A Review of Evidence for Area-based Conservation Targets for the Post-2020 Global Biodiversity Framework

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Summary

It is widely recognized that we are facing both a global biodiversity and a global climate change crisis. In recent decades, set against such rising concerns, much attention has been focused on the urgent need to scale-up area-based conservation targets employed by the global community. Some notable decisions have been taken, such as the widely supported 2016 IUCN Resolution to protect 'at least 30%' of the ocean in MPAs with high levels of protection. But what is the evidence to justify such positions, and what does science say about the scale of area-based targets that would be actually be necessary to address the severity of the problems we now face?

In this paper we set out the results of a review of the literature to determine scientific evidence for large scale percentage (%) area conservation targets. Percentage area targets have been determined from both a policy perspective and a scientific perspective. Our review shows that science-based estimates always produce higher percentages than policy-based estimates. Science-based estimates of the % area of the earth, or of an ecological region, required to conserve nature vary by the biodiversity selection parameters. Most approaches use systematic conservation planning methods that add in various biodiversity values such as rarity or endangerment, representativeness, abiotic features, ecological connectivity and conservation of ecosystem services, including carbon. Other approaches used to set conservation targets include species-area curves and minimum ecosystem sizes to avoid regime shifts.

The review concludes that:

1. The minimum targets of 17% terrestrial and inland waters, and 10% marine and coastal targets from Aichi Target 11 of the Strategic Plan for Biodiversity 2011-2020 are not considered adequate to conserve biodiversity by any research findings, either for ocean or for land.
2. Percentage area targets cannot be considered in isolation from the quality considerations presented in Aichi Target 11. There is concern that a focus on % area targets might draw away from a focus on quality. Protected and conserved areas are policy tools to achieve nature conservation and need to be selectively located, properly designed, well governed and effectively and equitably managed to achieve effective biodiversity outcomes.
3. All approaches to setting conservation targets call for much higher % area targets than are currently in Aichi 11. There is no unequivocal answer to the question of what % of the earth, or

of a region, should be protected in order to maintain biodiversity. The answers are complicated by spatial scale, patterns of biodiversity, and weaknesses in selection approaches. Studies that include a more complete set of values are universally very high; they estimate well over 50% and up to 80%. Studies that include a narrower subset of biodiversity values are lower, but rarely under 30%, and always with caveats that they are minimum or incomplete estimates. As such, protected area conservation targets should be established based on the desired outcomes (e.g. halting biodiversity loss by 2030).

4. The global protection of a minimum of 30% and up to 70%, or even higher, of the land and sea on earth is supported in the literature, whether by species-area curves, systematic conservation planning, or minimum system size approaches. Importantly, the suggested higher conservation targets are not discounted in any of the biodiversity literature. The call for 50% of the earth is a mid-point of these values and is supported by a range of studies.

5. Implementation of large global % area targets can be achieved through differentiating the kinds of areas that need protection at a national scale, and can be supported by nationally determined contributions in accordance with local conditions (see 3 conditions approach below).

Introduction

This paper was prepared as a background for considering large-scale conservation targets, as the world into the negotiation of the post-2020 Framework for Biodiversity under the Convention on Biological Diversity, scheduled for adoption at the Conference of the Parties in China in late 2020.

We face a global biodiversity crisis. Extinction rates are estimated to be 1000 times the background rate and future rates could be 10,000 times higher (De Vos et al., 2015). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Díaz et al., 2019) reports that 75% of the earth's land surface is significantly altered, 66% of the ocean area is experiencing increasing cumulative impacts, and over 85% of wetlands (by area) have been lost. On average, population sizes of wild vertebrate species have declined precipitously over the last 50 years on land, in freshwater and in the sea, and around 25% of species in assessed animal and plant groups are threatened (Díaz et al., 2019).

The most significant direct drivers of biodiversity loss are habitat loss and fragmentation (changes in land and sea use) and direct exploitation, with exploitation, or over-harvest, being more significant in marine systems. Factors of climate change, invasive alien species, disease, and pollution are also important (Díaz et al., 2019). Many of these drivers of biodiversity loss can be managed through area-based conservation, with protected and conserved areas being the backbone of area-based conservation. Because biodiversity loss is being driven primarily by habitat loss and fragmentation, and over-harvest, protected and conserved areas are key policy and practical solutions to biodiversity loss. Area-based conservation maybe less effective for addressing some drivers, including widespread pollution, and widespread disease and invasive species.

Setting global priorities for precisely where biodiversity should be conserved is complementary to the question of how much area of land and sea should be conserved. The question of how much land, sea and freshwater to conserve in protected areas and conserved areas (including OECMs under the Convention on Biological Diversity (Jonas et al., 2018)) is central to a larger set of conservation decisions, which include site selection and biodiversity conservation outcomes. In reviewing the % area question, the primary consideration must focus on the overall purpose of having such a goal. A reasonable assumption is that the goal of a global protected and conserved area network is to ensure that key drivers of biodiversity loss on land, ocean and freshwater, are no longer causing biodiversity loss. Area-based targets should include biodiversity targets (Noss & Cooperider 1993) and nature's contributions to sustaining people (ecosystem services including carbon storage). These values are expressed in the 2050 vision of Living in Harmony with Nature for the Strategic Plan for Biodiversity (https://www.cbd.int/kb/record/decision/12268).

Biodiversity, defined as the diversity of genes, species and ecosystems, is distributed very unevenly on planet earth. For example, the tropics have much higher levels of diversity than the poles, and isolated and island areas have higher species endemism because of their isolation. Diversity is a function of overall productivity, water availability, colonization history and disturbance. Therefore the amount of area required to protect biodiversity must be adjusted by this fact of uneven distribution.

Global conservation targets have driven much of the international focus on area-based conservation and there is a rich history of setting conservation targets for protected and conserved areas. Conservation targets have been changing with evolving ideas on biodiversity and ecosystem services and the emergence of sustainable development and conservation biology (Locke, 2018; Sala et al. 2018; Laffoley, 2019). The well-known targets of 10 or 12% of geographical areas, including for countries, natural regions, and vegetation types, were based on representing samples of the earth's ecosystems and did not include requirements for the persistence of species or ecological processes (Noss, 1996; Rodrigues and Gaston, 2001). The 10% target originated in 1982, at the Third World Congress on National Parks (Miller, 1984) and was later reinforced at the Fourth World Congress on National Parks and Protected Areas (McNeely, 1993). A 12% target was developed in 1987 with the goal of protecting a representative sample of Earth's ecosystems (World Commission on Environment and Development, 1987).

As conservation biology grew as a discipline, conservation targets continued to include representation but also encompassed broader goals expressed in conservation biology (Noss & Cooperider 1993) including:

1. Representing all native ecosystem types in protected areas;
2. Maintaining populations of all native species in natural patterns of abundance and distribution;
3. Maintaining ecological processes such as hydrological processes and fire; and
4. Ensuring resilience to short-term and long-term environmental change
5.

Aichi Target 11 of the Convention on Biological Diversity contains qualitative language that reflects some of the above goals, including representativeness, connectivity, and areas of particular importance for biodiversity and ecosystem services. But the targets of conserving a minimum of 17% of land and 10% of oceans that are included in Aichi Target 11 were set arbitrarily. The Target 11 percentages were formulated as an interim policy target to encourage progress and push the conservation agenda, while being considered to be achievable.

The IUCN-WCPA Beyond the Aichi Targets Task Force conducted a global survey of conservation scientists in 2018 to explore their perspectives on area-based conservation (Woodley et al. 2019 submitted.) It surveyed the membership of the International Society for Conservation Biology and received responses from 363 scientists from 81 countries. There was very strong support for large area-based targets from the respondents (78% agreed or strongly agreed they were important) and widespread agreement that the 17% and 10% areas were inadequate (72% agreed).

In recent years, there have been calls for significantly higher global % area targets, arguably based on assessing the scientific need for biodiversity conservation. Notable proponents include Half-Earth ((https://www.half-earthproject.org/) and the Nature Needs Half Movement (https://natureneedshalf.org/) which have been described generically as the movement to protect half the world (Locke, 2018).These efforts are backed by an international coalition of scientists, conservationists, and NGOs with the aim of conserving nature at a sufficient scale to allow nature to persist and function for the benefit of all life, including human well-being. A 50% conservation figure is actually not a new idea and was first expressed by the pioneering ecologists, the Odum brothers, almost 50 years ago, “It would be prudent for planners everywhere to strive to preserve 50% of the total environment as natural environment” (Odum and Odum, 1972).

Methods

This review identified scientific literature relating to area-based conservation targets by searching the titles, abstracts, and keywords of publications since 1980 in Web of Science and Google Scholar on July 10, 2019, with the keywords “conservation objectives, conservation planning, conservation site prioritization, representation targets, reserve selection, scale analysis, selection of conservation areas, cumulative species–area model, and holistic conservation strategy.” Search results were sorted by relevance and the search discontinued when results were determined to be of low relevance. Due to time and resource constraints, our review was restricted to publications in English. The review included published peer-reviewed journal articles and unpublished grey literature, with research findings and conservation plans from around the world covering terrestrial and marine ecosystems. Papers were retained if they contained original research of global or regional attempts to quantify % area targets or systematic or structured reviews of similar papers. The review has been supplemented by other references from known sources.

Results

The search yielded 1656 papers which were scanned for relevance by title and then abstract. A total of 70 papers were retained and examined in detail. Rondinini and Chiozza (2010) reviewed methods for setting % area conservation targets for habitat types. This is not precisely the same as setting global area-based targets, but the concepts are similar. In general, scientists have used three different types of approaches to determine the area required to conserve biodiversity at large scales, as follows (*key publications and conclusions are highlighted in Table 1*):

Species area curves - The species–area relationship, or species–area curve, describes the relationship between the area of an ecosystem and the number of species found within that area. Larger areas tend to contain larger numbers of species, and empirically, the relative numbers seem to follow systematic mathematical relationships (Brose et al., 2004). The number of species in an area is determined by only four rates: birth, death, emigration and immigration. In his book “*Half Earth*”, E.O. Wilson (2016) used species-area curves to argue that half of the earth should be protected. This is based on global species-area curves where conserving 50% of the earth would cover 85% of the species on the earth. If the 50% was configured and located properly, it would cover the species at risk, the endemic species and the naturally rare species. The remaining 15% of species would be lost or survive in the other 50% of the earth. Species-area curves have not been used extensively in the literature to determine % area targets. A review of their uses can be found in Rosenzweig (1995).

Systematic Conservation Planning - Systematic conservation planning approaches set targets and then select sets of valued ecosystem components, generally species (e.g. Red Listed Species), ecosystem types (e.g. rare or representative) or other abiotic features (e.g. caves, or bedrock outcrops) and ecosystem services (e.g. carbon storage). These can then be aggregated to determine an overall % area required to meet the selected range of conservation features. Sometimes policy elements are included in these analyses (e.g. redundancy). In contrast to species-area curves, these approaches are bottom-up, rather than top-down. They often require the use of surrogates for the biological features in an area. For example, areas of importance for biodiversity might be selected as Key Biodiversity Areas. Finally, systematic conservation approaches can be applied at a range of spatial scales, from local to regional or global.

In an editorial review of studies on conservation targets, Noss et al. (2012) concluded that conserving 25–75% of a typical region in a natural state was required to conserve biodiversity. Noss et al. (2012) argued that conservation scientists have failed to articulate a bold vision that was based on science, because the numbers are perceived as too high to be socially acceptable. They argued that we should set global and regional conservation targets at 50% of the area, which is slightly above the mid-point of recent evidence-based estimates.

Svancara et al. (2005) conducted a comprehensive review of terrestrial conservation targets, finding 159 articles reporting with 222 conservation targets. They focused on assessing differences between policy-driven and evidence-based approaches. On average, the % coverage of an area recommended for evidence-based targets were nearly three times as high as those recommended in policy-driven approaches. Average values reported for targets from conservation assessments was 30.6% ± 4.5% and for targets using threshold analyses was 41.6% ± 7.7%.

Notable for this review is a paper by Butchart et al. (2015), who asked how much of the earth would be required to achieve the quality elements of Aichi Target 11, and Target 12. The study specifically examined the representativeness of known species groups assessed by the Red List of Species, the representativeness of ecological regions, and KBAs as areas of importance for biodiversity. The conclusion was that an optimal solution to cover the selected elements equated to protecting 27.9% of the global terrestrial area. The paper notes that this is a likely underestimate % of the land surface as their selected biodiversity elements did not include all possible species, nor did it consider any ecosystem services.

Ecoregional planning is based on broad goals of conservation biology, including coverage of species, and representativeness of ecosystems and ecosystems. When broad conservation goals are considered, many studies call for about half of any given ecoregion to be protected (Noss et al. 2012, Locke 2014). Examples of comprehensive conservation planning for large regions are instructive for setting global targets. Such studies tend to have far better data sets than global analyses and are based on conserving or protecting selected biodiversity elements (e.g. concentrations or occurrences of rare species), representing all ecosystem types, and meeting the spatial needs of focal species, in particular large carnivores. As an example, in the Rocky Mountains of the USA, systematic conservation planning called for protecting 62% of the entire ecoregion, including 26% of the ecoregion in core areas and much of the remaining area in compatible use and linkage zones (Miller et al. 2003). Reviews of similar studies conducted using ecoregional planning techniques both globally (Locke 2013) and more specifically focused on the US (Locke, 2014) generally concluded that about 50% of the area was required to protect the conservation values of any given ecoregion. For example, a plan for the Greater Yellowstone Ecosystem in the USA, which added in explicit population modelling for focal species, concluded that 70% protection of the region was required (Noss et al. 2002). These are high % values, but they are based on peer-reviewed estimates of what is required to meet a broad suite of conservation goals, with good data sets.

In marine systems, O'Leary et al. (2015) reviewed 144 studies to assess whether the 10% target contained in Aichi Target 11 for marine protected areas was adequate to achieve, maximize, or optimize six environmental and/or socioeconomic objectives. They concluded that it was not adequate. Only 3%

of studies met all the objectives with 10% MPA coverage, 44% of studies met all the objectives with 30% coverage, and 81% of studies required more than 50% coverage to meet all the objectives.

The six objectives considered by O'Leary et al. were:

1. protect biodiversity;
2. ensure population connectivity among MPAs;
3. minimize the risk of fisheries/population collapse and ensure population persistence;
4. mitigate the adverse evolutionary effects of fishing;
5. maximize or optimize fisheries value or yield; and
6. satisfy multiple stakeholders

Table 1: Key Publications and Conclusions on Global or Regional % Area Required for Conservation Targets

Conclusions	Reference	Approach	Scale and Area
Solution to cover the selected elements equated to protecting a minimum of 27.9% of the global terrestrial area	Butchart et al. (2015)	Global assessment of the minimum needs of all elements of Aichi Target 11	global—terrestrial
Average values reported for targets from conservation assessments was 30.6% ± 4.5% and for targets using threshold analyses was 41.6% ± 7.7%.	Svancara et al. (2005)	Review of the literature - 159 articles reporting with 222 conservation targets	global - terrestrial
"Several tens of %" of the sea is required to meet conservation goals, with an average of 37%, and a median 35%. More than 50% of area required to meet 80% of conservation objectives.	O'Leary et al. (2015)	Review of the literature	global—marine
Set global and regional conservation targets at 50% of the area	Noss et al. 2012	Review of selected studies of conservation targets	global
Conserving 50% of the earth would cover 85% of the species on the earth.	Wilson, 2016	species area curves	global—terrestrial
"Recent comprehensive conservation plans have delineated around 50% or more of regions for nature conservation."	Pressey et al. 2003	Test of regional conservation goals	regional—Cape Floristic Region, South Africa
A wildlands design for the southern Rocky Mountains comprises 62% of the ecoregion	Miller, 2003	Systematic conservation planning	regional—Rocky Mountains, the USA
A retention target is that a minimum of 60% of the entire ecosystem should be conserved in order to avoid a regime shift. Lovejoy and Nobre suggest this be 80%.	Lapola, 2014; Lovejoy and Nobre, 2018.	minimum ecosystem size	regional—Amazon basin
60% of the world's lands area (excepting Antarctica) would need to be protected to minimize the extinction risk of the world terrestrial mammals	Moog et al. 2019	Systematic conservation planning using mammals	Global - terrestrial

O'Leary et al. also concluded that protecting "several tens of %" of the sea is required to meet the conservation goals, with an average of 37%, and a median 35%. Previous reviews (Roberts 2003 and Gaines *et al.* 2010) have suggested that 20–40% of coverage by marine protected areas was warranted. They concluded that even the more ambitious target of at least 30% protection called for by the IUCN World Parks Congress 2014 (World Parks Congress 2014) and its near-unanimous approval by Resolution at the 2016 Hawaii World Conservation Congress is likely insufficient to meet all of the multiple objectives expected of MPA networks. It should be noted that O'Leary et al. do not consider values such as carbon storage, so even these large % area targets are likely low.

Percent area targets used in conservation planning are challenging in that they relate to the scale at which they are applied (Pressey et al. 2003). Rodrigues and Gaston (2001) examined the underlying assumptions of using systematic conservation planning to set % area conservation targets. They concluded that no single universal target for the minimum % of area (such as the 10%) can be appropriate. The actual % area is a function of the features that go into the systematic conservation plan. They noted that nations with higher species diversity and/or higher levels of endemism, such as the tropical ones, would require substantially larger fractions of their areas to be reserved, perhaps up to 75% of the overall area (Mittermeier et al. 1999).

Rodrigues and Gaston (2001) also concluded that a minimum conservation network that is sufficient to capture the diversity of vertebrates will not be sufficient to conserve biodiversity in general (Howard et al. 1998; Kerr, 1997), because many other more diverse groups with higher levels of local endemism (including plants and many groups of invertebrates) are expected to require considerably larger areas to be fully represented. Even studies that come up with large % area numbers often leave important elements out of the calculation.

The third key conclusion from Rodrigues and Gaston (2001) was about the size of selection units (e.g. grid cell size). Small selection units will lead to smaller % area targets because the ecological feature can be represented in a small area. However this is likely misleading as the area will not be ecologically viable for the feature or species in question. (Pimm & Lawton 1998). For large selection units (e.g. the often used 1° ´ 1° or approximately 12,000 km^2), it is predicted that 74.3% of the global land area and 92.7% of the tropical rain forests would be required to represent every plant species once, and 7.7% and 17.8% for higher vertebrates.

Rodrigues and Gaston point out some of the challenges in using systematic conservation planning. More importantly they conclude that the inclusion of all species and ecological features in a realistic way always leads to a conclusion that very high % area targets are required to conserve biodiversity.

In a global gap analysis, Rodrigues et al. (2004 Nature) concluded that "the percentage of area already protected in a given country or biome is a poor indicator of additional conservation needs. They found that current protection levels should not be used as a significant criterion to guide priorities for allocation of future conservation investments." This is because protected areas are often not established in locations where they can make a significant conservation impact.

The most comprehensive analysis to date (Butchart et al. 2012) of protected area coverage of important sites for biodiversity (specifically, Important Bird & Biodiversity Areas [IBAs], and Alliance for Zero Extinction [AZE] sites) showed that the proportion of protected areas which are IBAs or AZEs has been decreasing over time since the 1980s. Recent re-analysis shows that this negative trend has continued over the 2011-2019, that is, the timeframe of Aichi Target 11. This trend has been accompanied by a flattening of the % of IBA and AZE sites which are protected, over the same time period (IPBES 2019).

Moog et al. (2019) used IUCN Red List criteria to assess area-based conservation targets that would minimize the extinction risk of the world terrestrial mammals. They concluded that approximately

60% of the Earth's non-Antarctic land surface would require some form of protection to conserve land mammals. They concluded that the Aichi targets, will be inadequate to secure the persistence of terrestrial mammals and suggest the need to implement a connected and comprehensive conservation area network, guided by targets based on species persistence.

Several analyses have shown persistent biases in establishment of protected areas away from places important for halting biodiversity loss, and towards places that are "residual" – that is, large, cheap areas not demanded by any other uses of land (Joppa & Pfaff 2009; Venter et. Al, 2016) or sea (Devillers et al. 2015). Thus, area protected alone is not a complete metric of conservation. It must be accompanied by a focus on area of importance for biodiversity.

The achievement of large % targets are also conflated by concerns over the quality the protected areas in delivering conservation outcomes after establishment. Leverington et al. (2010), in a study of 8000 protected areas globally reported that 40% has significant weakness in management. Sound management is critical to biodiversity outcomes in protected areas on land (Geldmann et al., 2018) and sea (Gill et al. 2017). Sala el al (2018) reviewed progress on marine conservation targets and concluded progress was often illusory because many reported protected are not well managed and thus have minimal conservation benefits. They reported that although 7% of the ocean was reported as only 3.6% of the ocean MPAs were implemented and only 2% were in strongly or fully protected MPAs.

Drawing from these concerns, Visconti et al. (2019) have proposed instead focusing solely on quantitative site conservation targets onto their desired outcomes, rather than on % protected area. Specifically they suggest that "The value of all sites of global significance for biodiversity, including key biodiversity areas, is documented, retained, and restored through protected areas and other effective area-based conservation measures" would constitute a post-2020 site conservation target most likely to deliver positive benefits for biodiversity. Woodley et al. (2019) argued that, in addition to a focus on quality, a focus on ambitious % areas targets was also requited to inform decision makers of the scale of conservation requited for science-based targets and to drive ambition.

Minimum sizes of ecosystems to avoid regime shifts— A third general approach to consider % area conservation targets is the minimum area required to maintain an intact, functioning ecosystem. This approach includes examining what area is required to maintain the ecological conditions necessary to avoid a regime shift (Rocha, 2018) or to maintain a keystone species. Perhaps the best example of this minimum ecosystem size approach is from the Amazon region (Lapola, 2014; Davidson, 2012). The Amazon river system produces about 20% of the world's freshwater discharge, and holds about 100 billion tonnes of carbon. Because the Amazon forest transpires so much water, it generates its own rainfall with a wave pattern across the basin. It is predicted that a loss of 40% of the tree cover in the basin would cause an irreversible change in the entire basin, causing it to change from forest to savannah. So in this case, a minimum of 60% of the entire ecosystem should be conserved. Lovejoy and Nobre 2018 call for a higher amount of 75–80% forest retention in the Amazon due to the synergies of widespread use of fire, climate change and deforestation.

In addition to the above three approaches, many authors are calling for the retention of intact ecosystems for a range of natural values, including forests (Watson et al., 2018). Intactness targets are based on what remains. For example, there is a call to conserve all the remaining intact forests (Watson et al., 2018).

Canada's boreal forest is one of the largest and most intact ecosystems on the planet. It is a vast storehouse of carbon, and hosts a breeding bird population of 1–3 billion. The boreal forest's Woodland caribou are highly sensitive to human disturbance and a keystone species. They are a good example of a species-based tipping point. It has been calculated that at least 65% of a boreal caribou range should remain undisturbed to provide a 60% probability of retaining woodland caribou in the system (Environment Canada 2008). As with the Amazon, a very high retention figure is needed to maintain even basic values in this large ecosystem.

Existing and Developing International Policy Guidance on Conservation Targets

A key outcome of the IUCN World Parks Congress 2014, held in Sydney, Australia, was the Promise of Sydney, which included the following statement: "Governments and peoples must move far beyond the Aichi targets to adaptive conservation systems that are based on halting biodiversity loss (Aichi Target 12). This must be done through balancing biodiversity and human needs. We need to increase conservation until biodiversity loss is halted. The total area of protected areas and connectivity lands needs to be far higher than current conceptions and delegates agreed on the importance of setting ambitious targets. Percent area targets are problematic in focusing on area at the expense of biodiversity objectives. Nonetheless, many delegates argued that these should be around at least 30% of the planet for no-take reserves, 50% overall protection, and 100% of the land and water managed sustainably."

Following Sydney, the IUCN members passed a resolution **WCC-2016-Res-050-EN**—**Increasing marine protected area coverage for effective marine biodiversity conservation (IUCN, 2016).** This widely supported resolution called for the following:

- ENCOURAGES IUCN State and Government Agency Members to designate and implement at least 30% of each marine habitat in a network of highly protected MPAs and other effective area-based conservation measures, with the ultimate aim of creating a fully sustainable ocean, at least 30% of which has no extractive activities, subject to the rights of indigenous peoples and local communities:
- ENCOURAGES the Parties to the CBD to consider a new process for developing post-2020 targets to increase the percentage of marine areas highly protected to 30% by 2030;

The history and rationale for the development of marine conservation targets were reviewed by Laffoley (2019). Note that resolution CC-2016-Res-050-EN establishes IUCN policy for marine protection of at least 30% in highly protected or no-take reserves, and calls for upgraded sustainable management on the rest of the ocean.

In 2019, with adoption of COP decision 14/8, the Convention on Biological Diversity adopted a definition and criteria or Other Effective Areas Based Conservation Measures (OECMs). Adding OECMs to protected areas should make large area-based conservation more achievable. (In this paper we refer to OECMS as conserved areas).

A key implementation challenge for large % area targets is that many areas of the terrestrial world are too developed to consider such targets. To deal with the implementation challenge that one simple % target does not fit all the various conditions of the world, the IUCN-WCPA Beyond Aichi Targets Task Force has developed an enabling framework that would operationalize local conservation objectives once a global percentage target is set. The Three Global Conditions for Biodiversity Conservation and Sustainable Use (Locke et al. 2019, in press) are Cities and Farms, Shared Lands and Large Wild Areas. The conservation policy objectives, that vary by condition, include the following:

Cities and Farms: Secure endangered species, protect all remaining primary ecosystem fragments, maintain pollinators, increase ecological restoration. Mainstream sustainable practices such as nitrogen use reduction and urban planning for compact cities that protect good farmland and provide access to nature for urban dwellers' health and well-being.

Shared Lands: Establish "ecologically representative and well-connected systems of protected areas … integrated into the wider landscape" (from Aichi Target 11); restore and maintain ecological processes and viable populations of native species (increase area protected and conserved to 25 to 75% of ecoregion). Practise sustainable resource extraction outside but integrated with well managed and properly funded protected area networks and sustainable tourism. Local livelihoods include use of wildlife where appropriate and sustainable.

Large Wild Areas: Retain overall ecological integrity and associated global processes such as carbon storage and rainfall generation, fluvial flows and large migrations; prevent further fragmentation allowing only rare nodes of intense industrial development enveloped in a largely wild matrix. Remove and restore anomalies. Control invasive species as needed. Secure Indigenous knowledge and livelihoods.

Intended for simultaneous use, these conservation responses and sustainable practices offer a coherent basis for common national actions and international cooperation to protect the "earth ecosystem." Countries with similar conditions have similar responsibilities and options for domestic action. Developed nations can also support efforts elsewhere, especially when their trade footprints cause biodiversity loss in other countries. Such an approach could enable a single global % target that is then applied appropriately across all Three Conditions.

A recent paper by Dinerstein et al. (2019) calls for a new global deal for nature where 30% of the planet is protected in well-located and well-connected systems of protected areas, and an additional 20% of the protected is focused on conserving ecosystems of high carbon value. This combined approach aims to tackle threats to nature from climate change and mass extinction. This call is consistent with IUCN policy statements in the Promise of Sydney and resolution **WCC-2016-Res-050-EN** for marine areas. In addition, with significant and accelerating impacts from climate change in polar, temperate and tropical ocean regions, there is a strong case that a new global deal for nature should also include an additional 20% of climate-sensitive management in the marine world (Laffoley – pers comms; Dinnerstein, 2019) as an essential element of an overall truly sustainable approach. Nature conservation on 30% or 50% of the land and sea must work in harmony with sustainability approaches on the entire planet.

Discussion

The key conclusions of this review, applicable equally to terrestrial, marine and freshwater ecosystems, are as follows:

1. The 17% terrestrial and 10% marine targets from Aichi Target 11 are not considered adequate to conserve biodiversity by any research, either on sea (O'Leary et al. 2016; Klein, et al. 2015) or on land (Butchart et al., 2015; Rodriguez and Gaston, 2001, Noss et al., 2012, Svancara et al. 2005). Even with the best siting of protected areas, there is simply too much species diversity and too high levels of endangerment to cover these elements in relatively small percentages of the global surface. Almost universally, when conservation targets are based on the research and expert opinion of scientists, they far exceed targets set to meet political or policy goals (Svancara et al. 2005, Noss et al 2012). This is supported by a global survey of conservation

scientists conducted in 2017, who massively supported very large % area targets to conserve biodiversity (Woodley et al. 2019 in prep.).

2. Percentage area targets cannot be considered in isolation from the quality considerations presented in Aichi Target 11. There is concern that a focus on % area targets might draw away from a focus on quality (Visconti et al., 2019). Protected and conserved areas are policy tools to achieve nature conservation and need to be selectively located, properly designed, equitably governed, and effectively managed in order to achieve biodiversity outcomes. Questions of ecological design, equitable governance and management effectiveness that lead to conservation outcomes are included in the IUCN Green List of Protected and Conserved Areas Standard (IUCN and World Commission on Protected Areas (WCPA), 2017). The question of where to locate protected and conserved areas is too complex for this review, but there is good agreement in the literature that they should focus on areas of importance for biodiversity, including Key Biodiversity Areas (IUCN, 2016), EBSAs (https://www.cbd.int/ebsa/), and equivalent national and open ocean priorities.

3. There are different approaches to considering % areas targets, but all approaches call for much higher % area targets than are currently in Aichi Target 11. There is no one unequivocal answer to the question of what % of the earth, or a region, should be protected in order to maintain biodiversity. The answers are complicated by spatial scale, patterns of biodiversity and weaknesses in selection approaches. The answers are further complicated by the selected conservation values used in systematic conservation planning approaches. Each selected conservation element raises the percentage targets. For example, selecting only for endangered or rare biodiversity elements will result in a lower % area than if ecological connectivity or ecosystem services are also considered. Studies that include a more complete set of values are universally very high, well over 50% and up to 80%. Studies that include a narrower subset of biodiversity values result in lower % area targets, but are never under 30% and always include caveats that they are likely inadequate and represent minimum estimates. As such, protected area conservation targets should be established based on the desired outcomes (e.g. halting biodiversity loss by 2030). It is clear in this respect that decisions already taken by the global conservation community on, for example, at least 30% protection of the ocean, can only be but way points on to what is really needed to address current crises in biodiversity and climate.

Large area-based targets should never be considered as percentages for percentages' sake. They should always be determined and implemented, whether at the global, regional or local scale through systematic conservation planning or other science-based approaches. However, there is strong evidence that percentage targets materially increase national conservation efforts. Target 11 is being seen as one of the most successful targets reached (IPBES 2019, Green et al. 2019) including in mega-diverse countries (Bacon et al. 2019).

Area targets alone are insufficient to halt biodiversity loss, and must be accompanied by a focus in quality, notably the equitable governance and effective management of systems of protected and conserved areas. Protected and conserved areas must also be carefully located in areas where they make a conservation impact for nature conservation. It is clear we need a dramatic increase in both the quality and quantity of protected and conserved areas as an essential means to halt and reverse the catastrophic loss of biodiversity that is undermining all life on earth. They must also be set in truly sustainable actions across the whole ocean and land space for realize the true benefits.

4. The key conclusion from this review is that calls for the global protection of a minimum of 30% and up to 70% or even more of the land and sea on earth are supported in the literature (after removing outliers) whether through studies based on species-area curves, systematic

conservation planning or minimum system size approaches. Importantly these suggested higher conservation targets are not discounted in any of the biodiversity literature. The call for conserving 50% of the earth is a mid-point of these values and is supported by a range of studies. More importantly there are no studies that argue that we can maintain biodiversity with low % coverage targets. There is consistent scientific agreement that very large-scale conservation is required to deal with the known drivers of biodiversity loss. Suggested conservation targets of 30% or 50% or even 70%, while not based on precision, are consistent with scientific literature on what is required to conserve biodiversity.

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