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# 1 **Area-based conservation in the 21<sup>st</sup> century**

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## 22 **Abstract**

23 Humanity will soon define a new era for nature – one that seeks to correct decades of  
24 underwhelming responses to the global biodiversity crisis. Area-based conservation efforts,  
25 which include both protected areas and other effective area-based conservation measures, are  
26 likely to extend and diversify. But persistent shortfalls in ecological representation,  
27 management effectiveness and measurable biodiversity outcomes diminish the potential role  
28 of area-based conservation in stemming biodiversity loss. Here we show how protected area  
29 expansion by governments since 2010 has had limited success in increasing biodiversity  
30 coverage, and identify four emergent issues that –if addressed – will enhance the performance  
31 of area-based conservation post-2020. We close with recommendations for a broad  
32 biodiversity agenda that maximises the potential of area-based conservation. Parties to the  
33 Convention on Biological Diversity must recognise that area-based conservation primarily  
34 focuses on local threats to species and ecosystems, and needs enhanced emphasis on  
35 biodiversity outcomes to better track and fund its contribution to global conservation efforts.

## 36 **Introduction**

37 Governments, policy makers and much of the conservation community have long heralded  
38 protected areas as a fundamental cornerstone of biodiversity conservation<sup>1,2</sup> (Box 1). The  
39 importance of other effective area-based conservation measures (OECMs) is also beginning  
40 to be recognised<sup>3-7</sup>. OECMs were defined by the Convention on Biological Diversity (CBD)  
41 in 2018 as places outside the protected area estate that provide effective biodiversity  
42 conservation, such as some private conservation initiatives, water catchment areas and  
43 territories conserved by Indigenous peoples and local communities. Both protected areas and  
44 OECMs (collectively referred to herein as ‘area-based conservation’) are acknowledged in  
45 the 2030 Agenda for Sustainable Development<sup>8</sup> and the CBD. In particular, the CBD’s  
46 current ten-year Strategic Plan for Biodiversity<sup>9</sup> – agreed by 168 countries in 2010 – has an  
47 explicit target (Aichi Target 11) that calls for “at least 17 per cent of terrestrial and inland  
48 water areas and 10 per cent of coastal and marine areas, especially areas of particular  
49 importance for biodiversity and ecosystem services, are conserved through effectively and  
50 equitably managed, ecologically representative and well-connected systems of protected  
51 areas and OECMs, and integrated into the wider landscape and seascape” by 2020.

52 Since 2010, protected areas have expanded from covering 12.7% to 15.0% of global land and  
53 freshwater environments and from 1.6% to 7.8% of the marine realm<sup>10</sup>. While it is not yet  
54 possible to track their global extent systematically, OECMs have also expanded since 2010<sup>11</sup>.  
55 Yet amongst the encouraging expansion of area-based conservation, there is growing concern  
56 that nations are paying less attention to the qualitative elements of Aichi Target 11 – such as  
57 the need for area-based conservation to be representative, connected and effectively  
58 managed<sup>12-17</sup>. Moreover, some long-standing issues, including poor resourcing and

59 governance and lack of management effectiveness, continue to compromise the ability of  
60 protected areas to conserve biodiversity and ecosystems<sup>18-24</sup>. As a consequence, there is a  
61 risk that humanity could meet the areal components of Aichi Target 11 but fail to deliver on  
62 the overall strategic goal for which it was established - to “improve the status of biodiversity  
63 by safeguarding ecosystems, species, and genetic diversity”<sup>9</sup>.

64 A post-2020 Global Biodiversity Framework will be agreed at the fifteenth Conference of the  
65 Parties to the CBD in China in 2020. This new strategic plan will likely be humanity’s last  
66 chance to halt global biodiversity loss<sup>10</sup>. The urgency to act has emboldened calls for a  
67 substantial expansion of area-based conservation globally<sup>25-28</sup> and fundamental changes in  
68 how environmental targets are framed and implemented<sup>18,23,29-31</sup>. It is therefore timely to  
69 assess the achievements and failures of national area-based conservation efforts over the past  
70 decade and place these findings within the wider context of the global biodiversity crisis. We  
71 then identify emergent issues that will influence area-based conservation policy and  
72 performance post-2020 and conclude with views on how the targeting and tracking of area-  
73 based conservation must be redefined to ensure it remain relevant in the 21<sup>st</sup> century.

74

## 75 **The performance of protected areas since 2010**

76 It is clear that Aichi Target 11 has encouraged some nations to expand area-based  
77 conservation efforts, particularly in the marine realm. Australia, Gabon and Brazil for  
78 instance have all grown their protected area estates by >20% since 2010 (Fig. 1). Here, we  
79 review how the recent expansion of protected areas globally has affected the qualitative  
80 components of Target 11. Where possible, we also provide an up to date temporal analysis

81 (between 2010 to 2019) on the performance of protected areas against the qualitative  
82 components of Target 11 (Fig. 2). We omit reference to OECMs in this section as a database  
83 showing the global extent of these sites is not yet available<sup>11</sup> (see Supplementary Methods for  
84 details of calculations).

### 85 *Protected areas being “ecologically representative”*

86 The concept of being “ecologically representative” has been interpreted as the coverage of  
87 species or ecoregions (areas containing geographically distinct assemblages of species<sup>32,33</sup>),  
88 especially those that threatened with extinction<sup>13,16,32,34-37</sup>. Most evidence to date suggests  
89 significant shortfalls in either approach. For species, Butchart and colleagues<sup>16</sup> showed that  
90 less than half of all known mammals, amphibians, lobsters, crayfish, mangroves, seagrasses,  
91 bony fishes, cartilaginous fishes and threatened birds had a sufficient proportion of their  
92 distributions covered by protected areas in 2013. An additional analysis showed that coverage  
93 of migratory bird species was particularly poor, with only 9% having their migratory flyway  
94 adequately protected<sup>38</sup> in 2013. The global marine protected area estate also had noticeable  
95 coverage shortfalls for mammalian species diversity (62% covered), taxonomic diversity  
96 (74% covered), functional diversity (78% covered) and threatened species (37% covered) in  
97 2016<sup>39</sup>.

98 We re-analysed how expansion of the global protected area estate between 2010 and 2019  
99 affected coverage of 4,854 vertebrate species listed as Vulnerable, Endangered or Critically  
100 Endangered (herein ‘threatened’ species) on the IUCN Red List<sup>40</sup> (Figure 2). Eighty-two  
101 (1.7%) of these species gained some level of protection for the first time in the last decade,  
102 and 87.8% (n = 4,264) of all species assessed had some portion of their geographic range

103 protected by 2019 (a change from 85.0% in 2010). While the majority of species assessed had  
104 some level of protection, only one-quarter had adequate representation in the global protected  
105 area estate in 2019 (from 23.7% in 2010) (representation targets for individual species were  
106 set according to their geographic range<sup>16,35,36</sup>; see Supplementary Methods for details of  
107 calculations).

108 Seventy-four threatened species had their representation target met between 2010 and 2019,  
109 and 43.2% (n = 16) of threatened marine mammal species received adequate representation in  
110 the global protected area estate in the last decade. However, 74.8% of threatened birds,  
111 amphibians and terrestrial mammals were still inadequately protected as of 2019, and 605  
112 threatened species remain without any representation at all (Table S1). In the last decade, the  
113 proportion of species with adequate protection grew by only three percent for birds (to  
114 34.5%; n = 462 to 499) and just one percent for amphibians (to 13.0%; n = 255 to 276) and  
115 terrestrial mammals (to 36.9%; n = 406 to 423), suggesting that the vast majority of new  
116 protected areas have not been established in locations that would safeguard species that had  
117 poor levels of protection in 2010<sup>13,14</sup>. Importantly, these coverage shortfalls are not solely  
118 driven by antecedent placement of protected areas – terrestrial and marine protected areas  
119 established post-2010 do not appear to have targeted species at risk of extinction<sup>14,41,42</sup>.

120 To assess coverage of ecoregions, we followed previous studies<sup>16,34,37</sup> that contrasted  
121 coverage of ecoregions against targets of 17% protection for terrestrial ecoregions and 10%  
122 for coastal and shelf marine ecoregions or off-shelf pelagic regions. We found that 40.4% (n  
123 = 351) of ecoregions were at least 17% protected in 2019 (from 36.4% in 2010), and 38  
124 ecoregions transitioned from zero to at least 17% coverage over the last decade (Figure 2;  
125 Table S2). We also found that over one-fifth (21.5%) of land protected since 2010 covered

126 tropical and subtropical grassland ecoregions (Table S3) – a critically endangered biome<sup>32</sup> -  
127 while 34.4% of land protected since 2010 covered dry or desert ecoregions, which are  
128 relatively species poor and over-represented<sup>32</sup>. In 2019, 128 ecoregions (15.1%) remain <2%  
129 protected (Table S2). Tropical and subtropical dry broadleaf forest ecoregions, in particular,  
130 remain chronically under-protected (<1% of new land protected covered this biome in the last  
131 decade) given their high biodiversity and rapid rate of habitat loss over the last two  
132 decades<sup>32,43</sup>.

133 We also assessed coverage of marine ecoregions<sup>33</sup> and off-shelf pelagic regions<sup>44</sup> between  
134 2010 and 2019. The number of marine ecoregions with  $\geq 10\%$  coverage increased  
135 substantially to 56.5% (n = 101) over the past decade (from 38.8% in 2010), with much of  
136 this growth occurring over ecoregions within the Southern Ocean (0.6 million km<sup>2</sup>; 3.9% of  
137 all new marine protected area). However, marine protected area expansion could have been  
138 more strategic –the number marine ecoregions with  $\geq 10\%$  coverage for every hectare of  
139 ocean protected has declined since 2010 (Figure 2). Coverage in off-shelf pelagic regions  
140 remain much lower on average, despite 89.0% (13.6 million km<sup>2</sup>) of new marine protected  
141 area targeting these regions since 2010. Eleven percent (n = 4) of off-shelf pelagic regions are  
142 now  $\geq 10\%$  protected (from 2.7% in 2010). Much of this new coverage focused on remote  
143 Antarctic waters, not areas in the high seas where marine biodiversity faces elevated human  
144 pressures<sup>41</sup>.



145 *Protected areas covering “areas of particular importance for biodiversity and ecosystem*  
146 *services”*

147 The Key Biodiversity Area (KBA) approach<sup>45</sup> offers a global standard for identifying  
148 marine, terrestrial and freshwater sites that contribute significantly to the global persistence  
149 of biodiversity. Over 15,000 KBAs have been identified, and host nations are encouraged to  
150 ensure that these sites are managed in ways that ensure the persistence of their key  
151 biodiversity elements, although this does not necessarily mean inclusion within a protected  
152 area<sup>45</sup>. The 2018 Protected Planet report<sup>34</sup> found that, between 2010 and 2018, average  
153 coverage of marine KBAs increased from 5.0 to 15.9%. This report also found average  
154 coverage was greater, but advanced at a much slower rate, for terrestrial (43.3% to 46.6%)  
155 and freshwater (41.1% to 43.5%) KBAs<sup>34</sup>. Our analysis showed similar coverage estimates  
156 for terrestrial and freshwater KBAs but higher estimates of average coverage of marine  
157 KBAs (20.8% protected on average by 2019) (Figure 2).

158 Wilderness areas are ecologically intact land and seascapes that are predominantly free of  
159 human-driven biophysical disturbance<sup>46,47</sup>. They underpin planetary life-support systems<sup>48</sup>  
160 and are critical for the long-term persistence of imperilled species<sup>49</sup>, especially in a time of  
161 climate change<sup>50</sup>. Only 4.9% of marine wilderness areas were protected in 2017<sup>46</sup>, and  
162 protected areas established between 1990 and 2015 covered just 8.3% of terrestrial  
163 wilderness areas<sup>51</sup>. When compared to these previous studies, our analysis shows coverage  
164 for marine wilderness areas has increased in recent years (8.5% protected in 2019 versus  
165 2.0% protected in 2010). This is despite marine wilderness areas often being in international  
166 waters, making protected area establishment complicated from a legal perspective. Our  
167 analysis also shows that the consideration of protected areas established pre-1990 and post-

168 2015 nearly trebles previous estimates of terrestrial wilderness coverage (22.1% protected by  
169 2019) (Figure 2).

170 Aichi Target 11 further requires protected areas to conserve “areas of particular importance  
171 for [...] ecosystem services”. Among the multitude of services that healthy, functioning  
172 ecosystems provide<sup>10,52</sup>, our ability to track coverage of carbon storage and sequestration is  
173 arguably the most advanced. Previous assessments of the amount of carbon stored in  
174 protected areas have been confined to national or regional scales<sup>34,53</sup>. We used a new global  
175 dataset (Soto-Navarro, C. *et al.* pers. comm; see Supplementary Information) to track  
176 coverage of biomass and soil carbon over the last decade. In 2010, 22.6% (94.4 gigatonnes)  
177 of the world’s biomass carbon was inside protected areas. By 2019, this proportion had  
178 increased only slightly to 23.7% (99.0 gigatonnes), indicating that post-2010 terrestrial  
179 protected areas captured less carbon per hectare than those established pre-2010 (Figure 2).  
180 Protected areas hold a lower proportion of soil carbon, ranging from 13.9% (379.9  
181 gigatonnes) in 2010 to 14.6% (400.5 gigatonnes) in 2019. Large unprotected repositories of  
182 soil carbon are prevalent across north-east North America, Russia and south-east Asia (Figure  
183 S1).

184 Incomplete mapping of other ecosystem services, including those pertaining to provision (e.g.  
185 fisheries, timber), regulation (e.g. coastal armouring, soil stabilisation) and culture (e.g.  
186 education, recreation), makes it difficult to track their coverage. The expansion of OECMs  
187 will be driven largely by ecosystem services, such as those relating to climate stabilisation  
188 and watershed protection, necessitating better understanding and documentation of these  
189 values. However, 44% of coral reef tourism value and 20% of coral reef coastal protection in  
190 2018 depended on protected areas<sup>34</sup>. The global protected area estate also holds

191 approximately 29% of all coral reef fisheries biomass and contributes to 31% of all mangrove  
192 fishery catch<sup>34</sup>. Moreover, nearly two-thirds of the global population is living downstream of  
193 the world's protected areas as potential users of freshwater provisioned by these areas<sup>54</sup>.

194 *Protected areas being “well connected” and “integrated into the wider landscape and*  
195 *seascape”*

196 Well-connected ecosystems are critical for maintaining important ecological and evolutionary  
197 processes, including species migration, gene flow and range shifts, especially when species  
198 face rapid climatic and environmental changes<sup>55,56</sup>. In 2016, only 30% of terrestrial  
199 ecoregions were at least 17% covered by protected areas that were theoretically reachable by  
200 species<sup>57</sup>. At the global scale, the percentage of connected terrestrial protected areas increased  
201 from 6.5% to 8.1% between 2010 and 2014, before decreasing 7.7% in 2018<sup>58</sup>. These  
202 assessments did not account for the permeability of unprotected land between protected areas,  
203 but show how the global protected area system is becoming increasingly fragmented, akin to  
204 land and seascapes generally<sup>59,60</sup>.

205 Connectivity is an important consideration for marine protected areas because, among other  
206 reasons, it helps to maintain networks of local populations<sup>61</sup> and to replenish fish populations  
207 on fished reefs<sup>62</sup>. High levels of connectivity also correspond to areas of enriched coral  
208 diversity<sup>63</sup>. Marine protected areas should therefore accommodate movement patterns among  
209 habitats that are critical to the life history of marine species (e.g. home ranges, nursery  
210 grounds, migration corridors, spawning aggregations)<sup>64</sup>. There have been no global-scale  
211 assessments of connectivity among marine or freshwater protected areas, but regional-scale  
212 studies show them to have limited connectivity for species with a dispersive larval stage<sup>65</sup>.

213 *Protected area management effectiveness*

214 Citizen science, earth observation technology and assessments of individual area-based  
215 conservation efforts have all advanced over the last decade<sup>66-68</sup>. Studies that intersect these  
216 data with networks of protected areas (so as to assess their effectiveness) show that, on  
217 average, protected areas slow but fail to completely halt human pressures and biodiversity  
218 loss within their borders<sup>69-73</sup>.

219 A recent assessment shows that over 12,000 protected areas established prior to 1995 were,  
220 on average, ineffective at reducing human pressures inside their borders between 1995 and  
221 2010<sup>74</sup>. An earlier study found that one-third of all protected land was under intense human  
222 pressure at the start of this decade<sup>73</sup>. This study by Jones and colleagues also found that  
223 human pressure had increased in 55% of protected areas between 1993 and 2009<sup>73</sup>. As for  
224 marine protected areas, 94% of those created before 2014 permit fishing activities<sup>75</sup> – a key  
225 driver of poor marine protected areas effectiveness<sup>76</sup>. Moreover, marine protected areas that  
226 prohibit the taking of living or dead natural resources (i.e. no-take marine reserves) are  
227 subject to illegal fishing activities<sup>77</sup>. There is, however, clear evidence that many protected  
228 areas do effectively abate human pressures. For example, marine protected areas reduce  
229 fishing vessel traffic<sup>78</sup> and the negative effects of some non-native species<sup>79</sup>. Terrestrial  
230 protected areas have been found to reduce rates of deforestation and forest degradation below  
231 those observed in nearby unprotected areas<sup>80,81</sup>, and to reduce increases in human pressure in  
232 wilderness areas<sup>82</sup>. Protected areas established and managed by Indigenous people are  
233 particularly effective at avoiding deforestation in regions with high deforestation pressure<sup>83</sup>.  
234 By lowering rates of deforestation inside their borders, tropical protected areas reduced  
235 carbon emissions from land use change by around 29% (4.88 gigatonnes) between 2000 and

236 2012<sup>84</sup>. Moreover, 54.8% of studies that assess their role in reducing deforestation show  
237 protected areas also reduce deforestation rates in surrounding, unprotected lands, whereas  
238 11.8% show protected area establishment increases deforestation in surroundings areas<sup>85</sup>.

239 In terms of biodiversity outcomes, several studies have reported beneficial effects of  
240 protected areas on species abundance and diversity<sup>72,86,87</sup>. For example, a study of 447  
241 terrestrial protected areas showed them to be effectively maintaining populations of birds and  
242 mammals within their boundaries<sup>88</sup>. Another study showed bird and mammal populations  
243 between 2007 and 2014 increased in abundance (17% of cases) or exhibited no change (22%  
244 of cases) within 15 protected areas (22 % of populations declined while 39% were detected  
245 too infrequently to assess occupancy changes)<sup>89</sup>. A review of 218 marine protected areas  
246 found that, on average, fish biomass is nearly double inside protected areas than in matched  
247 non-protected areas<sup>21</sup>. Marine protected areas also promote the recovery of fish  
248 populations<sup>90,91</sup>. No-take marine reserves, in particular, result in significant increases in  
249 species richness, density and biomass in both tropical and temperate systems<sup>21,92-94</sup>, as well as  
250 being effective at restoring trophic function<sup>95,96</sup> and lowering levels of coral disease<sup>97</sup>.

### 251 *Equitable management in protected areas*

252 Some nations have made clear commitments – beyond those stipulated in Aichi Target 11 - to  
253 improve protected area management equity<sup>98</sup>. Yet few studies have scrutinised the outcomes  
254 of such commitments because there is substantial variability in how equitable management is  
255 defined and assessed for protected areas<sup>99,100</sup>. There is evidence showing protected areas that  
256 integrate local people as stakeholders often result in higher conservation and socioeconomic  
257 outcomes<sup>101,102</sup>. For example, some community-managed terrestrial protected areas are more

258 effective than nationally-designated protected areas at reducing deforestation pressures in  
259 Brazil, Namibia and Australia<sup>83,103</sup>, and community-managed marine protected areas that are  
260 long-established and well-enforced enhance economic and social well-being<sup>104,105</sup>.  
261 Furthermore, a recent review of eleven countries across four continents showed terrestrial  
262 protected areas do not impinge on efforts to alleviate poverty<sup>106</sup>. However, limited data on the  
263 location and prevalence of equitably managed protected areas currently precludes a more  
264 complete understanding of their social and biodiversity outcomes<sup>21,107</sup>.

265

### 266 **Emerging issues for area-based conservation**

267 Our analyses reveal that countries will almost certainly fall short on achieving the quality  
268 components of Aichi Target 11<sup>34</sup>. The continued expansion of area-based conservation  
269 without addressing these shortfalls will lead to poor outcomes for biodiversity. We argue that  
270 at least four emergent issues must be considered and acted upon by governments, scientists,  
271 policy makers and other stakeholders to address current failings of area-based conservation in  
272 the coming decade.

#### 273 *The expanding opportunities for area-based conservation*

274 Opportunities to enhance land and water management practices that help to conserve  
275 biodiversity are expanding. Private conservation initiatives and Indigenous and community  
276 conserved areas (ICCAs) can be formally recognised as protected areas or “other effective  
277 area-based conservation measures” (OECMs), or achieve recognition on their own terms. Yet  
278 until recently, ICCAs and private conservation initiatives have been overlooked in national  
279 conservation policies, strategies and reports<sup>4</sup>. Indigenous Peoples manage or have tenure

280 rights over at least 37% of all remaining intact landscapes on Earth<sup>3</sup>, and ICCAs have been in  
281 existence since humans began to govern and manage landscapes and seascapes  
282 purposefully<sup>108</sup>. A recent study by Schuster and colleagues showed indigenous managed  
283 lands support higher concentrations of biodiversity than formal protected areas<sup>109</sup>, which  
284 exemplify the critical role that ICCAs can play in global biodiversity conservation efforts and  
285 the importance of working with Indigenous Peoples to increase ICCA coverage in their  
286 territories. Private conservation initiatives too have been established in various forms for well  
287 over a century<sup>4</sup>, and in some regions out-number nationally-designated protected areas<sup>110</sup>. A  
288 recent assessment of South Africa's Cape Floristic region showed 25% of large carnivore  
289 species and 22% of mesoherbivores (50-500 kilograms in weight) could only be supported in  
290 areas that were at least partly privately managed<sup>111</sup>.

291 Wider recognition of private conservation and ICCAs are likely to drive rapid expansion in  
292 the global protected area and OECM networks over the coming years. Recognition of  
293 OECMs is no mere formality (Box 1) as they have stricter benchmarks for biodiversity  
294 conservation than many nationally-recognised protected areas, and by formalising their role,  
295 owners recognise an obligation to biodiversity conservation and undergo public scrutiny of  
296 their management practices<sup>5</sup>. The wider recognition of OECMs could help address at least  
297 four current shortfalls of the global protected area estate. First, Indigenous and community  
298 sites could address management equity shortfalls because they are managed by and for the  
299 benefit of a diverse set of actors. More diverse management and siting arrangements should  
300 also help these areas to address current shortfalls in ecological representation and coverage of  
301 important areas for biodiversity. Over 76% of unprotected KBAs were at least partly covered  
302 by one or more potential OECMs in 2018<sup>6</sup>, and compared to protected areas with government

303 ownership, OECMs may prove to be more socially acceptable in productive land and  
304 seascapes<sup>112,113</sup> and thus enhance coverage of poorly protected species<sup>13,14</sup>. Finally, OECMs  
305 could enhance the connectivity of protected area networks, helping them to become better  
306 integrated within wider landscapes and seascapes<sup>113</sup>. Recognising and enhancing OECMs in  
307 inshore marine habitat, farmlands and managed forests will be particularly valuable in this  
308 regard, provided species composition and ecological functions can be restored in such  
309 areas<sup>114</sup>.

310 Expanding the conservation estate provides an opportunity to make meaningful contributions  
311 to global biodiversity conservation efforts if new sites can overcome issues currently faced by  
312 many protected areas, including inadequate resourcing and monitoring. A switch to a broader  
313 interpretation of area-based conservation will also require major changes in how governments  
314 and conservation actors uphold human rights and social safeguards, particularly on  
315 Indigenous and community areas. It will mean, for example, governments, conservation  
316 actors, Indigenous people and private entities working together towards shared goals as equal  
317 partners. Conservation outside government-run protected areas may enhance opportunities for  
318 private financing of biodiversity conservation, but clear operating procedures will be needed  
319 to ensure that involvement from private industry does not compromise the integrity of  
320 conservation management<sup>115</sup>. More generally, efforts must be made to ensure the whole  
321 conservation estate contributes substantively to biodiversity conservation globally. National  
322 governments cannot, for example, be permitted to view OECMs as a cheap and easy way to  
323 reach areal components of global area-based conservation targets, without due assessment of  
324 how they deliver positive and sustained biodiversity outcomes<sup>23</sup>.

325



326 *The increasing dynamism of Earth's protected area estate*

327 Throughout much of the 20th century, protected areas were considered permanent features of  
328 land and seascapes - legally protected in perpetuity. Today, protected areas face an  
329 increasingly uncertain future due to poor management by governments. A recent analysis  
330 showed that while 2.5 million km<sup>2</sup> of land and sea were added to the global protected area  
331 estate annually between 2006 and 2018, around 1.1 million km<sup>2</sup> were recorded as removed  
332 each year<sup>116</sup>. While many areal changes were bureaucratic in origin (e.g. changed data  
333 sharing policies), some of this loss can be attributed to an increase in protected area  
334 downgrading, downsizing, and degazettement (PADDD) events. Over 1,500 PADDD events  
335 affected over one-third of Australia's protected area network (416,740 km<sup>2</sup>) between 1997  
336 and 2014<sup>117</sup>. Qin and colleagues<sup>118</sup> also found 23 PADDD events that have affected  
337 UNESCO World Natural Heritage Sites – protected areas with “outstanding universal value”,  
338 meaning they are so exceptional as to transcend national boundaries and are important for  
339 present and future generations of all humanity (e.g. Virunga, Serengeti and Yosemite  
340 National Parks).

341 Official justifications for PADDD events are rarely made transparent, but most (62%) appear  
342 to be associated with activities that are in stark conflict with protected areas objectives<sup>2</sup>,  
343 including industrial-scale resource extraction and infrastructure development<sup>119</sup>. Moreover,  
344 only 5% of PADDD events are ever partially or fully reversed<sup>120</sup>. PADDD events can also  
345 accelerate forest loss and fragmentation<sup>121</sup> and may restrict dispersal and migration of wide  
346 ranging species<sup>122</sup>. Many PADDD events are also going undocumented, particularly in  
347 marine systems<sup>123</sup> and in privately protected areas<sup>110</sup>. Their poor documentation makes it

348 difficult to assess risk of future PADDD events and how they will affect the quality of  
349 protected area networks, or their capacity to conserve biodiversity in perpetuity.

350 It is important for any review of area-based conservation targets to account for protected area  
351 dynamics, particularly if they result in backsliding on commitments to biodiversity. However,  
352 dynamism could signal attempts to expand or enhance protected areas, either through  
353 improved resourcing and management<sup>124,125</sup>, or by enacting more conservation-focused  
354 regulation<sup>126,127</sup>. Alongside clear guidelines for documenting PADDD events, there is  
355 therefore a clear need to develop a separate protocol that can track and incentivise the  
356 continuum of changes to protected areas that can improve their ability to conserve  
357 biodiversity. We suggest that such changes be characterised collectively as protected area  
358 gazettment, expansion and enhancement (PAGEE). Clear, transparent tracking around both  
359 PAGEE and PADDD events will ensure nations address, and not exacerbate, current  
360 shortfalls in protected area networks globally.

361 *The need for more adequate measures of effectiveness*

362 Numerous approaches have been used to track the capacity of area-based conservation to  
363 abate human pressures and maintain biodiversity (Table 1). All these approaches have merit,  
364 but the conservation community remains too reliant on measures of effectiveness that are  
365 coarse or do not capture biodiversity outcomes of area-based conservation. For example, the  
366 Global Database on Protected Area Management Effectiveness (GD-PAME) provides useful  
367 information on the intention and means (including funding) of protected areas, but the  
368 majority of GD-PAME methodologies collect very limited quantitative information on how  
369 species and ecosystems have responded to protected area management activities<sup>68</sup>. The most

370 used GD-PAME methodology – the Management Effectiveness Tracking Tool (METT) –  
371 was not developed to assess a detailed evaluation of biodiversity outcomes<sup>128</sup> and cannot  
372 therefore be used to measure the state of biodiversity in protected areas.

373 High resolution maps of ecological change across land and seascapes, including forest cover  
374 change<sup>129</sup> and changes in cumulative human pressure<sup>130,131</sup>, have helped to advance some  
375 measures of effectiveness for area-based conservation. For example, changes in cumulative  
376 human pressure, when available at relatively fine spatial resolution (1km<sup>2</sup>) and available for  
377 multiple time steps<sup>130</sup>, are significantly correlated with trends in species risk of extinction<sup>132</sup>.  
378 However, ecological changes across land and seascapes do not always explain local  
379 biodiversity patterns<sup>133</sup>. Moreover, the temporal resolution of cumulative human pressure  
380 mapping lags behind that of forest cover mapping efforts and some maps of human pressure  
381 are at spatial resolutions (e.g. 77sqkm<sup>131</sup>) that preclude assessments of many small, but  
382 crucially important<sup>134</sup>, protected areas. Coarse measures of effectiveness also arise when only  
383 a subset of biodiversity threats is represented in mapping efforts. Threats such as invasive  
384 species and hunting pressure are not directly captured in any global maps of cumulative  
385 pressure, despite being among the major drivers of biodiversity loss globally<sup>135</sup>.

386 There are substantial practical challenges to assessing area-based conservation effectiveness  
387 more precisely and accurately<sup>136</sup>. Assessing the local-scale population response of a  
388 threatened species to environmental change, for example, in most cases requires long-term  
389 field monitoring data. New global-scale citizen science initiatives are rapidly expanding the  
390 coverage and increasing the frequency of biodiversity data across the planet<sup>67</sup>, and will play a  
391 crucial role in improving measures of area-based conservation effectiveness. Measures that  
392 combine near-real-time change in human pressures with on-ground reporting of management

393 capacity and biodiversity trends, will also enable area-based conservation outcomes to be  
394 reported with much greater accuracy and reliability. Studies of area-based conservation  
395 effectiveness could also make better use of scenario analysis and models to generate more  
396 predictive measures of outcomes<sup>137</sup> and account for uncertainty in composite indicators of  
397 environmental condition<sup>138</sup>.

#### 398 *Resourcing shortfalls in area-based conservation*

399 Among the most cited reasons for the poor performance of area-based conservation is a lack  
400 of resourcing (or related issues such as weak enforcement<sup>77</sup> or inadequate staff capacity<sup>21</sup>).  
401 Studies undertaken nearly two decades ago estimated a shortfall of \$1-1.7 billion per year just  
402 to manage existing protected areas<sup>139,140</sup>. More recently, an assessment of more than 2,000  
403 protected areas (representing ~23% of the global terrestrial protected area estate by area)  
404 found 47% (48% by area) suffer from inadequate staff and budget resources, with inadequate  
405 resourcing particularly pronounced in the Neotropics<sup>22</sup>. Staff and budget capacity shortfalls  
406 are also prevalent in the marine realm, and help to explain why many marine protected areas  
407 are ineffective or have inequitable management processes<sup>21</sup>.

408 Compounding resource shortfalls at existing sites are the costs associated with expanding  
409 area-based conservation efforts. One estimate suggests that the costs of covering all  
410 unprotected and partially protected Important Bird Areas (the avian subset of KBAs) would  
411 cost \$50.7 billion annually, combined with a further \$7.11 billion per annum for managing  
412 these sites<sup>141</sup>. Current and future resourcing needs could be met if the contribution of area-  
413 based conservation to national economies was fairly recognised. Recent estimates place the  
414 direct value generated by visits to protected areas at \$600 billion USD, and the indirect value

415 from consumer surplus (the net value to visitors from their visit, above what they actually  
416 paid) at a further \$250 billion annually<sup>142</sup>. However, there remain issues with how funding for  
417 area-based conservation is generated, retained and reinvested<sup>143</sup>. An emerging approach to  
418 financing area-based conservation includes funding from private industry, who in many  
419 countries are legally required to offset biodiversity impacts of development projects<sup>144</sup>. Yet  
420 this approach risks simply displacing, rather than supplementing current funding for  
421 biodiversity conservation<sup>145</sup>. There is therefore an urgent need for more transparent tracking  
422 of how private industry operations contribute (positively or negatively) to strategic goals for  
423 biodiversity<sup>146</sup>.

424

#### 425 **Future-proofing area-based conservation**

426 For all the achievements of area-based conservation, biodiversity is still declining globally at  
427 rates unprecedented in human history<sup>10</sup>. Humanity must transform how species and  
428 ecosystems are conserved<sup>10</sup>. In this final section, we define what this transformation could  
429 entail and how area-based conservation could play a role within it. This role recognises that  
430 area-based conservation acts primarily on local threats to species and ecosystems, and that  
431 clear conservation objectives, defined in terms of biodiversity outcomes, are needed to better  
432 track and fund the contribution of area-based conservation to global conservation efforts.

#### 433 *Placing area-based conservation within a broader conservation agenda*

434 No matter how well-sited, resourced or managed, area-based conservation can only act on a  
435 subset of drivers of, and pressures contributing to, global biodiversity loss (Figure 3). For  
436 example, expecting protected areas to maintain genetic diversity, abundant populations and

437 functional ecosystems, as well as contributing to sustainable management of agriculture and  
438 forestry, is likely asking too much. First and foremost protected areas must conserve  
439 biodiversity<sup>2</sup>. Many will also conserve ecosystem services and vulnerable human societies,  
440 but a large proportion of these wider societal goals will be met by OECMs and other forms of  
441 sympathetic land and water management. To stem the global loss of biodiversity, however, it  
442 is now clear that effective area-based conservation must be met with transformative change  
443 across all sectors of society<sup>10,147</sup>. Good siting, resourcing and management are themselves  
444 dependent on external socio-economic factors, including local and national governance,  
445 regulation of natural resource extraction and consumption and other underlying drivers of  
446 anthropogenic impacts on the environment<sup>14,148</sup>. We therefore need a new, bold  
447 environmental agenda that will make biodiversity conservation mainstream.

448 Most countries show glimpses of mainstreaming biodiversity conservation across sectors of  
449 society. For example, the Chinese government's "Ecological Red Lines" strategy involves  
450 identifying areas that require strict protection within planned development footprints to  
451 improve ecological functions and to ensure the sustainable supply of ecological goods and  
452 services<sup>149</sup>. In Portugal, the legally binding "National Ecological Reserve" aims to retain  
453 areas of ecological value or defend areas that are susceptible to natural hazards<sup>150</sup>. And in  
454 Brazil, the 2001 Forest Code stipulated that private landowners in the Amazon biome should  
455 conserve 80% of their property in native vegetation, and 20% if located in other biomes<sup>151</sup>.

456 While encouraging, existing efforts to integrate biodiversity into broader land and sea  
457 planning frameworks have major limitations. A number of these efforts have been criticised  
458 for their superficial integration of biodiversity<sup>136</sup>, or for containing loopholes that lead to  
459 perverse environmental outcomes<sup>152</sup>. Environmental safeguards that exist in broad planning

460 frameworks also remain largely subservient to economic development<sup>153</sup> and are subject to  
461 frequent policy changes, which create uncertainty in the minds of land and sea  
462 managers<sup>151,154,155</sup>. As a result, many national biodiversity conservation strategies rely almost  
463 entirely on networks of protected areas – made evident by nations making progress toward  
464 achieving Aichi Target 11, but little or no progress towards the other Aichi targets, such as  
465 preventing species extinctions<sup>147</sup>. This is despite biodiversity conservation underpinning  
466 many of the Sustainable Development Goals<sup>8</sup>.

467 Area-based conservation must be recognised as *one* essential solution to conservation  
468 problems, but not the *only* solution. The conservation community must elevate the  
469 importance of other interventions that work in concert with area-based conservation, such as  
470 payments for ecosystem services policies, carbon pricing schemes, legislation that limits  
471 industrial encroachment on lands and seas deemed important for biodiversity or ecosystem  
472 services, the coordination of restoration efforts on degraded land, coasts and seas, eliminating  
473 subsidies for activities harmful to biodiversity, and human development programs aimed at  
474 incorporating traditional knowledge and reducing inequalities (Figure 3). Getting these  
475 interventions right is just as important for biodiversity globally as addressing shortfalls of  
476 area-based conservation, and much can be learnt from what made combinations of  
477 conservation interventions successful in the past (e.g. Costa Rica greatly reducing  
478 deforestation rates with a suite of cross-sectoral interventions<sup>156</sup>). Integrating biodiversity  
479 more effectively into other conservation interventions would both reduce unrealistic  
480 expectations from area-based conservation and provide more effective landscape and  
481 seascape-scale responses.

482

483 *Rethinking target formulation and evaluation of area-based conservation*

484 Once their role in a broad conservation agenda has been defined, post-2020 targets for area-  
485 based conservation will need to be formulated<sup>30</sup>. Any such targets will need to recognise that  
486 individual protected areas and OECMs are not created equal, and what is required for these  
487 areas to be effective is complex - including elements of governance, management and  
488 ecological design. As such, we suggest that nations and – when appropriate – other  
489 management bodies be required under the CBD to better define, collate and publish the  
490 objectives of individual protected areas and OECMs. It will then be possible to assess how  
491 individual sites tracking toward their stated objectives, and how area-based conservation  
492 contributes to broader national and international biodiversity conservation strategies. Existing  
493 repositories (e.g. GD-PAME<sup>68</sup>; World Database on Protected Areas<sup>157</sup>; National Biodiversity  
494 Strategies and Action Plans) could be augmented to house these objectives, provided the  
495 repositories receive sufficient funding and resources.

496 An objective for a protected area or OECM should reflect the responsibility these sites have  
497 for species and ecosystems of conservation concern and their potential to maintain or restore  
498 them to a favourable conservation status<sup>23</sup>. Progress towards these objectives should  
499 constitute an integral part of area-based conservation effectiveness reports and could be  
500 aggregated taxonomically or geographically to assess progress towards broader biodiversity  
501 goals<sup>23,158</sup>. A new standard for recognising protected areas or OECMs that deliver meaningful  
502 outcomes for biodiversity – the IUCN Green List of Protected and Conserved Areas<sup>159</sup> –  
503 could energise progress toward stated objectives, provided the standard is used for systematic  
504 assessments and to build capacity in under-performing sites, rather than a mechanism to  
505 identify the best area-based conservation efforts. Nations could be further encouraged if area-



506 based conservation targets would only be considered achieved if its appropriate contribution  
507 to reaching broader biodiversity goals could be clearly demonstrated.

508

## 509 **Conclusions**

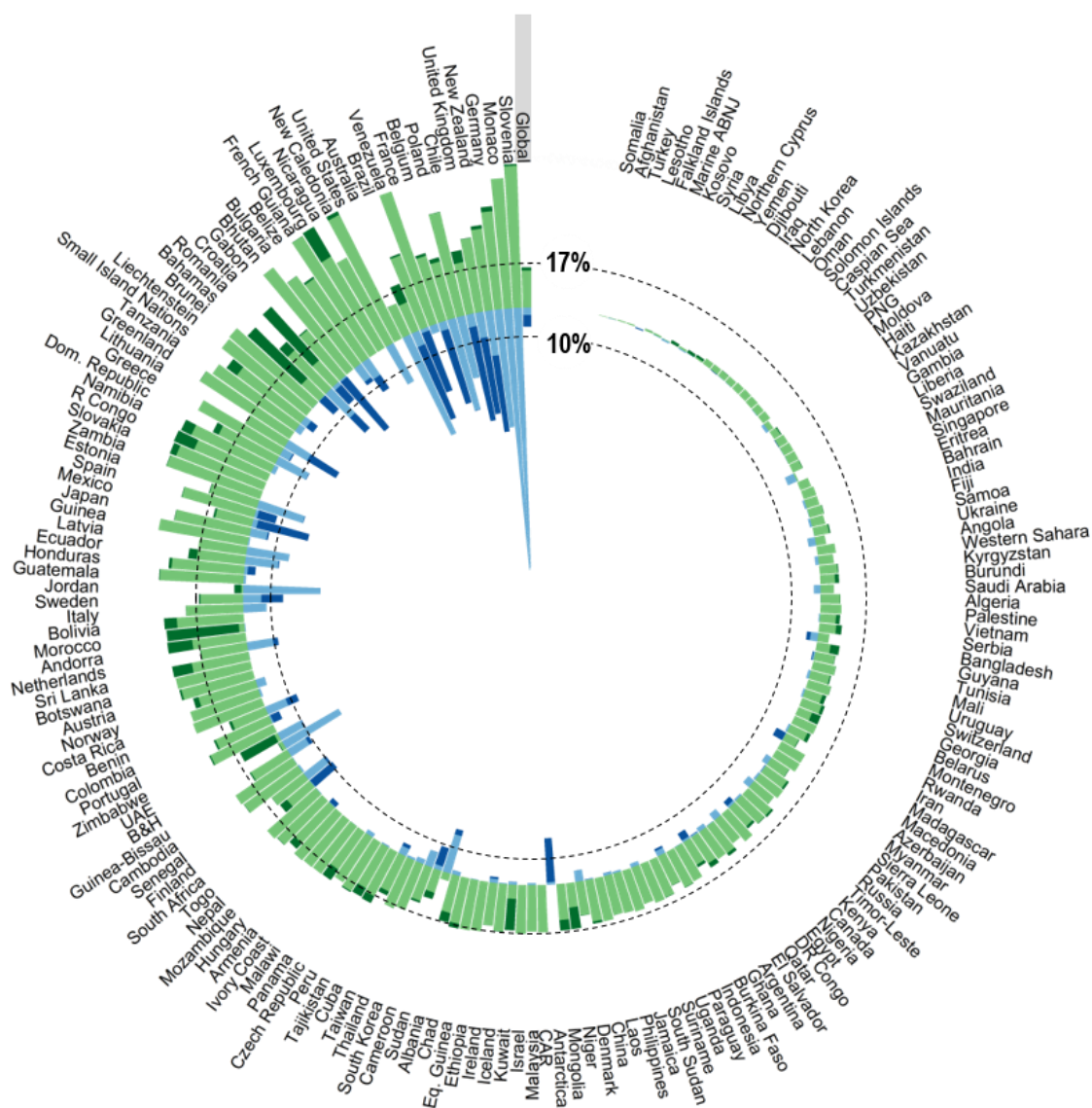
510 Area-based conservation will remain the cornerstone of conservation long into the 21<sup>st</sup>  
511 century. But governments have dramatically underinvested in protected areas and OECMs  
512 and been weak in legally protecting them. In addition to correcting these shortfalls, humanity  
513 needs to do more by making biodiversity conservation part of all aspects of life. Governments  
514 must define a new, bold era for nature that will make biodiversity conservation mainstream.  
515 We then need to invest more resources and intellectual energy in consolidating area-based  
516 conservation efforts and ensuring biodiversity conservation is a far stronger part of managed  
517 land and seas.

518

## 519 **Acknowledgements**

520 We thank B. Williams and R. Venegas for assisting the analytical components of this review.  
521 We also thank H.C. Jonas, P. Langhammer and those that attended the CBD's Thematic  
522 Workshop on Area-based Conservation Measures in Montreal in November 2019 for  
523 thoughts and discussion around these ideas.

## 524 Display items

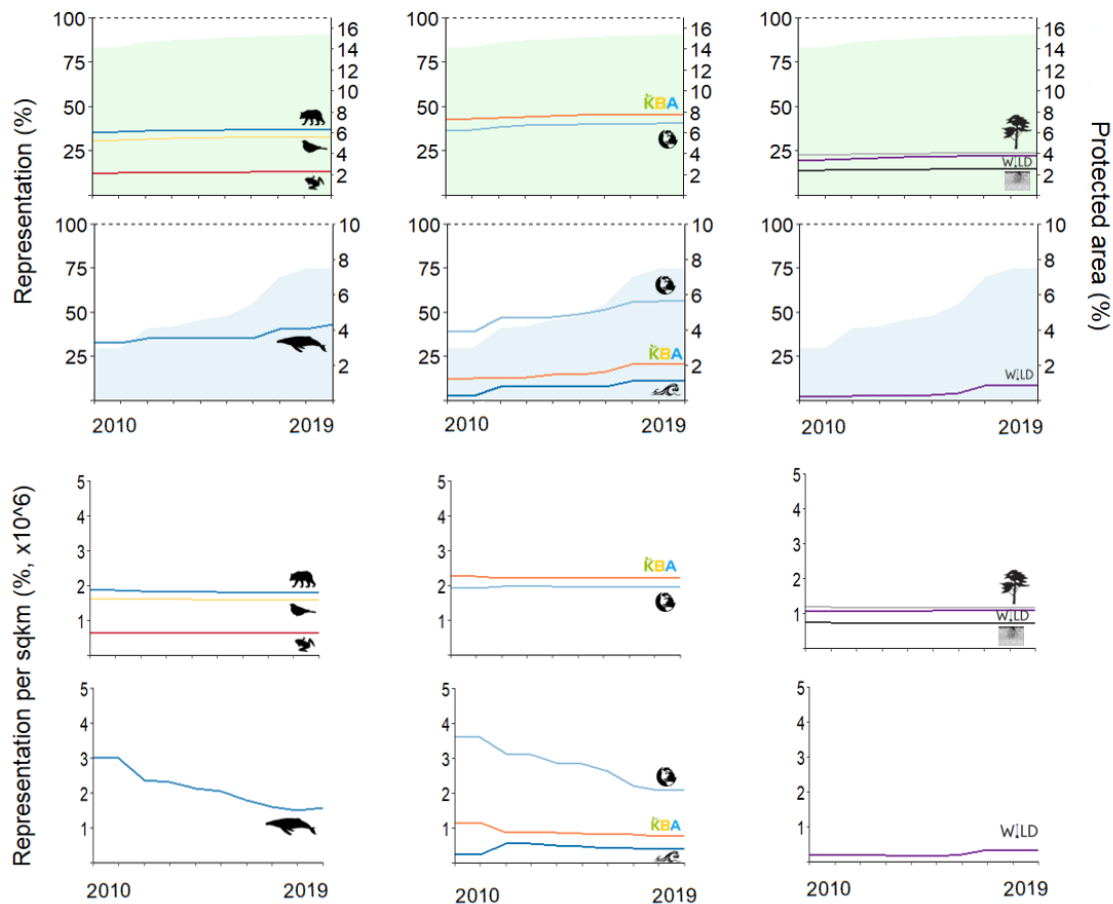


525

526 **Fig. 1.** Areal coverage (%) of marine (blue bars) and terrestrial (green bars) protected areas  
 527 on Earth. For each country of group of countries, protected areas coverage in 2010 (lighter  
 528 bars) is made distinct from growth in coverage by 2019 (darker bars). Progress toward a  
 529 globally agreed target - to have 17% of land and inland waters and 10% of coastal and marine  
 530 areas to protected by 2020 (black dashed circles) - is promising but incomplete.

531



























































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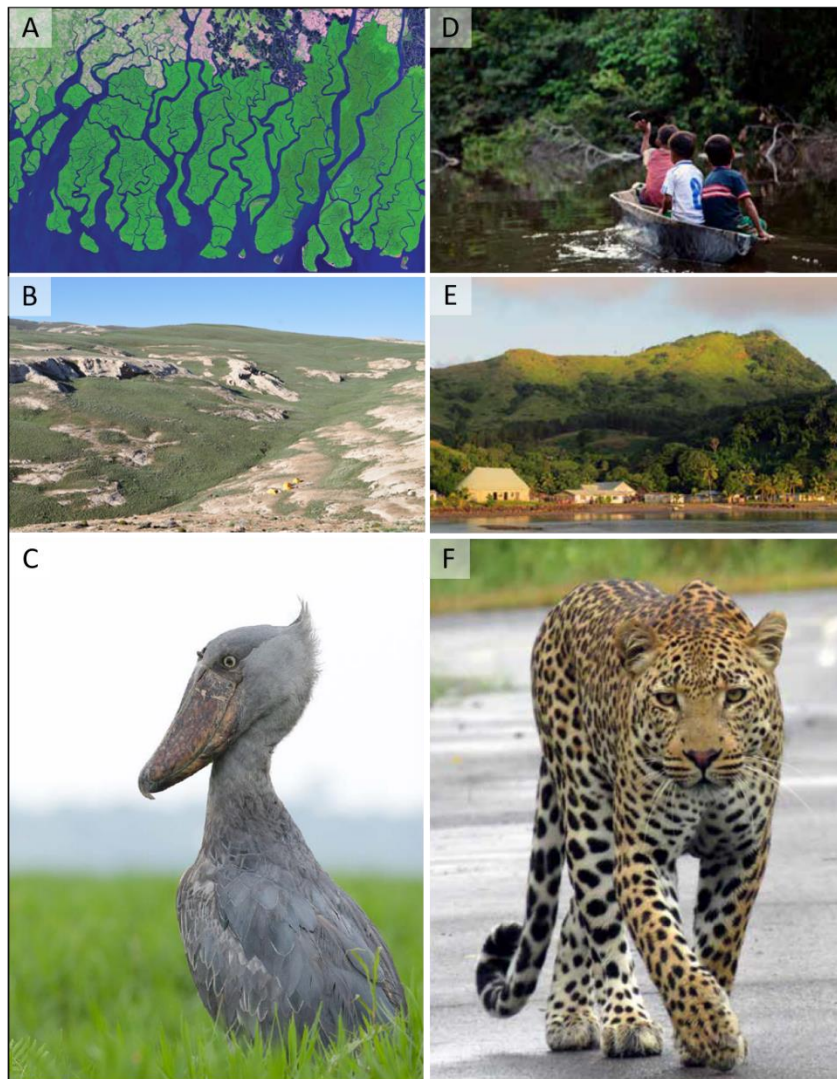
534 **Fig. 2.** Representation of biodiversity and ecosystem service values within the global  
 535 protected area estate between 2000 and 2019. The top panel shows average representation of  
 536 values as terrestrial (green shading) and marine (blue shading) protected area estates near  
 537 17% and 10% of global land and sea surfaces, respectively. The bottom panel shows  
 538 representation of values per area of land or sea protected. For threatened vertebrate species  
 539 (left-hand plots), trend lines show the proportion of species within each taxonomic group that  
 540 have had their individual representation targets met (these targets are proportional to species'  
 541 geographic range). Trend lines for ecoregions (planet icon; centre plots) and off-shelf pelagic  
 542 regions (wave icon; centre plots) show the proportion these features that are at least 17%  
 543 protected (for terrestrial ecoregions) or at least 10% protected (for marine ecoregions or off-  
 544 shelf pelagic regions). Trend lines for all other features, including Key Biodiversity Areas  
 545 (KBA icon; centre plots), wilderness areas (wild icon; right-hand plots), biomass carbon (tree  
 546 icon; right-hand plots) and soil carbon (soil icon; right-hand plots) represent global averages.

547

		Broad environmental agenda aimed at making biodiversity conservation mainstream					
		Area-based conservation	Ecosystem service policies	Restoration on degraded land, coast and sea	Programs for sustainable and equitable management	National biodiversity action plans	Programs for enhancing corporate knowledge and funding of biodiversity conservation
					 		 
Drivers	 Awareness						
	 Planning and accounting						
	 Incentives harmful to biodiversity						
	 Production and consumption						
Pressures	 Habitat loss						
	 Fisheries						
	 Agriculture and forestry						
	 Pollution						
	 Invasive species						
	 Human pressures on coral reefs						

548

549 **Fig. 3.** A role for area-based conservation as part of a suite of conservation strategies in a  
550 post-2020 environmental agenda. The post-2020 Global Biodiversity Framework should seek  
551 to address all drivers of, and pressures contributing to, global biodiversity loss, including  
552 those captured in Aichi Biodiversity Targets contained in the current Strategic Plan on  
553 Biodiversity of the Convention on Biological Diversity (blue and orange icons). Area-based  
554 conservation is well-suited to play a central role in abating some human pressures – primarily  
555 local threats to species and ecosystems (green tick icons). Other conservation interventions  
556 mentioned or implied in the Aichi Targets (purple and yellow icons), remain underutilised  
557 despite being well suited to abate human pressures or drivers of biodiversity loss that area-  
558 based conservation is in many cases unable to act on. Post-2020, better integration of  
559 biodiversity values into all conservation interventions will see them to contribute more  
560 substantively to global goals for nature.



561  
562

563 **Box 1.** Protected areas and other area-based conservation measures (OECMs) are  
564 complementary area-based conservation measures. Their distinguishing feature is that a  
565 protected area has a primary conservation objective<sup>2</sup> whereas an OECM delivers the effective  
566 in-situ conservation of biodiversity, regardless of its objectives<sup>7</sup>. (A) Protected areas are  
567 playing a central role in conserving the Sundarbans mangroves of Bangladesh and India  
568 (©NASA/JPL), (B) the Bamyán Plateau in Afghanistan (©N. Jahed/WCS) and (C) the  
569 Shoebill stork (*Balaeniceps rex*) that ranges from South Sudan to Zambia (©Daniel Field).  
570 (D) OECMs can be sites that prioritise conservation but this objective is not legally  
571 recognised by the governing body (e.g. a conservation concession in Loreto Region, Peru  
572 ©Bruno Monteferri), (E) places where conservation is effective but only a secondary  
573 management objective (e.g. a locally managed marine area on Totoya Island, Fiji ©Stacy  
574 Jupiter), or (F) ancillary conservation where conservation happens more-or-less by accident  
575 (e.g., the Hoedspruit Airforce Base, South Africa ©Hoedspruit Airforce Base).

576 **Table 1** Understanding the effectiveness of area-based conservation depends on the question  
 577 being asked. Commonly asked questions imply different spatial scales and measurements,  
 578 and are subject to strengths and weakness. Globally we have weak direct measures of the  
 579 biodiversity outcomes of individual protected areas or OECMs.  
 580

	Scale	What is Measured	Strengths (+) and Weaknesses (-)
<b>“Are area-based conservation efforts in the right place?”</b>	Global and regional	<ol style="list-style-type: none"> <li>Coverage of species, especially species at risk</li> <li>Coverage of ecoregions</li> <li>Coverage of ‘important’ areas, such as Key Biodiversity Areas</li> </ol>	<ul style="list-style-type: none"> <li>+ Can assess broad extent and examine cost per unit area of meeting area-based conservation targets</li> <li>+ Robust methods to establish appropriate counterfactuals that control for bias</li> <li>- Coarse scale that might not be adequate of local planning</li> <li>- Inaccuracies in global data sets</li> </ul>
<b>“What is the ecological condition of a protected area or OECM?”</b>	Individual sites	<ol style="list-style-type: none"> <li>Species population time series trends</li> <li>Measures of ecological integrity or health</li> </ol>	<ul style="list-style-type: none"> <li>+ Accurate and precise</li> <li>+ Can include Traditional Ecological Knowledge where available</li> <li>- Costly and requires considerable scientific input for both design and analysis</li> <li>- There is no other substitute for this kind of overall assessment</li> </ul>
<b>“What is the ecological condition of area-based conservation efforts?”</b>	Individual sites, aggregated to national, regional and global scales	<ol style="list-style-type: none"> <li>Species population time series trends</li> <li>Presence of key species or functional groups (e.g. predators, pollinators)</li> <li>Change in the state of an environmental condition (e.g. forest cover, fish biomass)</li> <li>Changes in cumulative human pressure</li> </ol>	<ul style="list-style-type: none"> <li>+ Human pressures are often useful proxies for broad-scale biodiversity impacts</li> <li>+ Often cheap and non-invasive (e.g. derived from satellites)</li> <li>- Often miss important drivers of biodiversity loss (e.g. disease, pollution, poaching) and do not always explain local or regional biodiversity patterns</li> <li>- Often difficult to develop appropriate counterfactual scenarios to assess what conditions would have been like in the absence of protection</li> </ul>
<b>“Is the management of area-based conservation effective?”</b>	Individual sites, aggregated to national, regional and global scales	<ol style="list-style-type: none"> <li>Resource adequacy (e.g. staff, training, funding)</li> <li>Adequacy of planning and enforcement</li> </ol>	<ul style="list-style-type: none"> <li>+ Established assessment frameworks and methodologies that can be conducted rapidly</li> <li>+ Growing coverage of global protected area estate</li> <li>- Database established but at present does not record assessment results, only that assessments have taken place</li> <li>- Most methodologies were not designed to measure biodiversity outcomes of protected areas and OECMs</li> </ul>

581

582 **Supplementary figures and tables**

583 **Figure S1.** The terrestrial protected area network overlaid on a global map of biomass and  
584 soil carbon.

585 **Table S1.** Threatened birds, amphibians and mammals who remain without any formal  
586 protection as of 2019.

587 **Table S2** Protected area coverage (%) of terrestrial ecoregions in 2010 and 2019.

588 **Table S3** Growth in coverage of terrestrial ecoregions as the global protected area estate  
589 expanded between 2010 and 2019.

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