efforts by regularly exchanging information regarding their expansion plans and actions. Hence, the probability of placing a new PA within an ecoregion in a county is inversely proportional to that ecoregion’s percentage of protected land across all the countries in which it is found. As in the second scenario, the probability becomes nearly zero once the protection level reaches 30\%. Importantly, the total amount of land protected within each country under all three scenarios remains the same. The exact methods and data used to simulate the three scenarios are described in detail in the supplementary materials.

3. Transboundary coordination results in higher ecological representativeness

Under the first two scenarios, in which PAs are established without coordination between countries sharing ecoregions, the percentage of ecoregions with less than 30\% of their land protected ranges from 32 ± 0.5\% (in scenario 2) to 50 ± 0.9\% (in scenario 1). By contrast, under the third scenario, the corresponding percentage is only 19 ± 0.5\%. These differences are striking and suggest that up to half of the world’s ecoregions could fail to reach the intended coverage target without appropriate transboundary planning (figure 1) even if all countries protected 30\% of their land by 2030—an endeavor that seems
already challenging considering the short timeframe available.

Importantly, even if countries made deliberate efforts to achieve ecological representatives within their territory (scenario 2), the number of ecoregions with at least 30% of their area protected would still be substantially lower than what could be achieved through transboundary coordination (figure 1). Many of the ecoregions that will not achieve the targeted protection level under scenarios 1 and 2 (figure 2; table S1) overlap with Global 200 ecoregions, i.e. priority regions for global conservation [19], underlining further the urgency for transboundary coordination between countries.

It is important to note, though, that even with successful coordination, a considerable number of the world’s ecoregions (19%; figure 1), particularly in sub-Saharan Africa and Latin America, will not reach the 30% coverage target (figure 2; table S1). Ecoregions in those areas known for their high biodiversity may have as little as <15% of their area protected (figure 1; table S1). Therefore, to adequately protect those ecoregions—several of which also overlap with Global 200 ecoregions [3]—some countries will need to protect a substantially higher proportion of their land. Moreover, habitat in degraded ecoregions worldwide [1] will require large-scale restoration to achieve the targeted coverage.

To maximize the number of ecoregions achieving the 30% coverage target, there need to be fundamental changes in how PAs are designed and established. Countries will need to consider the area protected in neighboring countries with which they share ecoregions. For that to happen, they will need to have access to reliable and up-to-date information regarding those countries’ expansion.
plans and actions. Although the first draft of the post-2020 GBF recognizes that a comprehensive system for planning and reporting is essential for the success of the post-2020 global biodiversity targets [9], it does not require that the Parties share their conservation plans and actions with each other. Yet, without this information, it is impossible for countries to plan their PA systems in a way that optimizes those systems at the regional level. We, therefore, recommend that before the new targets are adopted in May 2022, the post-2020 GBF is updated to include statements that: (a) Parties will provide frequent and timely information on their conservation plans and actions to other countries in their region, and (b) Parties will take into account the information they are provided on other countries’ plans and actions when making their own conservation plans.

This information exchange will need to be supported by other important initiatives. Local researchers and stakeholders will need to work together to identify the areas within each ecoregion that are most appropriate for protecting vulnerable habitats and species. Studies from the Mediterranean region, and elsewhere, have shown that conservation efforts are more successful and cost-effective when countries coordinate their conservation actions [20]. Such enhanced collaboration between countries and stakeholders could also help countries achieve the other key aspects of Action Target 3 [9]. For example, information exchange on best practices could help ensure that PAs are established and managed effectively and equitably [3].

Finding mechanisms through which such enhanced coordination can be achieved is imperative, but is likely to be challenging. Geopolitical factors and increased transaction costs can hinder transboundary coordination. Yet, there are several examples of successful transboundary cooperation, which could be replicated and adjusted based on the countries’ needs and conditions. Bilateral agreements, for example, have contributed to the establishment of hundreds of transboundary PAs worldwide. Similarly, regional treaties, such as the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (unep-aewa.org), have successfully coordinated the conservation and management of several habitats and species. Countries should also take advantage of existing regional bodies wherever appropriate. The Association of Southeast Asian Nations (ASEAN) Centre for Biodiversity (aseanbiodiversity.org), for example, is an intergovernmental body created specifically to facilitate coordination between ASEAN countries.

In conclusion, establishing and maintaining a global network of PAs and OECMs that effectively protects 30% of the planet by 2030 will require immense efforts and resources [14]. Countries must, therefore, coordinate their conservation efforts to ensure that the resulting network is as ecologically representative as possible. Only then can we hope to achieve the rest of the global biodiversity targets and sustainability goals [9].

Data availability statement

No new data were created or analyzed in this study.

Figure 2. The number of ecoregions reaching the 30% coverage target on average is significantly higher under the third scenario, which involves transboundary coordination.
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