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1 **Area-based conservation in the 21st 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^{1,2} (Box 1). The
39 importance of other effective area-based conservation measures (OECMs) is also beginning
40 to be recognised³⁻⁷. 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 Development⁸ and the CBD. In particular, the CBD’s
46 current ten-year Strategic Plan for Biodiversity⁹ – 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 realm¹⁰. While it is not yet
54 possible to track their global extent systematically, OECMs have also expanded since 2010¹¹.
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 managed¹²⁻¹⁷. 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 ecosystems¹⁸⁻²⁴. 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”⁹.

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 loss¹⁰. The urgency to act has emboldened calls for a
67 substantial expansion of area-based conservation globally²⁵⁻²⁸ and fundamental changes in
68 how environmental targets are framed and implemented^{18,23,29-31}. 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 21st 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 available¹¹ (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^{32,33}),
88 especially those that threatened with extinction^{13,16,32,34-37}. Most evidence to date suggests
89 significant shortfalls in either approach. For species, Butchart and colleagues¹⁶ 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 protected³⁸ 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 2016³⁹.

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 List⁴⁰ (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^{16,35,36}; 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^{13,14}. 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^{14,41,42}.

120 To assess coverage of ecoregions, we followed previous studies^{16,34,37} 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 biome³² -
127 while 34.4% of land protected since 2010 covered dry or desert ecoregions, which are
128 relatively species poor and over-represented³². 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^{32,43}.

133 We also assessed coverage of marine ecoregions³³ and off-shelf pelagic regions⁴⁴ 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 km²; 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 km²) 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 pressures⁴¹.

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

147 The Key Biodiversity Area (KBA) approach⁴⁵ 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 area⁴⁵. The 2018 Protected Planet report³⁴ 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%) KBAs³⁴. 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^{46,47}. They underpin planetary life-support systems⁴⁸
160 and are critical for the long-term persistence of imperilled species⁴⁹, especially in a time of
161 climate change⁵⁰. Only 4.9% of marine wilderness areas were protected in 2017⁴⁶, and
162 protected areas established between 1990 and 2015 covered just 8.3% of terrestrial
163 wilderness areas⁵¹. 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^{10,52}, 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^{34,53}. 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 areas³⁴. 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 catch³⁴. 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 areas⁵⁴.

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^{55,56}. In 2016, only 30% of terrestrial
199 ecoregions were at least 17% covered by protected areas that were theoretically reachable by
200 species⁵⁷. 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 2018⁵⁸. 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^{59,60}.

205 Connectivity is an important consideration for marine protected areas because, among other
206 reasons, it helps to maintain networks of local populations⁶¹ and to replenish fish populations
207 on fished reefs⁶². High levels of connectivity also correspond to areas of enriched coral
208 diversity⁶³. 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)⁶⁴. 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 stage⁶⁵.

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 decade⁶⁶⁻⁶⁸. 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 borders⁶⁹⁻⁷³.

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 2010⁷⁴. An earlier study found that one-third of all protected land was under intense human
222 pressure at the start of this decade⁷³. This study by Jones and colleagues also found that
223 human pressure had increased in 55% of protected areas between 1993 and 2009⁷³. As for
224 marine protected areas, 94% of those created before 2014 permit fishing activities⁷⁵ – a key
225 driver of poor marine protected areas effectiveness⁷⁶. 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 activities⁷⁷. There is, however, clear evidence that many protected
228 areas do effectively abate human pressures. For example, marine protected areas reduce
229 fishing vessel traffic⁷⁸ and the negative effects of some non-native species⁷⁹. Terrestrial
230 protected areas have been found to reduce rates of deforestation and forest degradation below
231 those observed in nearby unprotected areas^{80,81}, and to reduce increases in human pressure in
232 wilderness areas⁸². Protected areas established and managed by Indigenous people are
233 particularly effective at avoiding deforestation in regions with high deforestation pressure⁸³.
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 2012⁸⁴. 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 areas⁸⁵.

239 In terms of biodiversity outcomes, several studies have reported beneficial effects of
240 protected areas on species abundance and diversity^{72,86,87}. For example, a study of 447
241 terrestrial protected areas showed them to be effectively maintaining populations of birds and
242 mammals within their boundaries⁸⁸. 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)⁸⁹. 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 areas²¹. Marine protected areas also promote the recovery of fish
248 populations^{90,91}. No-take marine reserves, in particular, result in significant increases in
249 species richness, density and biomass in both tropical and temperate systems^{21,92-94}, as well as
250 being effective at restoring trophic function^{95,96} and lowering levels of coral disease⁹⁷.

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 equity⁹⁸. 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^{99,100}. There is evidence showing protected areas that
256 integrate local people as stakeholders often result in higher conservation and socioeconomic
257 outcomes^{101,102}. 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^{83,103}, and community-managed marine protected areas that are
260 long-established and well-enforced enhance economic and social well-being^{104,105}.
261 Furthermore, a recent review of eleven countries across four continents showed terrestrial
262 protected areas do not impinge on efforts to alleviate poverty¹⁰⁶. 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^{21,107}.

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 11³⁴. 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 reports⁴. Indigenous Peoples manage or have tenure

280 rights over at least 37% of all remaining intact landscapes on Earth³, and ICCAs have been in
281 existence since humans began to govern and manage landscapes and seascapes
282 purposefully¹⁰⁸. A recent study by Schuster and colleagues showed indigenous managed
283 lands support higher concentrations of biodiversity than formal protected areas¹⁰⁹, 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 century⁴, and in some regions out-number nationally-designated protected areas¹¹⁰. 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 managed¹¹¹.

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 practices⁵. 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 2018⁶, and compared to protected areas with government

303 ownership, OECMs may prove to be more socially acceptable in productive land and
304 seascapes^{112,113} and thus enhance coverage of poorly protected species^{13,14}. Finally, OECMs
305 could enhance the connectivity of protected area networks, helping them to become better
306 integrated within wider landscapes and seascapes¹¹³. 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 areas¹¹⁴.

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 management¹¹⁵. 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 outcomes²³.

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 km² of land and sea were added to the global protected area
331 estate annually between 2006 and 2018, around 1.1 million km² were recorded as removed
332 each year¹¹⁶. 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 km²) between 1997
336 and 2014¹¹⁷. Qin and colleagues¹¹⁸ 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 objectives²,
343 including industrial-scale resource extraction and infrastructure development¹¹⁹. Moreover,
344 only 5% of PADDD events are ever partially or fully reversed¹²⁰. PADDD events can also
345 accelerate forest loss and fragmentation¹²¹ and may restrict dispersal and migration of wide
346 ranging species¹²². Many PADDD events are also going undocumented, particularly in
347 marine systems¹²³ and in privately protected areas¹¹⁰. 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^{124,125}, or by enacting more conservation-focused
354 regulation^{126,127}. 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 activities⁶⁸. The most

370 used GD-PAME methodology – the Management Effectiveness Tracking Tool (METT) –
371 was not developed to assess a detailed evaluation of biodiversity outcomes¹²⁸ 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 change¹²⁹ and changes in cumulative human pressure^{130,131}, 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 (1km²) and available for
377 multiple time steps¹³⁰, are significantly correlated with trends in species risk of extinction¹³².
378 However, ecological changes across land and seascapes do not always explain local
379 biodiversity patterns¹³³. 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. 77sqkm¹³¹) that preclude assessments of many small, but
382 crucially important¹³⁴, 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 globally¹³⁵.

386 There are substantial practical challenges to assessing area-based conservation effectiveness
387 more precisely and accurately¹³⁶. 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 planet⁶⁷, 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 outcomes¹³⁷ and account for uncertainty in composite indicators of
397 environmental condition¹³⁸.

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 enforcement⁷⁷ or inadequate staff capacity²¹).
401 Studies undertaken nearly two decades ago estimated a shortfall of \$1-1.7 billion per year just
402 to manage existing protected areas^{139,140}. 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 Neotropics²². 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 processes²¹.

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 sites¹⁴¹. 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 annually¹⁴². However, there remain issues with how funding for
417 area-based conservation is generated, retained and reinvested¹⁴³. 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 projects¹⁴⁴. Yet
420 this approach risks simply displacing, rather than supplementing current funding for
421 biodiversity conservation¹⁴⁵. 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 biodiversity¹⁴⁶.

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 history¹⁰. Humanity must transform how species and
428 ecosystems are conserved¹⁰. 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 biodiversity². 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^{10,147}. 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^{14,148}. 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 services¹⁴⁹. In Portugal, the legally binding "National Ecological Reserve" aims to retain
453 areas of ecological value or defend areas that are susceptible to natural hazards¹⁵⁰. 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 biomes¹⁵¹.

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 biodiversity¹³⁶, or for containing loopholes that lead to
459 perverse environmental outcomes¹⁵². Environmental safeguards that exist in broad planning

460 frameworks also remain largely subservient to economic development¹⁵³ and are subject to
461 frequent policy changes, which create uncertainty in the minds of land and sea
462 managers^{151,154,155}. 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 extinctions¹⁴⁷. This is despite biodiversity conservation underpinning
466 many of the Sustainable Development Goals⁸.

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 interventions¹⁵⁶). 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 formulated³⁰. 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-PAME⁶⁸; World Database on Protected Areas¹⁵⁷; 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 status²³. 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^{23,158}. A new standard for recognising protected areas or OECMs that deliver meaningful
502 outcomes for biodiversity – the IUCN Green List of Protected and Conserved Areas¹⁵⁹ –
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**

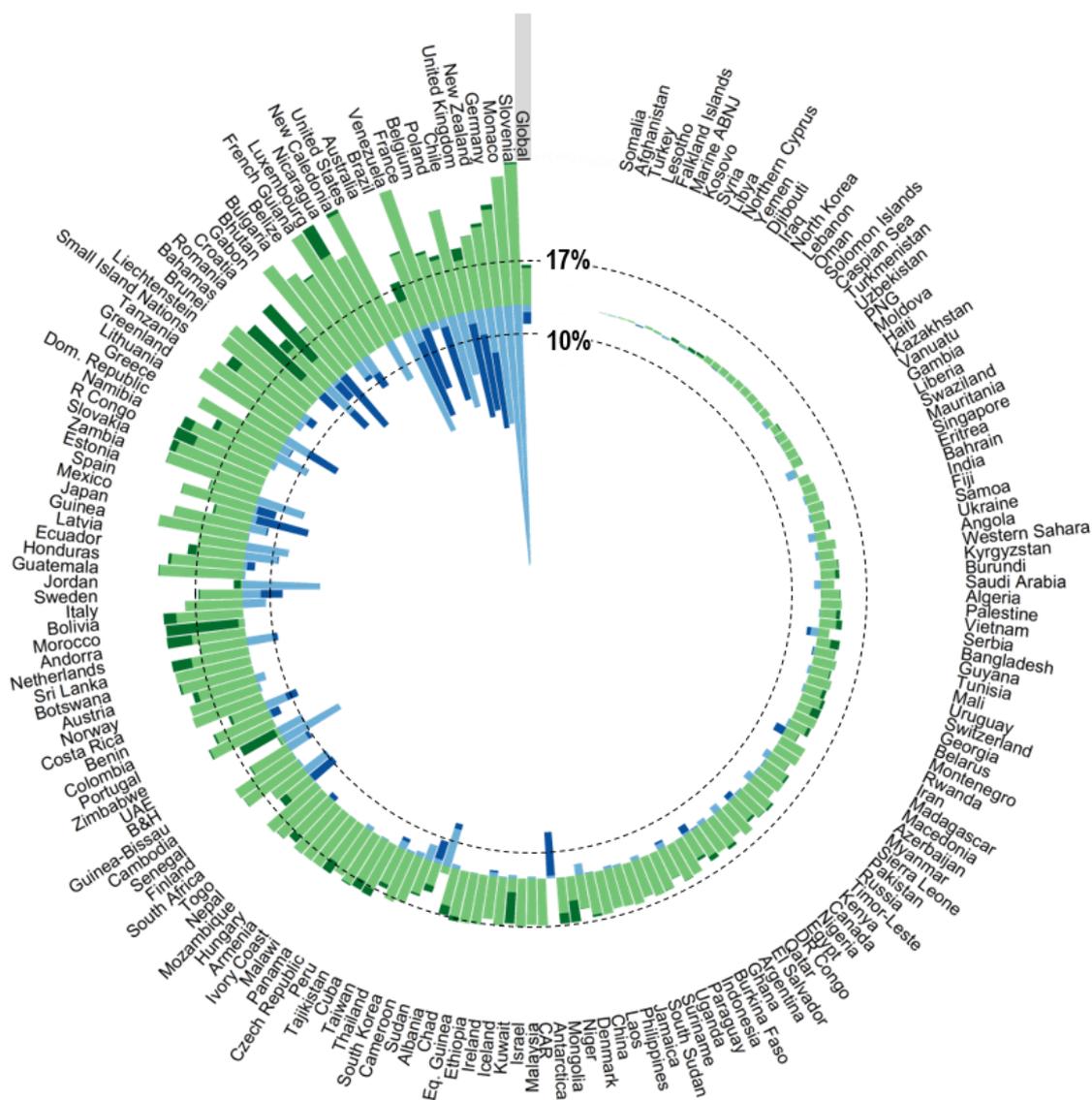
510 Area-based conservation will remain the cornerstone of conservation long into the 21st
511 century. But governments have dramatically underinvested in protected areas and OECMs
512 and been weak in legally protecting them. In addition to correcting these shortfalls, humanity
513 needs to do more 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

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523 thoughts and discussion around these ideas.

524 Display items

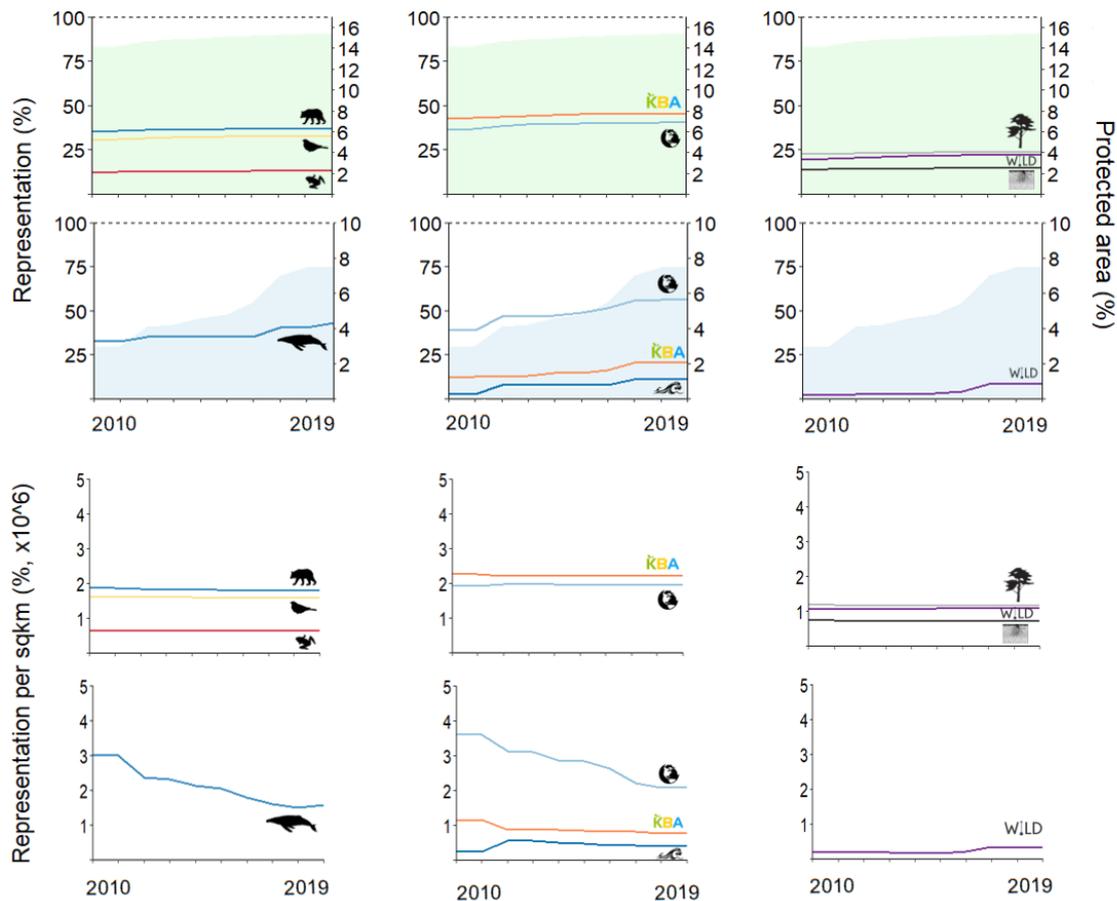


525

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

532



533

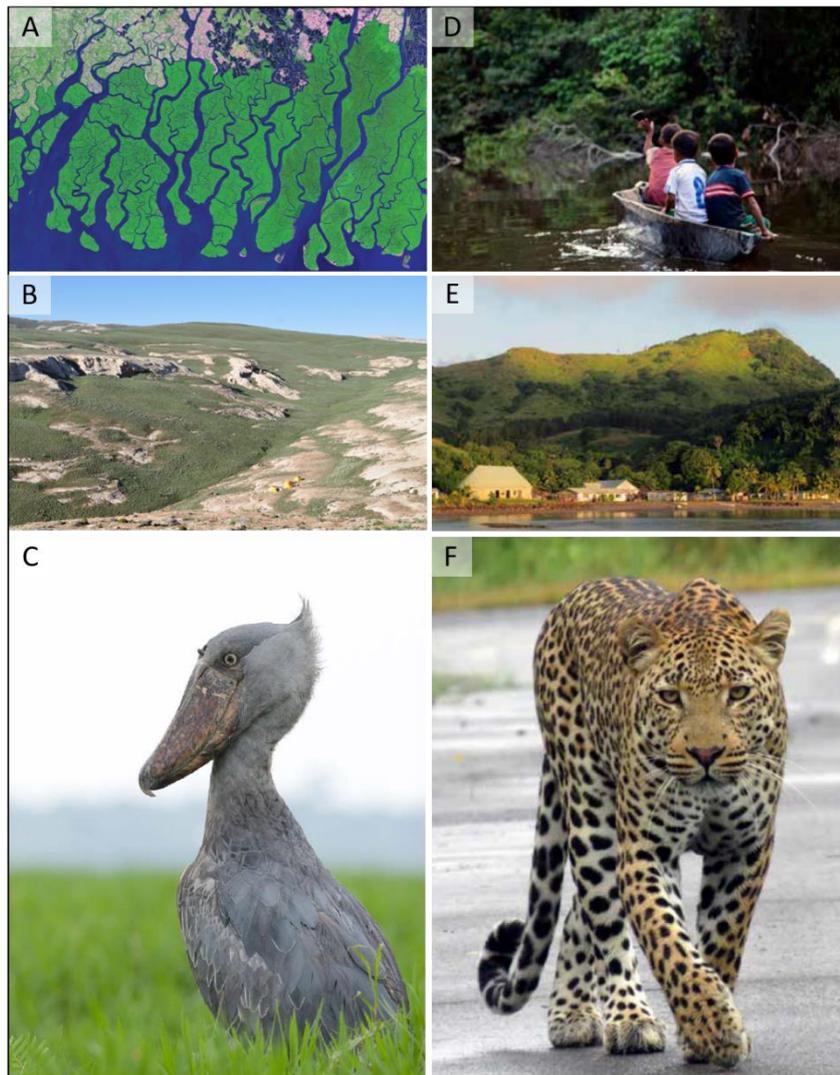
534 **Fig. 2.** Representation of biodiversity and ecosystem service values within the global
 535 protected area estate between 2000 and 2019. The top panel shows average representation of
 536 values as terrestrial (green shading) and marine (blue shading) protected area estates near
 537 17% and 10% 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 objective² whereas an OECM delivers the effective
566 in-situ conservation of biodiversity, regardless of its objectives⁷. (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 (-)
“Are area-based conservation efforts in the right place?”	Global and regional	<ol style="list-style-type: none"> 1. Coverage of species, especially species at risk 2. Coverage of ecoregions 3. Coverage of ‘important’ areas, such as Key Biodiversity Areas 	<ul style="list-style-type: none"> + Can assess broad extent and examine cost per unit area of meeting area-based conservation targets + Robust methods to establish appropriate counterfactuals that control for bias - Coarse scale that might not be adequate of local planning - Inaccuracies in global data sets
“What is the ecological condition of a protected area or OECM?”	Individual sites	<ol style="list-style-type: none"> 1. Species population time series trends 2. Measures of ecological integrity or health 	<ul style="list-style-type: none"> + Accurate and precise + Can include Traditional Ecological Knowledge where available - Costly and requires considerable scientific input for both design and analysis - There is no other substitute for this kind of overall assessment
“What is the ecological condition of area-based conservation efforts?”	Individual sites, aggregated to national, regional and global scales	<ol style="list-style-type: none"> 1. Species population time series trends 2. Presence of key species or functional groups (e.g. predators, pollinators) 3. Change in the state of an environmental condition (e.g. forest cover, fish biomass) 4. Changes in cumulative human pressure 	<ul style="list-style-type: none"> + Human pressures are often useful proxies for broad-scale biodiversity impacts + Often cheap and non-invasive (e.g. derived from satellites) - Often miss important drivers of biodiversity loss (e.g. disease, pollution, poaching) and do not always explain local or regional biodiversity patterns - Often difficult to develop appropriate counterfactual scenarios to assess what conditions would have been like in the absence of protection
“Is the management of area-based conservation effective?”	Individual sites, aggregated to national, regional and global scales	<ol style="list-style-type: none"> 1. Resource adequacy (e.g. staff, training, funding) 2. Adequacy of planning and enforcement 	<ul style="list-style-type: none"> + Established assessment frameworks and methodologies that can be conducted rapidly + Growing coverage of global protected area estate - Database established but at present does not record assessment results, only that assessments have taken place - Most methodologies were not designed to measure biodiversity outcomes of protected areas and OECMs

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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