Running title: Australian Red List Index

Adapting global biodiversity indicators to the national scale: a Red List Index for Australian birds

Judit K. Szabo[1,*], Stuart H. M. Butchart[2], Hugh P. Possingham[3], Stephen T. Garnett[1]

[1]Research Institute for the Environment and Livelihoods, Charles Darwin University, Northern Territory 0909, Australia

[2]BirdLife International, Wellbrook Court, Cambridge, CB3 0NA, UK

[3]Centre of Excellence for Environmental Decisions, University of Queensland, St Lucia, Queensland 4072, Australia

* corresponding author: judit.szabo@cdu.edu.au, tel: +61 8 8946 6427, fax: +61 8 8946 6949

Abstract

The Red List Index (RLI), which uses information from the IUCN Red List to track trends in the projected overall extinction risk of sets of species, is among the indicators adopted by the world's governments to assess performance under the Convention on Biological Diversity and the United Nations Millennium Development Goals. For greatest impact, such indicators need to be measured and used at a national scale as well as globally. We present the first application of the RLI based on assessments of extinction risk at the national scale using IUCN's recommended methods, evaluating trends in the status of Australian birds for 1990–2010. We calculated RLIs based on the number of taxa in each Red List category and the number that changed categories between assessments in 1990, 2000 and 2010 as a result of genuine improvement or deterioration in status. A novel comparison between trends at the species and ultrataxon (subspecies or monotypic species) level showed that these were remarkably similar, suggesting that current global RLI trends at the species level may also be a useful surrogate for tracking losses in genetic diversity at this scale, for which no global measures currently exist. The RLI for Australia is declining faster than global rates when migratory shorebirds and seabirds are included, but not when changes resulting from threats in Australia alone are considered. The RLI of oceanic island taxa has declined faster than those on the continent or on continental islands. There were also differences in the performance of different jurisdictions within Australia.

Keywords Australia, birds, IUCN Red List, biodiversity trends, state of the environment, threatened taxa

1. Introduction

Under the Convention on Biological Diversity (CBD) governments recently adopted a new strategic plan for reducing biodiversity loss, including 20 targets to be met by 2020 (Secretariat of the Convention on Biological Diversity, 2010). Monitoring progress towards, and achievement of, these goals and targets requires indicators (Balmford *et al.*, 2005, Jones *et al.*, 2011). Indicator sets have been adopted for the United Nations Millennium Development Goals (MDGs; United Nations, 2011), the CBD's previous 2010 target (Walpole *et al.*, 2009, Butchart *et al.*, 2010), and have been proposed for the 2020 targets (Secretariat of the Convention on Biological Diversity, 2010). For maximum effectiveness, such indicators need to be implemented at multiple scales, including both global and national.

One prominent indicator in both the MDG and CBD recommended indicator sets is the Red List Index (RLI; Butchart *et al.*, 2004, Butchart *et al.*, 2005, Butchart *et al.*, 2007). The RLI measures trends in the overall extinction risk of species, and is based on data from the IUCN Red List (IUCN Standards and Petitions Subcommittee, 2010), which is widely considered the most objective system for evaluating extinction risk at national or global scale (Hambler, 2004, Miller *et al.*, 2007). It uses standard criteria with quantitative thresholds for population and range size, structure and trends to assign species to categories of extinction risk, ranging from Least Concern through Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild and Extinct. Those species with insufficient data to apply the criteria are listed as Data Deficient (IUCN, 2001, IUCN Standards and Petitions Subcommittee, 2010). Assessments must be supported by quantitative data, as well as justifications, sources and estimates of uncertainty and data quality. The Red List categories and criteria can be used to assess extinction risk at global, regional and national scales, with guidance available for sub-global assessments in order to take account of potential interchange with populations beyond the scope of assessment (IUCN, 2003).

The RLI is based on the number of species in each Red List category, and the number that change categories between assessments owing to genuine improvement or deterioration in status. It excludes changes in category resulting from improved knowledge, taxonomic changes or revisions to Red List criteria (Butchart *et al.*, 2004, Butchart *et al.*, 2007). The RLI can be calculated for any set of species that has been assessed for the Red List at least twice (Butchart *et al.*, 2004, Butchart *et al.*, 2007). To date, global RLIs have been published for birds (1988 – 2008; BirdLife International, 2008, Butchart *et al.*, 2010), mammals (1996 – 2008; Butchart *et al.*, 2010, Hoffmann *et al.*, 2011), amphibians (1980 – 2004; Stuart *et al.*, 2004) and corals (1998 – 2008; Carpenter *et al.*, 2008). It is particularly useful for comprehensively assessed taxonomic groups (e.g. birds, mammals, amphibians, corals), for which cautions expressed about the use of the IUCN Red List to assess trends in biodiversity because of biases in species selection and knowledge limitations are largely inapplicable (Possingham *et al.*, 2002).

This is the first national RLI to be published using the methods as originally designed. While a national RLI was published for a number of taxa in China (Xu *et al.*, 2009), the trends are difficult to interpret because genuine improvements and deteriorations in status between assessments were combined with those resulting from improved knowledge or taxonomic changes, and because non-threatened taxa were excluded, contrary to recommended methods (Butchart *et al.*, 2007, Bubb *et al.*, 2009). National RLIs based on national-scale assessments of extinction risk allow more sensitive tracking of biodiversity trends (because more species move between Red List categories between assessments when the categories are assigned using national rather than global extinction risk) and hence are of greater utility at the national scale, which is where the decisions are made that have greatest influence on biodiversity trends. Furthermore, the development of national RLIs will likely lead to greater ownership and uptake by national governments.

The present study assesses recent trends in the extinction risk for birds in Australia by calculating an RLI based on national-scale assessments undertaken in 1990, 2000 and 2010. It also examines trends at both the species and subspecies level and on geographical, political and taxonomic subsets of the data. Since countries sharing taxa interact at the policy level we calculated RLIs both including and excluding status changes that resulted from threats acting outside the Australian part of a visiting taxon's distribution, in order to quantify the extent to which national biodiversity trends are driven by external threats.

2. Materials and methods

2.1. Red List assessments

We based our evaluations of the extinction risk of Australian bird taxa, both at the species and subspecies level, on assessments undertaken in1990 (Garnett, 1992), in 2000 (Garnett & Crowley, 2000) and in 2010 (Garnett *et al.*, 2011) using the IUCN Red List criteria pertaining at the time of assessment. Following recommended methods (Butchart *et al.*, 2007, Butchart *et al.*, 2010, Hoffmann *et al.*, 2010), we retrospectively corrected categorisations for 1990 and 2000 using current (2010) knowledge. We conservatively assumed that the current category applied to these earlier assessments, except where there was evidence that the species had undergone a genuine improvement or deterioration in status of sufficient magnitude to cross the Red List category thresholds. Such evidence included, for example, documented population trends and distribution declines, known trajectories of habitat extent or quality, and dates and outcomes of efforts to eradicate invasive alien species or to translocate populations of target species. In order to assess extinction risk nationally, we followed the IUCN guidelines to account for potential source and sink effects that result from interchange with populations beyond the national borders (IUCN, 2003, 2008, IUCN Standards and Petitions Subcommittee, 2010).

The geographic scope of the assessments was Australia and its overseas territories (Christmas, Cocos (Keeling), Norfolk, Lord Howe, Macquarie and Heard Islands), as well as the Australian Fishing Zone, which extends 370 km off the coastline of both the continent and the offshore islands. Taxonomy followed Marchant and Higgins (1990, 1993), Higgins and Davies (1996), Higgins (1999), Schodde and Mason (1999) and Christidis and Boles (2008) at the subspecies level and BirdLife International (2011) at the species level. We assessed all 725 species and 1238 ultrataxa (929 subspecies plus 309 monotypic species sensu Schodde & Mason, 1999) resident or occurring regularly in Australia or its territories, excluding introduced and vagrant taxa, and also visiting seabirds with no breeding Australian populations. For the 58 taxa with both breeding and visiting populations, we used the status of the breeding population, which in all cases was the same as, or more threatened than, that of the visiting population.

2.2. RLI calculations

For the calculation of RLIs we followed the methods of Butchart et al. (2007). We followed recent practice (e.g. Butchart, 2008, Butchart *et al.*, 2010, Hoffmann *et al.*, 2010, Hoffmann *et al.*, 2011) in using ‘equal steps’ weights for each Red List category (0 for Least Concern, 1 for Near Threatened, 2 for Vulnerable, 3 for Endangered, 4 for Critically Endangered and 5 for Extinct and Critically Endangered taxa tagged as Possibly Extinct *sensu* IUCN (2010)) rather than weights based on relative extinction risk, as the latter approach makes the index much less sensitive to changes in status of less threatened taxa (see Butchart *et al.*, 2004, Butchart *et al.*, 2005 for further discussion). The number of taxa in each IUCN Red List category was multiplied by these weights and the sum expressed as a fraction of the maximum possible sum (equating to all taxa having gone extinct). Taxa listed as Extinct or Possibly Extinct in the first year of assessment (1990) were excluded. Calculations were made using Microsoft Excel 2007.

2.3. Disaggregating Red List Indices

To understand underlying patterns and identify subsets of species for which extinction risk has changed most rapidly, the RLI can be disaggregated (Butchart *et al.*, 2004, Butchart *et al.*, 2005). For the RLI to be used to assess the performance of a country it should first be calculated only for taxa threatened by processes within that country, even if they occur elsewhere. We therefore first calculated the RLI including only the changes in status that resulted from processes occurring within Australia. We used this dataset for analysis of geographical variation, assessing the RLI separately for taxa occurring on oceanic islands (listed above), continental islands (including Tasmania) that were connected to the Australian mainland during the last glacial period, and those on the Australian continent. Some taxa occur on both the continent and on continental islands (n = 460), on continental and oceanic islands (n = 15) or on all three (n = 20). These taxa were included on each of the respective lists. We also used this dataset to show trends in extinction risk for taxa relevant to particular policy mechanisms. To do this, we disaggregated taxa on the basis of jurisdiction (six states: Queensland, New South Wales, Victoria, South Australia, Western Australia and Tasmania and two territories: Australian Capital Territory and Northern Territory). In each list we included breeding taxa and non-breeding migrants, but did not include vagrants or taxa living on oceanic islands administered by the states (i.e. Macquarie and Lord Howe Islands); some taxa occurred in multiple jurisdictions.

To understand the extent to which national trends in taxon status are driven by external threats, we recalculated RLI including all status changes regardless of the location of threat. We also used this dataset to show trends in extinction risk for particular taxonomic groups, calculating trends for the five most speciose orders individually and for the remainder of species as a group.

2.4. Analysis of threats and conservation effectiveness

We explored the principal threats classified following Salafsky *et al.* (2008) that drove the deterioration in status of those species that were uplisted to higher categories of extinction risk, or that were ameliorated by conservation action for those species downlisted to lower categories of extinction risk. For all threatened and Near Threatened taxa we also assessed what their category would have been in 2000 and 2010 if conservation interventions implemented during 1990–2010 had not been carried out. Following the approach of Butchart *et al.* (2006), we considered, both species-specific targeted interventions (e.g. captive breeding) and more general habitat and site protection (e.g. the establishment of protected areas). Since such assessments are necessarily hypothetical, we were conservative in our assessments, basing our judgement on proximity to status thresholds, population and distribution trends in 1990 and subsequently and the nature of the intervention and whether it had a direct bearing on the threatening processes most likely to affect the change in status.

3. Results

3.1. Red List Indices

At the national scale, the degree of threat, pattern of distribution of taxa between Red List categories, and rates of decline were similar for both species and ultrataxa (χ^2-test for 2010 p =

0.079). In 2010, 9.4% (68) of species were threatened compared with 11.7% (148) of ultrataxa (Fig. 1.). From 1990 to 2010, for taxa threatened in Australia alone, the RLI declined by $4.37*10^{-4}$/year for species and $2.99*10^{-4}$/year for ultrataxa (Fig. 2). For all taxa, including those threatened outside Australia, the RLI declined by $7.46*10^{-4}$/year for species and $6.38*10^{-4}$/year for ultrataxa. Compared to birds globally, for which 12.5% of extant species are threatened, with an RLI declining at $2.20*10^{-4}$/year in 1988–2008, Australian taxa are less threatened overall, but declining more rapidly). Declines at both the species and ultrataxon levels were greater during 2000–2010 than 1990–2000 (Fig. 3).

Because of the similarities between the indices for species and ultrataxa, our remaining analyses were conducted only with the ultrataxon dataset, both because it was larger and because this is the taxonomic unit of conservation commonly used in Australia. Within Australian territories, the extinction risk of taxa on the continent and on continental islands was similar both in values and in trend, with continental island taxa slightly worse off than continental taxa lacking populations on islands (Fig. 4). Oceanic island taxa were more threatened (with lower RLI values) compared with continental and continental island, and their RLI declined faster ($8.26*10^{-4}$/year *vs.* $1.83*10^{-4}$/year for continental islands and $2.59*10^{-4}$/year for the continent). Among jurisdictions, Australian Capital Territory taxa had the highest RLI score and Queensland taxa have shown the smallest decline ($1.41*10^{-4}$/year). Tasmania had the lowest RLI score in all three years and South Australia the most rapid overall decline ($3.57*10^{-4}$/year; Fig. 5). Of the five most diverse avian orders, the Procellariiformes consistently had the lowest RLI score in both periods (and is declining at $2.50*10^{-3}$/year). The steepest decline in RLI, however, was among the Charadriiformes, particularly during the last decade ($3.47*10^{-3}$/year; Fig. 6). These two orders contained over half of all taxa (25/49) for which the Red List status in the last two decades declined. The extent of the decline within the Charadriiformes meant that it had a lower RLI by 2010 than did Psittaciformes, for which the RLI showed a slight increase over the last two decades ($2.94*10^{-4}$/year). The RLI of pigeons, passerines and "other taxa" (i.e. the remaining orders combined), remained relatively stable.

3.2. Analysis of threats and conservation impact

For non-breeding visitors to Australia, most cases in which such species underwent a deterioration in status of sufficient magnitude to qualify for a higher Red List category were driven by residential and commercial development, agriculture and aquaculture. These are the major threats to stop-over sites for international migrant shorebirds. For Australian breeding taxa changed fire regimes and invasive species drove most uplistings to higher categories of threat (Fig. 7). Overall in 1990–2010, only two species and five subspecies underwent improvements in status of sufficient magnitude to qualify for a lower Red List category. These occurred primarily because of land and water protection and invasive species control (Fig. 8).

We estimate that 35 taxa would have changed status had there not been conservation action implemented during 1990–2010 (Table 1). Of these, we considered that eight would have become Extinct or now be presumed Extinct, from Critically Endangered in 1990. Six taxa would have been uplisted to higher categories of threat owing to deteriorations in status that resulted from unintended consequences of conservation action (herbivore increases following cat eradication and mesopredator release). Even so, despite these unexpected uplistings, the national ultrataxon RLI in 2010 would have been 0.9201 without conservation interventions, 0.64% lower than currently.

4. Discussion

National trends and drivers

Australian birds are less threatened at both the species (9.4%) and ultrataxon (11.6%) levels than globally, despite the fact that our assessments of extinction risk were carried out at the national scale (at which a higher proportion of non-endemic taxa would be expected to qualify as threatened because their populations outside Australia were excluded from the initial application of the Red List criteria). However, the downward trend in the RLI indicates that Australian bird taxa are slipping towards extinction overall. This matches the global pattern for birds, mammals, amphibians and corals (Stuart *et al.*, 2004, Carpenter *et al.*, 2008, Hoffmann *et al.*, 2011), among which birds are the least threatened (12.5%; Butchart *et al.*, 2010). The rate at which the RLI is declining, at both taxonomic levels, is higher than the global average if status changes driven by threats operating outside Australia are included. The rate of decline considering only threats operating within Australia is similar to the global average, although uncertainty around RLI values cannot yet be quantified, so statistical comparisons of these trends are not yet possible (see below).

The principal drivers of the decline in RLI can be determined by disaggregating the index (Butchart *et al.*, 2005). Much of the decline in the total Australian RLI is driven by seabirds and shorebirds that are non-breeding visitors (comprising 25 of the 49 species that deteriorated in status during 1990–2010). The principal threats to these species are fishing practices for the former and coastal development for the latter. While both orders are the subject of formal international agreements: the ACAP (Agreement on the Conservation of Albatrosses and Petrels) for Procelariiformes, the CAMBA (China-Australia Migratory Bird Agreement), JAMBA

(Japan-Australia Migratory Bird Agreement) and ROKAMBA (Republic of Korea-Australia Migratory Bird Agreement) for Charadriiformes, as well as EAAFP (East Asian – Australasian Flyway Partnership), the RLI analysis indicates that much is still to be done to halt declines and reverse trends.

By contrast the RLI for taxa driven by threats operating within Australia is declining relatively slowly. The RLI for parrots has actually increased even though the order is characterized globally by a high level of extinction risk (Bennett & Owens, 1997, BirdLife International, 2008). However this does not mean that efforts towards parrot conservation can now cease: three out of 16 Australian bird taxa considered Critically Endangered are parrots, the third highest for any order after seabirds and passerines, and the upward trend is driven by improvements in status in just three taxa, the southern subspecies of Western Corella (*Cacatua pastinator pastinator*), which has moved from Endangered to Least Concern, the Kangaroo Island subspecies of Glossy Black-Cockatoo (*Calyptorhynchuis lathami halmaturinus*), from Critically Endangered to Endangered, and, temporarily, the Tasman Parakeet (*Cyanorhamphus cooki*), which was downlisted to Endangered in 2000 but uplisted to Critically Endangered again in 2010. While this highlights the need to ensure that RLI trends are interpreted carefully, the overall performance within Australia is in contrast to global trends and suggests that conservation investment in threatened bird taxa over the last two decades has produced a measurable positive response.

Taxa on oceanic islands are known to be particularly susceptible to extinction (Blackburn *et al.*, 2004), so that the low and declining RLI values for such species are unsurprising, but worrying, especially given that the index excludes the 18 taxa that had already become extinct on Australian oceanic islands prior to 1990 (Fig. 4). Nevertheless the smaller scale of islands compared to the continent also increases the probability of a positive return from conservation investment. Invasive species control or eradication is more feasible for small islands with a low chance of reinfestation. In Australia, a good example is the elimination of Rabbits (*Oryctolagus cuniculus*) from Cabbage Tree Island off New South Wales, which effectively saved Gould's Petrel (*Pterodroma leucoptera leucoptera*) from extinction (Priddel *et al.*, 2000). However, efforts to address threats from invasive alien species need to be carefully researched and planned. A reason that five seabirds were uplisted to higher categories of threat during 2000–2010 is because the control of feral Cats (*Felis catus*) on Macquarie Island led to a proliferation of Rabbits that then removed the vegetation sheltering nesting petrels from natural predators and caused substantial soil erosion around albatross nest sites (Parks and Wildlife Service, 2006). An intensive baiting program has now been undertaken to remove the remaining exotic mammals (Rabbits, Ship Rats (*Rattus rattus*) and House Mice (*Mus musculus*) from the island (Raymond *et al.*, 2011). Similarly control of feral Foxes (*Vulpes vulpes*) in south-western Australia appears to have enabled an increase in abundance of feral Cats, causing rapid declines of several taxa that had larger populations when Foxes and Cats were present together (Garnett *et al.*, 2011). When eradication is not possible, control efforts and management must continue indefinitely. The density of Yellow Crazy Ants (*Anoplolepis gracilipes*) on Christmas Island has been reduced by repeated baiting programs (Beeton *et al.*, 2010), leading to downlisting of some taxa, but any cessation in effort would result in these species being uplisted again owing to an increase in extinction risk. Such relaxation occurred on Norfolk Island, where the Tasman Parakeet had to be uplisted because monitoring could not prove the persistence of the population (Garnett *et al.*, 2011).

While continental and continental island taxa have higher RLI values than those on oceanic islands, the lack of difference between them is of note. One might expect island taxa (even those on continental islands) to be inherently more susceptible than continental taxa owing to ecological naivety (as mammalian predators are often absent even from continental islands). The explanation for the lack of difference may be a combination of (a) the fact that many taxa are shared between the continent and islands immediately offshore; (b) a higher proportion of the area of continental islands is now protected for conservation compared to the mainland; and (c) ongoing effects on the continent of historical habitat loss, especially in the southeast (Szabo *et al.*, 2011) and of disruption of aboriginal fire regimes since settlement by Europeans coupled with grazing by introduced stock, particularly in northern savannas (Franklin, 1999).

Ultrataxa trends

The objective of the CBD is to conserve biodiversity across all levels, from genes to populations, species and ecosystems (CBD, 2011). However, there are currently no global indicators of trends in biodiversity at the genetic level (Walpole *et al.*, 2009, Butchart *et al.*, 2010). The use of ultrataxa, which includes subspecies, as well as monospecific species, is a step closer to measuring trends in genetic diversity, even though 25% of the ultrataxa are monotypic species. Inevitably, more taxa will meet the IUCN Red List criteria for threatened status if they are divided into smaller subunits, so that, among Australian birds, the proportion of threatened ultrataxa was 2.3% higher than the proportion of threatened species. However the trends in RLI were very similar, suggesting that the RLI may be a useful surrogate for measuring biodiversity trends at levels below the species (at least in birds), until adequate data on trends in genetic diversity are available. An area yet to be explored is variation in RLI trends between monotypic taxa and subspecies of polytypic taxa. Initial analyses suggest that trends in RLI differ between the two groups for complex reasons.

State of the Environment reporting

The RLI is a useful indicator of trends in the state of the environment, especially at a global level (Baillie *et al.*, 2008) and hence has been used in a wide variety of policy contexts. However, the RLI does not capture particularly well the deteriorating status of common species that are declining slowly as a result of general environmental degradation. Indicators based on population trends (e.g., Gregory *et al.*, 2007, Collen *et al.*, 2008) are better suited for this, and show finer temporal resolution, but require detailed data that are much less widely available than those underpinning the RLI (Butchart *et al.*, 2004). The RLI is a useful tool for measuring progress towards biodiversity targets, alongside a suite of complementary indicators, often using tailored data collection methods (Garnett, 2011). Presentation of national or regional scale RLIs should ideally be part of a wider narrative examining trends in biodiversity using several complementary measures. For example, trends in extinction risk can be discussed in the context of changes in extent of ecosystems and habitats and trends in species populations (Bubb *et al.*, 2009, Butchart *et al.*, 2010, CBD, 2011).

Various sources of uncertainty influence RLI values. At a global scale, an important source is introduced by Data Deficient species (those for which there is insufficient information to apply the Red List categories and criteria), which comprise a significant proportion of all taxa in some groups and in some countries. Methods have been developed to calculate confidence intervals based on this source of uncertainty (Butchart *et al.*, 2010). However, no Australian bird taxa are considered Data Deficient. For our data, the most significant source of uncertainty is probably assessment error (deriving from inaccurate underlying data, e.g. on population size or trend), even though the breadth of the Red List categories means that taxa may often be accurately categorized even if their underlying parameter estimates are inaccurate (for example, a species that is declining at a rate of more than 10% over three generations and that has a population estimate of 2,500 mature individuals would be correctly classified as Vulnerable even if the true population were as high as 9,999 mature individuals). Methods are currently being developed to quantify assessment uncertainty for each species (through using fuzzy number logic to estimate the range of possible Red List categories that may apply to each species), and to incorporate such uncertainty into the calculation of confidence intervals for RLIs.

Quantifying the impact of conservation

A simple way of quantifying the impact that conservation action has had on extinction risk trends is to examine the difference in the RLI trend brought about by excluding those species that were downlisted to lower categories of threat as a consequence of conservation measures. Globally, this shows that, in the absence of conservation, the RLI would have declined by an additional 18%, equivalent to preventing each of 39 species moving one Red List category closer to extinction between 1988 and 2008 (e.g. Hoffmann *et al.*, 2010). In Australia, however, the positive impact of conservation on 29 taxa was partly offset by the unintended consequences of conservation actions on Macquarie Island that resulted in uplisting of five taxa, which points to the potential for improvements in the RLI value when the current efforts to control introduced predators and herbivores on Macquarie Island are complete. Even so, conservation action reduced the decline in the Australian bird RLI from 1.55% to 1.36%, equivalent to preventing 16 taxa each moving one Red List category closer to extinction between 1990 and 2010.

5. Conclusion

The use of the RLI at a national level has four potential benefits. First, if it is calculated from national scale assessments of extinction risk, the index should provide a more sensitive metric of biodiversity loss than a national disaggregation of a global index. This is because a higher proportion of species tend to qualify as threatened or Near Threatened when their extinction risk is assessed at a finer spatial scale, and hence more species tend to move between categories when assessments are repeated, leading to RLI trends that are more representative of the changing status of the species concerned. Secondly, biogeographical and taxonomic disaggregation can then be used to assess the drivers of trends, and the actions required to alter them. For Australia, because of the majority of status changes are driven by factors outside Australia, enhanced international advocacy and assistance will be necessary if local losses are to be prevented. This is familiar situation for North America and Europe, but has perhaps been under-appreciated in Australia. Thirdly, the RLI can be applied at multiple taxonomic levels, suggesting that it can be used to inform assessment of trends in genetic diversity as well as that of species. Lastly, jurisdictional disaggregation can be used to highlight performance of individual national subunits, although measurements of performance need to be contextualised and carefully interpreted.

Limitations of a national-level RLI are that, if it is disaggregated into subsets that are too small and with too few taxa driving trends, these trends can be difficult to interpret and may be less useful as indicators. The RLI alone is also relatively slow to change and therefore difficult to incorporate into short-term political cycles. Globally, the index for birds is updated every four years (Butchart, 2008, BirdLife International, 2011), but in Australia assessments have been at 10-year intervals. Further work could usefully investigate the potential for linking RLI changes with conservation investment levels (McCarthy *et al.*, 2008), identifying the optimal expenditure to achieve the greatest improvement in RLI. Overall, we conclude that calculation of the RLI at the country level is a valuable addition to national biodiversity benchmarking, and one that will increase in value with time as the time-series of data becomes longer.

Acknowledgements

The Red List assessments upon which these analyses are based would not have been possible without input from hundreds of experts. For the 2010 assessment we wish to thank particularly members of the Birds Australia threatened species committee: Barry Baker, Andrew Burbidge, Allan Burbidge, Graham Carpenter, Les Christidis, Guy Dutson, Hugh Ford, Tim Holmes, Sarah Legge, Richard Loyn, Peter Menkhorst, James O'Connor, Penny Olsen, Don Saunders, Andy Symes, David Watson and John Woinarski. The project was funded under Australian Research Council Linkage Grant LP0990395 with support from Birds Australia, the Australian Wildlife Conservancy, Biosis and BirdLife International.

Figure legends

Fig. 1.Number of taxa in IUCN Red List categories for the three assessment years, 1990 (black), 2000 (grey) and 2010 (white) for subspecies (A) and species (B). NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered and EX = Extinct. Number of Least Concern taxa in 1990, 2000 and 2010, excluded for clarity, was 628, 616 and 606 species and 1108, 1088 and 1072 subspecies, respectively.

Fig. 2. Red List Index of survival for all bird species globally (n = 9853), Australian species (n = 710) and Australian ultrataxa (n = 1238) for taxa with drivers of status change operating within Australia as well as overseas (black lines) and taxa changing status solely because of threats operating within Australia (grey lines). An RLI value of 1.0 equates to all taxa being categorised as Least Concern, and hence that none would be expected to go extinct in the near future. An RLI value of zero indicates that all taxa have gone Extinct. The n values are the number of taxa that are extant and not Data Deficient and at start of the period.

Fig. 3. Cumulative percentage of species (black fill, n = 710) and ultrataxa (grey fill, n = 1238) qualifying for Red List category changes owing to genuine improvement (positive values) or deterioration (negative values) in status as a result of threats (mitigated or impacting) across the range of each taxa.

Fig. 4. Red List Indices of species survival for ultrataxa on the Australian continent (n = 1002), continental islands (n = 655) and oceanic islands (n = 121), excluding status changes driven by threats operating outside Australia. Some taxa are included in more than one of these subsets.

Fig. 5. Red List Indices of species survival for continental ultrataxa by jurisdiction, excluding status changes driven by threats operating outside Australia (ACT: Australian Capital Territory n = 230, Qld: Queensland, n = 706, NT: Northern Territory, n = 401, WA: Western Australia, n = 490, NSW: New South Wales, n = 457, Vic: Victoria, n = 373, SA: South Australia, n = 419, Tas: Tasmania, n = 178).

Fig. 6. Red List Indices of Australian species survival for ultrataxa in different orders (Columbiformes n = 41, Passeriformes n = 702; Psittaciformes n = 101; Charadriiformes n = 100; Procellariiformes n = 71 and other orders aggregated n = 218), based on changes in status resulting from threats anywhere in the taxon's range.

Fig. 7. Number of ultrataxa qualifying for uplisting to higher categories of threat in 1990–2000 and 2000–2010 owing to different drivers. Black bars signify drivers acting in Australia, white bars signify drivers acting overseas. Some taxa were impacted by multiple drivers.

Fig. 8. Number of ultrataxa qualifying for downlisting to lower categories of threat or not deteriorating in 1990–2010 owing to amelioration of different threats (A) and as a result of different actions (B).

Table 1. IUCN Red List category Australian ultrataxa in 1990, 2000 and 2010 (with the former two updated using current knowledge in 2010) and (where different) the estimated status in 2010 if there had not been conservation intervention during 1990–2010 (marked by 2010*)

Common name	**Scientific name**	**1990**	**2000**	**2010**	**2010***	**Reasons for revised 2010 status**
White-tailed Tropicbird (Indian Ocean)	*Phaethon lepturus lepturus*	EN	EN	EN	CR	Hunting on North Keeling I. would not have been prevented. Criteria met: B2ab(ii,iii,v); C2a(ii)
Emerald Dove (Christmas Island)	*Chalcophaps indica natalis*	NT	NT	NT	VU	Proliferation of crazy ants would have continued unabated. Criteria met: B2ab(iii)
Grey-headed Albatross	*Thalassarche chrysostoma*	EN	EN	CR	EN	Cats would not have been removed from Macquarie Island, preventing proliferation of rabbits. Criteria met: D
Light-mantled Sooty Albatross	*Phoebetria palpebrata*	VU	VU	EN	VU	Cats would not have been removed from Macquarie Island, preventing proliferation of rabbits. Criteria met: D2

Common name	Scientific name	1990	2000	2010	2010*	Reasons for revised 2010 status
Antarctic Prion	*Pachyptila desolata*	VU	VU	EN	VU	Cats would not have been removed from Macquarie Island, preventing proliferation of rabbits. Criteria met: D2
White-headed Petrel	*Pterodroma lessonii*	VU	VU	EN	VU	Cats would not have been removed from Macquarie Island, preventing proliferation of rabbits. Criteria met: D2
Gould's Petrel (Australian)	*Pterodroma leucoptera leucoptera*	EN	VU	VU	CR	Loss of nesting birds on Cabbage Tree Island would have continued and there would have been no translocation to other islands. Criteria met: B2ab(ii,iii,v)
Abbott's Booby	*Papasula abbotti*	EN	CR	EN	CR	Proliferation of crazy ants would have continued unabated . Criteria met: B2ab(iii)

Common name	Scientific name	1990	2000	2010	2010*	Reasons for revised 2010 status
Red-footed Booby	*Sula sula*	LC	LC	LC	NT	Hunting on North Keeling I. would not have been prevented. Criteria met: A2d
Wedge-tailed Eagle (Tasmanian)	*Aquila audax fleayi*	EN	EN	VU	EN	Loss of habitat to forestry would have continued, and there would have been no offsets from wind turbines. Criteria met: C2a(ii)
Buff-banded Rail (Cocos Keeling Islands)	*Gallirallus philippensis andrewsi*	VU	VU	VU	CR	Access to North Keeling I. would not have been restricted increasing likelihood of invasion by rats and cats. Criteria met: B2a(iii,v)
Lord Howe Woodhen	*Gallirallus sylvestris*	EN	EN	EN	CR	The woodhens would have been confined to the summit of Mt Gower because of predation by pigs. Criteria met:

Common name	Scientific name	1990	2000	2010	2010*	Reasons for revised 2010 status
Hooded Plover (eastern)	*Thinornis rubricollis rubricollis*	VU	VU	VU	EN	Declines from beach disturbance would have caused a more rapid decline. Criteria met: C2a(ii)
Little Tern (western Pacific Ocean)	*Sternula albifrons sinensis*	LC	LC	LC	VU	The breeding population in south-eastern Australia would be much lower without active protection. Criteria met: C1
Glossy Black-Cockatoo (Kangaroo Island)	*Calyptorhynchus lathami halmaturinus*	CR	EN	EN	CR(PE)	Failure to protect nests would have caused ongoing population decline, possibly to extinction. Criteria met: A2be+4be; C2a(i,ii), D
Western Corella (southern, Muir's)	*Cacatua pastinator pastinator*	EN	EN	LC	EN	Failure to enforce protection would have caused loss of nest sites and death of birds from poisoning and shooting. Criteria met: C2a(ii)

Common name	Scientific name	1990	2000	2010	2010*	Reasons for revised 2010 status
Tasman Parakeet (Norfolk Island)	*Cyanoramphus cookii cookii*	CR	EN	CR	CR(PE)	Failure to provide and protect nest sites would have caused continued decline and possible extinction. Criteria met: B2ab(iii,v), C2a(i,ii), D
Orange-bellied Parrot	*Neophema chrysogaster*	CR	CR	CR	CR(PE)	Failure to provide and protect nest sites would have caused continued decline and possible extinction. Criteria met: B2ab(iii,v), C2a(i,ii), D
Western Ground Parrot	*Pezoporus flaviventris*	EN	EN	CR	EN	Had foxes not been poisoned cat predation may have been less prevalent. Criteria met: B2ab(i,ii,iii,iv,c), C2a(ii)
Southern Boobook (Norfolk Island x New Zealand)	*Ninox novaeseelandiae undulata*	CR	CR	CR	CR(PE)	Failure to provide an additional male would have resulted in extinction. Criteria met: A2a, B1ab(i,ii,iv,v)+B2ab(i,ii,iv,v), C2a(i,ii), D

Common name	Scientific name	1990	2000	2010	2010*	Reasons for revised 2010 status
Christmas Island Hawk-Owl	*Ninox natalis*	VU	CR	VU	EN	Proliferation of crazy ants would have continued unabated . Criteria met: B2ab(iii)
Albert's Lyrebird	*Menura alberti*	VU	VU	NT	VU	Failure to protect forest from logging would have caused ongoing declines and habitat deterioration. Criteria met: B1ab(iii,v)+2ab(iii,v)
Noisy Scrub-bird	*Atrichornis clamosus*	EN	VU	EN	CR	An increased fire frequency is likely, leading to rapid depletion of the population as there would also have been no translocations. Criteria met: A2a, B1ab(i,ii,iv,v)+B2ab(i,ii,iv,v), C2a(i,ii), D
Southern Emu-wren (Fleurieu Peninsula)	*Stipiturus malachurus intermedius*	EN	EN	EN	CR(PE)	Ongoing loss of habitat to agriculture and fires may well have caused local extinction. Criteria met: A2a, B1ab(i,ii,iv,v)+B2ab(i,ii,iv,v), C2a(i,ii), D

Common name	Scientific name	1990	2000	2010	2010*	Reasons for revised 2010 status
Southern Emu-wren (Eyre Peninsula)	*Stipiturus malachurus parimeda*	EN	EN	EN	CR	Ongoing loss of habitat to agriculture and fires may well have caused extinction of more subpopulations. Criteria met: B1ab(i,ii,iv,v)+B2ab(i,ii,iv,v), C2a(i)
Western Bristlebird	*Dasyornis longirostris*	VU	VU	EN	CR	An increased fire frequency is likely, leading to rapid depletion of the population . Criteria met: C2a(ii)
Scrubtit (King Island)	*Acanthornis magnus greenianus*	CR	CR	CR	CR(PE)	Ongoing loss of habitat to agriculture and fires may well have caused local extinction. Criteria met: B1ab(i,ii,iii,iv,v)+B2ab(i,ii,iii,iv,v), C2a(i,ii), D
Chestnut-rumped Heathwren (Mount Lofty Ranges)	*Hylacola pyrrhopygia parkeri*	EN	EN	EN	CR	Ongoing loss of habitat to fires may well have caused local extinction. Criteria met: B1ab(i,ii,iii,iv,v)+B2ab(i,ii,iii,iv,v), C2a(i,ii), D

Common name	Scientific name	1990	2000	2010	2010*	Reasons for revised 2010 status
Brown Thornbill (King Island)	*Acanthiza pusilla archibaldi*	CR	CR	CR	CR(PE)	Ongoing loss of habitat to agriculture and fires may well have caused local extinction. Criteria met: B1ab(i,ii,iii,iv,v)+B2ab(i,ii,iii,iv,v), C2a(i,ii), D
Forty-spotted Pardalote	*Pardalotus quadragintus*	EN	EN	EN	CR	Ongoing loss of habitat to agriculture and fires may well have caused local extinction. Criteria met: B1ab(i,ii,ii,iv,v)
Yellow-tufted Honeyeater (Helmeted)	*Lichenostomus melanops cassidix*	CR	CR	CR	CR(PE)	Ongoing loss of habitat to agriculture and fires would probably have caused local extinction; also required translocation and ex situ conservation. Criteria met: B1ab(i,ii,iii,iv,v)+B2ab(i,ii,iii,iv,v), C2a(i,ii), D

Common name	Scientific name	1990	2000	2010	2010*	Reasons for revised 2010 status
Black-eared Miner	*Manorina melanotis*	EN	EN	EN	CR	Ongoing loss of habitat to fires would probably have caused local extinction; also reintroductions would not have occurred. Criteria met: A2b, B2ab(i,ii,iii,iv,v)
Western Whipbird (western heath)	*Psophodes nigrogularis nigrogularis*	VU	VU	EN	CR	An increased fire frequency is likely, leading to rapid depletion of the population . Criteria met: C2a(ii)
Island Thrush (Christmas Island)	*Turdus poliocephalus erythropleurus*	NT	NT	NT	VU	Proliferation of crazy ants would have continued unabated. Criteria met: B2ab(iii)

References

Baillie, J. E. M., Collen, B., Amin, R., Akcakaya, H. R., Butchart, S. H. M., Brummitt, N., Meagher, T. R., Ram, M., Hilton-Taylor, C., and Mace, G. M. (2008) Toward monitoring global biodiversity. *Conservation Letters* **1**: 18-26.

Balmford, A., Bennun, L., ten Brink, B., Cooper, D., Côté, I. M., Crane, P., Dobson, A., Dudley, N., Dutton, I., Green, R. E., Gregory, R. D., Harrison, J., Kennedy, E. T., Kremen, C., Leader-Williams, N., Lovejoy, T. E., Mace, G. M., May, R. M., Mayaux, P., Morling, P., Phillips, J., Redford, K., Ricketts, T. H., Rodríguez, J. P., Sanjayan, M., Schei, P. J., van Jaarsveld, A. S., and Walther, B. A. (2005) The Convention on Biological Diversity's 2010 Target. *Science* **307**: 212-213.

Beeton, B., Burbidge, A. A., Grigg, G., Harrison, P., How, R. A., Humphries, B., McKenzie, N., and Woinarski, J. (2010). *Final Report, Christmas Island Expert Working Group to Minister for the Environment, Heritage and the Arts.*

Bennett, P. M., and Owens, I. P. F. (1997) Variation in extinction risk among birds: chance or evolutionary predisposition? *Proceedings of the Royal Society of London, B* **264**: 401-408.

BirdLife International (2008). *State of the world's birds: indicators for our changing world.* BirdLife International, Cambridge, UK.

BirdLife International. (2011). *The BirdLife checklist of the birds of the world, with conservation status and taxonomic sources. Version 4.*

Blackburn, T. M., Cassey, P., Duncan, R. P., Evans, K. L., and Gaston, K. J. (2004) Avian Extinction and Mammalian Introductions on Oceanic Islands. *Science* **305**: 1955-1958.

Bubb, P. J., Butchart, S. H. M., Collen, B., Dublin, H. T., Kapos, V., Pollock, C., Stuart, S. N., and Vié, J.-C. (2009). *IUCN Red List Index - Guidance for National and Regional Use.* IUCN, Gland, Switzerland.

Butchart, S. H. M. (2008) Red List Indices to measure the sustainability of species use and impacts of invasive alien species. *Bird Conservation International* **18**: 245-262.

Butchart, S. H. M., Akçakaya, H. R., Chanson, J., Baillie, J. E. M., Collen, B., Quader, S., Turner, W. R., Amin, R., Stuart, S. N., and Hilton-Taylor, C. (2007) Improvements to the Red List Index. *PLoS ONE* **2**: e140.

Butchart, S. H. M., Stattersfield, A. J., Baillie, J., Bennun, L. A., Stuart, S. N., Akçakaya, H. R., Hilton-Taylor, C., and Mace, G. M. (2005) Using Red List Indices to measure progress towards the 2010 target and beyond. *Phil. Trans. R. Soc. B* **360**: 255-268.

Butchart, S. H. M., Stattersfield, A. J., Bennun, L. A., Shutes, S. M., Akçakaya, H. R., Baillie, J. E. M., Stuart, S. N., Hilton-Taylor, C., and Mace, G. M. (2004) Measuring global trends in the status of biodiversity: Red List indices for birds. *PLoS Biology* **2**: e383.

Butchart, S. H. M., Stattersfield, A. J., and Collar, N. J. (2006) How many bird extinctions have we prevented? *Oryx* **40**: 266–278.

Butchart, S. H. M., Walpole, M., Collen, B., van Strien, A., Scharlemann, J. P. W., Almond, R. E. A., Baillie, J. E. M., Bomhard, B., Brown, C., Bruno, J., Carpenter, K. E., Carr, G. M., Chanson, J., Chenery, A. M., Csirke, J., Davidson, N. C., Dentener, F., Foster, M., Galli, A., Galloway, J. N., Genovesi, P., Gregory, R. D., Hockings, M., Kapos, V., Lamarque, J.-F., Leverington, F., Loh, J., McGeoch, M. A., McRae, L., Minasyan, A., Hernández Morcillo, M., Oldfield, T. E. E., Pauly, D., Quader, S., Revenga, C., Sauer, J. R., Skolnik, B., Spear, D., Stanwell-Smith, D., Stuart, S. N., Symes, A., Tierney, M., Tyrrell, T. D., Vié, J.-C., and Watson, R. (2010) Global Biodiversity: Indicators of Recent Declines *Science* **10.1126/science.1187512**.

Carpenter, K. E., Abrar, M., Aeby, G., Aronson, R. B., Banks, S., Bruckner, A., Chiriboga, A., Cortés, J., Delbeek, J. C., DeVantier, L., Edgar, G. J., Edwards, A. J., Fenner, D., Guzmán, H. M., Hoeksema, B. W., Hodgson, G., Johan, O., Licuanan, W. Y., Livingstone, S. R., Lovell, E. R., Moore, J. A., Obura, D. O., Ochavillo, D., Polidoro, B. A., Precht, W. F., Quibilan, M. C., Reboton, C., Richards, Z. T., Rogers, A. D., Sanciangco, J. C., Sheppard, A., Sheppard, C., Smith, J., Stuart, S. N., Turak, E., Veron, J. E. N., Wallace, C., Weil, E., and Wood, E. (2008) One-third of reef-building corals face elevated extinction risk from climate change and local impacts. *Science* **321**: 560-563.

CBD (2011). *Report of the ad hoc technical expert group on indicators for the strategic plan for biodiversity 2011-2020. CBD Document UNEP/CBD/AHTEG-SP-Ind/1/3.* Convention on Biological Diversity, Montreal.

Christidis, L., and Boles, W. E. (2008). *Systematics and Taxonomy of Australian Birds.*CSIRO Publishing

Collen, B., Loh, J., Whitmee, S., McRae, L., Amin, R., and Baillie, J. E. M. (2008) Monitoring Change in Vertebrate Abundance: the Living Planet Index. *Conservation Biology* **23** 317-327.

Franklin, D. C. (1999) Evidence of disarray amongst granivorous bird assemblages in the savannas of northern Australia, a region of sparse human settlement. *Biological Conservation* **90**: 53-68.

Garnett, S., and Crowley, G. M. (2000). *The Action Plan for Australian Birds 2000*. Canberra, Environment Australia

Garnett, S. T. (1992). *The Action Plan for Australian Birds.* Canberra, Australian National Parks and Wildlife Service

Garnett, S. T. (2011). *Monitoring Australian birds to meet international obligations.* in D. B. Lindenmayer, and P. Gibbons (Eds.) Biodiversity Monitoring in Australia. Melbourne. CSIRO.

Garnett, S. T., and Christidis, L. (2007) Implications of changing species definitions for conservation purposes. *Bird Conservation International* **17**: 187-195.

Garnett, S. T., Szabo, J. K., and Dutson, G. (2011). *The Action Plan for Australian Birds 2010.* Collingwood, CSIRO Publishing

Gregory, R. D., Vorisek, P., Van Strien, A., Gmelig Meyling, A. W., Jiguet, F., Fornasari, L., Reif, J., Chylarecki, P., and Burfield, I. J. (2007) Population trends of widespread woodland birds in Europe. *Ibis* **149**: 78-97.

Hambler, C. (2004). *Conservation.* Cambridge, Cambridge University Press

Higgins, P. J., (Eds.). (1999). *Handbook of Australian, New Zealand and Antarctic Birds.* Melbourne Oxford University Press.

Higgins, P. J., and Davies, S. J. J. F., (Eds.). (1996). *Handbook of Australian, New Zealand and Antarctic Birds.* Melbourne Oxford University Press.

Hoffmann, M., Belant, J. L., Chanson, J. S., Cox, N. A., Lamoreux, J. F., Rodrigues, A. S. L., Schipper, J., and Stuart, S. N. (2011) The changing fates of the world's mammals. *Phil. Trans. R. Soc. B* **366**: 2598-2610.

Hoffmann, M., Hilton-Taylor, C., Angulo, A., Böhm, M., Brooks, T. M., Butchart, S. H. M., Carpenter, K. E., Chanson, J., Collen, B., Cox, N. A., Darwall, W. R. T., Dulvy, N. K., Harrison, L. R., Katariya, V., Pollock, C. M., Quader, S., Richman, N. I., Rodrigues, A.

S. L., Tognelli, M. F., Vié, J.-C., Aguiar, J. M., Allen, D. J., Allen, G. R., Amori, G., Ananjeva, N., Andreone, F., Andrew, P., Aquino Ortiz, A. L., Baillie, J. E. M., Baldi, R., Bell, B. D., Biju, S. D., Bird, J. P., Black-Decima, P., Blanc, J. J., Bolaños, F., Bolivar-G., W., Burfield, I. J., Burton, J. A., Capper, D. R., Castro, F., Catullo, G., Cavanagh, R. D., Channing, A., Chao, N. L., Chenery, A. M., Chiozza, F., Clausnitzer, V., Collar, N. J., Collett, L. C., Collette, B. B., Cortez Fernandez, C. F., Craig, M. T., Crosby, M. J., Cumberlidge, N., Cuttelod, A., Derocher, A. E., Diesmos, A. C., Donaldson, J. S., Duckworth, J. W., Dutson, G., Dutta, S. K., Emslie, R. H., Farjon, A., Fowler, S., Freyhof, J., Garshelis, D. L., Gerlach, J., Gower, D. J., Grant, T. D., Hammerson, G. A., Harris, R. B., Heaney, L. R., Hedges, S. B., Hero, J.-M., Hughes, B., Hussain, S. A., Icochea M., J., Inger, R. F., Ishii, N., Iskandar, D. T., Jenkins, R. K. B., Kaneko, Y., Kottelat, M., Kovacs, K. M., Kuzmin, S. L., La Marca, E., Lamoreux, J. F., Lau, M. W. N., Lavilla, E. O., Leus, K., Lewison, R. L., Lichtenstein, G., Livingstone, S. R., Lukoschek, V., Mallon, D. P., McGowan, P. J. K., McIvor, A., Moehlman, P. D., Molur, S., Muñoz Alonso, A., Musick, J. A., Nowell, K., Nussbaum, R. A., Olech, W., Orlov, N. L., Papenfuss, T. J., Parra-Olea, G., Perrin, W. F., Polidoro, B. A., Pourkazemi, M., Racey, P. A., Ragle, J. S., Ram, M., Rathbun, G., Reynolds, R. P., Rhodin, A. G. J., Richards, S. J., Rodríguez, L. O., Ron, S. R., Rondinini, C., Rylands, A. B., Sadovy de Mitcheson, Y., Sanciangco, J. C., Sanders, K. L., Santos-Barrera, G., Schipper, J., Self-Sullivan, C., Shi, Y., Shoemaker, A., Short, F. T., Sillero-Zubiri, C., Silvano, D. L., Smith, K. G., Smith, A. T., Snoeks, J., Stattersfield, A. J., Symes, A. J., Taber, A. B., Talukdar, B. K., Temple, H. J., Timmins, R., Tobias, J. A., Tsytsulina, K., Tweddle, D., Ubeda, C., Valenti, S. V., van Dijk, P. P., Veiga, L. M., Veloso, A., Wege, D. C., Wilkinson, M., Williamson, E. A., Xie, F., Young, B. E., Akçakaya, H. R., Bennun, L., Blackburn, T. M., Boitani, L., Dublin, H. T., da Fonseca, G. A. B., Gascon, C., Lacher Jr., T. E., Mace, G. M., Mainka, S. A., McNeely, J. A., Mittermeier, R. A., McGregor Reid, G., Rodriguez, J. P., Rosenberg, A. A., Samways, M. J., Smart, J., Stein, B. A., and Stuart, S. N. (2010) The Impact of Conservation on the Status of the World's Vertebrates. *Science* **330**: 1503-1509.

IUCN (2001). *IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission.* IUCN, Gland, Switzerland and Cambridge.

IUCN (2003). *Guidelines for Application of IUCN Criteria at Regional Levels. Version 3.0.*IUCN

IUCN (2008). *Red list of threatened species.* IUCN, Gland, Switzerland and Cambridge, UK.

IUCN Standards and Petitions Subcommittee (2010). *Guidelines for Using the IUCN Red List Categories and Criteria. Version 8.1. Prepared by the Standards and Petitions Subcommittee in March 2010.*

Jones, J. P. G., Collen, B., Atkinson, G., Baxter, P. W. J., Bubb, P., Illian, J. B., Katzner, T. E., Keane, A., Loh, J., McDonald-Madden, E., Nicholson, E., Pereira, H. M., Possingham, H. P., Pullin, A. S., Rodrigues, A. S. L., Ruiz-Gutierrez, V., Sommerville, M., and Milner-Gulland, E. J. (2011) The Why, What, and How of Global Biodiversity Indicators Beyond the 2010 Target. *Conservation Biology* **25**: 450-457.

Marchant, S., and Higgins, P. J., (Eds.). (1990). *Handbook of Australian, New Zealand and Antarctic Birds.* Melbourne Oxford University Press.

Marchant, S., and Higgins, P. J., (Eds.). (1993). *Handbook of Australian, New Zealand and Antarctic Birds.* Melbourne Oxford University Press.

McCarthy, M. A., Thompson, C. J., and Garnett, S. T. (2008) Optimal investment in conservation of species. *Journal of Applied Ecology* **45**: 1428-1435.

Miller, R. M., Rodríguez, J. P., Aniskowicz-Fowler, T., Bambaradeniya, C., Boles, R., Eaton, M. A., Gardenfors, U., Keller, V., Molur, S., Walker, S., and Pollock, C. (2007) National Threatened Species Listing Based on IUCN Criteria and Regional Guidelines: Current Status and Future Perspectives. *Conservation Biology* **21**: 684-696.

Parks and Wildlife Service (2006). *Macquarie Island Nature Reserve and World Heritage Area Management Plan.* Parks and Wildlife Service, Department of Tourism, Arts and the Environment, Hobart.

Possingham, H. P., Andelman, S. J., Burgman, M. A., Medellín, R. A., Master, L. L., and Keith, D. A. (2002) Limits to the use of threatened species lists. *Trends in Ecology and Evolution* **17**: 503-507.

Priddel, D., Carlile, N., and Wheeler, R. (2000) Eradication of European rabbits (*Oryctolagus cuniculus*) from Cabbage Tree Island, NSW, Australia, to protect the breeding habitat of Gould's petrel (*Pterodroma leucoptera leucoptera*). *Biological Conservation* **94**: 115-125.

Raymond, B., McInnes, J., Dambacher, J. M., Way, S., and Bergstrom, D. M. (2011) Qualitative modelling of invasive species eradication on subantarctic Macquarie Island. *Journal of Applied Ecology* **48**: 181-191.

Salafsky, N., Salzer, D., Stattersfield, A. J., Hilton-Taylor, C., Neugarten, R., Butchart, S. H. M., Collen, B., Cox, N., Master, L. L., O'Connor, S., and Wilkie, D. (2008) A Standard Lexicon for Biodiversity Conservation: Unified Classifications of Threats and Actions. *Conservation Biology* **22**: 897-911.

Schodde, R., and Mason, I. J. (1999). *The Directory of Australian Birds: Passerines.* Collingwood, Victoria, CSIRO

Secretariat of the Convention on Biological Diversity (2010). *Global Biodiversity Outlook 3.*, Montreal, Canada.

Stuart, S. N., Chanson, J. S., Cox, N. A., Young, B. E., Rodrigues, A. S. L., Fischman, D. L., and Waller, R. W. (2004) Status and Trends of Amphibian Declines and Extinctions Worldwide. *Science* **306**: 1783-1786.

Szabo, J. K., Baxter, P. W. J., Vesk, P. A., and Possingham, H. P. (2011) Paying the extinction debt: Declining woodland birds in the Mount Lofty Ranges, South Australia. *Emu* **111**: 59-70.

United Nations (2011). *The Millenium Development Goals Report.*, New York.

Walpole, M., Almond, R. E. A., Besançon, C., Butchart, S. H. M., Campbell-Lendrum, D., Carr, G. M., Collen, B., Collette, L., Davidson, N. C., Dulloo, E., Fazel, A. M., Galloway, J. N., Gill, M., Goverse, T., Hockings, M., Leaman, D. J., Morgan, D. H. W., Revenga, C., Rickwood, C. J., Schutyser, F., Simons, S., Stattersfield, A. J., Tyrrell, T. D., Vié, J.-C., and Zimsky, M. (2009) Tracking Progress Toward the 2010 Biodiversity Target and Beyond. *Science* **325**: 1503-1504.

Xu, H., Tang, X., Liu, J., Ding, H., Wu, J., Zhang, M., Yang, Q., Cai, L., Zhao, H., and Liu, Y. (2009) China's Progress toward the Significant Reduction of the Rate of Biodiversity Loss. *BioScience* **59**: 843-852.

Figure
Click here to download high resolution image

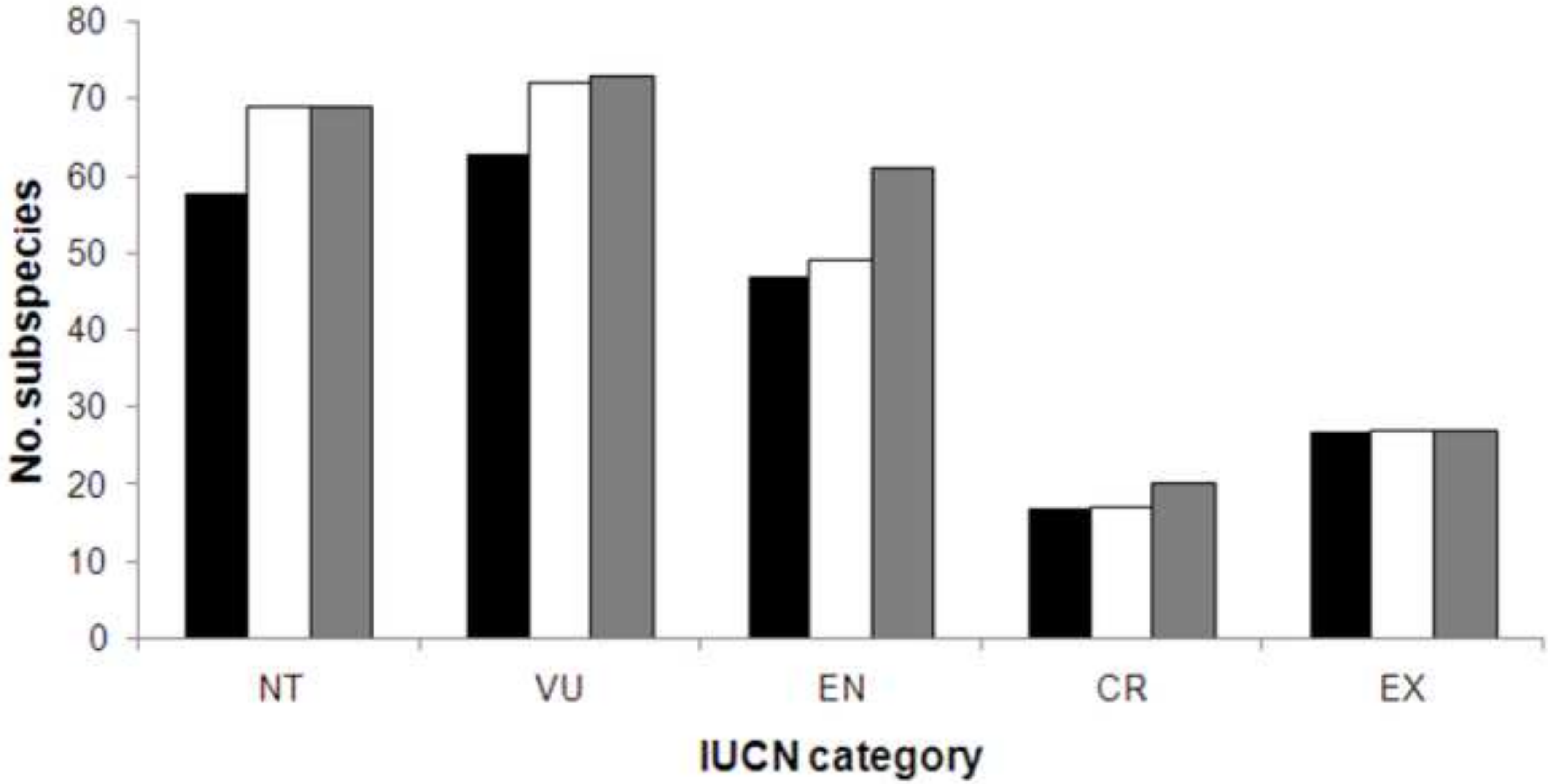

Figure1b
Click here to download high resolution image

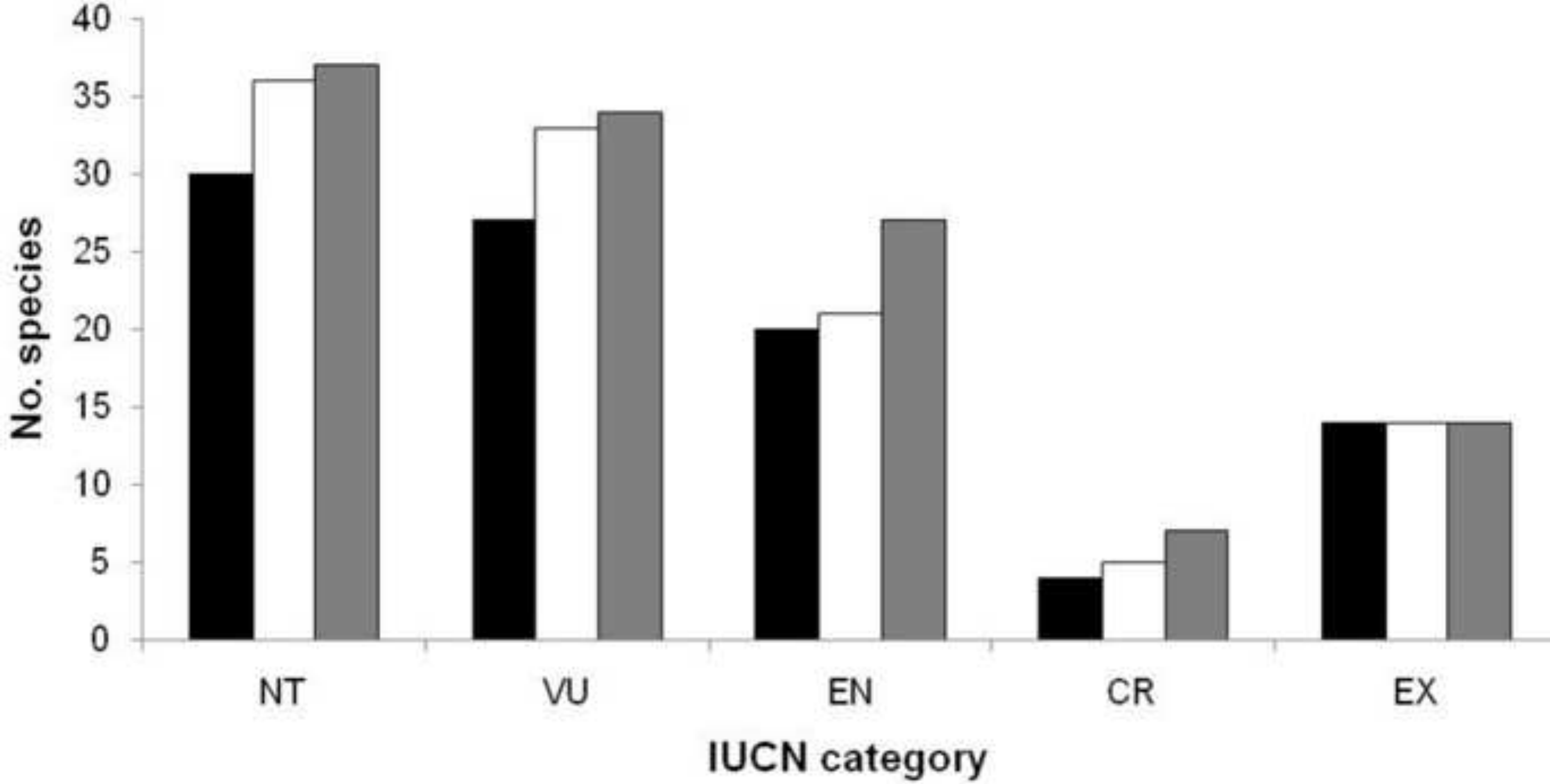

Figure2

Click here to download high resolution image

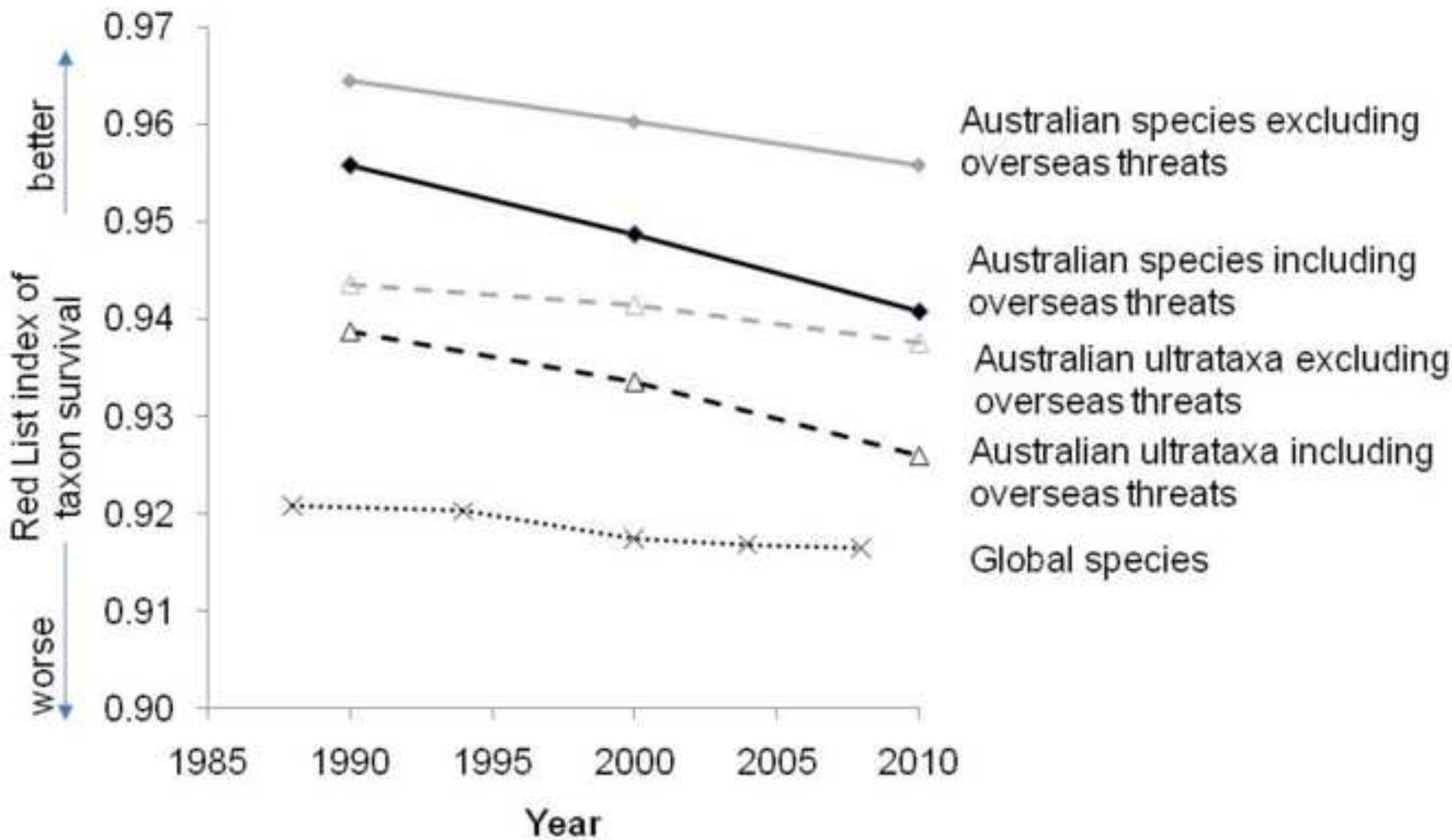

Figure3
Click here to download high resolution image

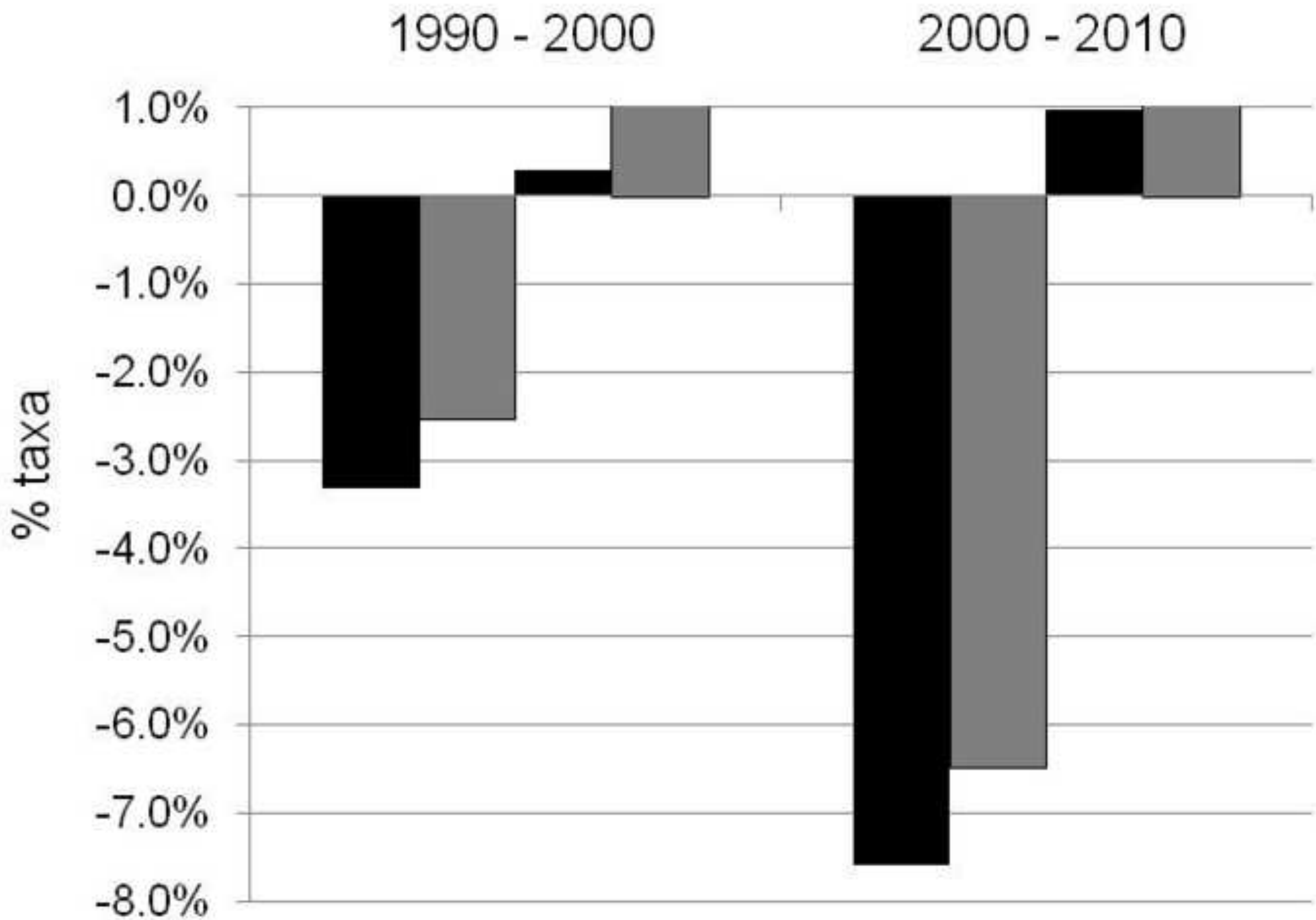

Figure4
Click here to download high resolution image

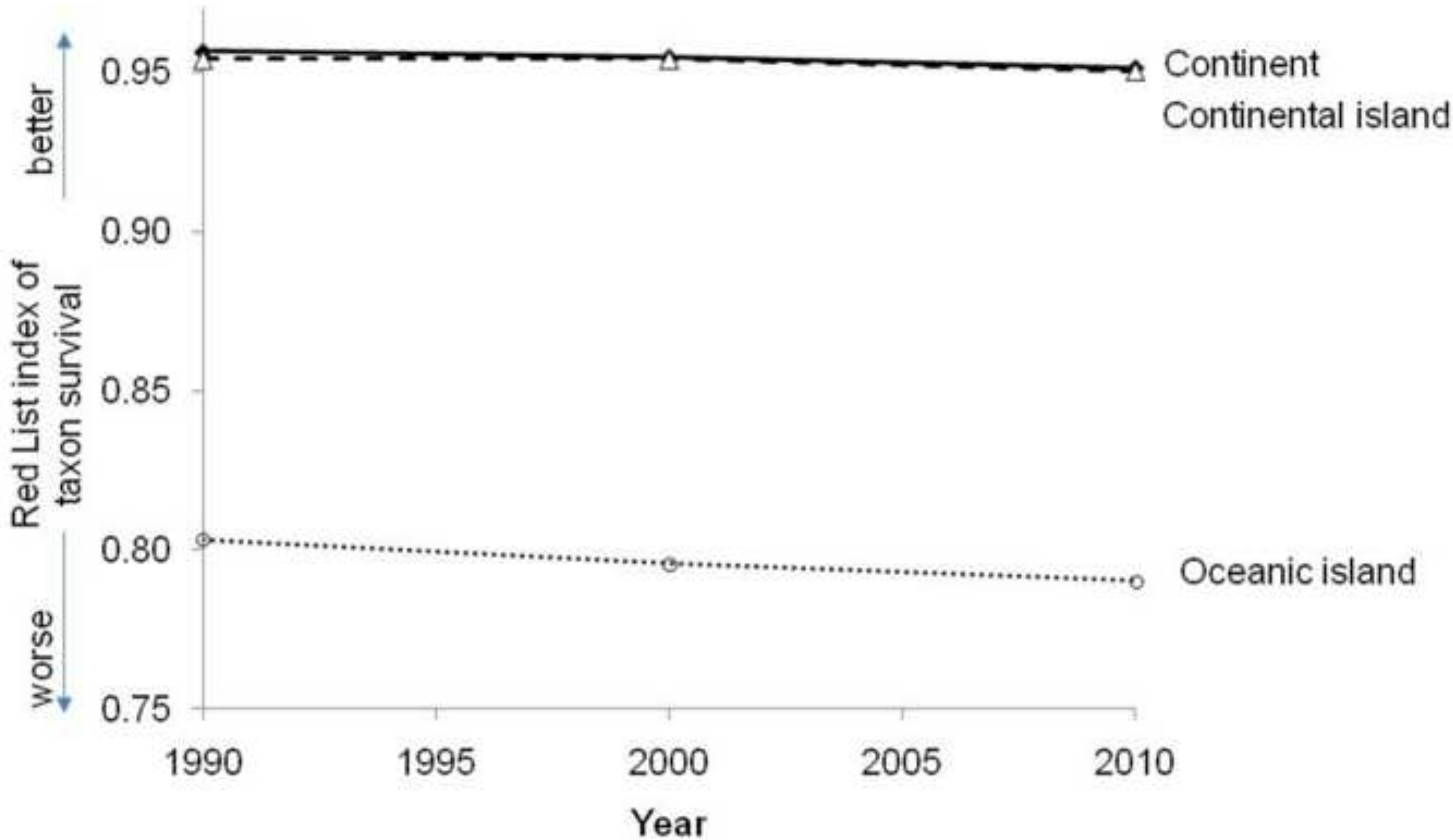

Figure5

Click here to download high resolution image

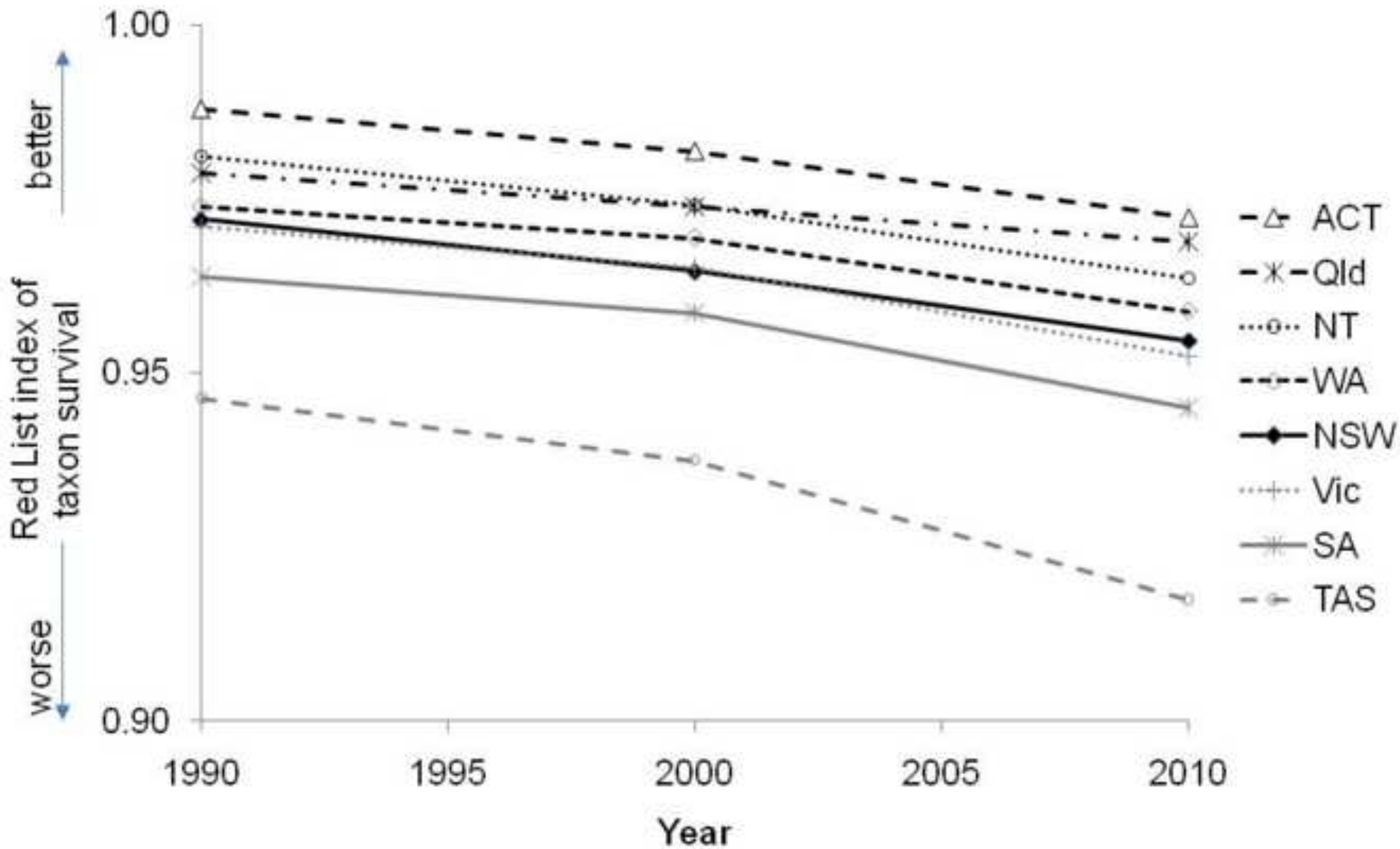

Figure6
Click here to download high resolution image

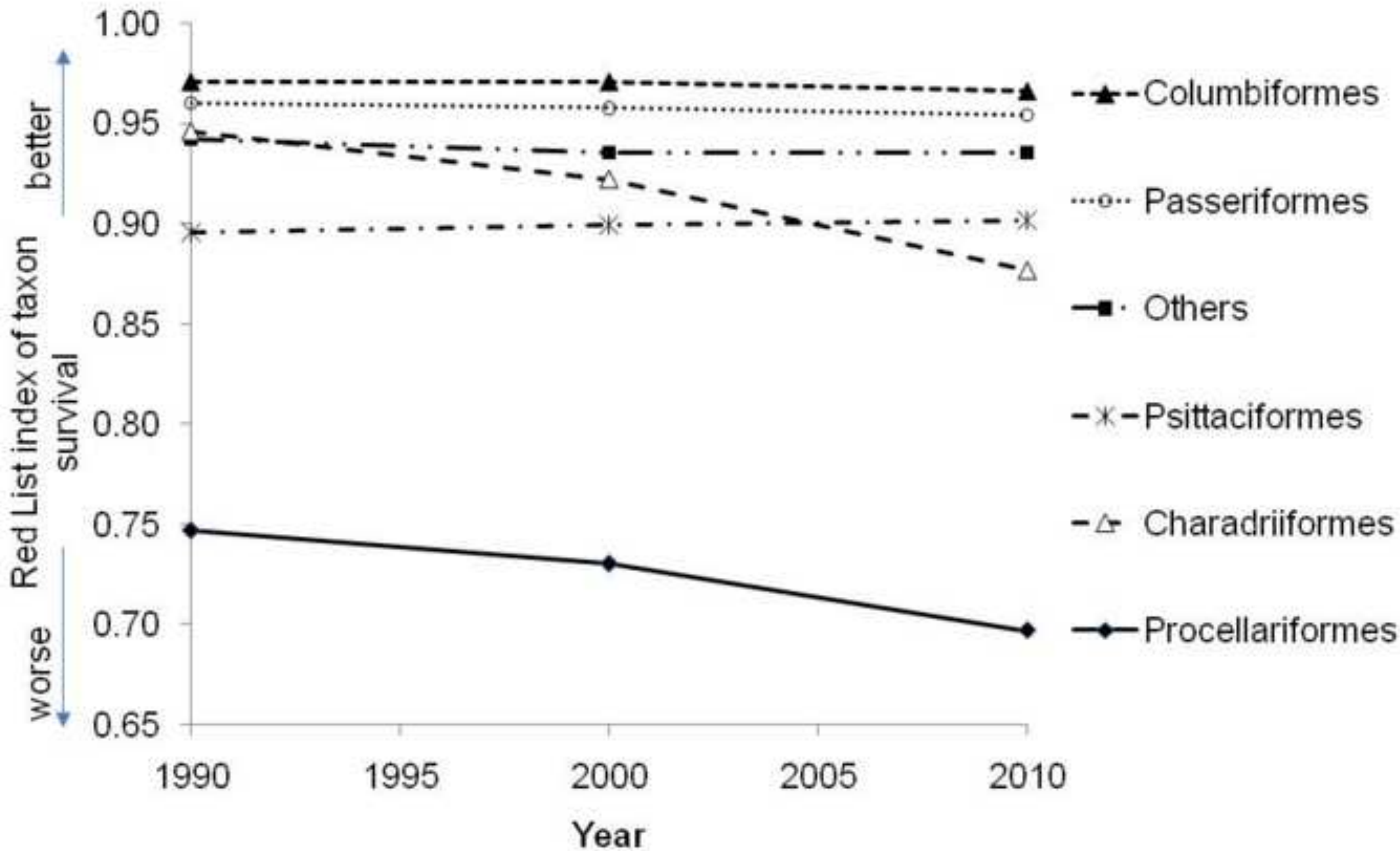

Figure7
Click here to download high resolution image

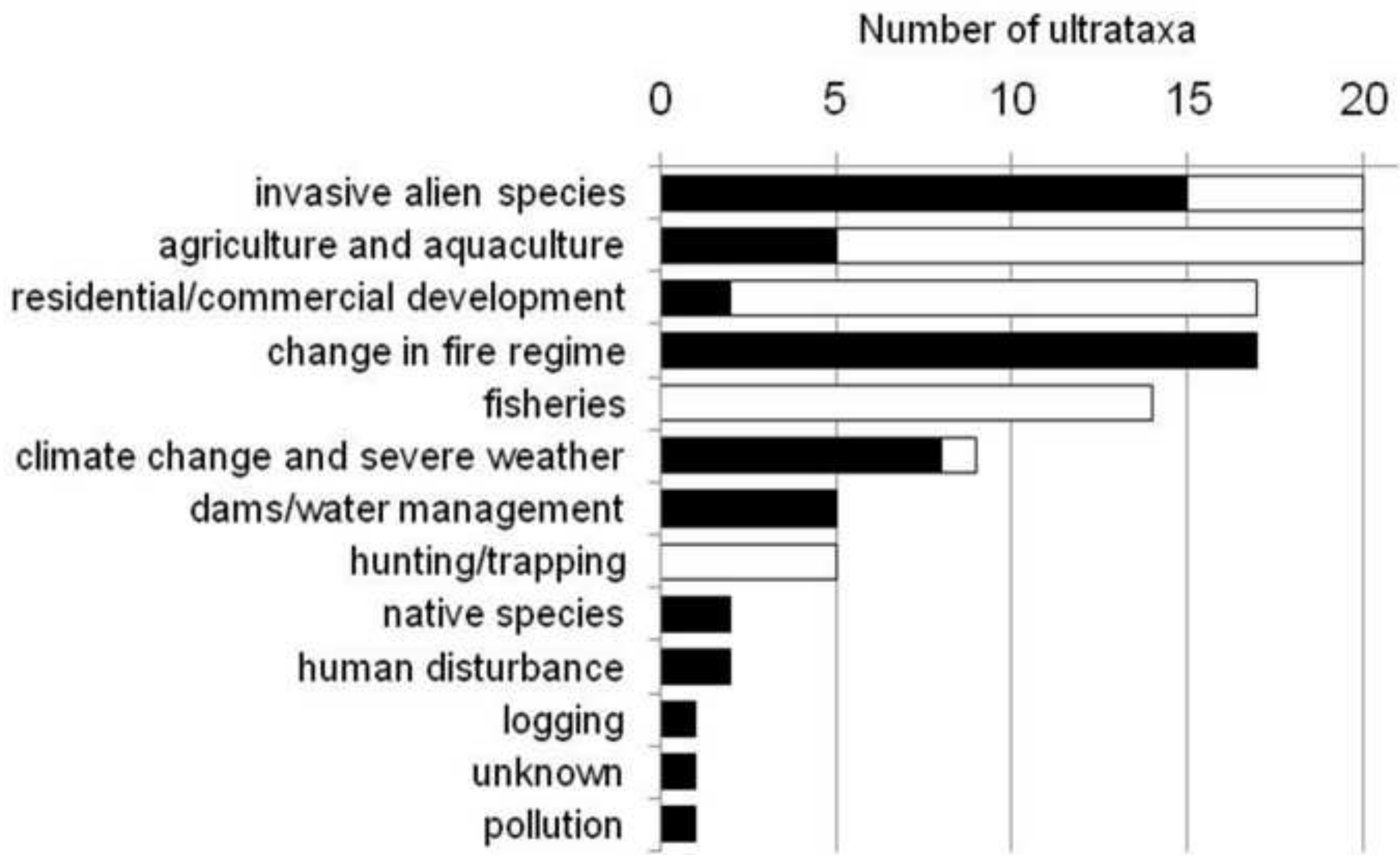

Figure8a
Click here to download high resolution image

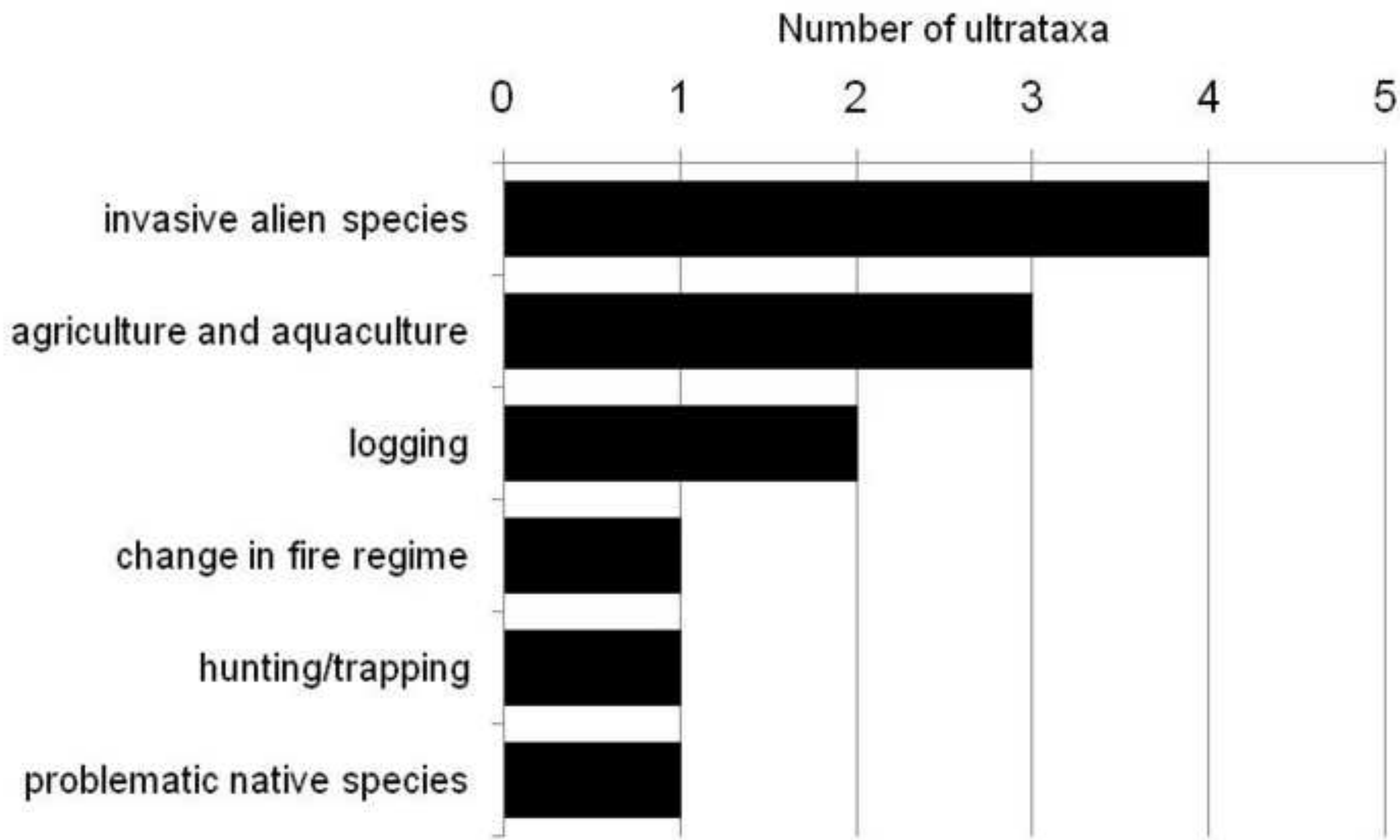

Figure8b
Click here to download high resolution image