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Preventing extinction in an age of species migration and planetary change

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Abstract

International and national conservation policies almost exclusively focus on conserving species in their historic native ranges, thus excluding species that have been introduced by people and some of those that have extended their ranges on their own accord. Given that many of such migrants are threatened in their native ranges, conservation goals that explicitly exclude these populations may overlook opportunities to prevent extinctions and respond dynamically to rapidly changing environmental and climatic conditions. Focusing on terrestrial mammals, we quantified the number of threatened mammals that have established new populations through assisted migration (i.e., introduction). We devised 4 alternative scenarios for the inclusion of assisted-migrant populations in mainstream conservation policy with the aim of preventing global species extinctions. We then used spatial prioritization algorithms to simulate how these scenarios could change global spatial conservation priorities. We found that 22% (70 species out of 265) of all identified assisted-migrant mammals were threatened in their native ranges, mirroring the 25% of all mammals that are threatened. Reassessing global threat statuses by combining native and migrant ranges reduced the threat status of 23 species (~33% of threatened assisted migrants). Thus, including migrant populations in threat assessments provides a more accurate assessment of actual global extinction risk among species. Spatial prioritization simulations showed that reimagining the role of assisted-migrant populations in preventing species extinction could increase the importance of overlooked landscapes, particularly in central Australia, Europe, and the southwestern United States. Our results indicated that these various and nonexhaustive ways to consider assisted-migrant populations, with due consideration of potential conservation conflicts with resident taxa, may provide unprecedented opportunities to prevent species extinctions.

KEYWORDS

climate change, extinction, introduced species, invasion, novel ecosystems, species migration

INTRODUCTION

The redistribution of organisms through human introductions has provided opportunities for a number of species outside their historic ranges. Many of these species are threatened or extinct

in their native ranges but are thriving in their new ranges, presenting a conservation paradox (Kiacz & Brightsmith, 2021; Lees & Bell, 2008; Lundgren et al., 2018; Marchetti & Engstrom, 2016). This process of biotic redistribution is expected to accelerate, from continuing species introductions and as species

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migrate in response to ongoing landscape and climatic changes (Twardek et al., 2023). However, migrant species, especially those introduced by humans but also some of those that have dispersed on their own (e.g., rusty crayfish [*Orconectes rusticus*] and cattle egret [*Bubulcus ibis*] in North America [Guiasu & Labib, 2021; Pereyra, 2020]), are widely considered pests, are excluded from biodiversity data sets and threat assessments (Schlaepfer, 2018), and are targeted by conservation eradication and control programs, regardless of whether they are endangered or extinct in their native ranges (Wallach et al., 2020). Although there has been considerable effort placed on understanding and mitigating deleterious effects that introductions can sometimes have, little consideration has been given to investigating how accounting for already established migrant populations may reshape how we might respond to the extinction crisis.

Preventing extinction is one of conservation's primary aims (Soulé, 1985). However, this aim can come into conflict with mainstream preferences for preserving only historically native life (Castelló & Santiago-Ávila, 2023). These conflicts raise important questions about whether conservation science should respond to widespread ecological and climatic changes by broadening its valuation of organisms beyond those restricted to their historically native ranges. For example, the Javan rusa deer (*Rusa timorensis*) is threatened by poaching and habitat loss in its native range of Indonesia (IUCN, 2018). However, a population has established in Australia after introduction by humans in the late 1800s (Centre for Invasive Species Solutions, 2009–2023). The primary response of conservation organizations to introduced Javan rusa, and all other deer in Australia (including other threatened species), is eradication (Bengsen et al., 2022; Hampton et al., 2022). What happens if the Javan rusa becomes extinct in its native range while the Australian population lives on? Under existing protocols, would the International Union for Conservation of Nature (IUCN) list the Javan rusa as extinct in the wild or extinct while Australia continued with its eradication plans? An alternative would be to engage in exploratory discussions of how conservation policies could attach value to introduced Javan rusa, either by accommodating their presence in their new range as part of biotic reorganization under planetary change or as a source population for future repatriation to Java.

For the most part, conservation has ignored these paradoxes (but see Bradshaw et al. [2006]) because of claims that introduced organisms have fundamentally different—and unwanted—effects relative to native organisms (Pauchard et al., 2018; Rejmánek & Simberloff, 2017). Although we acknowledge that in specific cases (especially on islands) introduced organisms have contributed to extinctions, multiple meta-analyses show that it is often impossible to distinguish between native and introduced organisms on the basis of their ecological effects (Boltovskoy et al., 2021; Charlebois & Sargent, 2017; Forgiione et al., 2022; Howard et al., 2017; Lundgren et al., 2024; Wallach et al., 2022); some introduced so-called invasive organisms targeted for eradication turn out to be native endemic species (Weijola et al., 2020); introduced organisms are not a leading cause of biodiversity loss relative to habitat loss and direct exploitation (IPBES, 2019; Jaureguiberry et al., 2022); the tem-

poral baselines of native ranges are defined by arbitrary historic thresholds (e.g., 1500 AD or time of European colonization) and fail to capture long-term changes in species distributions since prehistory (Monsarrat et al., 2019; Sales et al., 2022); and many introduced organisms sustain ecosystem services and facilitate other species (Bertness & Coverdale, 2013; Lugo, 2004; Lundgren, Ramp, Stromberg, et al., 2021; Mascaro et al., 2012; Schlaepfer et al., 2011). Although there remains considerable debate about these points among conservation scientists, consideration of the contributions migrant species may make to preventing extinctions and replacing lost functional services should be a priority in a time of monumental planetary change.

Earth is undergoing a rapid pace of landscape transformation, primarily from agriculture and development (Powers & Jetz, 2019). Likewise, some climate warming projections set the planet on a course to the Early Eocene (Burke et al., 2018), when northern Greenland was warm temperate forest (Herold et al., 2014; West et al., 2020). Although the concept of a native range is already fraught with ambiguities (Pereyra, 2020), this concern only escalates when organisms are no longer able to live in their historic distributions. Even intentional assisted migrations by conservationists have been met with controversy (McLachlan et al., 2007), despite the fact that these translocations are likely an essential tool to prevent future extinctions (Twardek et al., 2023). Likewise, unassisted species migrations are likely to dovetail with pervasive anthropogenic impacts on habitats, leading to unclear causality (Essl et al., 2019). Conservation's focus on only conserving populations whose distributions are unaffected by human beings may thus be increasingly unrealistic (and potentially always has been, given the extensive prehistoric and historic influences of humans on species distributions [Baker et al., 2024; Faurby & Svenning, 2015]).

For conservation policy to respond proactively and pragmatically to these changes, one must anticipate ways to value biodiversity in a time of species redistribution, including species introduced by humans and species migrating on their own accord (Schlaepfer & Lawler, 2023). Accounting for migrant species in conservation is not to dismiss potential conflicts with resident taxa and broader ecosystem-level effects but to reveal the novel ecological processes and conservation opportunities of our time.

To provide inspiration for these discussions, we quantified various ways the biotic redistribution of threatened species could be accounted for to prevent species extinctions, focusing on mammals as an example taxonomic group. There are multiple motivations for conserving biodiversity (Chan et al., 2006; Mace, 2014); however, we focused on the common objective of extinction avoidance. Although at least some species that have migrated on their own are considered invasive (Guiasu & Labib, 2021; Pereyra, 2020), given the scarcity of data on unassisted migrants, we focused on wild populations of assisted migrants whose ranges have expanded through human introductions. We henceforth refer to these organisms as *assisted migrants* instead of *introduced species* to align with projected future assisted and unassisted migrations and as a first step, albeit imperfect, toward a value-neutral terminology free from human–nature ontological dualism (Kopnina & Coghlan, 2022; Sagoff, 2020).

We considered the scale of biotic redistribution of threatened mammals and then devised 4 alternative scenarios for how migrant biodiversity might be valued with the aim of preventing global extinctions. To understand how these differing approaches could influence conservation policy, we tested the relative effect of these various formulations with quantitative spatial prioritization simulations to evaluate future global conservation goals that may be implemented to prevent the extinction of threatened terrestrial mammals.

METHODS

We focused on terrestrial mammals ($n = 1225$ species) because their threat statuses are well known and their native distributions have been mapped (IUCN 2018, Schipper et al. 2008). We added these ranges to assisted-migrant ranges (i.e., introduced ranges) digitized from data in the peer-reviewed literature, government reports, newspaper articles, and a variety of databases (Appendices S1 & S2). Some assisted migrants are described and mapped by the IUCN as native because their introductions were to geographically proximate areas or were intentional conservation translocations (although other intentional conservation assisted migrations are controversial [McLachlan et al., 2007]). These were treated as native following the IUCN to avoid confounding IUCN threat statuses. To describe the overall pattern of biotic redistribution for mammals, we quantified those biogeographic realms (Olson et al., 2001) from which mammals came (donor realms) and realms that received migrant mammals. We then calculated the percentage of threatened species per mammalian family and order that have migrant populations. Biogeographic realms were the Nearctic, Neotropics, Palearctic, Indomalay, Afrotropics, Australasia, Oceania, and Antarctica.

Scenarios

We formulated 4 scenarios based on different formulations of how conservation might value assisted migrants as biodiversity: native only, the conservation of native populations was prioritized; conservative, both native and migrant populations were prioritized; expansive, threat statuses were reassessed based on the full range (migrant plus native); and independent, native populations and migrant populations were valued independently. In the native-only scenario (i.e., the status quo), we assigned conservation value only to populations of threatened species in their native ranges (near-threatened species were considered threatened) based on the normative premise that non-native populations have no conservation value.

In the conservative scenario, the current IUCN Red List threat status of a species was established based only on populations in the native range, but the threat status was then extended to all populations, even those outside their native range and even if the migrant population was larger than the native population. In other words, assisted-migrant populations were considered akin to bonus populations. We did this under the normative premise that assisted-migrant populations could

one day acquire a value equivalent to native populations and that global stochasticity in human pressures may warrant the most conservative approach to prevent global extinctions. This also acknowledges that redistributed populations have not stood the test of time in their new regions and might therefore be unstable and collapse (Simberloff & Gibbons, 2004). In this scenario, assisted-migrant populations were assigned a threat status, in contrast with the native-only scenario, where they were not even considered.

In the expansive scenario, we reevaluated species threat statuses globally based on each species' full current range (the area of the combined native and migrant ranges). By doing so, some species became downlisted or delisted globally, deprioritizing both their native and migrant ranges. This scenario was based on the normative premise that migrant populations are legitimate components of biodiversity and are thus monitored and protected with equal care across their range. To reassess threat statuses, we used IUCN listing criteria and assumed a linear relationship between range size and population size (following Mogg et al. [2019]). Using the IUCN Red List listing criteria, we considered a 20% change in total range size relative to their native-only range size as criteria for a one-step change in threat level (e.g., from critically endangered to endangered).

Finally, in the independent scenario, we maintained current IUCN Red List statuses of species in their native ranges but assigned conservation value to migrant populations independent of native populations. This scenario was based on the normative premise that both native and migrant populations have equal value but should be considered independently due to their unique evolutionary trajectories (Faurby et al., 2022). In other words, assisted-migrant populations were considered de facto novel species or subspecies. Under the independent scenario, valuing assisted-migrant populations did not affect the threat status of native populations (unlike in the expansive scenario). The threat status of assisted-migrant populations was based on the total assisted-migrant range size relative to the native range size (Table 1).

Spatial prioritization

To gauge how these various scenarios might alter potential conservation action, we conducted spatial prioritization algorithms to identify areas of high conservation importance globally for each scenario. To do so, we rasterized species ranges to produce feature layers for prioritization analysis with the R package `exactextractr` 0.4.0 (Baston, 2022) with a Mollweide projection at a 30×30 -km resolution. Migrant ranges reported at the country scale or within provincial boundaries ($n = 12$ populations of 8 species) were omitted from spatial prioritization analyses because the large sizes of these political entities would lead to global delisting, even if populations were small. However, to account for these populations (many in central and eastern Asia), 1% of that total area was used in reassessing species' threat statuses for the *expansive* value scenario. This cutoff is arbitrary yet conservative for the purposes of this simulation.

TABLE 1 Alternative value scenarios^a for how migrant biodiversity (introduced species or assisted migrants) might be valued in conservation policy.

Scenario	Normative position	Rationale	Change to IUCN Red List threat status ^b
Native only	Only native populations have value.	Species threat status limited to native populations	Unchanged
Conservative	Native and migrant populations have equal value.	Species threat status based solely on native range, but applied throughout the full range because long-term viability of migrant populations is unknown	Unchanged
Expansive		Species threat status based on full range; if species' combined native and assisted-migrant range is large enough, entire species is delisted	Changes to include assisted-migrant population
Independent		Species threat status defined separately for native and assisted-migrant populations to account for independence of evolutionary trajectories and nonredundant value of native populations	Population in native range unchanged; assisted-migrant population assigned threat status

^aScenarios applied to conservation prioritization simulations to determine how different values might change how to best prevent species extinctions.

^bChanges in threat status (in expansive and independent scenarios) affected simulations by removing species (if delisted) and by changing priority weighting (IUCN, International Union for Conservation of Nature).

We conducted spatial prioritization analyses with the R package *prioritizr* 5.0.1 (Hanson et al., 2023), which uses integer linear programming techniques to find optimal solutions for spatial conservation planning problems (e.g., by identifying which land units should be conserved to meet conservation objectives). We used a maximum utility objective to find the solution that most cost-effectively conserved as many species as possible within a specified conservation budget—in this case, the number of land units (e.g., pixels). We iteratively calculated prioritization solutions for each value scenario, increasing the total number of land units in the conservation budget from 1% of Earth's surface to 30%. The resulting solutions were summed to provide a continuous ranking of relative priority per land unit.

Species were assigned weights based on their threat status: 1, near threatened; 3, vulnerable; 5, endangered; 7, critically endangered, extinct in the wild, and extinct. Thus, the prioritization algorithm gave extra importance to protecting the most endangered taxa. In doing so, changes in threat status in the expansive and independent value scenarios altered the importance of those populations in each prioritization simulation.

RESULTS

Biotic redistribution

We identified 265 mammal species with at least one assisted-migrant (introduced) population. Of these, 70 (22%) are threatened in their native ranges, mirroring the 25% of all terrestrial mammal species that are threatened (IUCN, 2018). Assisted migrants that were introduced to different realms originated from all realms, bar Antarctica and Oceania, and were most commonly donated from the Indomalaya (59 species, 32.1% of redistributed mammals) and the Palearctic (46, 25.0%), followed by the Afrotropics (31, 16.8%), the Nearctic (26, 14.1%), Australasia (11, 6.0%), and the Neotropics (11, 6.0%) (Figure 1a).

These species were received primarily by the Palearctic (57, 18.0%), Australasia (54, 17.0%), the Neotropics (51, 16.1%), and the Nearctic (47, 14.8%), followed by Afrotropics (39, 12.3%), Oceania (32, 10.1%), Indomalaya (29, 9.1%), and Antarctica (8, 2.5%) (Figure 1a).

Assisted migrants threatened in their native range were donated mostly from Indomalaya (16 species, 32.6%), followed by the Palearctic (14, 28.6%), Afrotropics (13, 26.5%), Nearctic (3, 6.1%), Australasia (2, 4.1%), and Neotropics (1, 2.0%) (Figure 1a). These species were received by the Neotropics (15, 16.1%), Nearctic (15, 16.1%), Australasia (14, 15.1%), and Afrotropics (13, 14.0%), followed by Oceania (12, 12.9%), Palearctic (11, 11.8%), Indomalaya (9, 9.7%), and Antarctica (4, 4.3%).

Biotic redistribution slightly increased threatened mammal species richness in Australia, southwestern Nearctic, the Caribbean, and the Nearctic (Figure 1b). Assisted-migrant mammals represented threatened species from 9 of 22 terrestrial mammal orders (Figure 1c) and 52 of 115 families, including up to 100% of threatened species in some families (Appendix S2).

Conservative scenario

Only valuing native populations and excluding redistributed migrant populations (native-only scenario) established tropical parts of South America, Africa, and Asia as the top priority for most effectively protecting the maximum number of threatened mammals per land area (Figure 2a). However, when assisted-migrant populations of threatened mammals were ascribed equivalent conservation value (conservative scenario), Australia—home to 16 threatened assisted-migrant mammals—became almost equally important for global conservation of threatened mammals (Figure 2a,b). Likewise, the Caribbean and parts of South America increased in priority, whereas parts of Africa and central Asia become slightly less emphasized (Figure 2b).

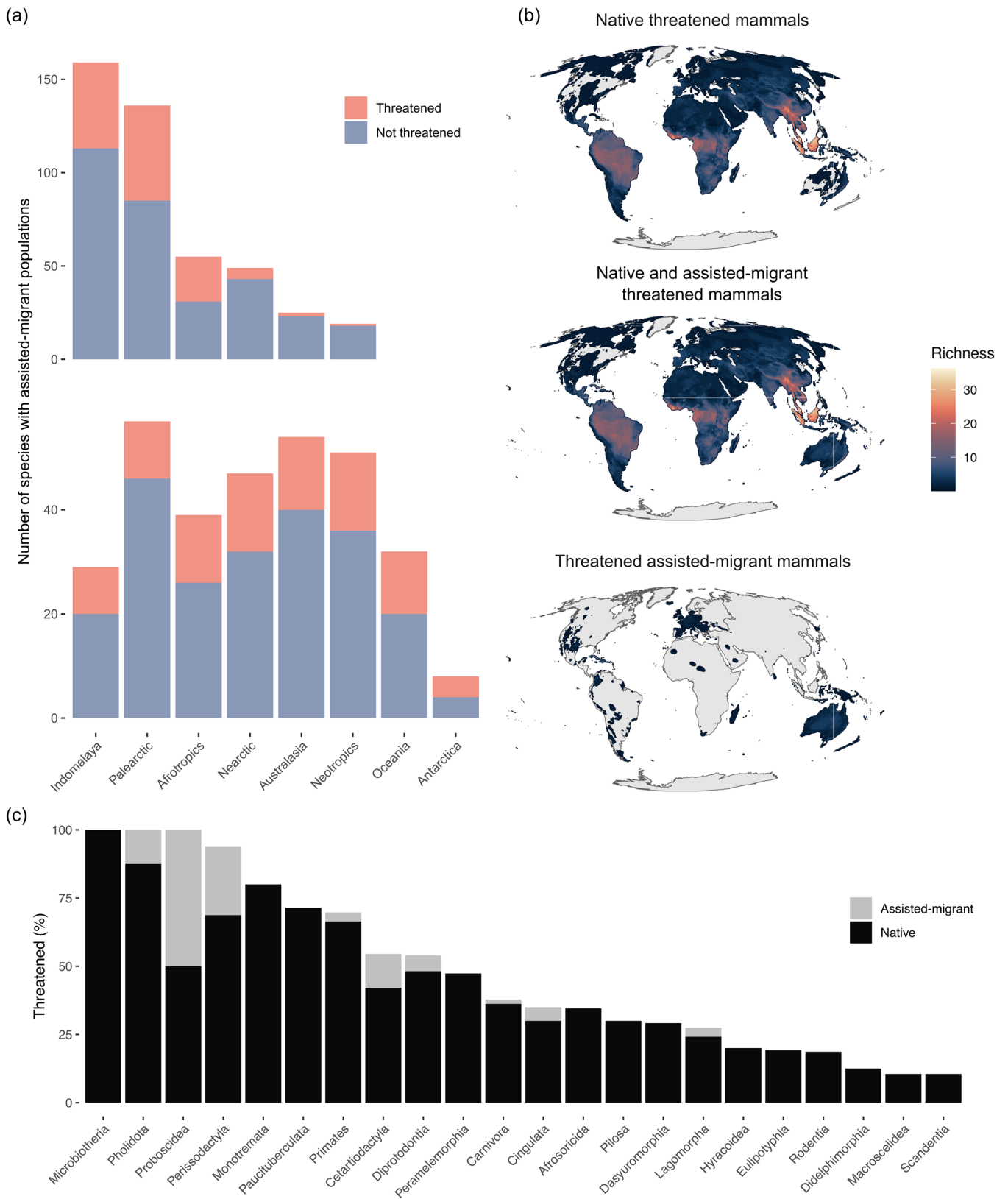


FIGURE 1 (a) Number of assisted-migrant mammals from donor biogeographic realms (top) and number received by realms (bottom) (color indicates whether the assisted migrant is threatened in its historic native range); (b) species richness of only native threatened mammals (International Union for Conservation of Nature Red List), of all threatened mammals, including assisted migrants, and of assisted migrants; and (c) percentage of mammal orders that are threatened and have assisted-migrant populations (see percentage of mammal families in Appendix S2).

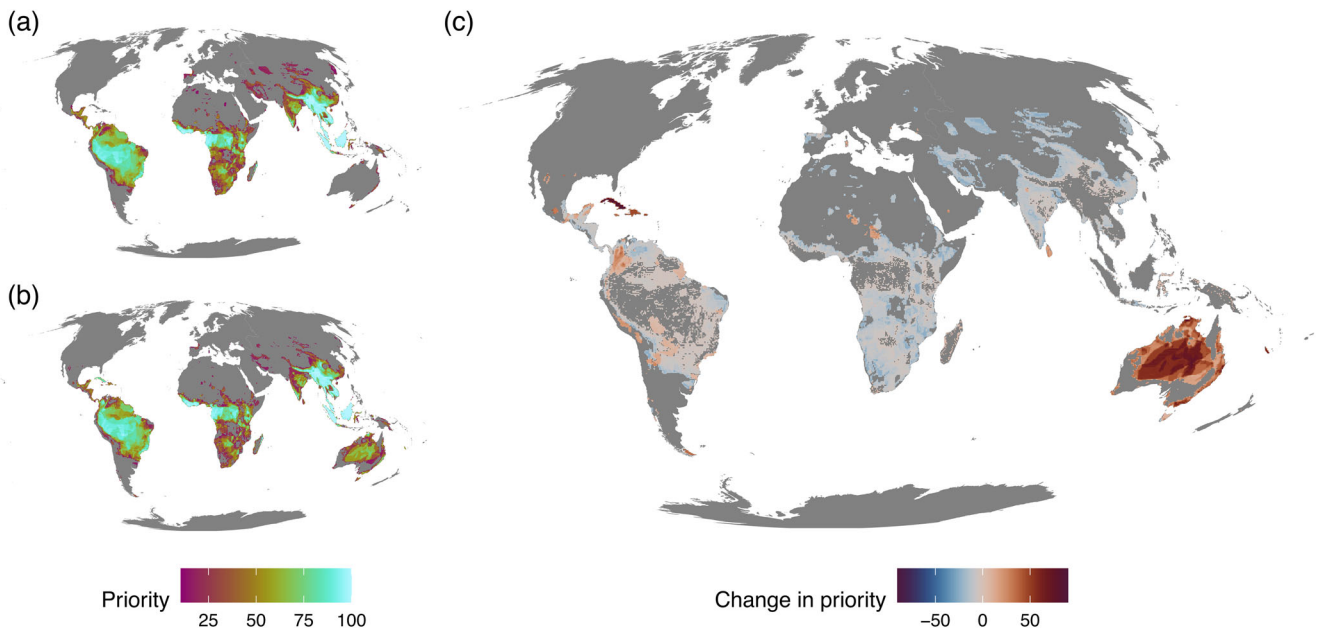


FIGURE 2 Results of conservation prioritization simulations that (a) only take into account native populations of threatened mammals and (b) include assisted-migrant populations of threatened mammals (i.e., introduced species) based on their threat status in their native range (conservative scenario) and (c) change in conservation priorities between native only and conservative prioritization scenarios (shown are results of conservation prioritization algorithms conducted to determine the optimal way to conserve as many threatened species as possible).

Expansive scenario

Of the 70 threatened assisted-migrant mammal species, redistribution extended their total range by an average of 781% (between 0.01% and 18,000%). Reassessing the global threat status of these mammals based on their entire range (e.g., the expansive value scenario) reduced the threat status of 23 (~33%) of these threatened mammal species, of which 20 (~29%) became least concern (e.g., delisted) (Figure 3a).

In this scenario, spatial prioritization solutions showed little difference from native-only solutions, except for the deprioritization of limited areas in Europe and central Asia due to the delisting or reduction in threat of these species. This led to increased prioritization among taxa that did not have migrant populations; thus, conservation resources would flow to those species that did not find refuge through global redistribution (Figure 3b).

Independent scenario

The independent scenario retained the threat status of native populations of species but considered the status of assisted-migrant populations separately, based on an independent assessment of threat and population resilience. Under this scenario, assisted-migrant mammals were valued as refuges for species threatened in their native ranges and in their own right and native populations were valued in a nonredundant way to assisted-migrant populations. Importantly, this scenario reframed the narrative of conservation from one dedicated to

recreating historic configurations to a futurist pursuit in which conservation works to promote adaptation while preventing extinction under planetary change.

Under this scenario, 12 of the 70 assisted-migrant populations had large enough distributions to be treated as Least Concern and could thus be omitted from spatial prioritization (17% of threatened migrant mammals), and 58 assisted-migrant populations were considered threatened based on their small assisted-migrant range size, which increased the total number of threatened and (and thus prioritized) mammal populations by 2.7% (Figure 4a). Prioritizing the conservation of these assisted-migrant populations alongside native populations increased the conservation importance of parts of the Nearctic (Texas and the Caribbean), the Neotropics, southeastern Australia, and Europe (Figure 4b).

Overall, we found that various methods to ascribe value to assisted-migrant threatened mammal species led to shifts in how one might best prioritize conservation efforts to prevent extinctions. Relisting mammals to include assisted-migrant ranges (either changing global threat status or adding migrant populations as their own valued entities) led to only slight changes in the total number of threatened mammals overall (Figure 5a), reflective of the broad scale of global mammal endangerment (Harfoot et al., 2021). However, including assisted-migrant populations did have consequences for the percentage of species' ranges that were prioritized (Figure 5b), especially for species currently listed as extinct or extinct in the wild. Doing so shifted conservation priorities spatially, increasing the importance of landscapes in Australasia and the Nearctic (Figure 5c).

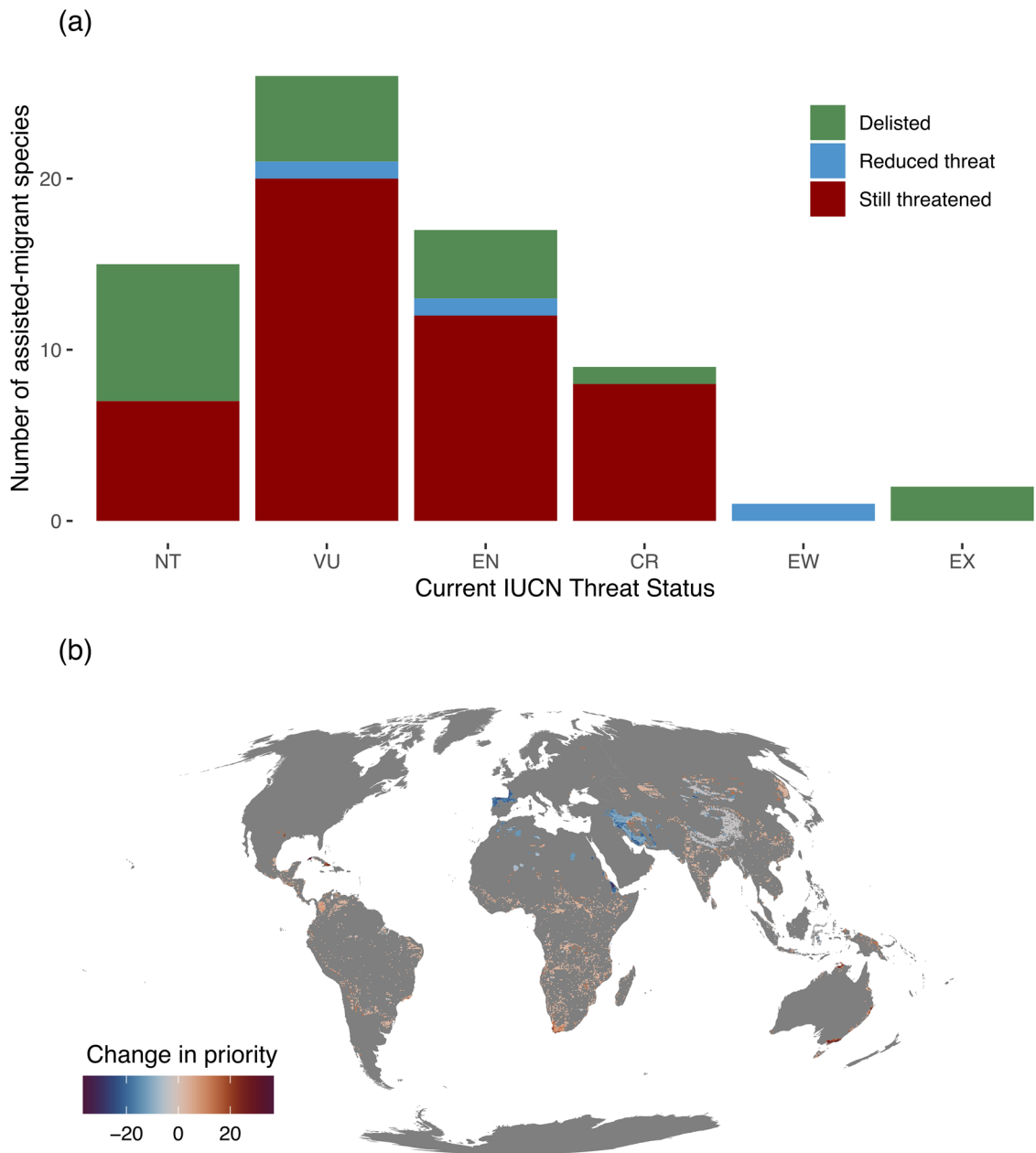


FIGURE 3 (a) Effects on threat status when it is reevaluated based on combined native and assisted-migrant ranges (expansive scenario) (x-axis, current threat status; color, change in threat status when assisted-migrant populations are included) and (b) conservation priorities showed limited changes when species' threat statuses were reevaluated based on combined ranges. However, some areas increased in priority reflecting species that have not found refuge through assisted migration.

DISCUSSION

We explored how different conservation policies for assisted migrants could change how conservation effort is allocated. Most current national and international conservation policies, including frameworks such as the IUCN Red List, ignore assisted migrants (Schlaepfer, 2018), rendering populations of 70 of the world's threatened mammal species invisible (Wallach, Lundgren, et al., 2018). Although reconsidering the conservation value of assisted-migrant populations of threatened

mammals did not radically alter the global conservation outlook for the majority of threatened terrestrial mammals—which have not found refuge through migration—some important opportunities for discussion were revealed.

For example, we found that if assisted-migrant populations were considered as native populations, then the rich assisted-migrant large herbivore (megafauna) community of central Australia could be considered a conservation priority, whose protection could reduce the risk of extinction of 8 of these ecologically important species and their globally

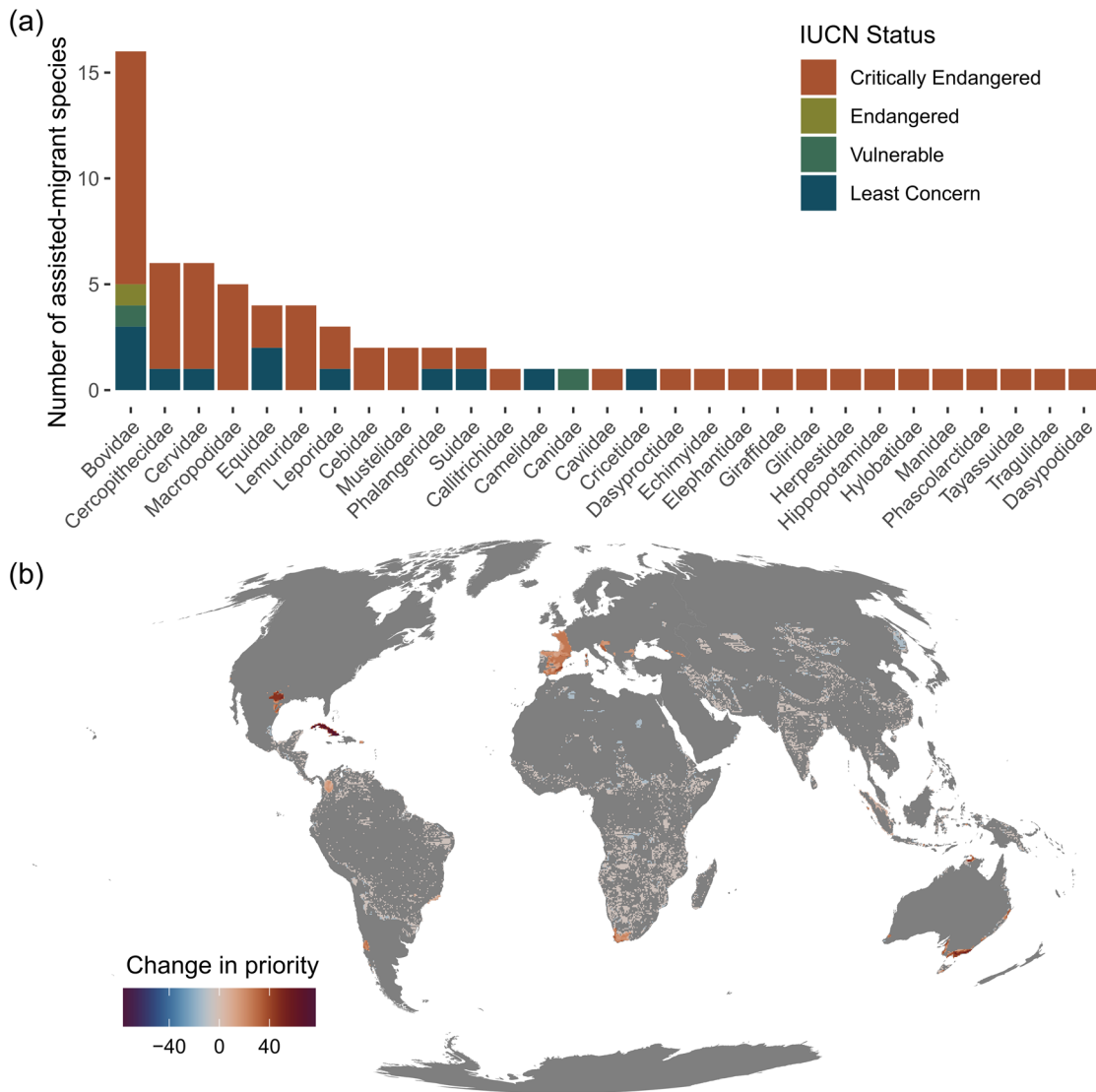


FIGURE 4 (a) The number of assisted-migrant species by taxonomic family and International Union for Conservation of Nature (IUCN) threat status categorized based on their evolutionary and intrinsic value (independent scenario [assisted-migrant populations of threatened mammals considered independent of native populations]) and (b) changes in conservation priority when small populations of threatened assisted migrants are prioritized for conservation relative to the native-only scenario (conservation of native populations only).

endangered functional group (Atwood et al., 2020; Lundgren et al., 2018; Malhi et al., 2016; Ripple et al., 2015; Werner, 2005). Among these Australian assisted-migrant megafauna are the world's only population of wild dromedary camel (*Camelus dromedarius*), which went extinct in the wild in its native range 3000–5000 years ago and is therefore not included on the IUCN Red List, as well as feral water buffalo (*Bubalus arnee bubalis*), critically endangered in its native range, and feral donkeys (*Equus africanus asinus*), also critically endangered (Figure 6a). Given their unique influences on ecosystem functioning and their global endangerment, such megafauna are key targets for rewilding efforts around the world, which includes the intentional introduction of feral or non-native megafauna (Svenning et al., 2016). Yet, for the most part, assisted-migrant mammals have been excluded from this vision (Di Bitetti et al., 2022).

Many assisted-migrant populations retain genetic diversity lost from their native conspecific populations (Bradshaw et al., 2006; Marchesini et al., 2021; Todd et al., 2022). Genetic diversity is itself an element of biodiversity, considered by many to have intrinsic value (Crozier, 1997); is important for future evolutionary dynamics; and may be a lifeline to the persistence of these species globally (Booy et al., 2000). Moreover, active conservation efforts in the native ranges of some of these species are difficult, if not impossible (e.g., the remaining 23–200 native African wild asses occur in areas occupied by warring groups [IUCN, 2018]). The success of these and other endangered megafauna in central Australia (and elsewhere in western North America and South America) suggests that these species are in the places with the socioecological conditions most amenable to their survival. Conservation of these

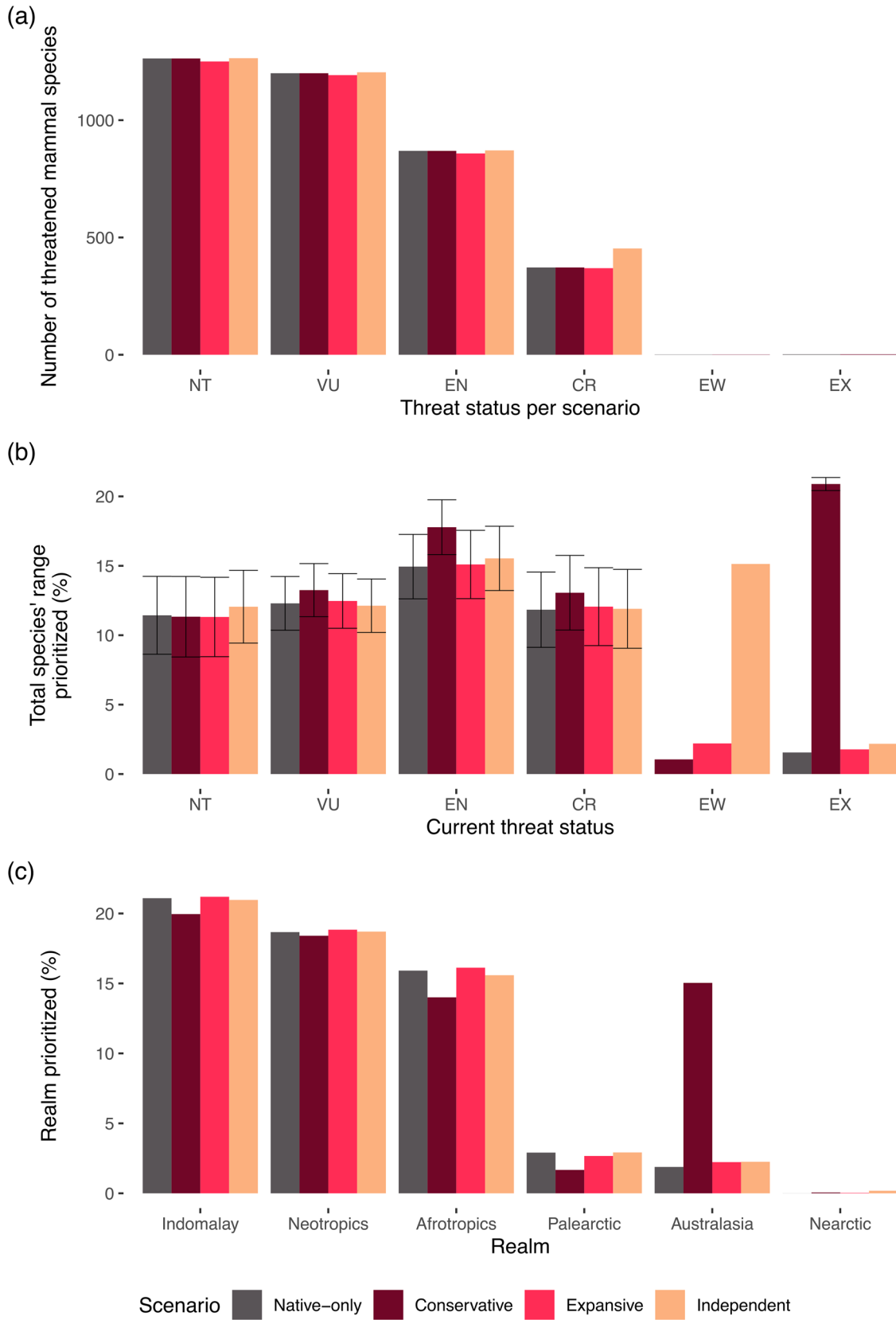


FIGURE 5 Effect of including assisted-migrant populations in global prioritization scenarios (native only, only native species prioritized; conservative, assisted migrants prioritized based on their threat status in their native range; expansive, species threat status reassessed based on their combined range size; independent, assisted-migrant populations prioritized as independent collectives with their own unique threat status) on (a) number of threatened mammal species per scenario, (b) percentage of threatened species' ranges prioritized for conservation (mean, SD), and (c) percentage of realm prioritized under each scenario.



FIGURE 6 Threatened species whose conservation may benefit, or already has, from inclusivity towards assisted-migrant populations: (a) African wild ass (*Equus africanus*) are critically endangered in their native range of Northeast Africa yet have extensive migrant populations in North and South America and Australia due to historic introductions (photo by C. Smeenk, Wikimedia Commons, Creative Commons), (b) fallow deer (*Dama dama*) are listed as least concern by the International Union for Conservation of Nature but only because of extensive historic introductions across Europe (photo by Michel Langeveld, Wikimedia Commons, Creative Commons), (c) European rabbits (*Oryctolagus cuniculus*) are endangered in their native European range yet have established at least 187 distinct assisted-migrant populations around the world (photo by Marie-Lan Tay Pamart, Wikimedia Commons, Creative Commons), and (d) yellow-crested cockatoo (*Cacatua sulphurea*) are critically endangered in their native range in Indonesia yet are thriving in novel urban environments in their assisted-migrant range in Hong Kong (photo by Astrid Andersson).

migrants would require little direct investment other than policy shifts away from eradication and toward coexistence. Importantly, protecting threatened species in their migrant ranges, which are often in wealthier regions, may help share some of the burden of species conservation with those who can best afford it (Monsarrat & Svenning, 2022).

However, valuing assisted migrant megafauna or any assisted migrant requires discussions that are honest about the limits of empirical evidence and the normative values involved in ascribing harm to the effects of an organism (Sagoff, 2020). For example, dominant views consider Australian assisted-migrant megafauna to be exclusively harmful by reducing the cover of preferred plants (Box, Nano, et al., 2016), causing trampling and soil compaction (Box, McBurnie, et al., 2016), and reducing small mammal abundance (Legge et al., 2011). However, these effects are common to all megafauna: meta-analyses and field experiments show that native megafauna also reduce small mammal abundance (Afonso et al., 2024; Daskin & Pringle, 2016; Keesing & Young, 2014; Trepel et al., 2024), reduce the cover of plants (Lundgren et al., 2024; Trepel et al., 2024), and cause trampling and soil compaction (Pringle et al., 2023; Trepel et al., 2024). Describing these impacts as harmful in one

location (i.e., where the megafauna is introduced) and beneficial or neutral in another location (i.e., where the megafauna are native) highlights the subjective nature of these designations and the perils of creating science and conservation policy based on normative values of “belonging” (Sagoff, 2020; Wallach, Bekoff, et al., 2018).

In contrast, removals of Australian assisted-migrant megafauna have led to increased wildfire frequency and intensity (Werner, 2005; Werner et al., 2006) and the extinction of endemic fish populations due to the loss of open water habitat (Kodric-Brown & Brown, 2007; Kodric-Brown et al., 2007). As with native organisms, these effects are context dependent (Lundgren et al., 2022; Wallach et al., 2015) and may simultaneously facilitate some species while suppressing others (Macdonald et al., 2007). Treating any organism as an ecological villain or hero simplifies and moralizes ecological science (Lundgren, Ramp, Wu, et al., 2021), excludes people with different values (Cardou & Vellend, 2023; Reo & Ogden, 2018), and can hinder the conservation of these species and their globally endangered functional group (Ripple et al., 2015). Thus, while remaining vigilant of the potential for assisted migrants to contribute to extinctions, we suggest that the safest

route to ensure a future with megafauna and their influences (Di Bitetti et al., 2022; Svenning, 2020) would be to consider valuing these assisted-migrant populations both in terms of their intrinsic value and their contribution to conservation agendas.

Valuing assisted-migrant populations by including them in global threat assessments (e.g., expansive scenario) delisted 20 species and reduced threat levels for 3 others. Although this is only 1.9% of all threatened mammals, the inclusion of assisted-migrant populations in global threat assessments reduces threat statuses for more species than the estimated 7–16 mammal extinctions prevented by active conservation interventions between 1993 and 2020 (Bolam et al., 2021). Moreover, assigning threat statuses based on both native and assisted-migrant populations provides a more accurate description of actual extinction risk. Given the constraints of finite conservation resources, this scenario provides a clear policy pathway for preventing further mammal extinctions by enabling the redirection of resources to those that need it most.

Including assisted-migrant populations in global threat assessments is not unheard of, particularly when the introduction is old enough and has become culturally adopted as native. For example, despite having a native population of <200 individuals, the fallow deer (*Dama dama*) is listed as least concern by the IUCN because of ancient introductions across western Europe (Baker et al., 2024; IUCN, 2018) (Figure 6b). This appears to contradict IUCN Red List guidelines. Introduced populations that lack “conservation intent” and that exceed “reasonable” geographic proximity (IUCN Red List 2018 guidelines section 2.1.3) are normally excluded from consideration. However, the case of the fallow deer establishes a useful precedent for engaging in discussions of how assisted-migrant populations can be considered to reexamine IUCN listings.

The third scenario we examined considered the threat status of assisted-migrant populations independently from native populations (e.g., independent scenario). This scenario maintained conservation concern for native populations while simultaneously valuing the emerging ecoevolutionary trajectories of assisted-migrant populations (Faurby et al., 2022). Rapid evolution in assisted-migrant populations—and interacting native ones—can conceive new taxa and ecological interdependencies (Carroll et al., 2005; Cattau et al., 2018; Herrel et al., 2008; Rozzi & Lomolino, 2017; Schlaepfer et al., 2005; Vellend et al., 2007; Vizentin-Bugoni et al., 2019). Although biotic redistribution and dispersal are fundamental to evolutionary diversification and potentially to ecosystem resilience (de Queiroz, 2005; Vermeij, 1991), human-assisted migration of species is generally considered aberrant and harmful. Instead of describing these processes as unnatural, this scenario values the emergence of new ecologies and evolutionary trajectories. For example, the European rabbit (*Oryctolagus cuniculus*) (Figure 6c) is classified as Endangered (IUCN, 2018) but has established at least 187 distinct populations from the subarctic to the tropics (Appendices S1 & S2). Charles Darwin initially considered one island population of introduced European rabbits to be a new species due to their remarkably divergent morphology (Darwin, 1868). Should consideration be made for the future biodiversity of *Oryctolagus*,

particularly given the threat status of European rabbits in their native range?

These are not straightforward debates, as the example of the European rabbit highlights. Australian farmers have long struggled to reduce rabbits, investing considerable resources to deliver technological solutions aimed at their eradication (Saunders et al., 2010). In the radically altered landscapes of the Anthropocene, emerging ecologies may be unpredictable and may increase conflict. Although this may be true in some circumstances, our results suggest that reimagining current policy frameworks around coexistence may be an effective way to prevent further extinction and biodiversity loss. Ultimately, the exclusion of assisted-migrant populations does not serve conservation universally well and establishes narratives that mirror political narratives that demonize the redistribution of people (Peretti, 1998). We suggest that the challenge for conservation in an age of biotic shuffling and planetary change is to articulate ways to protect nonhuman organisms and collectives beyond historic valuations of belonging (Schlaepfer & Lawler, 2023).

Doing so may also include broadening conservation concern to include overlooked, modified, and urbanized landscapes—conservation frontiers outside traditional wilderness models—where many threatened migrant populations reside. In addition to mammals, numerous threatened birds have established migrant populations, often in urban environments (Figure 6d). These consist of as many as 17 threatened parrot species (Pruett-Jones, 2021), including yellow-crested cockatoos in Hong Kong (*Cacatua sulphurea*) (critically endangered in their native range, Andersson, 2023), yellow-headed parrots in Stuttgart, Germany (*Amazona oratrix*, endangered), and representatives of other families, such as the Javan myna in Singapore (*Acridotheres javanicus*, vulnerable) (Cardador et al., 2021; Gibson & Yong, 2017; IUCN, 2018; Martens & Woog, 2017). In most cases, the very same process endangering their native populations—the wildlife trade—is the source of these new populations (Gibson & Yong, 2017). Expanding conservation efforts into these anthropogenic environments provides novel opportunities to protect species without land acquisition, finds common ground with efforts to improve urban environments, and may connect the populace with caring for the organisms with whom their lives intersect (Shaffer, 2018).

Global ecosystems, climate, and society are dynamically shifting, giving rise to unpredictable and unprecedented challenges. Excluding assisted-migrant biodiversity from conservation policy limits our ability to respond creatively and pragmatically. We presented 4 scenarios to investigate how valuing assisted-migrant species in different ways might influence global conservation priorities and frameworks such as the IUCN Red List. Indeed, it may be possible to conceive of how policy frameworks might utilize input from all these scenarios (and others we have not considered) to arrive at context-dependent decision-making that best protects ecosystems and prevents extinctions. Together, our results suggest that stewarding migrant populations of threatened species, with due consideration for potential conservation conflicts with resident taxa, may make important contributions to preventing global extinctions.

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SUPPORTING INFORMATION

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

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