When all life counts in conservation

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Abstract

Conservation biology involves the collection and analysis of data. These scientific practices emerge from values that shape who and what is counted. Currently, conservation data is filtered through a value system that considers "native" life the only appropriate subject of conservation concern. We examined how trends in species richness, distribution, and threats change when all wildlife count by adding "non-native" and "feral" populations to global IUCN Red List and local species richness assessments. We focused on vertebrate populations whose founding members were taken into and out of Australia by humans (hence *migrants*). We identified 87 immigrant and 47 emigrant vertebrate species. We found that formal conservation accounts underestimate global ranges by an average of 30% for immigrants and 7% for emigrants; that immigrations surpass extinctions in Australia by 52 species; that migrants are disproportionately threatened, with 33% of immigrants and 29% of emigrants threatened or decreasing in their native ranges; and that incorporating migrant populations into risk assessments could reduce global threat statuses for 15 (of 18) species. We also found that Australian policies define most immigrants as "pests" (76%), and that conservation is the most commonly stated motivation for targeting these species in killing programs (37% of immigrants). Inclusive biodiversity data opens space for dialogue on the ethical and empirical assumptions underlying conservation biology.

Introduction

The values driving conservation biology have been richly variegated since its inception, as conveyed in different understandings of how, why, and for whom humans should protect nature (Soulé 1985; Callicott 1990; Mace 2014; Sandbrook et al. 2019). One perspective that has become widely accepted among conservationists is encapsulated in a worldview called *nativism* (Chew & Hamilton 2011; Wallach et al. 2018a). Nativism attributes intrinsic value to perceived "native" elements of the more-than-human world, identifying them as worthy targets of moral concern. In this sense conservation can be seen as an ethically inclusive worldview, moving beyond purely anthropocentric (human-centered) values to also admit certain non-human entities within the scope of moral concern. However, nativism also establishes clear exclusions. Constituents deemed not to be native are set firmly outside conservation's moral world as "invasive aliens" (Wallach et al. 2018a). Nativism has been highly influential in guiding conservation research and policy. It even filters the most fundamental empirical information available to conservation: species counts.

Species counts underpin analyses of distribution, population size and trend, biogeographic diversity, and extinction risk. They are, therefore, fundamental to our understanding of, and responses to, the living world. The IUCN Red List is the most comprehensive and widely used repository of the conservation status of the world's species. It is used by scientists, governments, and activists to inform regional and global policy (Rodrigues et al. 2006). The Red List's stated aim is to serve as a "*complete barometer of life*" (IUCN 2018). However, like similar regional datasets, it excludes those that do not conform to some operative notion of nativeness. As a result, non-native populations are effectively expunged from the record before they can even be assessed for their potential relevance to conservation (Schlaepfer 2018). We contend that this is a critical shortcoming.

Despite its influence on conservation biology, nativism is a widely contested concept (Davis 2009; Chew & Hamilton 2011; Larson 2011; Srinivasan & Kasturirangan 2017; Wallach et al. 2018a; Pereyra 2019). It is based on assumptions of ecosystems in static equilibrium, which have been challenged by interpretations of ecosystems as dynamic and open-ended (Pickett 2013). It is also based on problematic value judgments about where non-human entities "belong" (Thompson 2014). It is important to ask, independent of these judgements, what might be revealed if biodiversity datasets were fully inclusive? How might our empirical and ethical views be shaped by datasets revealing, for example, that some species with small and decreasing populations inside their native ranges have large and increasing populations outside them; that some domesticated species have established wild populations; and that some regions contain more species today than they have had for thousands of years?

The Red List is a testament to humanity's commitment to adopt an expansive ethic. For example, it is well recognized that some taxonomic groups (e.g. mammals) receive more research attention than others (e.g. insects), mirroring common moral and biological inclinations (Trimble & Van Aarde 2010). Therefore, the Red List is increasing efforts to add species from less known taxonomic groups (IUCN 2018), to ensure its methodology aligns with its scientific mission to be a transparent, consistent, and inclusive source of knowledge (Rodrigues et al. 2006). Each species added to the Red List grows, not only scientific knowledge, but also the community of organisms included in conservation's moral world. We argue that removing nativist filters to include all of life is consistent with this mission.

Studies based on inclusive datasets have already found noteworthy trends that differ from those relying on conventional datasets (e.g. Sax & Gaines 2003; McGill et al. 2015; Thomas & Palmer 2015; Lundgren et al. 2018). For example, nativist-filtered data portray Australia as empty of terrestrial megafauna, even though there are eight species (Lundgren et al. 2018). Post-domestic ("feral") species are also not recognized in nativist datasets, although they may have more in common with their pre-domestic ancestors than with their domestic relatives (e.g. Hernández et al. 1999). Whether populations should be valued differently inside and outside their historic native ranges; or whether post-domestic animals should be valued differently to their pre-domestic ancestors, are ethical questions that require deft and deliberate handling. But it is undeniable that these populations are actual components of the living world. We argue conservation science should reflect that reality.

Here we examine how inclusive species counts may change conservation metrics such as species richness, distribution, and threat status. We focus on revealing one component of the Earth's wildlife so far excluded from conservation assessments: vertebrate populations whose ancestors were moved by humans into and out of Australia since European establishment. We identify where they were moved from and to; the extent their distributions extend outside their historic native ranges; their numeric contributions to species richness; and the policies and actions that affect them.

We use the language of *migration* rather than *invasion* to facilitate less loaded discourse (Larson 2005). We acknowledge that "migrant" is still an imperfect metaphor because the individuals in question did not choose to move, and their descendants were born there. We continue the use of the term *native* to correspond with existing definitions (e.g. IUCN Red List) while acknowledging that the concept is problematic (Chew & Hamilton 2011; Pereyra 2019).

Although we believe every life does and should count, in a moral sense, our primary goal in this paper is not to promote any particular worldview or set of values. Our main argument is that species lists that purport to be comprehensive should be as inclusive as possible, so that a broad spectrum of values can be expressed and debated. In presenting this work, our aim is to open space for transparent dialogue and critical reflection on the value judgments underpinning conservation biology.

Methods

We assessed the taxonomic composition, geographic ranges, and conservation statuses of Australia's migrant vertebrate species, including *immigrants*, defined as populations whose founding members were introduced into Australia, and *emigrants* whose founding members are considered native to Australia and were introduced elsewhere (from Australia or another part of their native range). Post-domestic animals were defined as migrants across their range, but were merged with their pre-domestic ancestors for inclusive assessments (Lundgren et al. 2018). Species were only included as migrants where we found evidence of self-sustaining populations (e.g. populations maintained only by reliance on human provisioning and continual introductions were excluded). Populations were considered *native* where they occur within their native ranges, as defined by the Red List (IUCN 2018), and if their ancestors were never domesticated. Vertebrates moved within Australia's political boundaries were also included in the native category.

Migrant lists, their conservation statuses (in their native ranges), and their native and full distributions were sourced from the peer-reviewed literature, online databases, and government sources, including Atlas of Living Australia (ALA 2018), Australian federal and state government sources, eBird Australia (eBird 2018), Fishbase (Froese & Pauly 2018), Global Invasive Species Database (GISD 2018), Red List (IUCN 2018), and the United States Geological Survey (USGS 2018). Lists of extinct natives and of conservation statuses of extant natives were sourced from Australia's Environmental Protection and Biodiversity Conservation Act (EPBC 2018) and from Chapman (2009). Migrant and native lists were compiled and analyzed at a species level.

Native and migrant ranges for each species were mapped in QGIS v 3.2.3. The highest level of detail available was used, which included georeferencing published range maps. We constructed an interactive site for each species' distribution map (https://feralglobe.shinyapps.io/australian_migrants_app/) using the R packages 'sf' (Pebesma 2018), 'leaflet' (Graul 2016), and 'shiny' (Chang et al. 2019). To assess the contribution of migrant ranges to total species distributions, ranges were transformed to the World Behrmann equal-area projection, and area was calculated using the R package "sf" v 0.6-3. For species whose geographic range was available only at coarse scales (e.g. at a country level), either in full or in part (31 immigrant species), we estimated their range size by averaging the maximum possible range (100%) with a defined minimum value (10%) (55% of the region's area). We acknowledge that distinct biases may inflict data available on some native vs. migrant populations (e.g. native populations may be underestimated while migrant populations overestimated).

We calculated the change in Australia's vertebrate richness since European establishment by adding immigrants to extant and extinct native vertebrate lists. We obtained the conservation status and population trends of migrant species in their native ranges from the Red List (IUCN 2018) and created three risk categories: threatened, at risk, and secure. *Threatened*, included species listed as vulnerable, endangered, and critically endangered. *At risk*, a broader category, encompassed those assessed as threatened, as well as those listed as near threatened, and decreasing. *Secure* was inclusive of species listed as least concern that are stable, increasing, or have unknown population trends. Post-domestic animals whose pre-domestic ancestors are extinct were included in the threatened category (Lundgren et al. 2018). We then compared the proportion of migrant vertebrates that are threatened to the proportion of Australian native vertebrates, and to global rates, of threatened species (IUCN 2018).

We assessed what the global conservation status of threatened species is likely to be if migrant populations and post-domestic animals were included in conservation data. We did this by adding migrant ranges, and, where possible, migrant population sizes, to their existing listings and followed Red List guidelines (IUCN 2017) to assess which species could be down-listed or de-listed.

To assess threats to migrants (outside their native ranges), we compiled information on policy categories and recommendations pertaining to each species. We focused on immigrants to limit the search to a single country. We calculated the proportion of immigrants defined in policy as "pests" in at least one state or territory (e.g. "declared pest" in Western Australia, "priority pest species" in New South Wales), and the proportion subjected to killing programs. We compared this to their threat status in their native ranges. Information on killing programs were sourced from government, NGO, and special interest websites. We grouped killing programs according to their stated motivations (e.g. conservation, farming, sport). Data collection ended in September 2018.

Results

The Immigrants

We identified 87 immigrant vertebrate species from 20 orders and 37 families (Supporting Information), originating from all continents, apart from Antarctica. They have established across Australia, particularly in the southeast, as well as New Zealand, North and South America, and the

Pacific (Figure 1A, https://feralglobe.shinyapps.io/australian_migrants_app/). On average, 30% of immigrants' global distribution is outside their native ranges (Figure 2), with 11% in Australia. Immigrant mammals have the largest proportion of their distribution outside their native range (60%) and inside Australia (29%), followed by reptiles (53% migrant range, 4% in Australia), fishes (21% migrant range, 6% in Australia), birds (14% migrant range, 4% in Australia), and amphibians (7% migrant ranges, 5% in Australia) (Figure 2, Supporting Information).

The net effect of immigrations and extinctions of natives on Australia's vertebrates has been to increase richness by 52 species (0.7%); including increases in fishes (by 35 species, 0.69% of fishes), birds (by 15 species, 1.79%), mammals (by 2 species, 0.49%), and reptiles (by 2 species, 0.22%), but a decrease in amphibians (by 2 species, -0.87%) (Figure 3A). Overall, immigrants represent 1.2% of Australia's extant vertebrate species richness.

Seventy immigrants have been assessed for extinction risk in their native ranges. Of these 23 (33%) are at risk, including eleven that are threatened, most of which are mammals (Figure 4A). Most immigrant species that are threatened in their native ranges originate from Eurasia, and have established across Australia, as well as on all other continents, apart from Antarctica (Figure 1A). At a class level, 13 immigrant mammals are at risk in their native ranges (65% of assessed immigrant mammals) including 10 threatened species (50%); 4 birds are at risk (33%); 2 fishes are at risk (10%), 1 of which is threatened (3%); and the 2 reptile and 2 amphibian species assessed in their historic native ranges are secure.

The proportion of threatened immigrants (12.6% of all immigrants) is about three times higher than the proportion of natives that are threatened (~4%, 310 of ~7,500 native vertebrate species) (Figure

3B). Most threatened immigrants are mammals (10 species, 45% of immigrant mammals), which is over twice the rate of threatened Australian native mammals (74 species, 19% of native mammals, Figure 3B) and higher than the global rate (25%, IUCN 2018). If immigrant populations were included in extinction risk assessments, all threatened and near threatened species could be delisted or down-listed (Figure 5, Supporting Information).

Policies define most immigrants as "pests" (76%), including all mammals, reptiles, and amphibians, and most fishes (69%) and birds (58%). Most immigrants at risk in their native ranges (82%), including all those threatened, are declared pests (Appendices S3 and S4). Over half of all immigrants are targeted in killing programs (56%), including all mammals. Conservation is the most commonly stated motivation (37%) (Figure 6).

The Emigrants

We identified 47 emigrants, representing 18 orders and 28 families (Supporting Information). Nearly half (21 species) were endemic to Australia, and the rest have native ranges which encompass all continents but Antarctica, and three oceans. Their distributions have expanded across the globe, most notably to New Zealand, and the Gulfs of Mexico and Panama (Figure 1B, https://feralglobe.shinyapps.io/australian_migrants_app/). On average, 7% of emigrant species' distributions are currently outside their native ranges (Figure 2). Emigrant amphibians have the largest proportion of their distribution outside their native ranges (average 24% migrant range), followed by mammals (9%), fishes (8%), birds (2%), and reptiles (1%) (Figure 2).

Emigrants represent 0.6% of native Australian vertebrate richness. Emigrant mammals (7 species) represent the highest proportion of their class richness (1.81% of native mammals are emigrants), followed by reptiles (1.76%), fishes (1.69%), amphibians (0.44%), and birds (0.36%).

Of 41 emigrants with conservation status assessments, 12 (29%) are at risk, including 3 (7%) threatened species (Figure 2B), which is higher than the proportion of threatened non-emigrant vertebrates. All three threatened emigrants were endemic, before establishing in New Zealand and Hawaii (Figure 1B). At a class level, 4 mammals are at risk (57% of assessed emigrant mammals) including 1 threatened species (14%); 4 birds are at risk (22%); 2 fishes are at risk (20%); and 2 reptiles are threatened (7%). If included in formal risk assessments, 2 threatened amphibians could be down-listed (Figure 5, Supporting Information).

Discussion

Inclusive conservation data can change our understanding of the living world. Using Australia's migrant vertebrate species as a case study, we found that formal conservation accounts can underestimate species' global distributions; that migrant populations can provide a safeguard for species threatened in their native ranges; and that they can increase local species richness even where extinction rates are high. However, the implications of these findings for conservation are not self-evident. There are many ways "biodiversity" is imagined and measured (Kaennel 1998; McGill et al. 2015).

Human-assisted migration is widely considered to reduce beta diversity even if local richness increases (McKinney & Lockwood 1999). Our study does not explicitly test this, but it does suggest that homogenization rates of Australia's vertebrates with the rest of the world are low, and that at least in some cases migration contributes to increased beta diversity. Both immigrants and emigrants represent only a small fraction of Australia's vertebrate species richness (~1%). In other words, Australia remains a distinct ecological community. Moreover, while it is a well-documented source of concern that Australia lost 35 endemic vertebrates to extinction (EPBC 2018), the possibility that Australia also gained a new endemic species (*Camelus dromedarius*) has not been broadly considered. Dromedary camels were extinct in the wild for ~5,000 years until they "rewilded" themselves in Australia (Root-Bernstein & Svenning 2016). Australia also supports over half of the global ranges of five additional immigrants, including Javan rusa (*Rusa timorensis,* 89% of their range is in Australia). Such animals, arguably, make Australia more regionally distinct.

Migrants with large global ranges may also become more distinctive over time, eventually even endemic, if they remain isolated for long enough. Indeed, some migrant populations have already come to acquire distinctive traits. For example, ~900 migrant European rabbit (*Oryctolagus cuniculus*) populations are isolated (Lundgren, unpublished data), many for hundreds of generations, and some are morphologically distinct. Charles Darwin observed that rabbits introduced to Porto Santo island could have been "*ranked as a distinct species*" due to their unique size, coloration, and behavior (Darwin 1868). Indeed, similar trait differences are the basis for the categorization of rabbits as subspecies in their native range (*O. c. cuniculus* and *O. c. algirus*) (Ferreira et al. 2015). Yet nativism does not allow for taxonomic distinction to be contemplated for migrant populations (Chew & Hamilton 2011).

Ultimately, value assumptions determine how processes such as migration, speciation, and extinction are interpreted and what actions we believe should follow. Even the concept of *species*, the fundamental unit being counted in studies such as this, is both biological and social (Hey 2001). But we suggest our results are at least pliant to the interpretation that migrants have expanded their species' ranges, thereby providing safeguards, particularly for those threatened in their native range. It is only by utilizing more inclusive datasets that we even have an opportunity to recognize this possibility.

Although our intent is primarily to recommend a descriptively inclusive account of life, we would be remiss by failing to mention the normative or ethical aspects of inclusiveness as well. Native populations and organisms are, of course, proper subjects of moral concern, and may be special objects of care where they are endemic, endangered, or of unique cultural value. Such value does not diminish by acknowledging the presence (or the moral standing) of additional lifeforms (Wallach et al. 2018a). Nor does the inclusion of migrants in conservation data negate the need to ask questions about how they influence local ecologies, or to debate how policy ought to most ethically deal with conflicts. But value judgements and policy decisions about migrants and their effects need to be made after we have the data, and in light of values that are made explicit and subjected to critical and transparent ethical analysis (Yanco et al. 2019).

Compared to the time of European colonization, today Australia has 52 more vertebrate species. It is important to be explicit that reporting this data does not equate with a claim that Australia's biodiversity is "higher" or "better" today. We are unequivocally *not* arguing that immigration cancels or diminishes the harms of extinctions. Nor do we believe that it negates the historical wrongs enacted against Australia's original inhabitants, and against those forcibly taken to Australia. Our argument here is that these perspectives ought to be debated openly on empirical and ethical grounds and not smuggled into species lists. The meaning one gives a number, such as "species richness = +52", will depend on the conceptual and ethical lens one applies.

Even the simplest form of assessing biodiversity – species richness – is a potentially complex space for scientific and ethical analysis, as it depends, for one, on the spatial and temporal scale at which it is measured (McGill et al. 2015). Comparing current species richness with a more distant point in time (e.g. to the Pleistocene) may show a negative trend (Lundgren et al. 2018); while attempting to predict future trends will depend on future extinctions of both natives and immigrants, the establishment of new immigrants, and rates of speciation (Thomas 2013). Even a number such as "52" could change depending on which species concept is used (Hey 2001).

Invasion biologists consider some immigrants as a leading cause (and potential future cause) of extinction of native species that are vulnerable to rapid ecological changes and incapable of sufficiently rapid adaptation (Sih et al. 2010). This analysis leads them to conclude that it is inappropriate to count migrants and natives together. Alternatively, novel ecosystem scientists posit that the diversity of migrant species reflects a diversity of ecological threats and opportunities (Davis et al. 2011). From this worldview, some may argue for a form of counting based on perceived costs and benefits. Pleistocene rewilding views current ecological changes and human impacts within longer timeframes. Proponents are more likely to consider immigrants as potentials for recovery of ecological functions lost in the more distant past (Lundgren et al. 2018). Yet another ecological and evolutionary perspective considers immigration as a key mechanism of resilience to change (Thomas 2013). Increased vertebrate species richness in Australia could, from this view, be seen as a form of flourishing. Finally, another important perspective is that of the individual 'migrants' themselves, who, being born where they are, would not identify as migrants at all (Celermajer & Wallach 2019).

Changing who and what counts in conservation would also influence conservation practice. One possible policy direction is to 'stay the course' by continuing to attempt to eradicate migrant populations and stop new ones from establishing (Figure 6). An opposite approach would be to promote migrations, particularly for those threatened in their native range. For example, the Australian Rhino Project's aim to establish rhinoceroses in Australia – to "*act as an insurance population should the rhino become extinct in its African homeland*" (www.theaustralianrhinoproject.org) – is a contentious one (Hayward 2016). In between these opposing approaches are various options for protecting existing migrant populations (Wallach et al. 2018a); allowing for limited forms of migrations and assisted colonization (Scheffers & Pecl 2019); and stemming the establishment of new migrant populations (Russell et al. 2005).

The current policy direction, as shown in our study, leads conservation to be the most common motivator for killing immigrant vertebrates in Australia. This reflects a belief that further extinctions of endemic wildlife will occur unless immigrants are controlled and eradicated. There are several reasons to question this binary: many migrants are themselves threatened, as our study has shown; species richness and diversity is potentially boundless, thus adding one species does not necessitate losing another (Cornell 2013); most migrants do not cause extinctions or have ecological effects that could be clearly defined as "harmful" (Davis et al. 2011); native species can develop ecological dependencies on non-native species (Schlaepfer et al. 2011); most killing programs are not science-based (Doherty et al. 2019; Lynn et al. 2019); many situations where migrants do contribute to extinctions arise as an artefact of other human-caused stressors (Doherty et al. 2015; Wallach et al. 2015); and finally, creative and compassionate approaches that focus on enabling coexistence can be more lasting and just (Wallach et al. 2018).

The contribution of migrant populations to their species' global distributions can be viewed as a process of rewilding at a scale unparalleled by controlled conservation programs. Fifteen (of 18) migrants that are threatened or near threatened in their native ranges could have their statuses down-listed or delisted if their full global populations were included. Similar results have been found for migrant plants and animals in Israel (Wallach et al. 2018b), and terrestrial megafauna worldwide (Lundgren et al. 2018). If the task of conservation is to ensure the persistence of Earth's diverse lifeforms, this is good news. Incorporating migrant populations need not reduce conservation efforts for populations in their native ranges, just as many current subspecies and geographically separate populations are included in the IUCN Red List (IUCN 2018). The conservation community could come to regard threatened migrants as "refugees" to be harbored, rather than "invaders" to be targeted.

How and whether to include migrant species in conservation's moral world has long troubled conservation biologists (Soulé 1990). Inclusive conservation lists, we argue, provide space for dialogue on what constitutes the "good" conservation aims to protect. The global conservation community is ethically pluralistic, including on whether non-native species have conservation value (Sandbrook et al. 2019). Species lists are imbued with ethics but the values that inform them have been narrowly defined. Putatively comprehensive accounts of nature that are filtered through unacknowledged values create hidden biases and preclude the expression of alternative perspectives. Nativist-filtered lists should not be uncritically accepted as an ethical default for conservation or, more problematically, as value-neutral accounts of "reality".

Founding species lists and counts, maps and threat assessments on inclusive ethics can do more than change our understanding of the world and open space for pluralism in conservation. It can also help place the "burden of proof" – appropriately, in our opinion (Wallach et al. 2018) – on those who wish to deny moral concern for large swaths of the living world, by requiring them to actively and intentionally exclude certain entities from their moral circle (Laham 2009). As such, inclusive conservation data could help enhance humanity's moral concern for all life on Earth.

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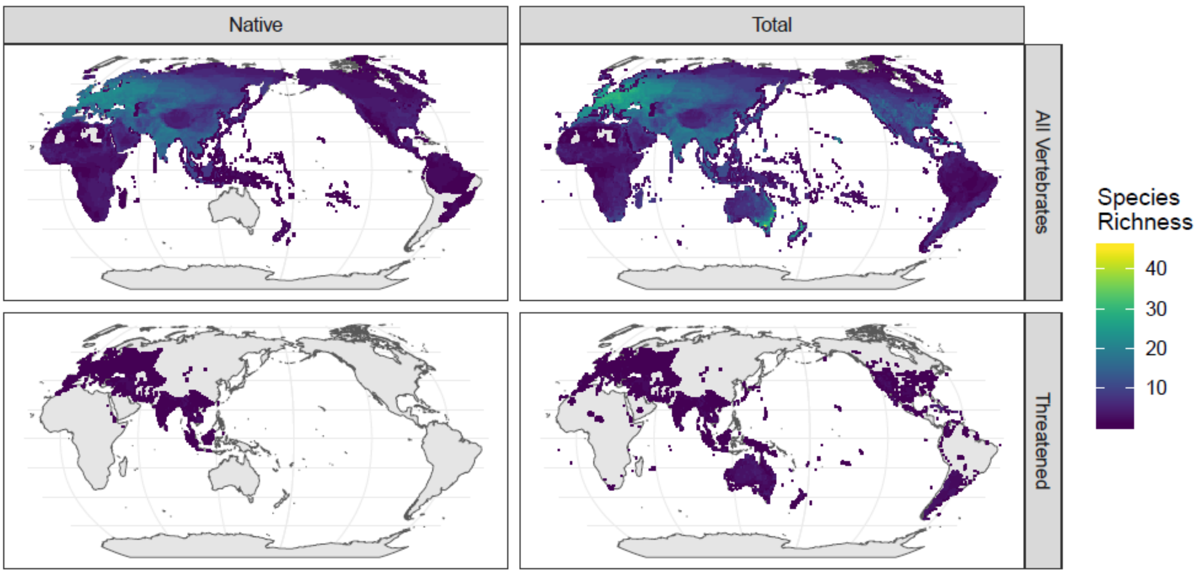
A



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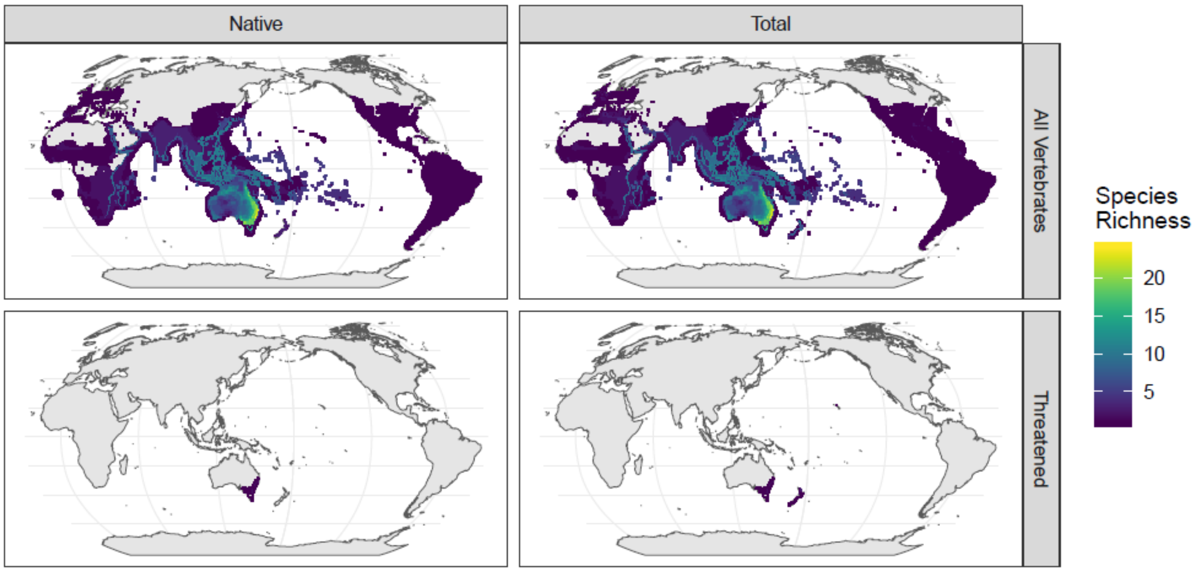

Figure 1 – Distribution of Australia's immigrant (A) and emigrant (B) vertebrate species, limited to their historic native ranges (left) and expanded to include their migrant ranges (right). Top rows

include all migrant species, and bottom rows focus on those threatened in their native ranges. Individual species' distribution maps are available at: https://feralglobe.shinyapps.io/australian_migrants_app/

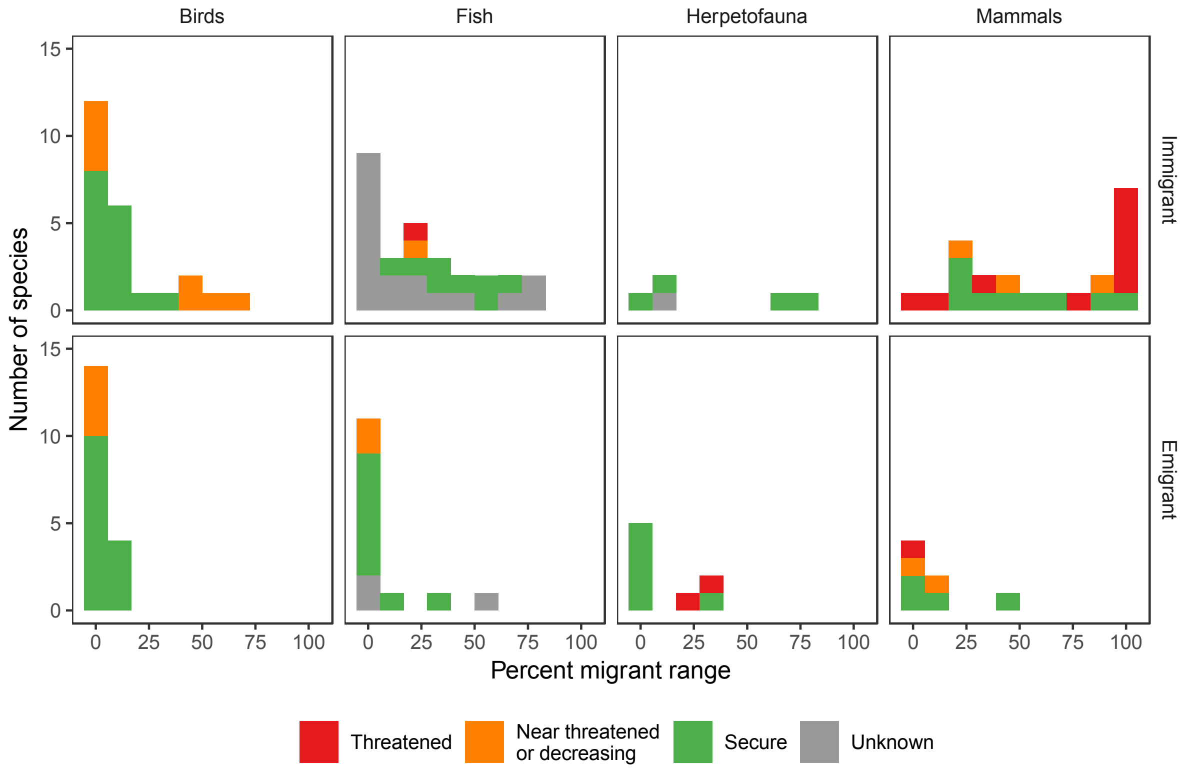

Figure 2 – A significant proportion of Australia's migrant vertebrate species' distribution is outside their historic native ranges, including those at risk in their native ranges.

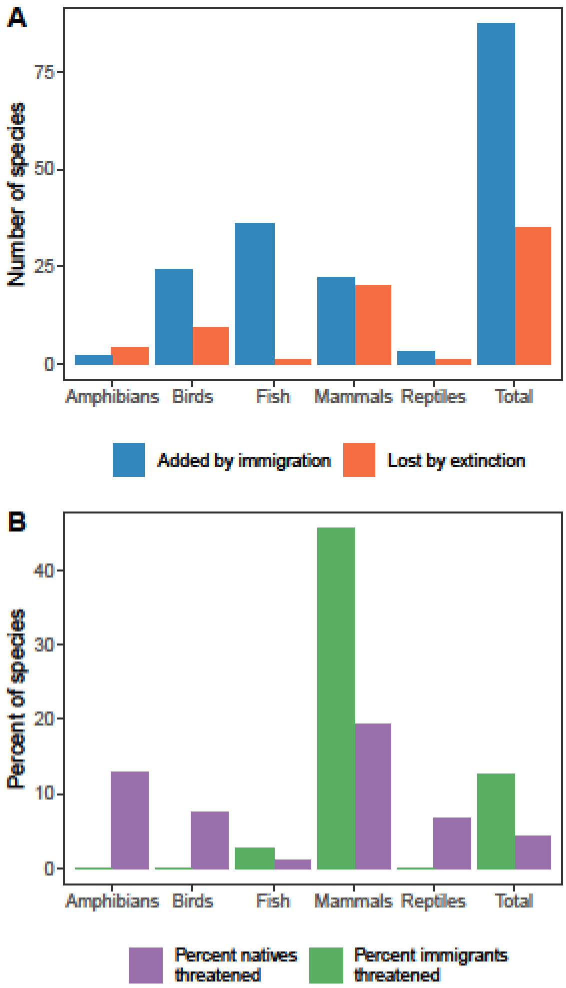

Figure 3 – Number of vertebrates added by immigration exceeds the number lost to extinction in Australia (A). Proportion of immigrants that are threatened in their native ranges exceeds the proportion of threatened vertebrates native to Australia (B).

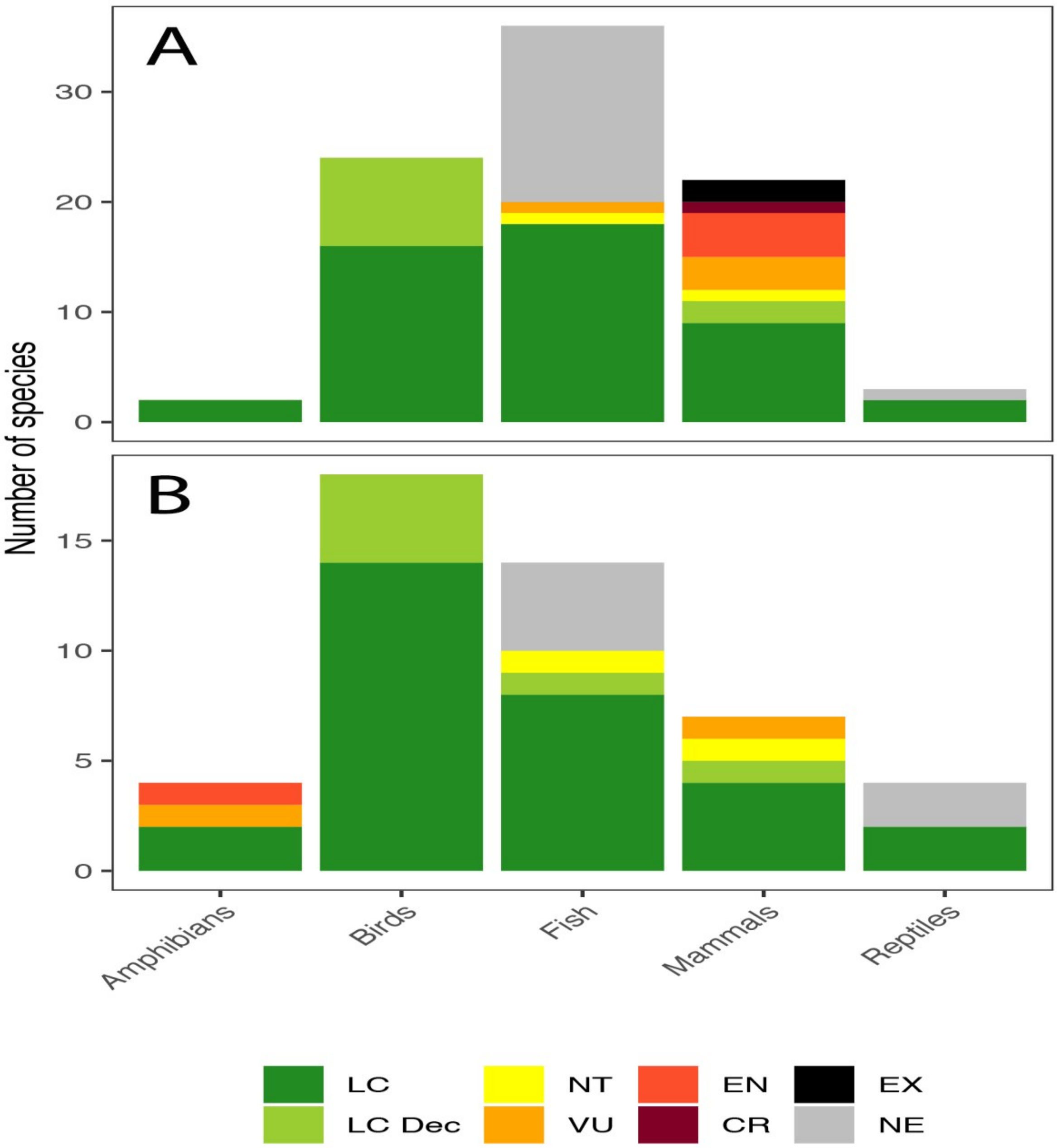

Figure 4 – A significant proportion of Australia's immigrant (A) and emigrant (B) vertebrate species are threatened or at risk in their historic native ranges. LC = least concern, population stable, increasing, or unknown; LC Dec = least concern, population decreasing; NT = near threatened; VU = vulnerable; EN = endangered; CR = critically endangered; NE = not evaluated or data deficient (IUCN 2018). EX represents extinct pre-domestic species.

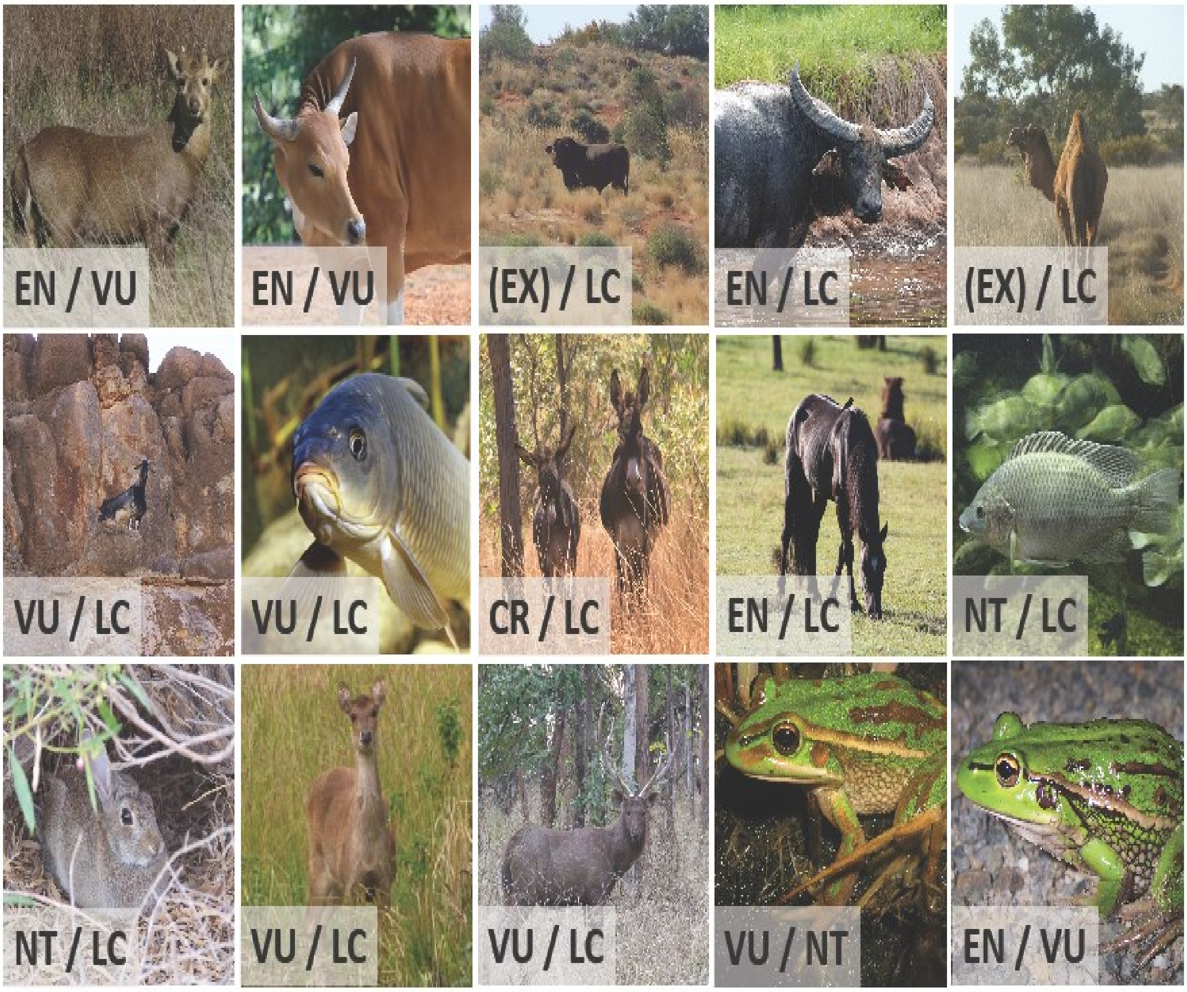

Figure 5 – Australia's immigrant and emigrant vertebrate species that could be delisted or down-listed if migrant and post-domestic populations were included in extinction risk assessment. Conservation statuses for each species are reported first for native ranges and extant pre-domestic species (IUCN 2018), followed by a re-assessment if all populations are included (see Table S2 for details). LC = least concern, NT = near threatened, VU = vulnerable, EN = endangered, and CE = critically endangered. EX represents extinct pre-domestic species. From left-to-right: top row, immigrants - *Axis porcinus*, *Bos javanicus*, *B. taurus*, *Bubalus bubalis*, *Camelus dromedaries*; middle row, immigrants - *Capra hircus*, *Cyprinus carpio*, *Equus asinus*, *E. caballus*, *Oreochromis mossambicus*; bottom row, immigrants - *Oryctolagus cuniculus*, *Rusa timorensis*, *R. unicolor*, and emigrants - *Litoria aurea*, *L. raniformis*.

Photos by Wayne Martin, *A. pornicus* (Atlas of Living Australia); cuatrok77 (Flickr.com, CC BY-SA 2.0) *B. javanicus*; Arian Wallach, *B. taurus*, *C. dromedaries C. hircus, E. asinus, O. cuniculus* and *R. timorensis*; Djambalawa (Wikimedia, CC BY 3.0) *B. bubalis*; IA CRC, *C. carpio*; Andrea Harvey, *E. caballus* (used with permission); Greg Hume (Wikimedia, CC BY-SA 3.0) *O. mossambicus*; LiquidGhoul (Wikimedia, CC BY-SA 3.0) *L. aurea*; and Tnarg (Wikimedia, CC BY-SA 3.0) *L. raniformis*.

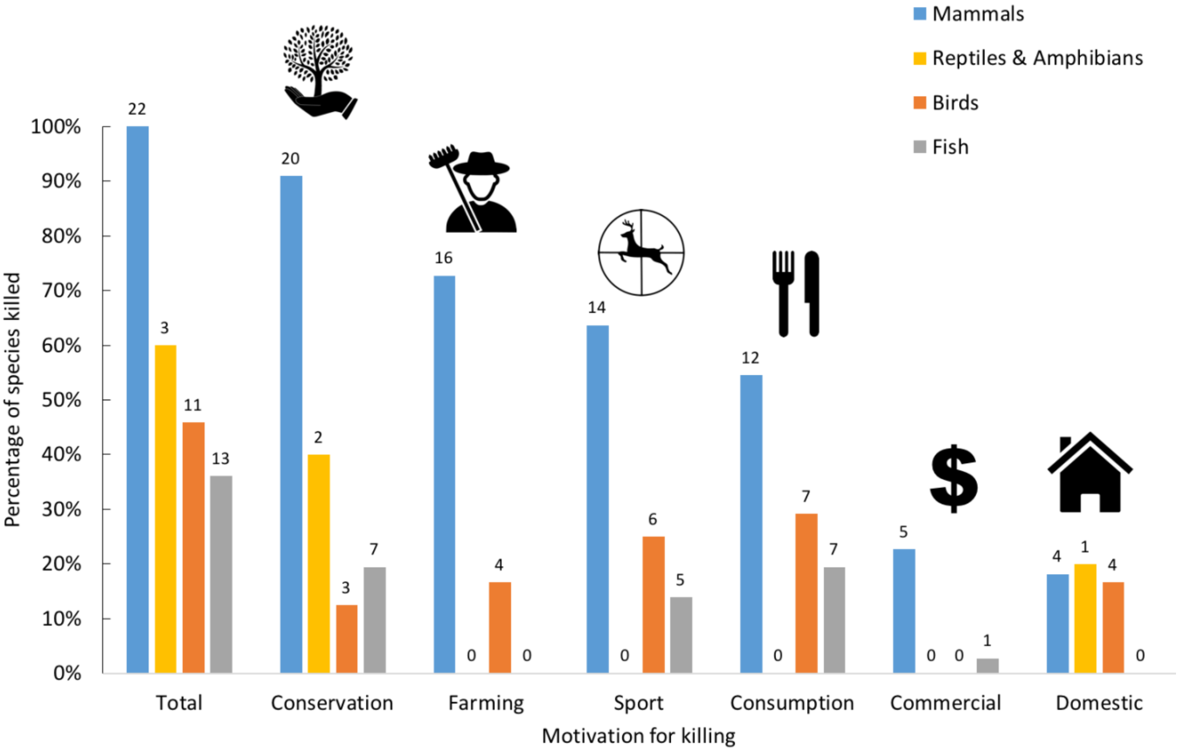

Figure 6 – Stated motivations for killing Australia's immigrant vertebrate wildlife, shown as percentages of species targeted per class. Numbers above bars indicate absolute number of species targeted.