Horizon scanning for South African biodiversity: A need for social engagement as well as science

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Abstract

A horizon scan was conducted to identify emerging and intensifying issues for biodiversity conservation in South Africa over the next 5–10 years. South African biodiversity experts submitted 63 issues of which ten were identified as priorities using the Delphi method. These priority issues were then plotted along axes of social agreement and scientific certainty, to ascertain whether issues might be "simple" (amenable to solutions from science alone), "complicated" (socially agreed upon but technically complicated), "complex" (scientifically challenging and significant levels of social disagreement) or "chaotic" (high social disagreement and highly scientifically challenging). Only three of the issues were likely to be resolved by improved science alone, while the remainder require engagement with social, economic and political factors. Fortunately, none of the issues were considered chaotic. Nevertheless, strategic communication, education and engagement with the populace and policy makers were considered vital for addressing emerging issues.

Keywords: Biodiversity futures, Consensus and scientific knowledge, Delphi approach, Future scenarios, Step changes, Threats and opportunities

Introduction

Conservation biology is viewed as a "crisis discipline" where rapid decisions are needed before all the facts are known (Soulé 1985). Recently, proactive methods have shifted this paradigm, with approaches including horizon scanning (Sutherland et al. 2010; Brown et al. 2016), scenario planning (Mitchell et al. 2015), identification of priority actions (Souza and Bernard 2019), research questions (Fleishman et al. 2011) and possibilities presented by new methods or technologies (Arts et al. 2015). This allows some degree of anticipation and planning, that can complement or even pre-empt crisis approaches.

Horizon scanning sets out to identify emerging issues that have yet to become highly visible, but may have serious positive or negative effects on biodiversity conservation in the near future (5–10 years). It can inform policy makers, funders and scientists (Sutherland et al. 2011b), directing research and enabling better preparation for impacts and exploration of potential scenarios, responses and solutions. Global horizon scanning for biodiversity has been conducted annually for over a decade (e.g. Sutherland et al. 2019a, 2010, 2011a, 2014, 2018). A recent review of the earliest horizon scan found that of the 15 issues identified in 2010 (Sutherland et al. 2010), five had become major global issues and another six had increased in importance (Sutherland et al. 2019b), suggesting that the horizon scan reliably identified future issues for conservation.

The issues highlighted during global scans inevitably vary in intensity and impact by region, and individual countries differ in the degree of control over actions in response. There is value, therefore, in conducting horizon scans at regional, national or local scales to prioritise context-specific interventions. To this end, some countries have conducted their own horizon scans: for example, the UK (Sutherland et al. 2008) and Israel (Kark et al. 2016). There have also been exercises to prioritise research questions [e.g. the USA (Fleishman et al. 2011), Canada (Rudd et al. 2011), Ecuador (Arturo Izurieta et al. 2018) and South Africa (Allsopp et al. 2019)], actions (Souza and Bernard 2019) or educational needs (Shackleton et al. 2011) in support of biodiversity conservation. Here, we present a horizon scan for South Africa, performed by a broad group of biodiversity practitioners and researchers representing a wide array of conservation fields and experience. This study focuses on upcoming issues for biodiversity conservation that are either new or undergoing a marked increase in intensity (i.e. a "step change"). We are unaware of such exercises for any other countries within the African continent.

South Africa shares many traits with other developing countries. There is an exceptionally rich biodiversity, supporting much of the tourism industry, which contributes substantially to employment and GDP (Maia et al. 2011). Challenges include poaching of rare and threatened species by local and international syndicates, and growing human population and urbanisation: between 2007 and 2017, the percentage of people living in cities increased from 60.6 to 65.8%[1]. These factors are linked with declines in biodiversity (Faeth et al. 2012), placing pressure on natural resources and making the effects of environmental disasters pronounced in terms of intensity and the number of people affected. The country's Gini coefficient, a measure of how much an economy deviates from equal distribution of wealth, is currently one of the highest in the world (Sulla and Zikhali 2018), which may exacerbate socio-ecological challenges. Thus in South Africa, there is a confluence of environmental, economic and socio-political challenges, which frame the context of horizon scan issues and our responses to them.

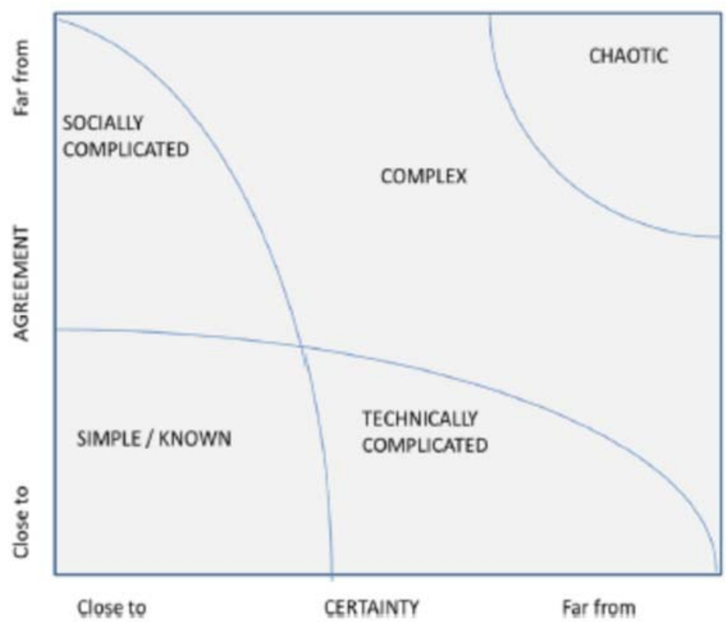

Fig. 1. The axes of certainty of knowledge and agreement among scientists, managers, policy makers and communities can help to identify whether these issues are "simple", "complicated", "complex" or "chaotic", and may help inform appropriate responses Reproduced with permission from Patton (2011)

Uncertainty is inevitable in complex scenarios where the impacts of environmental change have political, socio-economic and ecological dimensions. However, horizon scanning exercises must consider these contexts if they are to guide future responses. Therefore, once we identified key issues, we also assessed the type of response that might inform future scenario planning and pre-emptive management. Specifically, we sought to identify issues that might be solved using science alone and those requiring collaboration across disciplines and stakeholder groups. We did this by categorising issues according to their level of certainty and social agreement, using a modification of Patton's (2011) framework, and adopting the terminology used in that framework (Fig. 1).

For “simple” and “technically complicated” problems, cause and effect are repeatable, with little controversy about the desired outcomes of management options. These “knowable” problems are amenable to evidence-based responses, with recommendations for good practice (Gillson et al. 2019). Most conservation issues are embedded within complex socio-ecological contexts, however, and have economic, social and political dimensions. In “complex” issues, outcomes may be unpredictable owing to emergent properties or shifts in social or ecological states, and stakeholders may differ regarding what constitutes a preferred outcome. In these cases, science alone cannot provide complete responses to emerging issues, and strategies including social, economic and political considerations alongside scientific approaches are needed. Identifying where issues fall on the axes of knowledge and agreement helps inform scenario planning exercises, identifying where engagement beyond science is necessary for policy makers, managers, landowners and other communities. These engagements also allow for inclusion of debate alongside scientific knowledge and encourage transdisciplinary approaches. A state of “chaos” ensues when there is neither consensus nor knowledge.

Our aims were to (1) identify horizon issues for biodiversity in South Africa, either new issues or “step changes” (defined as an increase in intensity) and (2) categorise issues in terms of social “agreement” and the need for scientific “certainty”, to assess the level of complexity and the types of engagement required in response.

Materials and Methods

A group of 17 biodiversity professionals gathered issues considered as arising in the next 5–10 years that might have positive or negative impacts for biodiversity conservation in South Africa specifically, but perhaps also regionally and globally. The group included members of non-governmental organisations, academia, and government departments and organisations, with a wide array of experience.

Each participant, by either consulting their networks or independently, identified 3 to 5 new or intensifying issues, resulting in 63 issues that were circulated to all participants. To avoid bias, four versions of the list were generated by shuffling the sequence of issues so that they did not appear consistently at the beginning, end or middle across the different versions. Each participant received one version of the list and scored each issue out of 1000, with issues that were well known and not important scoring low and those that were either poorly known or about to undergo a “step change”, and crucially important for biodiversity, scoring highly. No issues were to be allocated the same score. Respondents also indicated whether they had heard of an issue. Scores were converted into ranks that were summed to identify the top 32 issues. Participants were allowed to clarify any issues they felt had been misunderstood or to propose new issues they felt were vital for inclusion.

An approach based on the Delphi method (Dalkey and Helmer 1963) was applied to identify a final list of issues, as has been successfully done elsewhere (e.g. Sutherland et al. 2010, 2019a). The Delphi method is an inclusive structured technique that reduces social pressure among participants (Mukherjee et al. 2015). Using this method, the 32 issues, plus one new issue, were discussed at a meeting in Cape Town, South Africa, in October 2018. Before the meeting, each issue was allocated to two participants, neither of whom had proposed the issue, who acted as “cynics” (i.e. to provide a more in-depth assessment). Cynics and the original authors of issues remained anonymous. After timed discussion on each issue, each participant again scored the 33 issues out of 1000. New rankings were calculated, and the 11 highest-scoring issues were identified. Of these, two were coalesced, as there was considerable overlap between them, yielding ten issues.

We assessed the final ten issues as to whether they could be considered “simple”, “complicated”, “complex” or “chaotic” on our framework of knowledge and consensus. Each participant provided a score out of 10 each for “consensus” and “scientific knowledge”. Consensus scores (e.g. degree of agreement between and within various stakeholder groups) were rated such that zero represented relatively little controversy about the desired outcome or way forward, and 10 represented high controversy. Scientific scores were similarly low where the science was considered well known and practicable, or the system relatively simple, with higher scores for technically complicated issues, and very high scores (> 7) for issues considered technically untested or with potentially unanticipated tipping points that could produce surprising consequences. These were used to generate a mean score for each axis and standard error around that mean, plotted on the two axes of agreement and scientific certainty.

Results

We provide a synopsis for each issue, grouped according to common themes, and not according to the rank order.

Issues

Risk of growing populism threatening conservation objectives

Populism is a political approach used to gain support of people who feel their concerns are disregarded by established elites. Populism is on the rise across the globe (Inglehart and Norris 2016), and a recent poll of 23 countries[2] placed South Africa second after Brazil in proportion of respondents who expressed populist beliefs[3]. Populist rhetoric sometimes portrays environmental concerns as opposing the needs of the wider populace for job opportunities, access to resources and growth in gross domestic product. In Europe, this plays out through beliefs about climate change: a third of populist groups refute or are sceptical of anthropogenic climate change (Schaller and Carius 2010). The conflict between environmental concerns and populism could be particularly marked in South Africa, given its struggling economy and high unemployment rate (currently > 25%). However, the large rural populace is directly dependent on ecosystem services and could also be powerful advocates for the environment.

Disaster management leads to short-term decisions where biodiversity is disregarded

South Africa has progressive environmental spatial planning capability, products and legislation. When disasters occur, however, and emergency legislation and decision-making are triggered, environmental considerations may be circumvented (SA National Disaster Management Framework 2005), with unintended and severe consequences for the environment. For example, in the Western Cape Province, severe and prolonged drought spurred drilling for groundwater that threatened unique biodiversity[4]. Fortunately, water management authorities worked with scientists to reassess initial drilling plans, ultimately siting boreholes in less-sensitive areas[5], but such cooperation may not always occur. Although rushed responses to disasters are not new, disasters are expected to escalate in frequency and magnitude, given extreme weather events linked to climate change predictions

(Hewitson and Crane 2006; IPCC 2013). Proactive environmentally aware responses to disasters are crucial for building resilience to extreme events, while ensuring the ability of ecosystems to deliver services for future generations.

Acceleration of land reform and land-use change

Land reform (equitable access to land, security of tenure and restitution) is an incendiary issue in South Africa. Because much biodiversity lies in privately owned land (Gallo et al. 2009), land reform could present threats and opportunities for biodiversity conservation (Kepe et al. 2005). Land reform could reverse recent gains in biodiversity conservation if private conservation areas are transformed to agricultural production. Alternatively, urbanisation and associated land abandonment[6] could present an opportunity to increase conservation on private and public land, enabling community conservation projects, wildlife areas, land rehabilitation and rewilding, with benefits for biodiversity and associated ecosystem services (Stafford et al. 2017). At present, it is difficult to assess how land reform may influence the conservation of biodiversity, although it is likely to have some effect.

Foreign global development goals could threaten local biodiversity

Growing populations and unemployment rates, poorly performing economies and financial inequality put many developing nations under pressure to industrialise and exploit resources. At the same time, global powers aim to boost their trade and access to minerals across new economic and geographic frontiers (Lee 2006; Carmody 2016). Development banks have proliferated in recent years, supporting large infrastructure projects; much of this development may happen at a cost to the environment (Alexander 2014). The G20 estimate that infrastructure capacity required for the world by 2030 will cost US$ 60–70 trillion (Alexander 2014), pointing to an impending infrastructure explosion. Rapid development in richly biodiverse, less-developed regions, including parts of South Africa (e.g. Pondoland[7]), could spell disaster for biodiversity in a step-change fashion.

Domestication and commodification of wildlife could lead to loss of ecosystem functioning

The game industry generates approximately R7 billion (~ US$ 488 million) annually in South Africa from approximately 17 million hectares of privately owned land (Taylor et al. 2016). The South African government aims to further unlock the economic benefits of biodiversity to redress poverty, unemployment and inequality. A pledge of a further R600 million (~ US$ 42 million) over the next three years for game farming activities (e.g. stocking, trading, breeding and hunting; Department of Environmental Affairs 2018) signals support from government, and potentially a step change in the scale of the industry and its biodiversity consequences. Although adding a monetary value to wildlife may benefit biodiversity in certain cases (Di Minin et al. 2016), commodification of high value species without consideration of population and ecosystem impacts pose numerous threats to biodiversity (Cousins et al. 2010; Ripple et al. 2016; Child et al. 2019). Management practices to enhance the commercial value of populations include selective breeding to produce desired traits (e.g. horn length), introduction of species outside their native range and cross-breeding with extra-limital ecotypes or subspecies. Landscape-level interventions include electric fencing, persecution of predators, and habitat alteration to enhance focal species production. These interventions disconnect populations from ecosystems, fragment the landscape, and homogenise ecological communities. The future scale and duration of this issue is uncertain.

However, given that widespread breeding of high value species and variants has increased supply, and thus reduced their value[8], game farming may be less attractive to landowners.

Large increase in impermeable and lethal fencing poses threats to biodiversity

South Africa's burgeoning wildlife ranching industry, lucrative tourism and hunting sectors, stock and crop theft, predation on domestic stock and high contact-crime rate (Taylor et al. 2016; Crime Stats SA 2018) have driven an increase in impermeable fencing throughout urban, agricultural, rural and protected landscapes (Whittington-Jones and Retief 2017). The estimated 6 million km of fencing in the country prevents wildlife migration, dispersal, foraging and mating. Furthermore, fencing technology (i.e. electric fencing and multiple strands of razor and/or barbed wire) is responsible for considerable wildlife mortality, particularly of reptiles, larger bird species and mammals (Beck 2009; Whittington-Jones and Retief 2017). The drivers of fence construction are likely to be sustained or increase. The threats presented by impermeable fencing are not new, but are likely undergoing a step change in South Africa and other countries, within this region. Alterations to fence design could ameliorate mortality risks (Beck 2009; Pietersen et al. 2011) and merit further research.

Extinction of experience and loss of engagement with nature

Two major characteristics of the Anthropocene are the shift in the human population towards towns and cities (Elmqvist et al. 2013) and the rise of information technology. Globally, 55% of people live in urban areas (United Nations 2018), with the most dramatic changes occurring in the developing world. Rapid urbanisation, at a rate of 1.36% per year since the 2000s, has occurred in sub-Saharan Africa. Shifts to urban lifestyles and values and a loss of biodiversity knowledge have increased the disconnect between urbanising populations and the natural world (Balmford and Cowling 2006). At the same time, social media and interactive platforms create an interface that could either increase or decrease the gulf between nature and people (Büscher 2016). Virtual experiences (e.g. virtual hiking trails on Google Earth) could either supplant physical engagement with nature (Arts et al. 2015), or encourage an interest and concern about environmental problems. While the extinction of experience is globally relevant and not novel, a step change is proposed for South Africa and the region driven by increasing urbanisation and access to information technologies.

Using nudging to change behaviour to the benefit of conservation of resources and biodiversity

"Nudging"—the use of positive reinforcement to influence people's decision-making—is widely used in marketing, but remains unexplored for use in advancing biodiversity conservation (Reddy et al. 2017). Incentivising pro-environmental behaviour through green consumerism, regulation or rational argument, may not always bring about desired changes in behaviour. People inherently avoid making difficult decisions, so nudging them towards choices most beneficial to biodiversity or sustainability can reduce the cognitive "cost" of behaviour change. During the drought of 2015–2018, the City of Cape Town used several "nudges" to reduce water consumption. These included online resources such as a water-level dashboard and an interactive map that identified compliant and non-compliant neighbourhoods and households. Publicly recognising households for water conservation or appealing to certain high-use households to act in the public interest were the most effective nudges (Brick et al. 2018). In Canada, nudging is used to make individuals aware of their carbon footprint and encourages them to make lower carbon choices (Murray and Rivers

2015; Guzman and Clapp 2017). Nudging in the form of interactive dashboards on mobile apps and gamification could transform consumer behaviours in South Africa for various conservation concerns.

Technological advances for monitoring invertebrates and informing their conservation

Recent research has sparked concern about the possible global decline of insects (Hallmann et al. 2017; Leather 2018; Sánchez-Bayo and Wyckhuys 2019). Such losses will have severe consequences for ecosystems because of the central role of insects in food webs and ecological functions (Losey and Vaughan 2006). Monitoring insects using new technology could allow assessment of insect distributions and abundances over time, generating much-needed data to inform and galvanise conservation strategies. Radar and LIDAR are two examples of methods to detect insects remotely (Chapman et al. 2004; Brydegaard et al. 2016; Bombi et al. 2019). Specifically, data from weather radar scans, in which invertebrates appear as "white noise", could be used to detect flying insects and has the potential to generate time-series data on insect abundances and distributions. Research is already underway, in a collaboration between physicists and biologists, to use weather radar in this way[9].

A One Health approach to minimise the risks of infectious diseases for biodiversity conservation

In South Africa, wildlife-based activities such as eco-tourism, game breeding, translocation and hunting have grown in popularity (Bekker et al. 2012). This increases interactions between wildlife, domestic or agricultural animals and humans, raising the risk of infectious diseases spreading among species. There have been several cases of emerging infectious diseases (EIDs) including anthrax, botulism, brucellosis, rabies, toxoplasmosis, and tuberculosis in several species of wildlife in South Africa (Bekker et al. 2012). The likelihood of unexpected outbreaks increases with declining scavenger populations (O'Bryan et al. 2018) and climate change, which alters the distributions of disease vectors (Thomson et al. 2018). A One Health Program has been established in South Africa and aims to reduce morbidity and mortality in humans as well as animals. The One Health approach will improve wildlife disease diagnostic assays and establish robust programmes for monitoring, surveillance (Miller et al. 2017) and epidemiology of infectious wildlife diseases.

Position of issues along axes of scientific knowledge and social agreement

Most of the final issues emerged as "complex", when mapped on to axes of scientific certainty and social agreement (Fig. 2), i.e. scientific knowledge is incomplete or uncertain, and there are relatively low levels of social agreement. Exceptions to this were nudging and use of weather radar to monitor (WRM) invertebrates. For these two, social agreement was high, but in the case of WRM, the level of scientific expertise required was also high. Fortunately, no issues were considered truly chaotic.

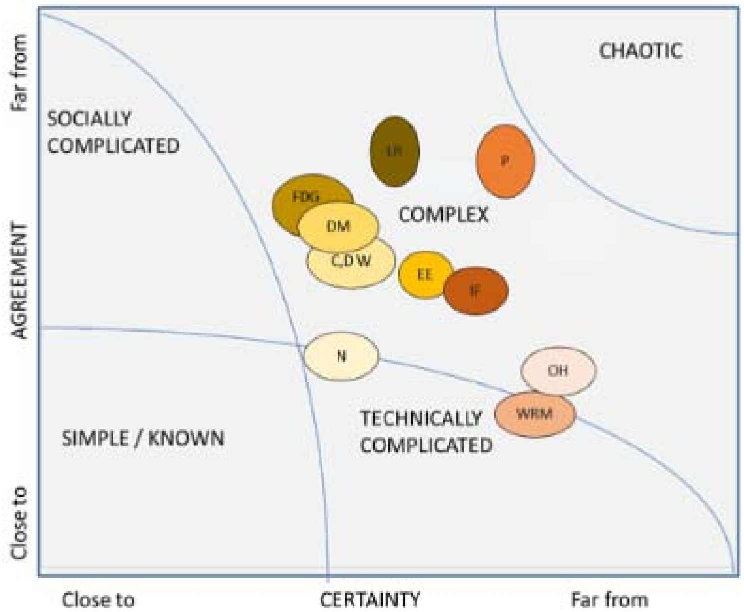

Fig. 2 Mapping of shortlisted issues onto axes of agreement and scientific certainty. We positioned issues along the axes guided by scores between 0 and 10, where 10 represents very little consensus on an issue and high uncertainty in the science. The issues are mapped with the centre of the ovals as the mean score, and the x and y values for the ovals are based on the standard errors along two axes. The issues are abbreviated as follows: *C, D W* commodification and domestication of wildlife, *DM* disaster management, *EE* extinction of experience, *FDG* foreign development goals, *IF* impermeable fencing, *LR* land reform, N nudging, *OH* a One Health approach to disease management, *P* rising populism, *WRM* Weather Radar Monitoring to assess invertebrate distributions and population dynamics

Discussion

This is the first horizon scan for biodiversity conservation in South Africa, and to our knowledge, for the African continent. Many of the issues are relevant to other countries in the region, if not the continent, given the shared socio-economic and biodiversity characteristics of many African countries. An innovation on previous horizon scans is the categorisation of horizon issues along axes of scientific certainty and social agreement, with the aim of guiding appropriate responses. Almost all of the issues fell between medium to high levels for one or both of scientific certainty or social lack of agreement, meaning that most were "complex" (Fig. 2). This suggests that science alone will not be sufficient to address the issues, but that social, economic, educational and political factors will be needed.

Figures 1 and 2 are used to provide guidance on how issues should be tackled. Issues that fall into the bottom left of the figures can be tackled with current knowledge, those in the top left quadrant require more consensus before action is taken, those in the bottom right require more scientific evidence before formulating an intervention, and those in the top right quadrant require both research and consensus and thus cannot be acted on immediately. Our horizon scan identified no issues that can be acted on with existing knowledge as yet, two which require some additional scientific research, and eight that will require more technical research as well as social agreement (Fig. 2). The issues differ in the degree of importance of technical versus social agreement, and none of the issues falls into the top right corner ("chaos"), where little is known and agreement is almost non-existent.

Of the ten shortlisted issues, four highlight the key role for technological advances, notably detection, diagnosis and monitoring of emerging infectious diseases, improved monitoring of declining invertebrate populations (using WRM), and enhanced fencing technology to reduce wildlife mortality associated with impermeable fencing. The fourth, growing populism, also scored highly from a scientific uncertainty view, likely because its development and unanticipated effects for conservation of biodiversity are difficult to predict.

For issues with fairly good social consensus (invertebrate monitoring and infectious wildlife diseases), solutions are primarily technical and can be resolved chiefly by advances in scientific research and technology. New technology is already being developed to address these issues, and this horizon scan can raise awareness about the availability of these technologies, stimulate further advances and perhaps encourage further innovation, funding, and collaboration between disciplines. Consensus is high for these two issues, possibly because invertebrate decline is now recognised globally (e.g. Hallmann et al. 2017; Lister and Garcia 2018; Sánchez-Bayo and Wyckhuys 2019), and of particular concern in megadiverse countries such as South Africa. Technologies to address wildlife disease are applicable worldwide, although there is sometimes conflict around wildlife being viewed as a possible reservoir for disease, despite disease often originating from humans or livestock (e.g. De Garine-Wichatitsky et al. 2017).

Most (seven of ten) issues had relatively low social agreement, highlighting the future importance of social engagement, and interdisciplinary and transdisciplinary approaches for addressing their biodiversity impacts. In addition to land reform, the global juggernauts of populism and foreign development goals are associated with high levels of social disagreement. Our uncertainty about these is also reflected in the relatively high standard errors for these issues (Fig. 2). Science may play a relatively minor role in the courses of these issues. In the case of populism, policy makers, scientists or the proponents of international conventions may be construed as an elite group with agendas far from the concerns of ordinary people. Likewise, the potential economic and social benefits of foreign investment, in a region wracked by poverty and unemployment, could easily overwhelm environmental concerns. Similarly, disaster management can place immediate needs of affected communities first, with little regard given to long-term negative implications for biodiversity and ecosystem services. Robust science can inform the environmental impacts of certain choices, but improved management will require collaboration across fields, including politics, education and communication.

Extinction of experience and commodification of wildlife have strong roles for science but also little consensus. Sensationalising nature could devalue the real experience of biodiversity. A loss or an increase in direct engagement with nature is also socially complicated. Although increasing direct engagement with nature may enhance opportunities for education, recreation and tourism revenue, it can also lead to damage to biodiversity if poorly managed. Nudging emerged with the greatest social agreement and scientific knowledge. High social agreement may be because nudging is already widely used in other fields (e.g. marketing and public health). From a scientific research point of view, however, there remains considerable room for further studies on how nudging might best be used to achieve positive conservation outcomes, particularly in collaboration with researchers from other fields (e.g. psychology and marketing).

Horizon scans are driven by a consensus between group members as to the issues most relevant to conservation of biodiversity at the time of the scan. These scans do not seek to systematically address all ecosystem types and fields of study, but we took care to ensure that participants in this scan included representatives from various sectors working across diverse topics and ecosystems, to capture as wide a range of issues as possible. A different team might have identified a different list of issues, but it is likely that many issues on this list would have emerged, regardless. It is possible that issues may have moved on the agreement/certainty axes had the placement of issues along those axes also been subjected to a Delphi approach. We did not use a Delphi approach for this part of the exercise, because we wanted to capture the degree of uncertainty within the group about these two axes of scientific certainty and social consensus. Future horizon scans assessing issues along these axes could consider using both approaches to see whether more issues move out of the "complexity" (middle) zone into other parts of the framework as consensus is reached using the Delphi approach.

As a way forward, we suggest that strategic scenario planning exercises are used to identify the best responses to the issues highlighted. This will bring together diverse stakeholder groups to explore possible alternative pathways, enhancing social agreement. Furthermore, the identified issues highlight areas that require capacity development and planning. Some of the topics are borrowed from other fields (e.g. nudging), but may offer exciting opportunities if adapted to local conservation science. The novelty of our approach has been the attempt to distinguish issues that can primarily be resolved using science and technology from those that require collaboration between science and other sectors. Our findings highlight that science alone will rarely be the sole means for addressing biodiversity challenges and opportunities. That most of the horizon issues fell within the domain of complexity, where outcomes are uncertain and social disagreement is high, means that strategic communication, education and engagement with public and policy makers will need to be prioritised.

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Footnotes

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