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LETTER

How many bird and mammal extinctions has recent conservation action prevented?

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Abstract

Aichi Target 12 of the Convention on Biological Diversity (CBD) contains the aim to 'prevent extinctions of known threatened species'. To measure the degree to which this was achieved, we used expert elicitation to estimate the number of bird and mammal species whose extinctions were prevented by conservation action in 1993–2020 (the lifetime of the CBD) and 2010–2020 (the timing of Aichi Target 12). We found that conservation action prevented 21–32 bird and 7–16 mammal extinctions since 1993, and 9–18 bird and two to seven mammal extinctions since 2010. Many remain highly threatened and may still become extinct. Considering that 10 bird and five mammal species did go extinct (or are strongly suspected to) since 1993, extinction rates would have been 2.9–4.2 times greater without conservation action. While policy commitments have fostered significant conservation achievements, future biodiversity action needs to be scaled up to avert additional extinctions.

KEYWORDS

Aichi biodiversity target 12, Convention on Biological Diversity, Delphi method, extinction risk, species conservation, IUCN Red List

1 | INTRODUCTION

The Parties to the Convention on Biological Diversity (CBD) adopted an ambitious strategic plan for 2011–2020, comprising 20 'Aichi Biodiversity Targets'. Target 12 states that '*By 2020, the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained*'. A mid-term assessment concluded that further extinctions were likely by 2020, but that conservation measures had prevented some extinctions (CBD, 2014).

Considering compelling evidence of a continued deterioration of the state of nature under increasing pressures (Díaz et al., 2019; IPBES, 2019), investigating the impact of conservation efforts is key to evaluating whether we have the knowledge and techniques to reverse negative trends, and to galvanise further action. Previous assessments of conservation impact investigated whether trends in extinction risk would have changed if no species had improved in conservation status (Hoffmann et al., 2010; Szabo, Butchart, Possingham, & Garnett, 2012), or if no conservation actions had taken place (e.g., Hoffmann et al., 2015; Young et al., 2014). Butchart, Stattersfield, and Collar (2006) estimated which bird species would have gone extinct without conservation action during 1994–2004 based on expert knowledge. Looking ahead, green listing will provide standardised methods to quantify species recovery (Akçakaya et al., 2018).

Here, we build on these studies to quantify the extent to which the commitment to prevent '*the extinction of known threatened species*' was achieved. Our aim was to identify those species for which there is high certainty that conservation action prevented their extinction. We focused on birds and mammals as some of the best documented taxonomic classes on the International Union for Conservation of Nature (IUCN) Red List of threatened species (hereafter Red List). We considered two time periods: 1993–2020 (the lifetime of the CBD) and 2010–2020 (approximately the timing of Aichi Target 12).

2 | METHODS

We identified a list of bird and mammal species for which conservation action prevented extinction by (a) identifying candidate species that could plausibly have gone extinct (i.e., the death of the last individual in the wild) without conservation action; (b) documenting for these species the key information needed to evaluate whether the actions implemented could plausibly have prevented their extinction; (c) using a Delphi technique to estimate the probability that each candidate species would have gone extinct in a counterfactual scenario without conservation action; and (d) retaining species with a high probability that conservation action prevented their extinction. We combined our results with the number of known extinctions to quantify the effect of conservation action on observed extinction rates. For full details of methods, see the Supporting Information.

2.1 | Identifying and documenting candidate species

To be included as candidates, species had to be listed as extinct in the wild, critically endangered or endangered on the Red List at any time since 1993, with ongoing threats to their persistence and with conservation actions implemented. We examined all bird and mammal species. First, species currently classified as extinct in the wild would be extinct without captive breeding; therefore, we considered them to have 100% probability that extinction was prevented. Second, among critically endangered and endangered species, we retained those with fewer than 250 mature individuals at any point since 1993, leaving 368 bird and 263 mammal species. Third, of those species, we used information in the species' Red List accounts to identify those with persistent threats, and implemented conservation actions, leaving 48 bird and 25 mammal species. Fourth, we compiled standardised information for these 73 species on their population size and trends in 1993, 2010 and in the latest assessment year, and on threats and conservation actions. We also summarised what we considered to be key arguments that the species would have gone extinct without conservation action. Taxon experts reviewed this information. Based on their feedback, we reduced the final candidate list to 39 bird and 21 mammal species for 1993–2020, and 23 bird and 17 mammal species for 2010–2020. Our resulting candidate list therefore represents a suite of species that we adjudge to have benefited positively from conservation actions at some point since 1993. All excluded species were considered to have 0% probability that conservation action prevented extinction.

2.2 | Delphi exercise

We asked 28 bird and 26 mammal evaluators (all authors of this publication) to estimate independently and anonymously the probability that each candidate species would have gone extinct in the wild without conservation action. We used a Delphi expert elicitation technique following the IDEA protocol (*Investigate, Discuss, Estimate,* *Aggregate*; Hemming, Burgman, Hanea, McBride, & Wintle, 2018), which is based on Delphi techniques (Mukherjee et al., 2015). Specifically, we asked evaluators three questions for each time period: *Realistically, what do you think is the (1) lowest plausible probability; (2) highest plausible probability; and (3) best estimate for the probability that conservation action prevented extinction for this species during the period (i.e., what is the probability that, if action had ceased in 1993/2010, and no subsequent actions were implemented, the species would have gone extinct in the wild by 2020)?*

To answer these questions, evaluators were instructed to use the information summarised for each species and any other information they had access to, and to assume that all conservation action would have ceased at the start of the period.

We aggregated the results across evaluators for each species and time period, by calculating the median lowest (question 1), highest (question 2) and best estimate (question 3) of probabilities that extinction was prevented (von der Gracht, 2012). We calculated agreement by defining seven classes of probability (Table S1), with high agreement if >50% of evaluators had placed their estimates within the same class, medium agreement if >50% of evaluators had placed their estimates within two adjacent classes and low agreement otherwise. These results were shared with all evaluators, followed by teleconference calls in which evaluators discussed each species in turn. Evaluators could then revise their scores (independently and anonymously) to incorporate insights gained during the calls. We then calculated final median scores (Table S7).

2.3 | Analysis

We summarised the median scores as the number of species whose extinction was prevented as *X*–*Y*, with *X* representing species with a median best estimate ≥90% that extinction was prevented and *Y* representing species with a median best estimate >50%, following an analogous approach for defining extinct and critically endangered (possibly extinct) species (Butchart et al., 2018). For all species with a median best estimate >50% for 1993–2020, we analysed their distribution, threats, actions implemented, current Red List category and current population trend, as documented on the Red List. Finally, we compared the total number of these species with numbers of species confirmed or strongly suspected to have gone extinct in the same period (Tables S2 and S3).

3 | RESULTS

3.1 | Prevented bird extinctions

Of 39 candidate bird species for the 1993–2020 period, 15 had a median best estimate ≥90% that their extinction was prevented, of which 11 had high and four had medium agreement (Figure 1a), with a further 11 species having a median best estimate >50% (three had high and eight had medium agreement). Including six additional species listed as extinct in the wild during the time period (Table S4), we consider that 21–32 bird species would have gone extinct without conservation during 1993–2020. In contrast, there were 10 confirmed or suspected extinctions since 1993 (Table S2). Hence, in the absence of conservation, the total number of bird extinctions since 1993 would have been 3.1–4.2 times higher (31–42 vs. 10) (Table S3).

Of 23 candidate bird species for 2010–2020, three had a median best estimate ≥90% that their extinction was prevented (Figure 1b), with a median best estimate >50% for a further nine species. Agreement among evaluators for these 12 species was high for one and medium for 11 species. Including six species listed as extinct in the wild, we consider that 9–18 bird species would have gone extinct without conservation during 2010–2020. In contrast, one bird species went extinct since 2010 (Table S2). Overall, the number of bird extinctions since 2010 would have been 10–19 times higher without conservation (10–19 vs. 1) (Table S3).

3.2 | Prevented mammal extinctions

Of 21 candidate mammal species for 1993–2020, four had a median best estimate ≥90% that their extinction was prevented (Figure 2a), and a further nine a median best estimate >50%. Agreement among evaluators for these 13 species was high for eight and medium for five species. Three species were listed as extinct in the wild during the time period (Table S4). Hence, we consider that 7–16 mammal species would have gone extinct without conservation during 1993–2020. Given that five mammal species are confirmed or suspected to have gone extinct since 1993 (Table S2), the number of mammal extinctions since 1993 would have been 2.4–4.2 times higher without conservation (12–21 vs. 5) (Table S3).

Of 17 candidate mammal species for 2010–2020, none had a median best estimate of ≥90% that their extinction was prevented and five had a median best estimate >50% (Figure 2b). Agreement among evaluators for

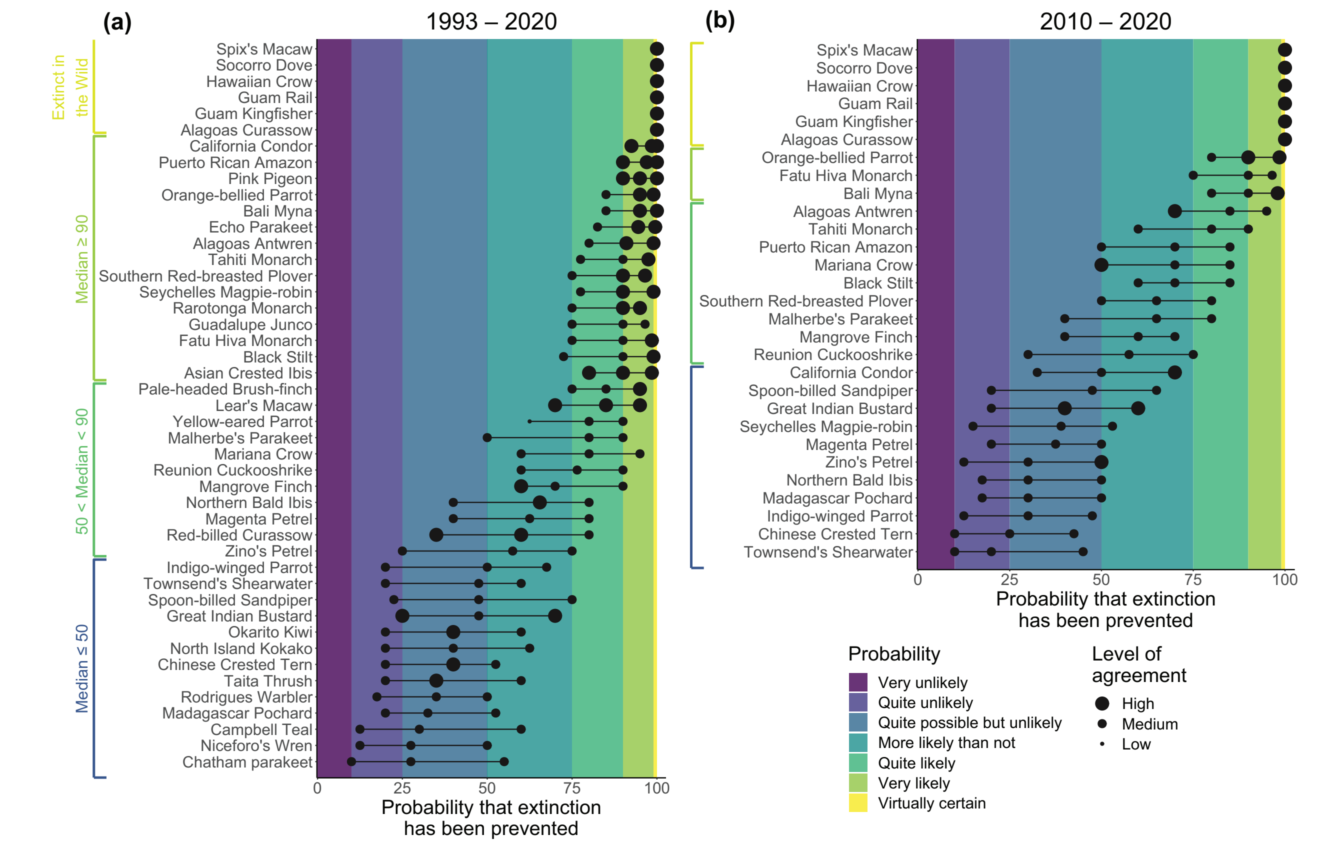

FIGURE 1 Probability that extinction of bird species would have occurred in the absence of conservation action during (a) 1993–2020 ($N = 45$ species) and (b) 2010–2020 ($N = 29$ species). Values represent medians calculated from estimates by 28 evaluators, except for species that are extinct in the wild, which were set at 100%. For a description of the probability categories see Table S1, based on Keith et al. (2017). Guam Rail was assessed as extinct in the wild until 2016, but was translocated and assessed as critically endangered by 2019 (BirdLife International, 2020). We therefore set its probability to 100% for both time periods

these five species was high for one and medium for four species. Including two species listed as extinct in the wild, we consider that 2–7 mammal species would have gone extinct without conservation during 2010–2020. No mammal species have been documented to have become extinct since 2010, so for this group all extinctions have been prevented by conservation.

These numbers of prevented extinctions are broadly consistent with values obtained by summing the median best estimates across all candidates (analogous to the approach for estimating the number of extinctions proposed by Akçakaya et al., 2017): 32.9 bird and 15.9 mammal species in 1993–2020, and 18.7 bird and 9.0 mammal species in 2010–2020.

3.3 | Characteristics of species whose extinction was prevented

The 32 identified bird species whose extinction was likely prevented during 1993–2020 occur (or occurred, for extinct in the wild species) in 25 countries, including six in New Zealand, five in Brazil and three in Mexico (Figure 3a); 65% are restricted to islands (excluding mainland Australia). The 16 identified mammal species occur in 23 countries, including five in China and three in Vietnam and the United States, respectively (Figure 3b); 19% are restricted to islands.

Of the 32 identified bird species, 16% are currently classified as extinct in the wild, 47% as critically endangered, 28% as endangered and 9% as vulnerable, with 53% having increasing or stable populations (Figure 4a). Of the 16 identified mammal species, 13% are extinct in the wild, 56% critically endangered and 31% endangered (Figure 4b), with 31% having increasing or stable populations.

The most frequent current and past threats to the 32 identified bird species are invasive species, followed by habitat loss through agriculture and aquaculture, and hunting (impacting 78%, 56% and 53% of species, respectively) (Figure 5a). The most frequent threats to the 16 identified mammal species are hunting, agriculture and

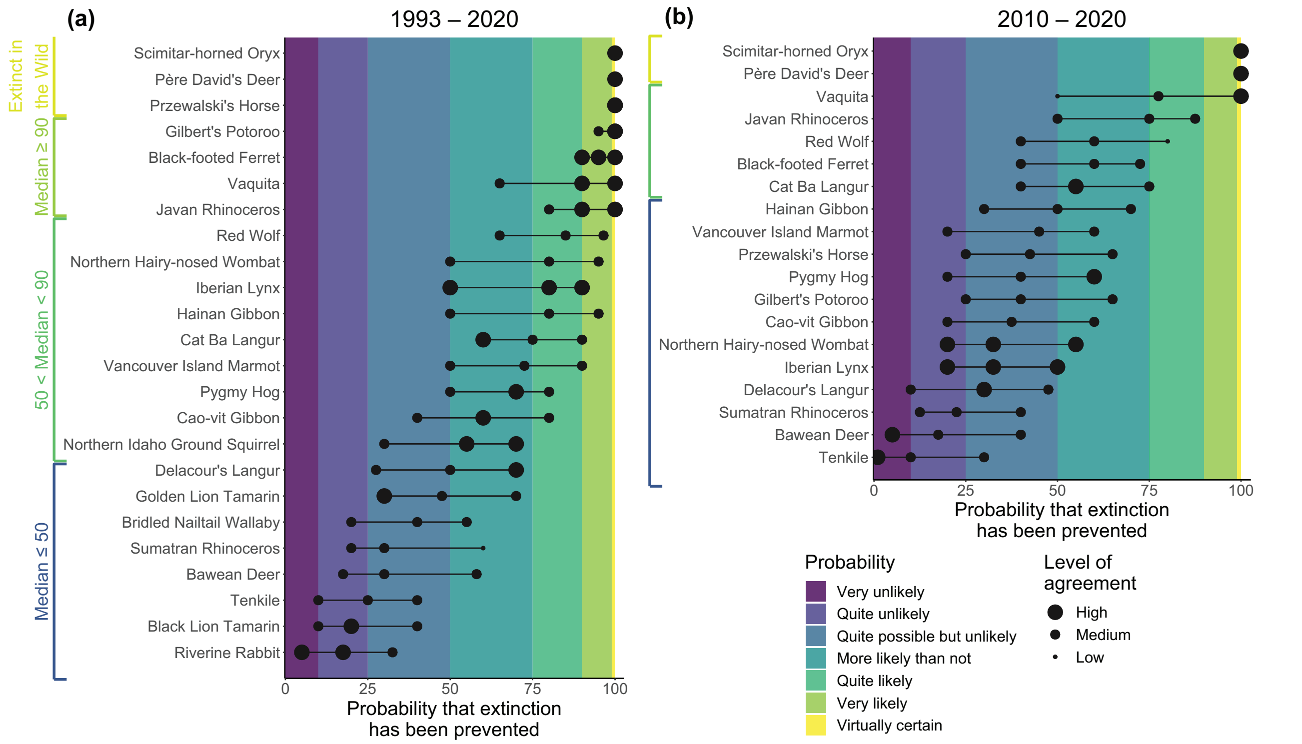

FIGURE 2 Probability that extinction of mammal species would have occurred in the absence of conservation action during (a) 1993–2020 ($N = 24$ species) and (b) 2010–2020 ($N = 19$ species). Values represent medians calculated from estimates by 26 evaluators, except for species that are extinct in the wild, which were set at 100%. For a description of the probability categories see Table S1, based on Keith et al. (2017). Przewalski's Horse was assessed as extinct in the wild in 1996, but was reintroduced and assessed as critically endangered by 2008. We therefore set its probability to 100% for 1993–2020, but asked evaluators to assess its probability for 2010–2020

aquaculture, and invasive species (impacting 75%, 75% and 50% of species, respectively) (Figure 5b).

The most frequently implemented actions for the 32 identified bird species were invasive species control, ex situ conservation, and site/area protection (for 66%, 63% and 59% of species, respectively) (Figure 6a). For the 16 mammal species, the most frequent actions were legislation, reintroductions and ex situ conservation (for 88%, 56% and 56% of species, respectively) (Figure 6b).

4 | DISCUSSION

Our results indicate that the extinction of at least 28–48 bird and mammal species was prevented between 1993–2020, and of 11–25 bird and mammal species between 2010–2020. At the same time, 15 confirmed or strongly suspected bird and mammal extinctions were documented since 1993, including one since 2010 (Alagoas Foliage-gleaner *Philydor novaesi*). Hence the number of extinctions would have been at least 2.9–4.2 times higher for 1993–2020, and 12–26 times higher for 2010–2020. Further extinctions since 2010 may come to light due to time-lags before detecting extinctions (Butchart et al., 2018). If the rate of extinctions observed in 1993–2009 (8.2/decade) is found to have continued during 2010–2020, the number of extinctions without conservation would still be two to four times higher (19.2-33.2 vs. 8.2). Our counterfactual analyses therefore provide a strikingly positive message that conservation has substantially reduced extinction rates for birds and mammals.

Our analyses underestimate the impact of conservation in several ways. First, our process to identify candidate species may have potentially missed some species whose extinction was prevented, such as endangered species that are rapidly declining. Others may have been missed owing to lack of information (for example, critically endangered species tagged as possibly extinct, whose continued survival is uncertain). Second, we used the definition of extinction (the death of the last individual) adopted by IUCN (2012). Without conservation in the time periods considered, some additional long-lived species may have become functionally extinct. Third, we considered only birds and mammals, yet an additional 70 species in other taxa are listed as extinct in the wild on the Red List (IUCN, 2020). These would be extinct without ex situ efforts, while other extant species would have gone extinct without in-situ efforts. Lastly, we examined only species at the brink

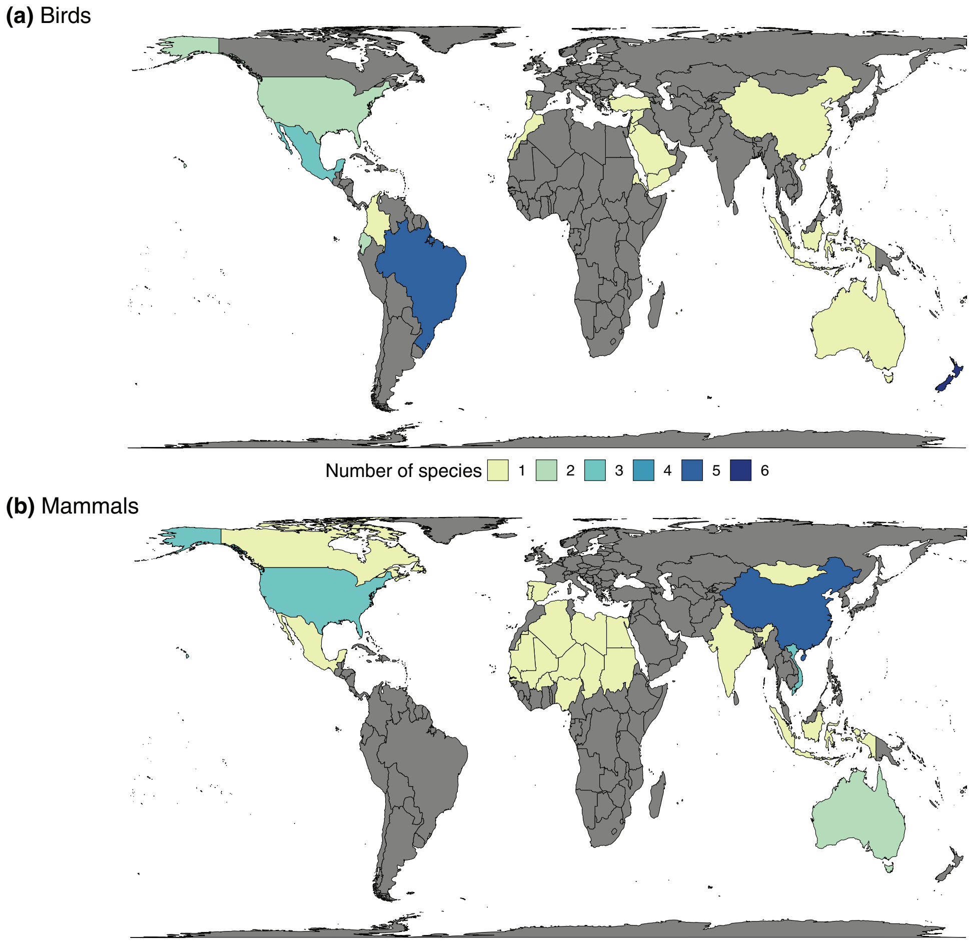

FIGURE 3 Number of (a) bird ($N = 32$) and (b) mammal ($N = 16$) species for which extinction is likely to have occurred (i.e., median probability >50%) in the absence of conservation action during 1993–2020, per country. Squares show small island nations and overseas territories, and are coloured according to the key. Species listed as extinct in the wild (IUCN, 2020) were mapped in the last countries where they occurred, or are presumed to have occurred

of extinction: a large number of other species would have deteriorated in conservation status in the absence of conservation (Hoffmann et al., 2010; 2015).

Conversely, not all species we identified as prevented extinctions are conservation successes, and we did not investigate the future survival prospects of the species. For example, for the Vaquita *Phocoena sinus*, of which just six individuals were known to remain in September 2018 (Jaramillo-Legorreta et al., 2019), conservation may have slowed the catastrophic decline but appears to be failing to halt it.

The conservation actions implemented for species whose extinctions were prevented echo the respective main threats. The most frequent threat to birds was invasive species, and management of invasive species was the key response. For mammals, the prominence of legislation as a conservation action likely reflects efforts to curb the main threat of hunting and collecting. Site/area protection are featured frequently as actions for both taxa, considering that agriculture and aquaculture, logging and residential development are persistent threats. The importance of ex situ conservation and reintroductions reflects the large numbers of species whose persistence has relied on captive-bred populations, sometimes completely (for the extinct in the wild species, Table S4), or for translocations and population reinforcements (Table S6). Two formerly extinct in the wild species have been the subject of successful conservation translocations since 1993: Przewalski's Horse *Equus ferus* and Guam Rail *Hypotaenidia owstoni*.

We investigated conservation actions associated with avoided extinctions, but not specifically which actions worked for individual species, or the effectiveness of the actions. Similarly, we did not investigate what conservation actions took place for those species that did go extinct since 1993.

Assessing the probability that species would have gone extinct under a counterfactual scenario inherently involves

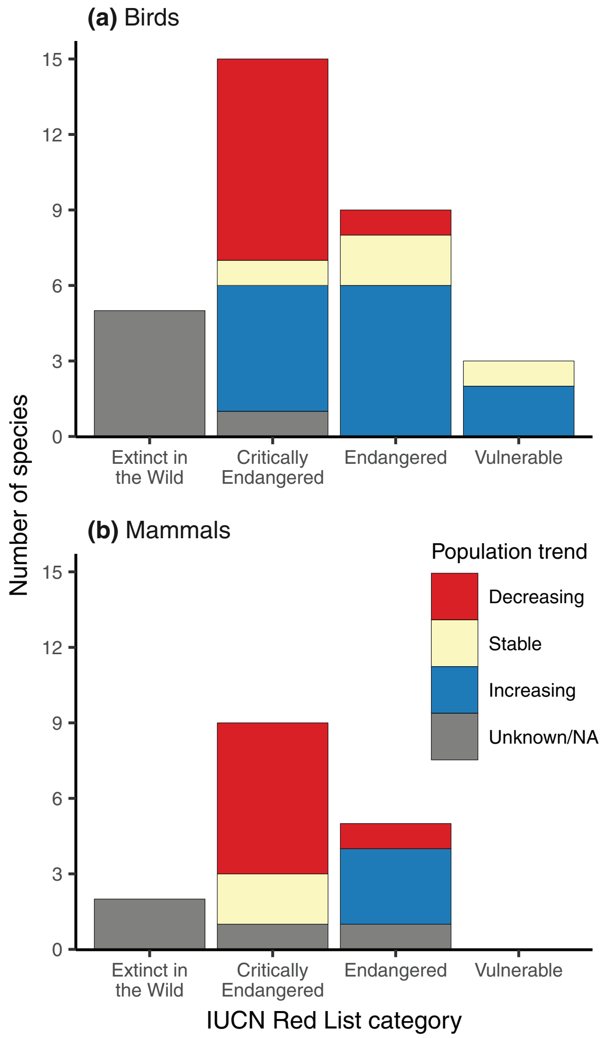

FIGURE 4 2019 IUCN Red List categories and population trends of (a) bird ($N = 32$) and (b) mammal ($N = 16$) species for which extinction is judged to have been likely (i.e., median probability >50%) to have occurred in the absence of conservation action, during 1993–2020

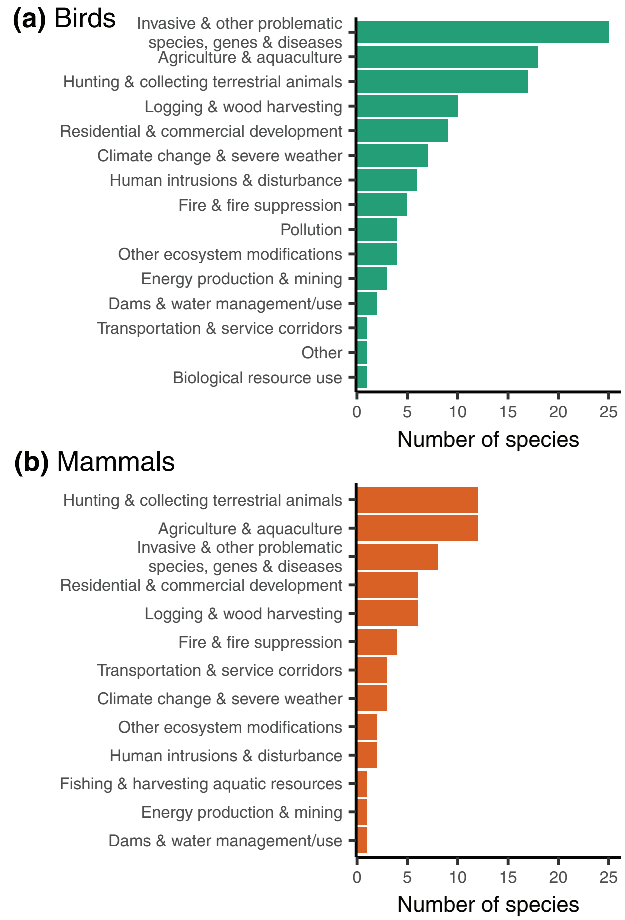

FIGURE 5 Current and past threats to (a) bird ($N = 32$) and (b) mammal ($N = 16$) species for which extinction is judged to have been likely (i.e., median probability >50%) to have occurred in the absence of conservation action during 1993–2020, as identified through the Red List. Threats are taken from the IUCN threat classification scheme level 1 (Salafsky et al., 2008)

a degree of uncertainty. Judgements are more certain with better information available, and it is possible that we missed information that would have changed the probabilities assigned to species. We attempted to minimise this risk by starting with all Red List assessments of bird and mammal species, incorporating up to date information from 124 species experts, and asking each evaluator to examine more thoroughly a small subset of species prior to the calls. We undertook two calls per taxon, with largely different sets of evaluators per call. As slightly different information was discussed during each call, there were some differences in probability estimates between calls. To reduce this effect, we relayed information gained during the first call to evaluators on the second call, but in some cases new information came to light during the second call (see Supporting Information). However, differences between calls had little effect on the overall results. Two mammal species had an overall probability ≤50%, but would be included (i.e., an estimate >50%) based on scores from the second call only, and two bird and one mammal species had an overall probability >50%, but would be excluded (i.e., an estimate ≤50%) based on scores from the second call only.

The costs of conservation actions undertaken for each species were not known. Quantifying these investments and comparing them with investments for species that did go extinct, should be prioritised for future research.

Our results show that despite the ongoing loss of biodiversity, a substantial number of extinctions was prevented since the inception of the CBD. While Aichi Target 12 has not been met (Díaz et al., 2019), the rate of extinctions since its adoption would have been at least twice as high (and potentially an order of magnitude higher) without conservation action. These actions were implemented by a

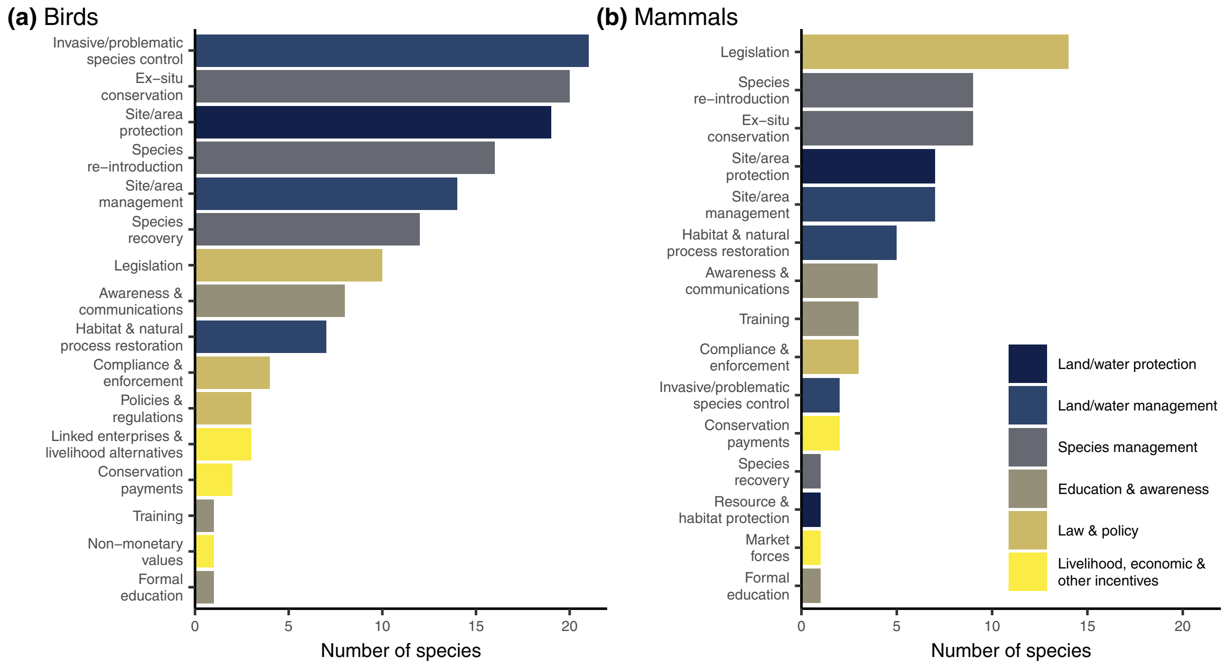

FIGURE 6 Conservation actions for (a) bird ($N = 32$) and (b) mammal ($N = 16$) species for which extinction is judged to have been likely (i.e., median probability >50%) to have occurred in the absence of conservation action during 1993–2020. Actions are taken from the IUCN action classification scheme level 2, while colours denote level 1 (Salafsky et al., 2008). Both in-situ and ex situ actions are included for species that are extinct in the wild

combination of governments, Non-Government Organisations, zoos, scientists, volunteers and others. Nevertheless, the species we identified remain highly threatened, and most require continued substantial conservation investment to ensure their survival. Given the ongoing scale and projected growth in pressures on biodiversity (IPBES, 2019), considerably greater efforts are needed to prevent the extinction and improve the status of the 6,811 species currently assessed as critically endangered on the Red List (IUCN, 2020). Our results should motivate the world's governments currently negotiating goals and targets on nature conservation in the CBD's post-2020 global biodiversity framework to redouble their commitments to prevent extinctions. Not only is this hugely important (Gascon et al., 2015) but also, as we have demonstrated here, eminently feasible.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

The study was conceived and designed by Friederike C. Bolam, Stuart H.M. Butchart, Louise Mair, Mark Burgman, Michael Hoffmann, Philip J.K. McGowan and Ana S.L. Rodrigues. Friederike C. Bolam, Louise Mair, Philip J.K. McGowan, Claudia Hermes, Rob W. Martin, James R.S. Westrip, Hannah Wheatley and Marco Angelico undertook the first filtering of candidate species. Friederike C. Bolam, Stuart H.M. Butchart and Louise Mair compiled information per candidate species. All authors participated in the Delphi exercises for birds and/or mammals, that is, they reviewed the information across all species and estimated the probabilities that each species would have gone extinct without conservation. The following authors took part in the Delphi exercise for birds: Friederike C. Bolam, Louise Mair, Claudia Hermes, Michael Hoffmann, Rob W. Martin, Philip J.K. McGowan, Ana S.L. Rodrigues, Hannah Wheatley, Yuliana Bedolla-Guzmán, Matthew F. Child, Peter A. Cranswick, Birgit Fessl, Stephen T. Garnett, Jim J. Groombridge, John F. Lamoreux, Alexander C. Lees, Luc Lens, Simon P. Mahood, David P. Mallon, Federico Méndez-Sánchez, Luis Miguel Renjifo, Malin C. Rivers, Roger J. Safford, Paul Salaman, Tom Squires, James R.S. Westrip, Richard P. Young and Stuart H.M. Butchart. The following authors took part in the Delphi exercise for mammals: Friederike C. Bolam, Louise Mair, Thomas M. Brooks, Michael Hoffmann, Philip J.K. McGowan, Ana S.L. Rodrigues, Carlo Rondinini, Javier Calzada, Matthew F. Child, Christopher R. Dickman, Diana O. Fisher, Christopher N. Johnson, Rosalind J. Kenerley, Sarah R.B. King, John F. Lamoreux, David P. Mallon, Erik Meijaard, Alexandre Reis Percequillo, Tracey J. Regan, Nicolette S. Roach, Lizanne Roxburgh, Ella Vázquez-Domínguez, Piero Visconti, John C.Z. Woinarski, Richard P. Young and Stuart H.M. Butchart. All authors reviewed and commented on the draft manuscript and approved the final text. This study also benefited from the input of external experts who reviewed and corrected when needed the information compiled for each candidate species. They are listed in the acknowledgements.

ETHICS STATEMENT

This research has been granted approval by the Newcastle University Ethics Committee (Reference 15388/2018).

DATA ACCESSIBILITY STATEMENT

All code and data can be found at http://github.com/rbolam/Prevented_bird_and_mammal_extinctions.

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REFERENCES

Akçakaya, H. R., Keith, D. A., Burgman, M., Butchart, S. H., Hoffmann, M., Regan, H. M., … Boakes, E. (2017). Inferring extinctions III: A cost-benefit framework for listing extinct species. *Biological Conservation*, *214*, 336–342.

Akçakaya, H. R., Bennett, E. L., Brooks, T. M., Grace, M. K., Heath, A., Hedges, S., … Mallon, D. P. (2018). Quantifying species recovery and conservation success to develop an IUCN Green List of Species. *Conservation Biology*, *32*(5), 1128–1138. https://doi.org/10.1111/cobi.13112

BirdLife International. (2017). Apteryx rowi. The IUCN Red List of Threatened Species 2017: E.T22732871A119169794. Retrieved from https://doi.org/10.2305/IUCN.UK.2017-3.RLTS.T22732871A119169794.en

BirdLife International. (2019). Hypotaenidia owstoni. The IUCN Red List of Threatened Species 2019: E.T22692441A156506469. Retrieved from https://doi.org/10.2305/IUCN.UK.2019-3.RLTS.T22692441A156506469.en

BirdLife International. (2020). IUCN Red List for birds. Retrieved from http://www.birdlife.org (accessed 10 February 2020).

Butchart, S. H., Stattersfield, A. J., & Collar, N. J. (2006). How many bird extinctions have we prevented? *Oryx*, *40*(3), 266–278. https://doi.org/10.1017/S0030605306000950

Butchart, S. H., Lowe, S., Martin, R. W., Symes, A., Westrip, J. R., & Wheatley, H. (2018). Which bird species have gone extinct? A novel quantitative classification approach. *Biological Conservation*, *227*, 9–18. https://doi.org/10.1016/j.biocon.2018.08.014

CBD. (2014). *Global biodiversity outlook 4*. Montréal, Canada: Secretariat of the Convention on Biological Diversity.

Díaz, S., Settele, J., Brondízio, E. S., Ngo, H. T., Agard, J., Arneth, A., … Garibaldi, L. A. (2019). Pervasive human-driven decline of life on Earth points to the need for transformative change. *Science*, *366*(6471), eaax3100. https://doi.org/10.1126/science.aax3100

Gascon, C., Brooks, T. M., Contreras-MacBeath, T., Heard, N., Konstant, W., Lamoreux, J., … Al Mubarak, R. K. (2015). The importance and benefits of species. *Current Biology*, *25*(10), R431–R438. https://doi.org/10.1016/j.cub.2015.03.041

Hemming, V., Burgman, M. A., Hanea, A. M., McBride, M. F., & Wintle, B. C. (2018). A practical guide to structured expert elicitation using the IDEA protocol. *Methods in Ecology and Evolution*, *9*(1), 169–180. https://doi.org/10.1111/2041-210X.12857

Hoffmann, M., Hilton-Taylor, C., Angulo, A., Böhm, M., Brooks, T. M., Butchart, S. H. M., … Stuart, S. N. (2010). The impact of conservation on the status of the world's vertebrates. *Science*, *330*, 1503–1509. https://doi.org/10.1126/science.1194442

Hoffmann, M., Duckworth, J. W., Holmes, K., Mallon, D. P., Rodrigues, A. S., & Stuart, S. N. (2015). The difference conservation makes to extinction risk of the world's ungulates. *Conservation Biology*, *29*(5), 1303–1313. https://doi.org/10.1111/cobi.12519

IPBES. (2019). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Díaz S., Settele J., Brondízio E. S., Ngo H. T., Guèze M., Agard J., … Zayas C. N., (Eds.). Bonn, Germany: IPBES Secretariat.

IUCN. (2019). The IUCN red list of threatened species. Version 2019–1. Retrieved from https://www.iucnredlist.org

IUCN. (2020). The IUCN red list of threatened species. Version 2020–2. Retrieved from https://www.iucnredlist.org

Jaramillo-Legorreta, A. M., Cardenas-Hinojosa, G., Nieto-Garcia, E., Rojas-Bracho, L., Thomas, L., Ver Hoef, J. M., … Tregenza, N. (2019). Decline towards extinction of Mexico's vaquita porpoise (*Phocoena sinus*). *Royal Society open science*, *6*(7), 190598. https://doi.org/10.1098/rsos.190598

Keith, D. A., Butchart, S. H., Regan, H. M., Harrison, I., Akçakaya, H. R., Solow, A. R., & Burgman, M. A. (2017). Inferring extinctions I: A structured method using information on threats. *Biological Conservation*, *214*, 320–327. https://doi.org/10.1016/j.biocon.2017.07.026

Mukherjee, N., Huge, J., Sutherland, W. J., McNeill, J., Van Opstal, M., Dahdouh-Guebas, F., & Koedam, N. (2015). The Delphi technique in ecology and biological conservation: Applications and guidelines. *Methods in Ecology and Evolution*, *6*(9), 1097–1109. https://doi.org/10.1111/2041-210X.12387

Salafsky, N., Salzer, D., Stattersfield, A. J., Hilton-Taylor, C., Neugarten, R., Butchart, S. H. M., … Wilkie, D. (2008). A standard lexicon for biodiversity conservation: Unified classifications of threats and actions. *Conservation Biology*, *22*(4), 897–911. https://doi.org/10.1111/j.1523-1739.2008.00937.x

Szabo, J. K., Butchart, S. H., Possingham, H. P., & Garnett, S. T. (2012). Adapting global biodiversity indicators to the national scale: A red list index for Australian birds. *Biological Conservation*, *148*(1), 61–68. https://doi.org/10.1016/j.biocon.2012.01.062

von der Gracht, H. A. (2012). Consensus measurement in Delphi studies. Review and implications for future quality assurance. *Technological Forecasting and Social Change*, *79*, 1525–1536. https://doi.org/10.1016/j.techfore.2012.04.013

Young, R. P., Hudson, M. A., Terry, A. M. R., Jones, C. G., Lewis, R. E., Tatayah, V., … Butchart, S. H. M. (2014). Accounting for conservation: Using the IUCN Red List Index to evaluate the impact of a conservation organization. *Biological Conservation*, *180*, 84–96. https://doi.org/10.1016/j.biocon.2014.09.039

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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