

1 **A horizon scan of emerging global biological conservation issues for 2020**

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## 53 **Abstract**

54 In this horizon scan we highlight 15 emerging issues of potential relevance to global  
55 conservation in 2020. Seven relate to potentially extensive changes in vegetation or  
56 ecological systems. These changes are either relatively new, for example conversion  
57 of kelp forests to simpler macroalgal systems, or may occur in the future, for  
58 example as a result of the derivation of nanocellulose from wood or the rapid  
59 expansion of small hydropower schemes. Other topics highlight potential changes in  
60 national legislation that may have global effect on international agreements. Our  
61 panel of 23 scientists and practitioners selected these using a modified version of the  
62 Delphi technique from a long-list of 89 potential topics.

## 63 **Introduction**

64 This eleventh annual horizon scan identified novel issues that may have substantive  
65 positive or negative effects on global biological conservation. We do not aim to  
66 predict outcomes but to highlight issues to which societies may wish or need to  
67 respond in the future on the basis of improved knowledge. Here we present the 15  
68 topics identified by our panel, which comprised 23 scientists, conservation  
69 practitioners, and experts in foresight research and horizon scanning. These topics,  
70 about which we believe relatively little is known amongst those working in  
71 conservation, are diverse. They include effects on wildlife of a range-expanding,  
72 invasive tick species; implications of new legislation to promote sourcing of energy  
73 from wood; and the application of a genetically modified fungus to kill malaria-  
74 carrying mosquitoes. Many of the issues we identified in previous scans have been  
75 realized or become much better understood ([1]).

76 **Identification of Issues**

77 Our annual horizon scanning methods have been consistent (Figure 1). We apply a  
78 modified version of the Delphi technique, which facilitates a process that is repeatable,  
79 inclusive and transparent ([2], [3]). This year's 23 core participants had diverse  
80 subject-matter expertise, including but not limited to agriculture and land use,  
81 microbiology, conservation practice and technology, sustainability, environmental  
82 management, policy, economics, research programming, science communication and  
83 professional horizon scanning.

84 [FIGURE 1 HERE]

85 Figure 1: Our process for identifying and evaluating issues during the 2020 scan.

86 Members of our team used different methods to identify and select issues, including  
87 but not limited to consulting with colleagues in person or by email, soliciting issues  
88 via Twitter and other forms of social media or through established networks, and  
89 tracking via curation tools such as pearltrees ([www.pearltrees.com](http://www.pearltrees.com)). We engaged  
90 approximately 830 people. If face-to-face meetings were held, then we counted all  
91 participants. If messages were sent by email or social media, we counted only those  
92 who responded. In addition, we noted issues that we encountered throughout the  
93 year in the popular and social media, scientific journals, seminars and other  
94 professional presentations, and even casual conversations in which we engaged or  
95 that we overheard.

96 We assessed each issue's suitability for inclusion on the basis of criteria established  
97 during the first horizon scan ([4]): issues must be novel or represent novelty through a  
98 step-change in impact, have potentially substantive positive or negative impacts on

99 conservation of biological diversity at a global or regional level, and seem likely to have  
100 greater impact in the future.

101 For this scan we compiled a long-list of 89 issues and grouped them on the basis of  
102 theme. Where two closely related issues were submitted by different participants, we  
103 combined the issues and assessed them as one. Participants independently and  
104 confidentially scored each issue from 0 – 1000 (low – high) on the basis of its  
105 potential effects on biological conservation, and noted if they previously were aware  
106 of the issue. Participants often added notes or queries to their scoresheet, e.g.,  
107 suggesting issues that could be combined or topics that were well-known. These  
108 notes and queries informed discussion at the expert meeting (see below). Fatigue  
109 can result in attention waning throughout a process of scoring issues (e.g. [5]). To  
110 counter this potential bias, the long-list was ordered in three different ways, and  
111 participants randomly assigned to each list. Each participant's scores were  
112 converted to ranks (1 – 89). The most highly ranked 38 issues (due to a four-way tie  
113 for 35<sup>th</sup> place) were retained for further discussion and a second round of  
114 assessment (described below).

115 Two weeks before the expert meeting, each topic was assigned to two participants  
116 for further investigation to ensure detailed preparation. The person who submitted a  
117 given topic was not assigned that topic. Therefore, investigators were unlikely to be  
118 experts on the topic, but could collate relevant information to allow assessment of its  
119 potential impacts. Investigators focused on the issues' novelty, likelihood of  
120 occurrence, magnitudes of impact and relevance to biological conservation.

121 At an expert meeting in Cambridge (UK) in September 2019, we discussed each  
122 issue in relation to the above criteria. During discussions, we clarified technical

123 details and levels of awareness, and presented further sources of evidence. After the  
124 discussion of each issue, all participants re-scored that issue as in the first round.  
125 These scores again were converted to ranks, from which we calculated a median  
126 rank. We present the 15 issues with highest median ranks below. The issues are in  
127 thematic rather than rank order.

## 128 **The 2020 Issues**

### 129 **Land-use change in response to derivation of nanocellulose from wood**

130 Innovations in materials science, particularly in nanocomposites, are beginning to  
131 create novel opportunities for manufacturing that may increase demand for wood.  
132 Cellulose is a strong, stiff polymer produced by plants (particularly trees), animals  
133 and bacteria. When cut into nanocellulose, its key properties change ([6]), making it  
134 suitable as a feedstock for industrial processes. Nanocellulose is used to produce a  
135 wide range of products including construction materials, packaging for clothing, and  
136 consumer products such as transparent wood-based packaging. The global  
137 nanocellulose market is growing by 18% per annum and is estimated to reach  
138 US\$660 million by 2023 ([7]), thus increasing demand for wood. In response, tree  
139 planting may increase, temporarily boosting carbon stocks and reducing reliance on  
140 fossil fuels. Nanocellulose products could replace plastics, so the volume of plastic  
141 waste also may decrease. However, unregulated demand for wood for the  
142 nanocellulose market could accelerate global forest loss. Biological diversity also will  
143 be lost if monoculture tree plantations replace natural ecosystems, or if stands of  
144 mature trees are clear harvested.

### 145 **Policy incentives for derivation of energy from wood**

146 Demand for wood may increase substantially in response to the combination of the  
147 European Union (EU) Renewable Energy Directive of 2018, which treats wood, even  
148 from biologically diverse forests, as a renewable energy source, and the EU pledge  
149 to double Europe's 2015 renewable energy levels by 2030 to meet commitments in  
150 the 2015 Paris Agreement. As a result, EU demand may no longer be satisfied by  
151 current practices of deriving wood from forests in the United States and Canada and  
152 promoting the intensification of European forestry ([8]). Such commercialisation of  
153 forest biomass may accelerate the loss of primary forest and exacerbate climate  
154 change. The latter changes could be amplified if similar policies are adopted by other  
155 countries following the lead of the EU. A lawsuit is now challenging the EU's  
156 inclusion of forest biomass as a source of renewable energy.

### 157 **Manipulating floral species composition to improve bee health**

158 Variation in the nutritional content of nectar and pollen among plant species  
159 influences how bee species forage, but little is known about differences in nutritional  
160 requirements among species or populations of bees. Land uses that reduce the  
161 species richness and abundance of flowering plants are likely to interact with other  
162 factors, such as pathogens, to drive bee declines. Two recent studies conducted in  
163 the United States suggested that pollen from sunflowers *Helianthus* spp. and closely  
164 related Asteraceae species reduces the prevalence of parasite infection in bees.  
165 Laboratory studies indicated a reduction in the load of the gut parasite *Crithidia*  
166 *bombi* in bumblebees *Bombus pensylvanicus*, and a field survey indicated lower  
167 levels of infection in areas with high cover of planted sunflowers, even though  
168 sunflower pollen has relatively low nutritional value compared to other pollens ([9],  
169 [10]). *C. bombi* also reduces reproductive success in colonies of the European



170 bumblebee *Bombus terrestris* ([11]). This new knowledge could be used to alter crop  
171 choices or planting regimes for bees before impacts on wild bee populations are fully  
172 understood. The latter actions may disrupt host-parasite dynamics in wild bees  
173 ([12]), and could also potentially reduce nutritional availability relative to native  
174 wildflowers.

### 175 **Asian long-horned tick reaches the Americas**

176 The non-native Asian long-horned tick *Haemaphysalis longicornis* is well established  
177 in Australia and New Zealand, where it is associated with economically important  
178 cattle pathogens, including *Theileria orientalis*. First detected in the United States in  
179 2017, the tick has spread to nine states. Coincident infection of three unrelated cattle  
180 herds in Virginia, USA by the virulent, pathogenic Ikeda genotype of *T. orientalis* led  
181 to seven cattle deaths ([13]). The tick has a wide climatic tolerance, with potential to  
182 colonise the eastern and western seaboard of the United States and Canada south  
183 into Central America ([14]) and to extend across South America. Invasion by both a  
184 novel tick and associated pathogens would represent a major emerging disease for  
185 the Americas. If the potential effects on animal health and livestock farming are of  
186 sufficient magnitude to affect regional and national economies by reducing milk or  
187 meat production, land use may change across extensive areas ([13]). *H. longicornis*  
188 also has been associated with mortality of cattle in New Zealand and is carried by  
189 diverse host mammals and birds ([15]). Its introduction to the Americas with at least  
190 one associated pathogen therefore also may have population-level effects on native  
191 wildlife.

### 192 **Global declines of kelp forest**

193 Kelps are an order of brown algae (Laminariales) with high primary productivity that  
194 occur on around 25% of the world's coastlines and function as complex habitats for  
195 many other species. Declines in kelp abundance have been reported widely, albeit  
196 with substantial regional variability ([16]). Kelps long have been considered resilient  
197 to environmental stress. However, this resilience may be waning in response to  
198 diversification of potential drivers of decline, which include increases in sea  
199 temperatures caused by anthropogenic climate change, non-native invasive species,  
200 eutrophication, and harvesting ([17]; [18], [16]). The declines may result in  
201 fundamental shifts from complex kelp forests to simpler macroalgal turf systems  
202 ([18]). Future kelp forest declines in response to accelerating climate change would  
203 have significant consequences for biological diversity and ecosystem processes  
204 ([17]). The ecological benefits to humans that are supported by kelp forests,  
205 including commercial fisheries and shoreline protection, are valued at billions of  
206 dollars annually ([17]).

### 207 **Atmospheric circulation and the shrinking Antarctic ozone hole may affect** 208 **extent of polar ice**

209 Rising sea levels, in large part caused by melting of the polar ice caps and thermal  
210 expansion of water, affect human societies, land uses, and coastal ecosystems  
211 worldwide. Understanding of how the extent of Antarctic coastal and sea ice  
212 responds to interactions with stratospheric ozone, atmospheric circulation, and  
213 storms and waves is evolving rapidly (e.g., [19]). Reduced chlorofluorocarbon  
214 emissions since the Montreal Protocol of 1987 have led to less ozone depletion  
215 during polar winters and, as a result, a reduction in the size of the ozone holes.  
216 However, in the Antarctic, the shrinking of the ozone hole may weaken the north–

217 south movement of the westerly wind belt that circles the continent ([20]), the  
218 Southern Annular Mode (SAM), counteracting the general strengthening of the SAM  
219 as concentrations of greenhouse gases increase. Variation in the movement of the  
220 (SAM) alters Antarctic temperature and storm patterns ([21]). For example, when the  
221 SAM is at its southernmost position, westerly winds strengthen over Antarctica and  
222 sea-surface and air temperatures decrease. Decreases in the size of the ozone hole  
223 are among the factors implicated in changes in wind and other weather patterns that  
224 likely will contribute to decreases in the extent of Antarctic ice and increases in  
225 global sea levels.

### 226 **Effects of small hydropower systems on riverine ecosystems**

227 The cumulative environmental effects of more than 80,000 small hydropower dams  
228 built on small upland streams have received much less attention than those of large  
229 dams. There are now over 11 small dams for every large dam ([22]), and efforts are  
230 underway in the Himalayas, other mountain ranges in Asia, and the Andes ([23]) to  
231 increase their use to empower local communities. Such small run-of-river schemes  
232 are associated with a much smaller footprint of land-cover conversion than large  
233 storage schemes. However, guidance to decrease negative impacts on biological  
234 diversity often is not provided. Moreover, impact assessments rarely are required for  
235 small individual dams, although they could be associated with considerable  
236 cumulative impacts on particular watersheds and species. For example, although  
237 few studies of their local and downstream ecological effects have been conducted,  
238 small dams can be associated with altered hydrological and sediment flow regimes.  
239 These alterations may cause sediment scarcity downstream, limit the dispersal of  
240 organisms and serve as barriers to migratory fishes, and reduce oxygen

241 concentrations and increase water temperatures, decreasing habitat quality for some  
242 endemic fish species ([24]).

### 243 **Large Recirculating Aquaculture Systems**

244 Intensive aquaculture is associated with high levels of water use, local environmental  
245 pollution ([25]) and loss of coastal ecosystems. Recirculating aquaculture systems  
246 (RAS) circulate water around tanks that hold cultured species, treat the water to  
247 maintain high quality, and reduce water flow through the system. Such enclosed  
248 systems usually have fewer direct environmental effects than traditional aquaculture.  
249 Small RAS have been successful, notably in freshwater ecosystems ([26]), but there  
250 is a growing trend in the development of large saltwater systems (e.g., for salmon  
251 production) capable of producing tens of thousands of tonnes of fish annually (e.g.  
252 [27]). Intensive RAS have 1-3% of the water demand of throughflow aquaculture  
253 ([26]). Recent technological advances linked RAS to aquaponics systems that utilise  
254 the high-nutrient effluents. However, implementation of RAS is constrained by the  
255 need for high capital investment, with payback periods of around 8 years or more.  
256 Establishment of extensive RAS could increase the sustainability of food production  
257 from aquaculture and may reduce the risks from pollution and parasite release often  
258 associated with throughflow aquaculture. Other challenges, such as impacts from the  
259 sources of aquaculture feed, and energy requirements have not yet been addressed.

### 260 **Genetically modified fungus kills malaria-carrying mosquitoes**

261 The evolution of insecticide resistance by mosquito species that serve as malaria  
262 vectors means that development of novel approaches to limit the spread of malaria-  
263 carrying mosquitos is becoming necessary to reduce prevalence of the disease

264 ([28]). Entomopathogenic fungi are promising in this regard, but their use is limited  
265 by the time lag in host mortality and the high dose required for infection. The fungus  
266 *Metarhizium pingshaense*, which naturally infects a mosquito species capable of  
267 carrying malaria, recently was genetically modified to produce a toxin derived from  
268 spider venom. The modified pathogen killed mosquitoes faster and at lower spore  
269 doses than the unmodified fungus. Its mode of action differs from that of pyrethroids,  
270 enabling the two control agents to act synergistically ([29]). In a demonstration  
271 village that was isolated for bioinsecticide application, the modified fungus led to  
272 increased fungal lethality and likelihood of mosquitoes being eliminated locally.  
273 Although fungal insecticides are not new ([30]), successful translation to semi-field  
274 conditions, with high mortality of the mosquito population, is novel ([28]). Reduced  
275 use of insecticides, particularly in wetlands close to urban centres, could have  
276 ecological benefits. However, any change in the host range of the modified pathogen  
277 could affect non-target organisms.

## 278 **Use of artificial wombs and ectogenesis in mammalian conservation**

279 Biobags are artificial wombs that allow partial ectogenesis (foetal development  
280 outside the mother's body). Lamb fetuses that had partially developed *in utero* were  
281 successfully transferred into biobags to continue their gestation to full term *ex utero*  
282 ([31]). Biobags contain the foetus, a pumpless oxygenator circuit and a synthetic  
283 amniotic fluid, and are designed for human neonatal intensive care. Although human  
284 testing is several years off, biobags could be used by parents to overcome troubled  
285 pregnancies or to aid premature children ([32]). Artificial wombs also could assist  
286 conservation breeding programmes for threatened mammals, particularly if the  
287 technology matures to support complete ectogenesis (embryos created with *in vitro*  
288 fertilisation and gestated entirely within an artificial womb), and the rate of production

289 of mammalian offspring increase markedly. Complete ectogenesis will raise  
290 numerous practical, ethical and financial challenges ([33]). These challenges include  
291 developmental or behavioural problems for embryos not biologically attached to a  
292 mother. Additionally, understanding of the role of the placental environment on gene  
293 activation in embryos and its effects on immunity in offspring is quite limited.

#### 294 **International growth of traditional Asian medicine**

295 Traditional medicine, largely centred on ancient Asian medicine, has been included  
296 for the first time in the International Classification of Disease ([34]), endorsed by the  
297 World Health Assembly in May 2019. Inclusion has been viewed as an endorsement  
298 of traditional medicine and may accelerate already increasing patterns of its use  
299 ([35]). Traditional medicine applies diagnostics and treatments that often have few  
300 similarities to western medicine, although efforts to expand the use of randomised  
301 controlled trials are increasing ([35]). The government of China is investing in  
302 promotion of traditional Asian medicine through methods including health tourism  
303 and international market expansion. China has established some 25 traditional Asian  
304 medicine institutes in a range of cities, and more will be launched as a major  
305 component of Belt and Road Initiative ([35]). Sales of traditional Asian medicine  
306 products such as herbal medicines are growing: sales in Belt and Road countries  
307 grew by 54% in 2016 and 2017, reaching US\$295 million annually ([35]). The growth  
308 of traditional Asian medicine will increase demand for ingredients that include some  
309 plant and animal species already endangered by harvest for international trade  
310 ([36]). Increased connectivity across the Belt and Road route may increase access to  
311 formerly inaccessible wildlife populations and increase trafficking of wildlife for use in  
312 medicine ([37]).

313 **Rise of blockchain companies with hidden owners**

314 Blockchain, the distributed ledger technology, is revolutionising traditional corporate  
315 structures. The distributed consensus mechanism fundamental to blockchain  
316 technology ensures the network's security, integrity and performance. . Although  
317 blockchain technology is secure in principle applications running on top of them,  
318 such as self-enforcing contracts, can be subject to coding errors or security  
319 vulnerabilities just like any other software and security systems will need to evolve in  
320 order to meet the needs of different applications. Companies that use blockchain  
321 need not adhere to a conventional management or financial infrastructure. In  
322 particular, self-enforcing agreements embedded in computer code may change how  
323 energy resources ([38]) and other natural assets are owned and managed. For  
324 example, in Berlin, two artists launched terra0, a blockchain experiment in which a  
325 forest autonomously sells its trees, harvests timber, and eventually uses the  
326 accumulated capital to buy itself and become a self-owned economic unit ([39]). The  
327 rapid development in these self-enforcing contracts could enable companies to  
328 confirm resource streams and commit to future actions well beyond current political  
329 and regulatory timeframes and without the need for any physical or identifiable  
330 company. These resource transactions, which are secure, immutable and verifiable,  
331 may strengthen environmental governance. They also can be used to reinforce  
332 entitlements to long-term resource extraction or even to substantiate indigenous land  
333 rights. Additionally, it may be necessary to clarify or amend existing laws, for  
334 example, to recognise the use of distributed ledgers as records of ownership ([40]).

335 **Ecocide as an internationally recognised crime**

336 Currently, the International Criminal Court, governed by the Rome Statute, can  
337 prosecute individuals and states for 'widespread, long-term and severe'  
338 environmental destruction ([41]), but only in certain circumstances, such as during  
339 conflict or when the destruction has serious humanitarian consequences. However,  
340 as currently drafted, the Rome Statute contains no provisions to protect non-human  
341 inhabitants of a given territory or indigenous or cultural rights. Nor does the Rome  
342 Statute cover environmental loss, damage or destruction during peacetime. Legal  
343 scholars (e.g. [42]) argue that this international law must change to allow the crime of  
344 ecocide. Ecocide is defined as 'the extensive damage, destruction or loss of  
345 ecosystems of a given territory ... to such an extent that peaceful enjoyment by the  
346 inhabitants of that territory has been severely diminished' ([43]). Research to  
347 establish forensic standards for admissible evidence of ecocide is advancing ([44]).  
348 Efforts to encourage the ICC to recognize ecocide focus on either the inclusion of  
349 ecocide under crimes against humanity or the establishment of ecocide as a distinct  
350 Crime Against Peace. Such changes to international law would enable individuals,  
351 states and perhaps corporations (not possible under the current statute) to be  
352 prosecuted for extensive land-cover modification, pollution and even contributing to  
353 climate change.

354 **New United Nations legal principles to reduce the environmental impact of**  
355 **armed conflict**

356 In July 2019, the United Nations' International Law Commission adopted draft  
357 principles on the protection of the environment in relation to armed conflicts. Its  
358 action represented a major step toward conclusion of a process to review the  
359 international law that was passed in 2013 (<http://legal.un.org/ilc/sessions/71/>). This



360 new international legislation, which would oblige states and other actors to protect  
361 the environment during periods of armed conflict, could have substantial effects on  
362 species and ecosystems worldwide given the environmental impacts of modern  
363 warfare ([45]). The detrimental effects of armed conflicts on species and ecosystems  
364 can be direct, through tactical military operations, or indirect, through their effects on  
365 institutions, human migration, and economies ([46]). At the same time, degradation  
366 of ecosystems could cause armed conflict and human migration, e.g. as  
367 demonstrated in the Sahel, where the degradation of wetlands has resulted in  
368 conflict over resources ([47]). Given that the most common links between armed  
369 conflicts and ecological responses are subsequent changes to institutions, societies,  
370 and economies rather than direct impacts of conflict ([46]), the new legislation's set  
371 of principles applicable after armed conflict (<http://legal.un.org/ilc/sessions/71/>) are  
372 particularly relevant; draft principle 14 encourages parties to an armed conflict to  
373 address environmental restoration during the peace process.

#### 374 **New regulations jeopardise net neutrality**

375 Conservation relies on the communication of knowledge to, and engagement with,  
376 the general public ([48]). Digital tools such as blogging and social media provide  
377 authors who have diverse perspectives or agendas ([49]) with unprecedented access  
378 to the general public, often with no filter between author and audience. Easy and  
379 equal access to all websites and types of data underlies net neutrality, i.e. all internet  
380 data are treated equally by internet service providers. Without network neutrality,  
381 providers may block or restrict access to pages and content on the basis of their  
382 corporate policies or interests, allowing accurate information to be restricted or  
383 distorted. Such blocking already affects content in some countries, but network

384 neutrality is now under a general threat: it was repealed in the United States (vote of  
385 the Federal Communications Commission, July 2018) ([50]), and other countries  
386 could follow suit. Loss of network neutrality could have major effects on conservation  
387 and climate regulation if access to accurate or sensitive information is denied or  
388 biased, or conversely if guaranteeing such access is prioritised.

## 389 **Discussion**

390 The pace of data exchange and the volumes of information available continues to  
391 accelerate, with the quantity of data available on the internet doubling every two  
392 years. The challenges of horizon scanning include not only the process of searching  
393 for issues but also understanding whether such information is sufficiently unknown to  
394 a given community to warrant inclusion. Some topics we initially considered, such as  
395 the effect of nocturnal harvesting of olives on roosting songbirds, subsequently were  
396 widely reported by the press, and consequently we considered them too well-known  
397 to include in this year's scan. However, this does not mean that the issues are any  
398 less relevant to policy-making and conservation.

399 Last year we identified the importance of national government policy or economic  
400 decision making in driving global environmental impacts ([51]), a theme echoed by  
401 two of our issues this year, the potential impact of the new European Union policy on  
402 the derivation of energy from wood and the repealing of network neutrality in the  
403 United States. Another two of our issues this year are based on the potential for  
404 decisions by global institutions, such as the International Criminal Court and United  
405 Nations, to drive change, whilst a third highlighted the potential impact of decisions  
406 by the World Health Assembly. Whether these international instruments determine  
407 global environmental trajectories ultimately will depend on the extent to which

408 countries become signatories and then incorporate decisions into national legislation.  
409 This challenge was exposed by the high profile public protests over climate change  
410 during 2019, which highlighted the failure of national governments to realise their  
411 international commitments. With a number of major international meetings focused  
412 on the protection, restoration and sustainable use of biological diversity, such as the  
413 IUCN World Conservation Congress and the 15th meeting of the Conference of the  
414 Parties to the Convention on Biological Diversity, scheduled for 2020, this tension  
415 between national decision-making and international commitment is likely to persist.  
416 In particular, new conservation agendas, the European green deal, and indicators  
417 and targets to 2030 and beyond will focus attention on addressing future threats and  
418 opportunities, such as those we seek to identify through horizon scanning.

419 There is increasing awareness of the role that unconscious bias can play in decision-  
420 making ([52]). We recognise that the majority of the people participating in the  
421 horizon scan are residents of the United Kingdom, Europe, or the United States,  
422 which may create implicit biases in both the scope of the topics considered and the  
423 levels of awareness of the issues. We aim to incorporate a wider range of  
424 perspectives, particularly from the global south, into future horizon scans. Solicitation  
425 of topics could better reflect scientific knowledge and ways of knowing from  
426 individuals and societies in regions where biological diversity is frequently stated to  
427 be at the greatest level of risk. Nevertheless, we believe that the topics identified this  
428 year may affect global conservation, and we hope that this paper will prompt  
429 discussion and new research.

430 Strategic foresight can be defined as “The systematic examination of potential  
431 threats, opportunities and likely future developments which are at the margins of

432 current thinking and planning. [The research] may explore novel and unexpected  
433 issues, as well as persistent problems or trends. Overall, it is intended to improve the  
434 robustness of policies and the evidence base” ([53]). Strategic foresight methods are  
435 relevant to experts in any discipline. Horizon scanning is one of many methods used  
436 in strategic foresight research, which also includes, but is not limited to, risk  
437 prioritisation, trend extrapolation, scenario development, backcasting, and stress-  
438 testing ([54]). Although no single method is applicable in all situations, horizon  
439 scanning provides the foundations on which all subsequent foresight research is  
440 based. The initial stages of horizon scanning are highly inclusive and by definition  
441 emphasise novelty, but are not intended to prioritise topics that are well-known or  
442 proven. Horizon scanning aims to identify and explore new insights and evidence  
443 regardless of whether they are consistent with existing trends and developments  
444 ([55]). The focus of horizon scanning is to provide an evidence base of current  
445 knowledge that suggests the potential for future change. Horizon scanning can be  
446 used to identify, assess and understand gaps in knowledge, identify potential  
447 opportunities and risks, and inform research programing and resource allocation. As  
448 a tool for decision makers, horizon scanning aims to support strategic activities  
449 ([56]). The insights identified through horizon scanning are intended to stimulate  
450 multi-party discussion and debate, leading to potentially collaborative solutions to  
451 complex issues ([57]).

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