



Disparity between ecological and political timeframes for species conservation targets

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Received: 9 June 2020 / Revised: 19 February 2021 / Accepted: 29 March 2021 / Published online: 12 April 2021
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Abstract

The Convention on Biological Diversity's (CBD) Aichi Target 12 aimed to prevent species extinctions and improve the conservation status of known threatened species by 2020 but has not been met. As the post-2020 global biodiversity framework is negotiated, it is essential that we learn lessons from past failures. Here, we investigate whether a reduction in extinction risk could realistically be achieved within the ten-year timeframe of the Aichi Targets. We identified threatened bird and mammal species for which a population increase could lead to down-listing on the IUCN Red List and created population models that assumed exponential population growth to predict how long it would take to reach the population size threshold required for down-listing. We found that in the best-case scenario, 39/42 birds (93%) and 12/15 mammals (80%) could be expected to show the population increase required to achieve down-listing by one Red List category within a ten-year timeframe. In contrast, under the worst-case scenario, 67% birds and 40% mammals were predicted to take > 10 years to reach the population threshold. These results indicate a disparity between the ecological timeframes required for species to show a reduction in extinction risk, and the political timeframes over which such ecological change is expected to be achieved and detected. We suggest that quantitative analyses should be used to set realistic milestone targets in the post-2020 framework, and that global indicators should be supplemented with temporally sensitive measures of conservation progress in order to maintain political and societal motivation for species conservation.

Keywords Aichi Target 12 · Convention on Biological Diversity · Species extinctions · IUCN Red List · Population growth rate

Communicated by Stephen Garnett.

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Introduction

The rapid decline in biodiversity driven by human activities over recent decades (Chase 2014; Pimm et al. 2014) has resulted in losses similar to those last seen during mass-extinction events recorded over geological time periods (Ceballos et al. 2017; Drira et al. 2019). In recognition of this, in 2010 the signatory countries of the Convention on Biological Diversity (CBD) adopted 20 ‘Aichi Biodiversity Targets’ as part of the Strategic Plan for Biodiversity 2011–2020, with the aim of halting biodiversity loss by 2020 (CBD 2010). Among these, Aichi Target 12 addresses species conservation specifically, stating 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” (CBD 2011). Despite increasing policy and management responses, at the conclusion of the Aichi Targets, the evidence shows that we have failed to halt biodiversity loss, and species extinction risk continues to increase (IPBES 2019; CBD Secretariat 2020). As Parties to the CBD now negotiate a new post-2020 global biodiversity framework (CBD 2020) it is essential that we learn lessons from the Aichi Targets, in order that new targets will promote greater progress in conserving biodiversity over the coming decades.

The formulation of targets is considered an important determinant of successful implementation (Butchart et al. 2016), and the Aichi Targets have been criticised for being arbitrary, ambiguous, overly complex, difficult to quantify and unachievable (Adenle et al. 2015; Nicholson et al. 2018). Target 12 however, is regarded as operational and quantifiable (Butchart et al. 2016; Hagerman and Pelai 2016; Montoya et al. 2018). Furthermore, while Target 12 may have been ambitious, a recent study found that progress towards achieving global conservation targets was not related to the ambitiousness of the target (Green et al. 2019). One of the most fundamental questions regarding the appropriateness of a target, however, is whether the target can realistically be met within the timeframe set; in other words, is the target achievable?

Progress towards Aichi Target 12 is assessed by quantifying species conservation status using the IUCN Red List of Threatened Species, which is the most comprehensive resource detailing the conservation status of taxa globally (Rodrigues et al. 2006). The IUCN Red List categorises species extinction risk based on a range of population or distribution criteria (Mace et al. 2008) and the Red Listing process is deeply embedded within CBD approaches to species conservation (e.g. CBD 2016). For an improvement in species conservation status to be detected, species must show a substantial enough improvement in population and/or distribution trends to warrant a change in Red List category. Such changes in response to conservation action may take years or even decades to realise, particularly in long lived species (Jones et al. 2016; Kuussaari et al. 2009). Thus a critical question concerning whether Target 12 was achievable, is whether the ten-year time frame allocated to achieve Target 12 was long enough to detect improvements in the conservation status of species through assessment on the IUCN Red List.

Appropriate policy timeframes are important not only for understanding progress—or lack thereof—towards existing targets, but also for informing future target setting. Parties to the CBD are now focussed on the 2050 Vision of ‘living in harmony with nature’, and are negotiating milestones towards this vision, including 2030 goals that will almost certainly include a species target (CBD 2020). The scientific community therefore has an important opportunity to inform ambitious yet realistic species targets over multiple timeframes. Previous work has demonstrated how policy and decision making could be informed by projecting changes in species conservation status under alternative management scenarios (e.g.

Nicholson et al. 2012; Costelloe et al. 2015; Visconti et al. 2016). Such studies projected impacts of alternative scenarios on the Red List Index (RLI), which is derived from the Red List and quantifies overall change in global species extinction risk. The CBD Secretariat regards the RLI to be the most relevant indicator for measuring progress towards Target 12 (CBD 2011), yet the RLI is a relatively coarse measure that would not be expected to change rapidly (Jones et al. 2011). Furthermore, focussing on overall change in RLI masks variation among species in their responses to conservation action. Successful conservation would ideally see an improvement across all species, however some species, such as those that are long-lived, may be slow to respond to change due to traits such as low fecundity (Watts et al. 2020). It has proposed that post-2020, progress towards species conservation targets could be measured using a suite of indicators, including the percentage of threatened species that are improving in status according to the Red List (CBD 2021). Projecting changes in the conservation status of individual species based on species-specific population growth rates would thus allow us to test whether improvements in conservation status can be realistically achieved for all species, within a given timeframe.

In this study, we investigate the potential mismatch between the timescale of Aichi Target 12 and the timescale of potential measurable improvement in species conservation status. Specifically, we tested whether the population growth rates of a range of threatened bird and mammal species could lead to sufficient increases in population size for the species to be down-listed on the IUCN Red List within a ten-year timeframe. Projecting changes in species population size, and consequent changes in Red List category, allows us to measure improvement in conservation status at the individual species level. We focussed on population growth rates because it is generally a greater challenge to improve species' conservation status through an increase in population size (as required for species with very small population sizes) compared to simply halting decline (as required for species that are threatened due to declining population and/or distribution). We obtained estimates of the number of mature individuals from the IUCN Red List and conducted a literature search to identify species' population growth rates. We then used population models to determine the time it would take to detect an improvement in species Red List status, and assessed whether this was achievable within the ten-year timeframe of Aichi Target 12.

Methods

Identifying study species and population sizes

Aichi Target 12 refers to 'known threatened species' and thus we included species listed as threatened (Vulnerable, Endangered or Critically Endangered) according to the IUCN Red List. We focussed specifically on birds and mammals, as these taxonomic groups are comprehensively assessed on the IUCN Red List (meaning that > 80% of species within the taxa have been assessed; IUCN 2019) and are well-studied within the scientific literature (Clark and May 2002), meaning that data availability is generally better than for other taxonomic groups.

The IUCN Red List categories of species extinction risk are based on a set of quantitative criteria (A-E) with threshold parameters (Mace et al. 2008; IUCN 2012). Three of the IUCN Red List criteria (A-C) are based on the rate of decline of the population and/or geographic range, while criterion E is based on quantitative models of extinction risk (Mace et al. 2008). Criterion D is based on population size, and thus under this criterion,

an increase in population size to above the threshold parameters will result in an improvement in the species Red List status (IUCN 2012). We therefore only considered species listed under criterion D in this study. Further, we excluded species listed under Criterion D2 as this refers to restricted area of occupancy rather than number of mature individuals in the population.

We downloaded Red List assessments from the IUCN Red List (IUCN 2019) for all threatened birds and mammals listed under Criterion D between the years 2008 and 2016. A full global assessment of the extinction risk of Mammalia was carried out in 2008 (Rondinini et al. 2011) and of birds in 2016 (BirdLife International 2018) and we made use of the most recent assessment available for each species during this time period.

For each of these species, we extracted the number of mature individuals in the population from the IUCN Red List assessments to use as the starting population size in the population models. The IUCN Red List threshold parameters for categories of extinction risk are measured in terms of number of mature individuals (Mace et al. 2008). The number of mature individuals is defined as “the number of individuals known, estimated or inferred to be capable of reproduction” (IUCN 2017). As population growth is ultimately shaped by reproductive and mortality rates, and population sizes of species would be compared against IUCN threshold criteria, the number of mature individuals was considered a more appropriate starting population size than the total population size. Where estimates were provided as a range, both the minimum and maximum values were recorded.

We assumed that species listed under Criterion D would have had historically larger population sizes. However, some species are naturally rare, or are restricted to islands and so have naturally small populations. Therefore, to investigate our assumption, we used distribution data from the IUCN Red List to determine whether study species were restricted to islands. We also inspected the species’ accounts for statements providing evidence that species’ population sizes were historically larger pre-human impact. Suitable evidence was a statement that the species had a historically larger population size, or that the species was known or inferred to have gone or be undergoing a decline. Conversely, species were considered to have a naturally small population size if the account included a statement that current populations were known or inferred to be similar to historic populations, or that population trends were stable and no mention was made of past declines. Finally, we recorded species historic population sizes as uncertain where there was a lack of data on current or historical population sizes in the Red List accounts.

Literature search to obtain estimates of population growth rate

For all identified species, we searched the literature to obtain estimates of species population growth rate. We first searched Web of Science, Google Scholar and Scopus for articles published before July 2019 using the species’ scientific name and the search terms “population growth”, “growth rate*”, “population dynamic*”, “population parameter*”, “population model*”, “population viability” or “matrix”. In order to obtain population growth rate data for as many species as possible, we assumed that species within the same genus were suitable analogues for estimating species population growth rate (Bland et al. 2015 make a similar assumption and use information from the same genus or family to predict the extinction risk of data-deficient mammals). We therefore conducted an additional search in January 2021 for the species’ genus and the search terms above. We included only articles published in English and that reported empirical or projected population growth rate data for the species.

From each article maintained, we extracted the name of the study species (scientific and common name), population growth rate and variation around the population growth rate. For articles that provided projected data with multiple population growth rates based on different scenarios, we selected the growth rates that did not include captive rearing or supplementation of individuals into the population or that were based on observations of the largest sample size.

Population growth rate was recorded as the finite rate of increase (λ). Where population growth rates were given as the intrinsic rate of increase (r), it was assumed that:

$$1 + r = \lambda$$

where population growth rates were given as a percentage increase, an annual population increase of 8% would give $\lambda = 1.080$.

Variation around the population growth rate was recorded as standard deviation (σ). 95% confidence intervals were converted to standard deviations, following the assumption in Altman and Bland (2005) that:

$$95\% \text{ confidence interval} = \bar{x} + 1.96\sigma$$

where a 95% Bayesian confidence interval or credible interval was provided in the study that was symmetrical either side of the mean population growth rate, we assumed that these intervals matched the 95% confidence intervals and treated them as such.

Predicting time to species down-listing

In order to determine the minimum time required for a species to change Red List category, we created simple population models that assumed a best-case scenario of exponential population growth (i.e. no density dependence, and no negative human interference such as hunting or habitat loss). We created exponential population growth rate models, using the equation:

$$N_{(t+1)} = N_t \times \lambda$$

where $N_{(t+1)}$ is the population size at year $t + 1$, N_t is the population size at time t , and λ is the population growth rate.

Where the IUCN Red List provided the number of mature individuals of a species as a range of values, we used both the maximum and minimum values as the starting population size in models. Uncertainty around population growth rates obtained from studies was accounted for by predicting population size using the growth rate \pm standard deviation.

In order to be assessed as threatened under Criterion D on the IUCN Red List, a species must fall below the population size threshold of the appropriate category. For Critically Endangered, the population size must be estimated to be < 50 mature individuals, for Endangered < 250 mature individuals, and for Vulnerable < 1000 mature individuals. Thus, conversely, for a species to be down-listed (transferred to a category of lower threat) the estimated population size must exceed the threshold. However, a major caveat is that for a species to be down-listed, the species must have met the criteria of the lower threat category for at least five years (IUCN 2017). Thus a species must cross the threshold parameter within the first five years to qualify for down-listing by 2020.

Results

Data availability and study species

For the period 2008 to 2016, there were 735 bird and 925 mammal species assessed as threatened (Vulnerable, Endangered or Critically Endangered) on the IUCN Red List. Of these, 98 bird and 38 mammal species were categorised as threatened under criterion D. We excluded species without a population size estimate and species with a population estimate that exceeded the threshold for down-listing, leaving 97 bird and 22 mammal species (Online Resource Table S1).

Of these 119 species obtained from the Red List, 79 species (66%) occurred on islands (Online Resource Table S2). There was evidence in the Red List accounts that at least 69 species (58%) were known or inferred to have historically larger population sizes (52% of island species and 70% of mainland species). Of the remaining species, there was a lack of data on current and/or historical population sizes for 27 species (23%), leaving only 23 species (20%) that had some evidence that current population sizes were comparable to historic sizes (Online Resource Table S2).

We found species-specific population growth rate estimates in the scientific literature for only 14 species (12%) from 16 articles (Table 1). This included seven bird species, five of which were categorised as Endangered and two as Vulnerable, and seven mammal species, three of which were Critically Endangered, two Endangered and two Vulnerable. Population growth rates varied from 1.006 (for *Ailuropoda melanoleuca*) to 1.35 (for *Falco punctatus* and *Mustela nigripes*).

Of the remaining 105 species for which no species-specific population growth rate estimate was obtained, we found estimates for species within the same genus for 43 of our study species from 55 articles (Online Resource Table S3). This included 22 genera within Aves, covering 35 of our bird study species (23 Vulnerable, eight Endangered and four Critically Endangered), and eight genera within Mammalia, covering eight of our mammal study species (one Vulnerable, three Endangered and four Critically Endangered). In total, we built population models for 42 of 97 bird species (43%) and 15 of 22 mammal species (68%).

Not all studies reported variability around the mean population growth rate and thus we could not assess uncertainty in all cases (Table 1, Online Resource Table S3). Several studies (including Fisher et al. 2000 and Fisher et al. 2001) reported variability around the population growth rate as a measure of standard error. It was not possible to transform these values to standard deviation, however we nevertheless included these data as we considered that it was better to include an underestimate of uncertainty than no measure of uncertainty.

Predicted time to species down-listing

We used simple population models to determine how many years it would take for each species to reach the population size threshold that would qualify them for down-listing on the IUCN Red List under criterion D. Standard deviations of mean population growth rates were used to quantify uncertainty, however for succinctness in reporting, we focus on the predicted population sizes based on the mean estimated population growth rate.

Table 1 The species included in this study for which species-specific population growth rate estimates were available.

Species	IUCN red list status	Year of IUCN red list assessment	Estimated population size	Population growth rate	Uncertainty around population growth rate	Reference
Birds						
<i>Atlapetes pallidiceps</i>	EN	2016	226	1.095	0.009	Hartmann et al. (2017)
<i>C. blumenbachii</i>	EN	2016	130–170	1.04	0.13	São Bernardo et al. (2014)
<i>F. punctatus</i>	EN	2016	170–200	1.03	0.15	São Bernardo et al. (2014)
<i>Petroica traversi</i>	EN	2016	230	1.35	–	Temple (1986)
<i>Thinnornis novaeseelandiae</i>	EN	2016	156–220	1.132	0.012	Kennedy (2009)
<i>Hemiphaga chathamensis</i>	VU	2016	250–999	1.124	–	Davis (1994)
<i>Vini stephensi</i>	VU	2016	480–1200	1.119	0.013	Lavers et al. (2010)
Mammals						
<i>N. hainanus</i>	CR	2008	15–20	1.104	0.015	Lavers et al. (2010)
<i>Nomascus nasutus</i>	CR	2008	45–47	1.046	0.030	Bond et al. (2019)
<i>Rhinoceros sondaicus</i>	CR	2008	46–66	1.034	–	Bryant (2014)
<i>Equus ferus</i>	EN	2015	178	1.037	–	Bryant (2014)
<i>M. nigripes</i>	EN	2015	206	1.01	–	Hariyadi et al. (2011)
<i>A. melanoleuca</i>	VU	2016	500–1000	1.169	0.080	Tatin et al. (2009)
<i>Onychogalea fraenata</i>	VU	2016	800–1,100	1.066	–	King & Gurnell (2005)
				1.35	–	Grenier et al. (2007)
				1.006	–	Wei et al. (1997)
				1.0186	–	Carter et al. (1999)
				1.330	0.408	Fisher et al. (2000)
				1.0644	0.1063	Fisher et al. (2001)

Species extinction risk according to the IUCN Red List, the year of Red List assessment used in this study, and the species estimated population size (either as a best estimate or estimated range) are shown. The population growth rate and associated uncertainty retrieved from the literature search for each species are given, along with the source of these data. References are given in full in the Supplementary References in Online Resource 1

Of the seven bird species with species-specific population growth rate estimates, six were predicted to reach the population size threshold for down-listing in ≤ 5 years under at least one scenario (combination of population starting size and estimated population growth rate; Fig. 1; Online Resource Fig. S1). As a result, under these scenarios, if re-assessment was carried out in a timely manner then these species could be down-listed within the ten-year policy timeframe. However, variation in the estimated starting population size for species has a large impact on predictions, and meant that three out of seven species were predicted to take ≥ 10 years to reach the population size threshold under at least one scenario. One species, *Crax blumenbachii*, was predicted to take ≥ 10 years to reach the threshold under all scenarios, meaning that there was no scenario for this species under which it would achieve down-listing within the policy timeframe (Fig. 1; Online Resource Fig. S1).

Of the seven mammal species with species-specific population growth rate estimates, six were predicted to reach the population threshold within five years under at least one scenario, and so could achieve down-listing within the ten-year timeframe (Fig. 1; Online Resource Fig. S2). Four species were predicted to take > 5 years under at least one scenario, and of these two were predicted to take > 10 years to reach the threshold. Furthermore, based on minimum population size estimate and the lower estimate of population growth rate, *A. melanoleuca* was predicted to take > 100 years to reach the down-listing threshold. One species, the Critically Endangered *Nomascus hainanus*, had no scenario under which the threshold was reached within ten years; the species was predicted to take ≥ 28 years to reach the down-listing threshold.

Of the 35 species of birds with estimated population growth rates obtained from other species in the same genus, 33 species were predicted to reach the population threshold within five years under at least one scenario (Fig. 2; Online Resource Fig. S3). However, twenty-nine species were predicted to take > 5 years under at least one scenario, and of

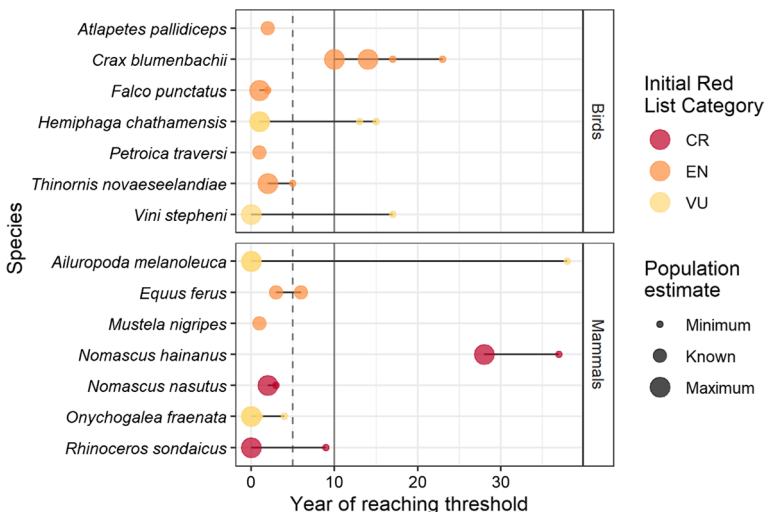


Fig. 1 The number of years taken for the species population size to reach the thresholds required for down-listing by one category on the IUCN Red List, according to predictions from population models for birds and mammals with species-specific population growth rate estimates. Species have either a best estimate starting population size, or a minimum and maximum population size estimate, and in some cases have more than one population growth rate estimate (see Table 1)

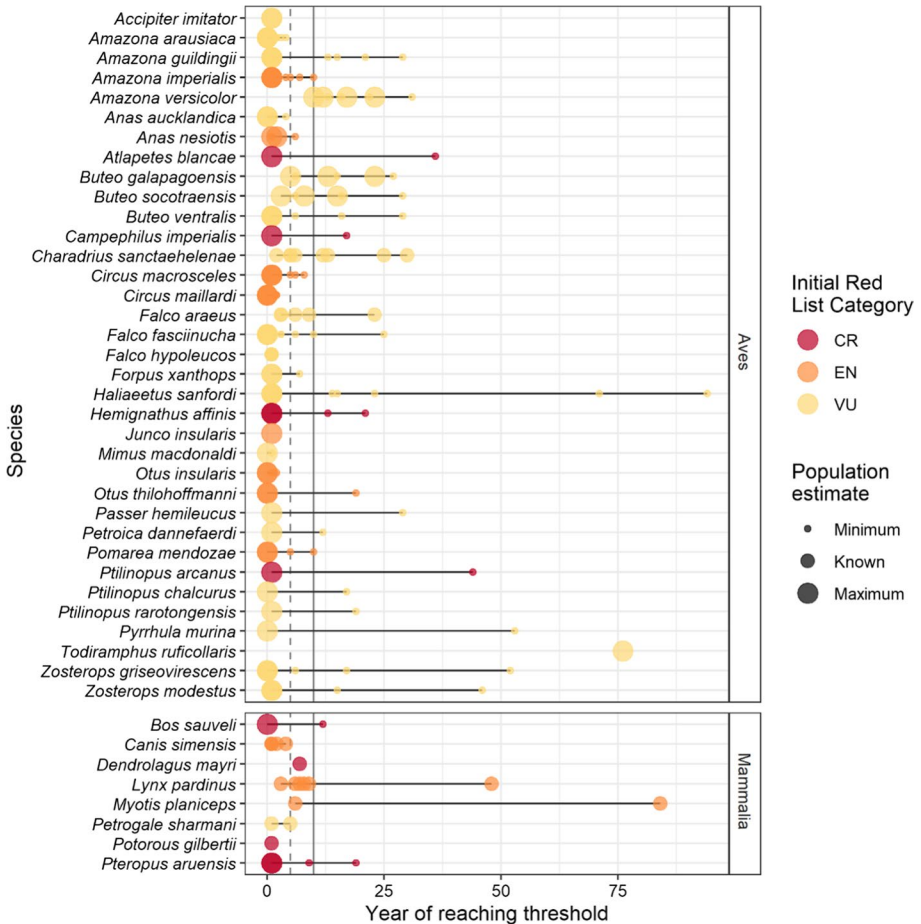


Fig. 2 The number of years taken for the species population size to reach the thresholds required for down-listing by one category on the IUCN Red List, according to predictions from population models for birds and mammals using population growth rate estimates for species within the same genus. Species have either a best estimate starting population size, or a minimum and maximum population size estimate, and in some cases have more than one population growth rate estimate (see Online Resource Table S3)

these 25 were predicted to take > 10 years to reach the threshold under at least one scenario. Furthermore, there were seven species of bird that were predicted to take > 100 years to reach the down-listing threshold under at least one scenario. Among these, *Todiramphus ruficollaris* had no scenario under which the threshold was reached within ten years and was predicted to take ≥ 76 years to reach the down-listing threshold.

Of the eight species of mammal with estimated population growth rates obtained from other species in the same genus, six were predicted to reach the population threshold within five years under at least one scenario, and all eight were predicted to reach the population threshold within ten years under at least one scenario (Fig. 2; Online Resource Fig. S4). However, five species were predicted to take > 5 years under at least one scenario, and of these four were predicted to take > 10 years to reach the threshold under at least one scenario.

Discussion

Our study used simple population models to test whether the ten-year timeframe of Aichi Target 12 was long enough for a selection of threatened species to achieve down-listing on the IUCN Red List. We predicted population growth for a total of 57 species of birds and mammals out of 119 species documented as threatened due to small population sizes on the IUCN Red List. We found that in the best-case scenario, 39/42 birds (93%) and 12/15 mammals (80%) could be expected to show the population increase required to achieve down-listing by one Red List category within a ten-year timeframe. In contrast, under the worst case scenario, 28/42 birds (67%) and 6/15 mammals (40%) were predicted to take more than ten years to reach the population threshold, indicating that even when effective conservation measures are in place, the ten-year timeframe of the Aichi Targets may be too short for the impact of conservation action to be detected as a change in Red List category for some threatened species.

To achieve down-listing on the Red List within the timeframe of the Aichi Targets, species' population sizes would have to cross the extinction risk category threshold within the first five years. The predicted ability of species to do so varied depending on the estimate of population growth rate and on the starting population size. Many species had an estimated maximum population size that was close to the down-listing threshold, meaning that this threshold could be reached within only a few years. Yet some of the same species were predicted to take > 20 years to reach the threshold when the estimated minimum population size was used. This variation in outcomes reflects substantial uncertainty in our knowledge of species' population sizes, as well as variation in reported growth rates. The long times taken for many species to reach the threshold under some scenarios also emphasises the coarse nature of Red List categories (Jones et al. 2011); downlisting may not be achieved for decades, despite consistent population increases. These results suggest that there is a disparity between the ecological timeframes required for species to show a reduction in extinction risk, and the political timeframes over which such ecological change is expected to be achieved. This disparity has implications for the achievability of future species conservation targets. As the post-2020 global biodiversity framework is shaped this year, we suggest that careful consideration should be given to both the achievability of time-bound targets and the temporal sensitivity of the methods used to measure progress towards these targets.

With the current orientation of the CBD towards their 2050 vision and the ongoing negotiations of milestones towards this vision, there is the opportunity for ecological modelling to inform realistic policy targets. Scenario modelling can be used to project the impacts of alternative policy and management options on species conservation outcomes (e.g. Nicholson et al. 2012; Costelloe et al. 2015; Visconti et al. 2016). To date, such work has modelled overall changes in species extinction risk and has not taken account of individual species population growth rates, which may be low particularly for long-lived species. We suggest that the accuracy and utility of scenario modelling could be enhanced by including species-specific parameters, such as expected population growth rates. Moreover, models that account for species-specific traits could be used to set realistic, incremental milestones towards the 2050 vision, for example by setting realistic targets for the proportion of species that should have improved conservation status per decade (such as suggested by Butchart et al. 2019). Such detailed information could also be used to identify 'quick wins' that could boost political and public morale and provide impetus for further conservation action and investment (McAfee et al. 2019). In particular, models could be

used to identify the species for which conservation action must be implemented early if the species are to recover sufficiently to meet targets later on.

The ability to develop models that incorporate species-specific parameters is likely to be limited by data availability. Despite identifying 119 species of mammals and birds that had estimated population sizes and were listed as threatened under criterion D, we found species-specific population growth rate estimates in the scientific literature for only fourteen of these species. Given that birds and mammals are among the most studied taxa (Clark and May 2002), we would expect even greater data limitations in other taxonomic groups. Lack of species-specific data can be overcome to some extent; we found estimates for species within the same genus for a further 43 species. Population projection models are increasingly being used to identify effective management strategies for threatened species (Alemayehu 2013; Earl 2019; Hartmann et al. 2017; Hegg et al. 2013), and as such, the availability of demographic data is likely to continue to improve, particularly for known threatened species.

Our study necessarily made some broad assumptions. The population models assumed that effective conservation was implemented immediately following the adoption of Aichi Target 12 and that this action produced an exponential population growth. From a political perspective, this assumption is extremely optimistic, as conservation responses to biodiversity continue to be offset by the rising pressures on biodiversity (Johnson et al. 2017). From an ecological perspective, this assumption means that we did not consider demographic, environmental or genetic stochasticity or the effects natural catastrophes may have on population responses to conservation action (Saunders et al. 2018; Shaffer 1981). Our models also did not consider potential time-lags in the responses of species' populations to conservation action (Watts et al. 2020). As a result, our predictions are highly optimistic, and we would expect that more nuanced population models would predict substantially longer times to achieve reductions in species extinction risk.

A further assumption our study made was that species listed under Criterion D (threatened due to small population size) had historically larger population sizes. Although 66% of our study species occurred on islands, where population sizes are more likely to be naturally small, there was evidence in the Red List accounts that 52% of island species and 70% of mainland species historically had larger population sizes. A further 25% of island and 18% of mainland species had insufficient data to assess whether population sizes were larger in the past. We therefore consider it a reasonable assumption that the majority of our study species would naturally occur at larger population sizes pre-human impact. While for the majority of threatened species, halting population and/or distribution declines would accomplish down-listing on the Red List, species at risk of extinction due to small population sizes merit special attention, as these species are more prone to inbreeding effects and more at risk of stochastic events. They are therefore likely to require targeted conservation action, such as translocations or population augmentation, in order to increase population sizes. They are also likely to be the species for which the inclusion of species-specific parameters is most important in scenario modelling and conservation planning.

Our study demonstrates that the timeframe of Target 12 was too short to detect an improvement in Red List status for all threatened species. This implies that Target 12 was overly ambitious, as the quantitative elements of a target should be based on scientific evidence to ensure that the target is well founded (Nicholson et al. 2018). However, global conservation target setting requires a careful balance of conservation ambition, political reality and scientific evidence. We therefore do not suggest a reduction in ambition, but instead suggest that quantitative analyses such as the one we provide here should be used to set realistic milestone targets towards the 2050 vision. Furthermore, consideration should

be given to the temporal sensitivity of indicators used to measure progress towards time-bound targets (Collen and Nicholson 2014). Changes in Red List category—and ultimately the trend in Red List Index—provide a long-term global indicator of species conservation status. These global indicators could be supplemented with more local and temporally sensitive measures, such changes in the proportion of species with expanding distributions or increasing population trends, and the proportion of species that showed declines before 2020 but have since stabilised (Butchart et al. 2019). Monitoring the population and distribution changes that can be expected to eventually drive changes in species extinction risk provides shorter-term evidence of the effectiveness of implemented action. Such evidence may be important to allow biodiversity change to be measured over time periods of relevance to policy makers.

Appropriate conservation action can produce population and/or distribution increases, and consequently achieve species down-listing on the Red List (Jones et al. 2016). Moreover, intensive conservation efforts can pull species back from the brink of extinction (Bolam et al. 2020). There is therefore good reason to be optimistic and ambitious when setting species conservation targets in the post-2020 global biodiversity framework. However, if we are to maintain political and societal motivation, targets need to be realistic and measures of progress towards targets need to be able to detect positive conservation impact over short time periods of relevance to policy makers. Analyses such as those presented here can be used to identify where complementary indicators that respond over short time-frames need to be adopted, and set realistic, science-based milestones towards the CBD's 2050 vision.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s10531-021-02173-z>.

Acknowledgements We thank Philip McGowan, Stephen Garnett and two anonymous reviewers for comments on an earlier version of this manuscript.

Author contributions Stella Piipponen-Doyle and Louise Mair contributed to the study conception and design. Material preparation, data collection and analysis were performed by Stella Piipponen-Doyle. The first draft of the manuscript was written by Stella Piipponen-Doyle and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding LM and FCB were funded by Newcastle University.

Data availability All data analysed during this study are included in this published article.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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