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Policy analysis

Half of the habitat of Australia's highly imperilled narrow-range species is outside protected areas

Michelle Ward[a,b,c,*], Martine Maron[b,c], Jeremy S. Simmonds[b,c,d], Mark Lintermans[e,f], Nick S. Whiterod[g,h], David G. Chapple[i], Hugh P. Possingham[b,c], Sarah M. Legge[j,k], Rachael V. Gallagher[l], Brendan A. Wintle[m], Samantha Vine[n], Kita Ashman[u,o], Conrad J. Hoskin[p], Stephen T. Garnett[j], John C.Z. Woinarski[j], Ben C. Scheele[k], Cerin Loane[q], James A. Fitzsimons[r,s,t], Romola R. Stewart[u], Ayesha I.T. Tulloch[v], Isabel T. Hyman[w], Kate Pearce[x], Allan H. Burbidge[y,z], Tarmo A. Raadik[aa], Gerald Kuchling[ab,ac], Arthur Georges[ad], Matthew West[ae], Vanessa M. Adams[af], J.P. Emery[ag,ah], James E.M. Watson[b,c]

[a] *School of Environment and Science, Griffith University, 170 Kessels Road, Nathan, Queensland 4111, Australia*
[b] *School of the Environment, The University of Queensland, Brisbane, Queensland 4072, Australia*
[c] *Centre for Biodiversity and Conservation Science, The University of Queensland, Brisbane, Queensland 4072, Australia*
[d] *2rog Consulting, Brisbane, Queensland 4000, Australia*
[e] *Centre for Applied Water Science, University of Canberra, Canberra, Australian Capital Territory 2617, Australia*
[f] *Fish Fondler Pty Ltd, Bungendore, New South Wales 2621, Australia*
[g] *Nature Glenelg Trust, Victor Harbor, South Australia 5211, Australia*
[h] *CLLMM Research Centre, Goyder Institute for Water Research, Goolwa, South Australia 5214, Australia*
[i] *School of Biological Sciences, Monash University, Melbourne, Victoria 3800, Australia*
[j] *Research Institute of Environment and Livelihoods, Charles Darwin University, Darwin, Northern Territory 0909, Australia*
[k] *Fenner School of Society and the Environment, The Australian National University, Canberra, Australia Capital Territory 2601, Australia*
[l] *Hawkesbury Institute for the Environment, Western Sydney University, Locked Bag 1797, Penrith, New South Wales 2751, Australia*
[m] *Melbourne Biodiversity Institute, School of Agriculture, Food and Ecosystem Science, University of Melbourne, 3010, Victoria, Australia*
[n] *BirdLife Australia, Suite 2-05, 60 Leicester Street, Carlton, VIC 3053, Australia*
[o] *The Gulbali Institute, Charles Sturt University, Albury, New South Wales 2640, Australia*
[p] *College of Science & Engineering, James Cook University, Queensland 4811, Australia*
[q] *Environmental Defenders Office, Suite 8.02 Level 8, 6 O'Connell St, Sydney, New South Wales 2000, Australia*
[r] *The Nature Conservancy, Suite 2-01, 60 Leicester Street, Carlton, Victoria 3053, Australia*
[s] *School of Life and Environmental Sciences, Deakin University, 221 Burwood Highway, Burwood, Victoria 3125, Australia*
[t] *School of Law, University of Tasmania, Private Bag 89, Hobart, Tasmania 7001, Australia*
[u] *WWF-Australia, Level 4B, 340 Adelaide Street, Brisbane, Queensland 4000, Australia*
[v] *School of Biology and Environmental Science, Queensland University of Technology, Brisbane, Queensland 4000, Australia*
[w] *Australian Museum Research Institute, 1 William St, Sydney, New South Wales 2010, Australia*
[x] *Melbourne Zoo, Elliott Avenue, Parkville, Victoria 3052, Australia*
[y] *School of Science, Edith Cowan University, Joondalup, Western Australia 6027, Australia*
[z] *Department of Biodiversity, Conservation and Attractions, Bentley Delivery Centre, Western Australia 6983, Australia*
[aa] *Arthur Rylah Institute for Environmental Research, Department of Energy, Environment and Climate Action, 123 Brown Street, Heidelberg, Victoria 3084, Australia*
[ab] *Department of Biodiversity, Conservation and Attractions, Swan Coastal District, Wanneroo, Western Australia 6065, Australia*
[ac] *School of Biological Sciences, The University of Western Australia, Western Australia 6009, Australia*
[ad] *Institute for Applied Ecology, University of Canberra, Australian Capital Territory 2601, Australia*
[ae] *School of BioSciences, University of Melbourne, Parkville, Victoria 3010, Australia*
[af] *School of Geography, Planning, and Spatial Sciences, University of Tasmania, Tasmania 7001, Australia*
[ag] *Research and Innovation, Centre for Sustainable Agricultural Systems, The University of Southern Queensland, Toowoomba 4350, Queensland, Australia*
[ah] *School of Agriculture and Environment, University of Western Australia, Western Australia 6009, Australia*

* Corresponding author at: Griffith University, Nathan, Queensland 4111, Australia.
E-mail address: michelle.ward@griffith.edu.au (M. Ward).

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A R T I C L E I N F O

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A B S T R A C T

Globally, species with small distributions face disproportionate extinction risk, with the impacts of land use change more likely to have catastrophic consequences. Identifying, protecting and managing sites where such species occur is essential for minimising their extinction risk. Yet across Australia, efforts to protect and manage such species' habitats have hitherto been insufficient. Here, we present an example of an analytical and interpretive pathway for the conservation of such species, for a continental-scale case study. We identified 305 Critically Endangered species that have narrow ranges (<20,000 km^2), and are distributed in fewer than six discrete patches. We refined existing species' habitat maps with advice from 18 experts via a modified Delphi approach. We assessed how much of each species' habitat is outside protected areas and considered to have agricultural capability, potentially elevating risk of conversion. We identified ~85,000 km^2 of habitat (~1% of Australia) for these 305 species that must receive protection and management if the nation is going to meet its commitment to halt new extinctions. Approximately half of this habitat is outside the protected area estate, including the entire distribution of 39 species. Approximately 55% of habitat outside of protected areas had at least some agricultural capability. Protecting and managing the habitats of these narrow-range species should be a high priority in state and national conservation policy. Our case study serves as a template for the identification of important habitat for threatened species and could be applied in other regions of the world.

1. Introduction

Globally, ~60 % of terrestrial surfaces have been directly modified by industrial human activities (Williams et al., 2020), 97 % of the ocean has been altered (Jones et al., 2018), and freshwater extraction has now surpassed planetary boundaries (Richardson et al., 2023). Consequently, habitat loss is the key threat for most threatened species (BirdLife International, 2021; Kearney et al., 2023; Maxwell et al., 2016; Lintermans et al., 2024; Ward et al., 2021). While drivers of habitat loss are numerous, including native forest logging, urban development, modification of streams, mining and other industrial development, land conversion for agriculture is a leading cause of habitat loss and hence extinction risk globally (Nic Lughadha et al., 2020), including in South America (Edwards et al., 2015), Africa (Zhang et al., 2021; Shaw et al., 2019) and Australia (Adams et al., 2023; Engert et al., 2023; Kearney et al., 2018; Grill et al., 2019; Morden et al., 2022; Australian Bureau of Statistics, 2024).

Threatened species and ecological communities with narrow ranges tend to only occur in a small number of habitat patches (Tulloch et al., 2016; Wintle et al., 2019b) because they either have always occupied only a few discrete areas across a small distribution (Bertola et al., 2018) or because disturbance events like land clearing, wildfires, long-term drought, alien invasion, or diseases have left only small residual areas (and populations) from an originally more extensive range (Legge et al., 2022; Ward et al., 2020; Nic Lughadha et al., 2020; Humphreys et al., 2019; Gallagher et al., 2023; McDowall, 2006), or both. These species are particularly vulnerable to actions that cause habitat loss, as even localised impacts (such as small-scale habitat destruction or severe wildfire) can have large consequences for their persistence by reducing already small population sizes, depleting already scarce resources, and increasing competition (Staude et al., 2020; Harvey et al., 2011). With climate change directly impacting species' habitat and population structure through many mechanisms (Scheffers et al., 2016), the risk to those species that have a small amount of habitat remaining is amplified (Pearson et al., 2014; Purvis et al., 2000). The most recently reported global extinction in 2024 was a species with a very small range (*Alosa vistonica*), endemic to a single shallow lake in Greece (IUCN, 2025). In addition, two recent Australian extinctions were small ranged species: Banksia montana mealybug *Pseudococcus markharveyi* (range < 100 m^2; extinct in 2020) (Moir, 2021) and Bramble Cay melomys *Melomys rubicola* (0.05 km^2; extinct between 2009 and 2014) (Woinarski et al., 2017). Proactively identifying, delineating and safeguarding these habitats of such species is therefore crucial (Bertola et al., 2018; Grace et al., 2021; Spiliopoulou et al., 2023; Woinarski et al., 2023; Jones et al., 2021), especially as climate-driven disturbance events are predicted to increase in frequency and severity (Dowdy et al., 2019), and are coupled with high rates of continued habitat loss (World Resources Institute, 2024).

Habitats for narrow-range species are often considered irreplaceable under methods to identify areas most important for biodiversity; as such, they should be considered a high priority when considering site-based conservation efforts (Pressey et al., 1993). Here, using expert knowledge and recent species occurrence records, we refine maps of the remaining habitats of Critically Endangered, narrow-range Australian species, with <6 patches of habitat remaining. This threshold was selected because species restricted to fewer than six patches of habitat generally have a higher risk of extinction (McCarthy et al., 2005). We defined a patch as a single polygon not directly connected to or touching any other polygon (Tulloch et al., 2016). As per other studies (Tokarz and Condit, 2021), we employed the IUCN Red List range size threshold under criterion B of 20,000 km^2 (IUCN Standards and Petitions Committee, 2019) to define narrow-range species.

To understand potential threats to these narrow-range species, we assessed data on both the tenure (ABARES, 2021) and the agricultural capability of the land on which this habitat occurs (Adams and Engert, 2023). Agricultural capability is the land's ability to support agriculture, determined by biophysical factors such as geology, soil, slope, and climate, along with physical constraints like drainage, flooding, and erosion risk (Adams and Engert, 2023). We concentrated on agricultural capability because agriculture currently drives more habitat loss than do logging, urbanization, mining or other industrial developments (Evans, 2016). For example, in Queensland alone, 6800 km^2 of woody vegetation was cleared in 2018–2019, most of it for agriculture (Queensland Government, 2020).

By identifying the habitat remaining for narrow-range species, we provide the baseline data that are essential for policy development and conservation action of some of Australia's most imperilled species, whether through formal protection, collaboration with land managers or other site-based activities.

2. Methods

2.1. Identifying species most at risk of extinction

Under Australia's national environmental legislation, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), terrestrial and freshwater species (and subspecies; referred to here as species) can be listed as Extinct, Extinct in the Wild, Critically Endangered, Endangered, or Vulnerable based on listing criteria that largely resembles the International Union for Conservation of Nature (IUCN) criteria (IUCN, 2024; Commonwealth of Australia, 1999; Petrov et al., 2023). We excluded all marine species, as well as Vulnerable and Endangered species due to their lower probability of extinction, retaining only terrestrial and freshwater species listed as Extinct in the Wild (a single species that was listed as Extinct and has had a population reintroduced into its indigenous range since then), and Critically Endangered, and those currently under formal assessment for potential listing as Critically Endangered (Commonwealth of Australia, 2025). Using the Australian Government's publicly available Species of National Environmental Significance Distributions (hereafter SNES data; downloaded 28 February 2023) (Commonwealth of Australia, 2022a; Tulloch et al., 2016), we extracted the habitats for species listed as Extinct in the Wild, and Critically Endangered, and those under assessment for Critically Endangered listing (Commonwealth of Australia, 2025). These maps are divided into two categories: 'Species or species habitat likely to occur' (this was a combination of both known and likely to occur categories) and 'Species or species habitat may occur'. The 'likely to occur' areas were the specific habitat type or geographic feature that represents the recent observed locations of the species or modelled preferred habitat occurring within an ecologically sensible distance to these locations. 'May occur' areas were the broadscale modelled environmental envelope or geographic region that encompasses all areas that could provide habitat for the species. We used only the 'Species or species habitat likely to occur' category as they represent more accurate, current maps of habitat. The SNES data often contain multi-part shapes, where a single row in the attribute table is linked to multiple polygons representing distinct habitat patches. Here, we counted the number of separate polygons for each species using ArcPro (version 3.4) and included only species with <6 polygons (hereon 'patches') of habitat (ESRI, 2024). As the SNES data have been generalised to 1 km^2–10 km^2, species with many scattered, nearby observations would be counted as one patch, although this variation depends on how the occurrence records were processed to create the polygons—whether they were simply buffered or their distribution was modelled. For example, if occurrence records were buffered and occurred within 2 km of one another, they would form a single polygon. For others, species distribution models (SDMs) generated by the Australian Government were used, sometimes in combination with expert refinement, and this may result in one or more than one polygon (Fig. 1).

We further filtered species by including only those listed as Critically Endangered pursuant to EPBC Act criterion 2 (species that have restricted ranges, very few locations, continued decline or fluctuations) or criterion 3 (very small population size), because any habitat loss for these species could be disproportionally detrimental. To identify these species, we used a combination of Australian Government documents (i.e., Recovery Plans, Conservation Advices, and Listing Advices). Many species listed under legislation preceding the EPBC Act were simply added into contemporary lists when the EPBC Act came into force, and most of those species had no descriptions of the qualifying criteria. To overcome this issue, and as we are only focused on small-ranging species, we exclude all species with habitats >20,000 km^2 (Commonwealth of Australia, 2022b).

Note that our approach of including all mapped likely habitat may overstate the functional distributions of some species that have highly restricted breeding colonies but also disperse more widely beyond these. A notable example is the Critically Endangered southern bent-wing bat *Miniopterus orianae bassanii*, which only uses two cave systems (with a total area of <10 km^2) for breeding but has a far broader (mapped) distribution in the non-breeding season (Commonwealth of Australia, 2021).

2.2. Refining habitat maps

We drew on knowledge from 18 experts to help provide more complete occurrence data, and to review and refine the known and likely Australian Government habitat maps for all included animal species. Due to the high number of plants, plant maps were checked via herbarium occurrence records only. While herbarium data are the best available data for these species, this does not represent independent validation because many herbarium occurrence records were used to develop the original plant habitat maps. As many of these plants are under-surveyed, no cut-off survey date was used, to use the full extent of data available. The expert elicitation process to refine animal habitat maps was done using an online modified Delphi approach (Northcote et al., 2008). Experts were defined and chosen based on if they had conducted recent research on the species of interest and were invited via email to participate in the elicitation process, as well as co-author the manuscript. In the first round of communication, experts were asked to check whether maps matched their knowledge of species current occurrence, add any additional species that were currently being considered for Critically Endangered listing and their accompanying habitat maps, and, if necessary, modify the boundaries of habitat maps. These modifications were implemented using a variety of different data, including vegetation (e.g., extracting rainforest vegetation only), cleared areas, geology, new occurrence records, and elevation, with the final maps re-checked by the experts. We then rechecked to ensure every

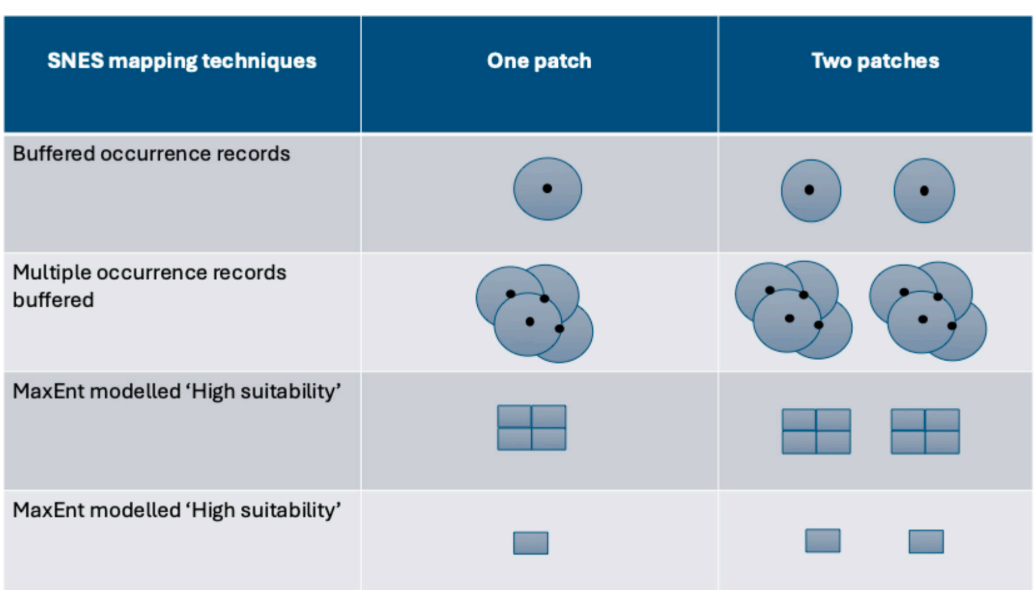

Fig. 1. Methodological figure showcasing how patches were defined, identified, and counted using SNES data.

species still had <6 habitat patches and had <20,000 km^2 of habitat. These final single species maps were then merged to create one final layer, representative of the of habitat of the 305 species considered in our analysis. We recognise that the condition and occupancy of the habitat identified in each species' maps is uncertain given issues of mapping resolution and spatial/temporal dynamics. Nonetheless, given the data at hand, these refined maps represent a logical starting point to inform conservation decision making.

Some species were removed from the analysis due to taxonomic uncertainty (i.e., Glenelg freshwater mussel *Hyridella glenelgensis* and Round Island petrel *Pterodroma arminjoniana*). The Phillip Island helicarionid snail *Advena phillipii*, Banksia montana mealybug *Pseudococcus markharveyi*, Christmas Island shrew *Crocidura trichura*, mountain mistfrog *Litoria nyakalensis*, Stoddart's helicarionid land snail *Advena stoddartii*, and Tiwi Island hooded robin *Melanodryas cucullata melvillensis* are listed as Critically Endangered under the EPBC Act but were also removed from this analysis as they are likely now Extinct (Ward et al., 2022b; Woinarski et al., 2024a, 2024b; Woinarski et al., 2025). In addition, while Gray's helicarionid land snail *Advena grayi* was recently rediscovered on Phillip Island, a lack of survey data did not allow us to accurately undertake the mapping of the species, thus we removed it from the analysis (Hyman et al., 2023). Seventeen additional species (beyond those found on the EPBC Act list) that are currently being assessed for Critically Endangered status as of September 2023 were included in the assessment as the expert elicitation found they should be treated as Critically Endangered.

2.3. Identifying tenure and land capability of habitat patches

Finalised habitat maps were overlaid with existing Australian Government maps of land tenure including Freehold, Multiple-use public forest, Nature conservation reserve, Other perpetual lease – Indigenous, Other Crown land, Other Crown purposes, Other Crown purposes – Indigenous, Other lease, Freehold – Indigenous Freeholding lease, Other perpetual lease, Other term lease, Pastoral perpetual lease, and Pastoral term lease (ABARES, 2021). We also investigated how habitats overlapped with Australia's protected area network in 2020 (Collaborative Australian Protected Areas Database, 2020), bioregions (n = 89; Commonwealth of Australia, 2018), and state and territory boundaries.

We also built upon previous assessments of Australian plants at risk from land use change (Adams et al., 2023) and evaluated how much narrow-range Critically Endangered species' habitat had 'Very low' to 'Extremely high' agricultural capability (Adams and Engert, 2023). This layer harmonized state agricultural land capability datasets and modelled pastoral capability to map land capability. Land capability mapping is broadly defined as applying a classification system that ranks land according to its capability to support agricultural production, based on various uses such as broadscale grazing and cropping (Wang, 2020; Office of Environment and Heritage, 2012). Land in agricultural classes 'Extremely high'–'Moderate' (i.e., 1–4) would be expected to primarily be under agricultural uses, including all types of cropping. Land in classes 'Moderate–low' and 'Low' (i.e., 5 and 6) is generally unsuitable for intensive agriculture and would be expected to be used for grazing and forestry. Land in class 'Very low' (i.e., 7) is expected to be restricted to use for low intensity production such as native vegetation grazing and forestry, or non-productive land uses such as conservation. Land in class 'Extremely low' (i.e., 8) is unsuitable for any productive land uses and is expected to be primarily intact vegetation. As this land capability layer is tenure blind, it does cover areas unlikely to be lost to agriculture such as protected areas, World Heritage Areas, and public native forests. Therefore, we assume that habitat in protected areas, World Heritage Areas, and Nature conservation reserves have no agricultural capability.

We also assessed the extent of inter-specific overlap amongst the habitat patches identified to explore where expanding protection and subsequent management could be efficient and cost-effective for supporting multiple species.

3. Results

We identified 305 narrow-range, Critically Endangered species with fewer than six patches of habitat remaining (making up ~15 % of the 2004 terrestrial and freshwater species listed as threatened under the EPBC Act in Australia, and 74 % (132 animals and 280 plants) of the listed Critically Endangered terrestrial and freshwater species). Most were plants (228 species), followed by reptiles (20 species), frogs (14 species), other animals (invertebrates other than freshwater crayfish; 14 species), freshwater crayfish (11 species), freshwater fish (10 species), birds (five species), mammals (three species; **Supplementary Table 1**). The 305 narrow-range Critically Endangered species occurred in patches with a total area of 85,000 km^2 (~1 % of Australia; **Supplementary Table 2**). We found that the habitat of 180 species (59 %) overlapped spatially with at least one other narrow-range Critically Endangered species, and the highest number of overlapping species within any one habitat patch was 14, in Norfolk Island (Fig. 2).

Roughly 52 % of the combined habitat area for the 305 narrow-range Critically Endangered species fell within protected lands, including government, Indigenous and privately protected areas, nature conservation reserves, and World Heritage Areas (from hereon referred to as 'protected lands'; ~44,000km^2), closely followed by freehold land (17,000km^2), and multiple-use public forest (excluding protected areas; 7000km^2; **Supplementary Table 3**). Freehold land held the highest proportion of habitat for 'other animals' (invertebrates other than crayfish). Protected lands held the highest proportion of habitat for birds, frogs, crayfish, plants, mammals, fish and reptiles (**Fig. 3**).

It is noteworthy that approximately half (41,000 km^2) of the combined habitat area for the narrow-range Critically Endangered species is outside public or private protected lands, with 39 species having their entire habitat outside protected areas (32 of which were plants; Fig. 4). Approximately 23,000km^2 (55 %) of this habitat outside protected lands, covering 221 species, also overlaps with land categorized between 'Very low agricultural capability land' and 'Extremely high agricultural capability land' (**Supplementary Table 4)**. We found that 116 species had >50 % of habitat outside of protected lands and overlapping with very low to extremely high agricultural capability, 77 species had between 11 and 50 %, and 28 species had between 1 and 10 % (**Supplementary Table 5–6**).

Habitats for narrow-range Critically Endangered species were identified in every Australian state and territory, with 76 species occurring in New South Wales (NSW), 72 in Western Australia, and 41 in Queensland. Some bioregions had habitat areas for many narrow-range species within them, notably the South Eastern Highlands (n = 33 species) across NSW and Victoria, the Jarrah Forest bioregion of Western Australia (n = 29 species), and the Sydney Basin bioregion in NSW (n = 26 species). Several islands were identified as hotspots including Norfolk Island, Lord Howe Island, Macquarie Island, and Christmas Island (Fig. 2).

4. Discussion

Threatened, narrow-range endemic species are highly vulnerable to incremental and cumulative loss of habitat over time, and require concerted global efforts to enhance their protection and management (Ward et al., 2019). Because these species often only persist in small, scattered patches, we need accurate knowledge of their distributions and potential threats to remnant habitat to ensure informed conservation decisions can be made. We developed a robust methodology that can be applied worldwide to identify and refine mapping for threatened narrow-range species. We demonstrated our approach on a case study of 305 Critically Endangered Australian species to evaluate the distribution of their potential habitat in relation to tenure and land capability, which we used as proxies for the threat of habitat loss from human activities such as agriculture. We found that the habitat for these species covered ~85,000 km^2 (~1 % of Australia) and that approximately half of that

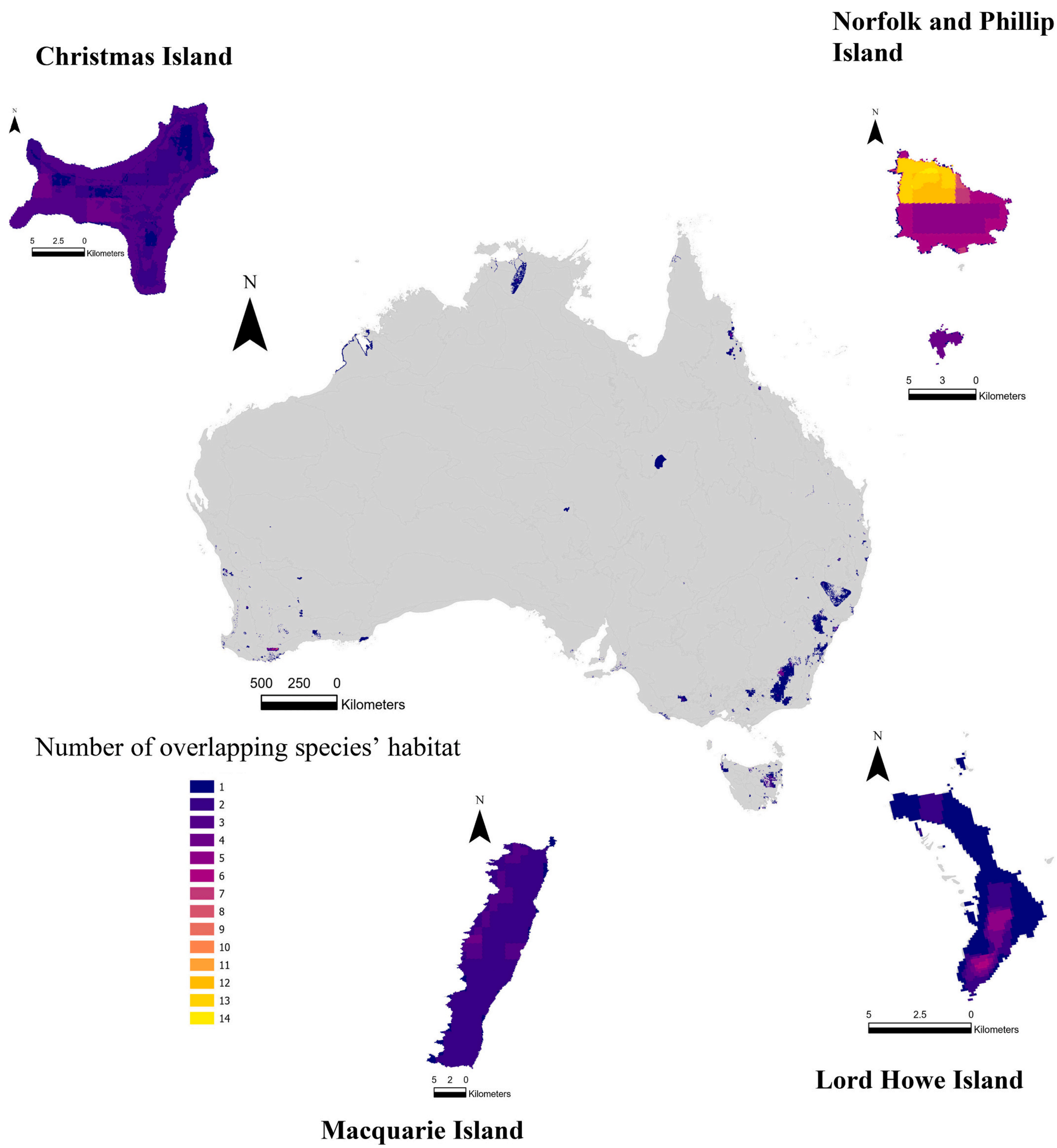

Fig. 2. Habitats for 305 narrow-range Critically Endangered species in Australia. Five key islands have been enlarged: Christmas Island (top left, located in the Indian Ocean, 1500 km west of the Australian mainland and 2600 km from Perth), Norfolk and Phillip Islands (top right, located in the southwestern Pacific Ocean, 1676 km northeast of Sydney), Lord Howe Island (bottom right, located approximately 700 km northeast of Sydney and southeast of Brisbane), and Macquarie Island (bottom left, located 1500 km south-south-east of Tasmania).

habitat is within protected lands (i.e., protected areas, nature conservation reserves, and World Heritage Areas). Most habitat outside the protected lands estate was found on freehold land (~17,000 km^2 or 20 % of all habitats assessed) and multiple-use public forest (~7000 km^2 or 9 % of all habitats assessed). Approximately 55 % (~23,000 km^2) of the habitat outside the protected area estate had some mapped agricultural capability.

We found that 87 % of the considered species had at least parts of their habitat in protected lands. However, 39 species had their entire habitats outside of the protected lands estate. Most of these were plants (n = 32), but the list also included four invertebrates (Margaret River burrowing crayfish *Engaewa pseudoreducta,* short-tongued native bee *Hesperocolletes douglasi,* southern sandstone cave cricket *Micropathus kiernani,* and a land snail *Ordtrachia septentrionalis*), two reptiles (Lyon's

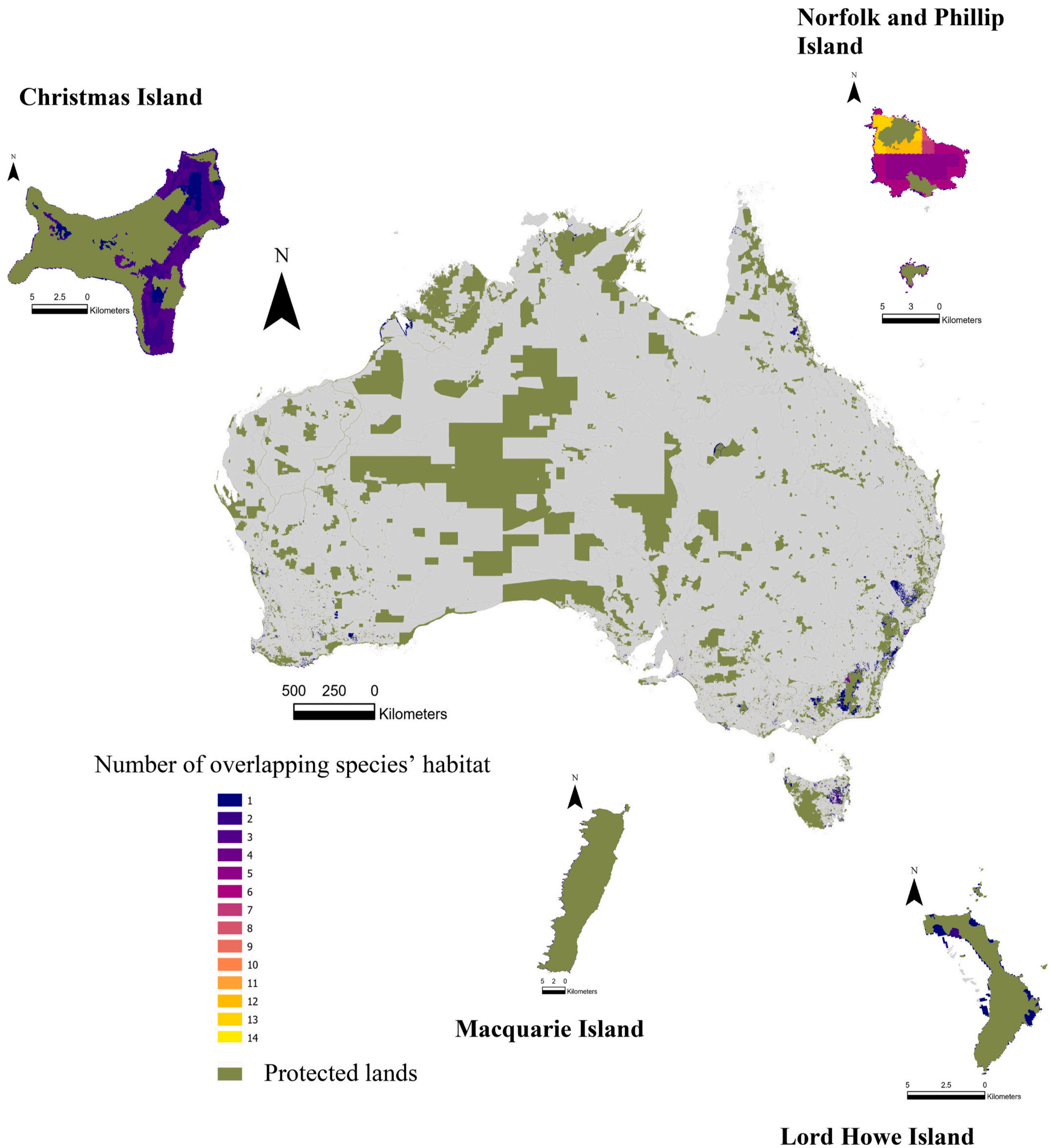

Fig. 3. The number of habitats for narrow-range Critically Endangered species outside protected lands (blue = 1 through to yellow = 14). The entire protected lands as of 2020 are shown in green. Five key islands have been enlarged: Christmas Island, Norfolk and Phillip Islands, Lord Howe Island, and Macquarie Island.

snake-eyed skink *Austroablepharus barrylyoni* and Pinnacles leaf-tailed gecko *Phyllurus pinnaclensis*), and one bird (Grey Range thick-billed grasswren *Amytornis modestus obscurior*).

If Australia is to achieve its 2030 'no new extinctions' commitment (Commonwealth of Australia, 2024) and its global commitment to halting species extinctions (as per the Kunming-Montreal Global Biodiversity Framework) (Convention on Biological Diversity, 2022), the habitat we have identified must be prioritized for protection and management. Areas not already receiving active management should be treated as having a high priority for conservation measures. These mechanisms may include private protected areas, Indigenous protected areas, government protected areas, and other effective area-based conservation measures (OECMs), as well as stewardship schemes and other approaches. Given we found 55 % of the habitat outside the protected area estate had some mapped agricultural capability, adequate financial incentives may be needed to cover for opportunity cost of protecting

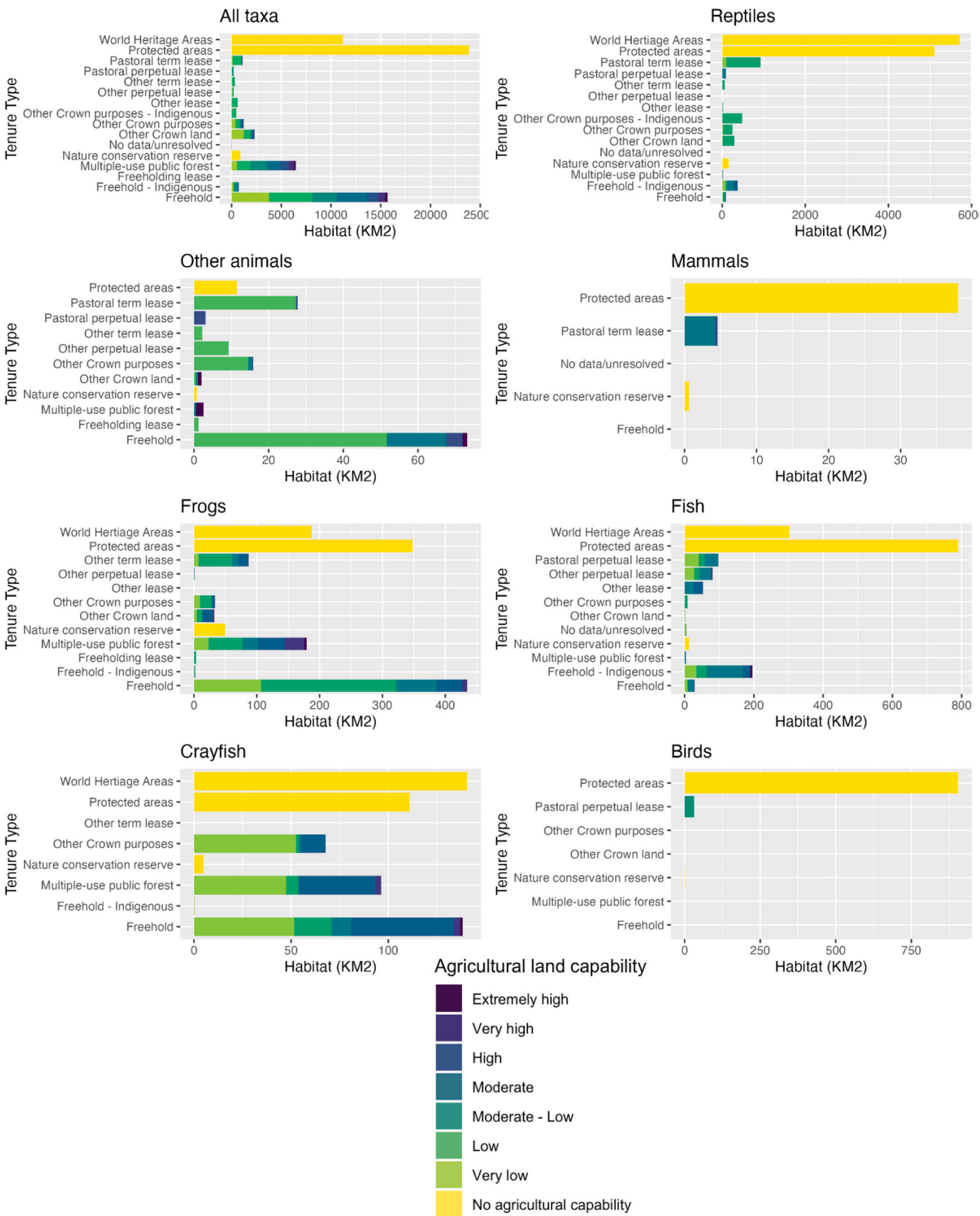

Fig. 4. Mapped habitat area for 305 narrow-range Critically Endangered species in Australia. Habitat area varies across tenure for each group. Areas that have no to extremely high agricultural capability are shaded from yellow to dark purple. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

these areas as well as for the management needed to conserve the affected species (e.g., invasive species management). In addition to rigorous regulation of development impacts (Thomas et al., 2025; Ward et al., 2019) and management mechanisms, voluntary initiatives (e.g., Land for Wildlife; Prado et al., 2018) that engage private landholders in conservation will be important to ensure Australia meets its conservation goals (Munro and Lindenmayer, 2011). The maps we have refined here are instructive as they could guide application of the mitigation hierarchy (helping prioritise areas for avoidance of impacts), as well as broader planning initiatives like regional planning.

While safeguarding habitat (and any additional buffer zones or areas required for connectivity) in protected lands will likely ensure species are protected from most direct destructive activities, a sole focus on protected lands will not secure all species from extinction (Moir, 2021). This is because formal designation of a protected site does not always result in species 'protection' against threats such as inappropriate fire regimes, climate change, disease, reservoir construction, and invasive species (Kearney et al., 2020). For example, in many Australian protected areas, recreational harvest of native fish is still permitted (Jackson et al., 2004; Jarvis et al., 2019; Lintermans et al., 2020). In fact, four of the five most recent Australian extinctions were of species for which occurrences were entirely or largely already within protected areas (Woinarski et al., 2024a, 2024b; Woinarski et al., 2025). Active management and policy change is commonly needed to combat these threats. Given so much habitat occurs on freehold land (**Fig. 3**), incentives for landholders to manage for positive biodiversity outcomes is essential (McDonald et al., 2018). In other cases, management of Indigenous-owned lands for the health of Country and people is a key mechanism for achieving good outcomes for nature, but must be adequately funded. It is also acknowledged that Indigenous people have priorities for their land that are independent of conservation (Renwick et al., 2017; Corrigan et al., 2018).

While some legislative levers such as the United States' Endangered Species Act or the European Union's Habitat Directive work by conserving habitats, much conservation action requires reform (Henson et al., 2018). In Canada, critical habitat located outside Federal land can be destroyed or degraded (Palm et al., 2020). Similarly, under the Australian EPBC Act, habitat identified on the Register of Critical Habitat is only protected by law if that habitat is on Commonwealth land or sea, or on private land with agreement of the landholder. While some Australian state-based legislation has greater provision for identifying and listing of critical habitat on private land, this has only been done sparingly (Fitzsimons, 2020). In some instances, where illegal conversion continues to be a key threat, effective enforcement of environmental laws is urgently required to ensure habitat remains intact for the persistence of these species. This must be coupled with appropriate public funding to support the delineation, mapping, protection, and management of other threatened species and ecosystem habitats — funding that is currently inadequate (Wintle et al., 2019a; Ward et al., 2025).

We recognise that our habitat maps have been refined based on information that is skewed to species' current known ranges. Historically, many now-threatened species had large distributions and possibly a slightly different range due to climate change, which has gradually altered temperature regimes, precipitation patterns, and fire regimes. These shifts have caused some species distributions to move, expand, or contract (Wiens, 2016; Lawlor et al., 2024). In other cases, some current habitats have arisen from species persisting in suboptimal areas where the threat load is lowest, rather than where the habitat is most suitable (Raadik, 2014; Britnell et al., 2023). For example, many threatened galaxiid species are now confined to small, upland streams above barriers that exclude introduced trout (Salmonidae), but they were likely much more widespread before trout invasion (Raadik, 2014). In cases where habitat persists, but species have been locally extirpated, habitat protection remains imperative as the loss of unoccupied habitat reduces opportunities for natural recovery, future reintroductions, and movement under climate change (Ward et al., 2022a, 2022b).

While we used the best available information, uncertainties persist in our analysis, especially regarding false absences and presences in habitat mapping. It remains unknown if the current extent of habitat mapped here represents the habitat necessary to meet the persistence, let alone recovery potential, of each species, especially if the needs of species shift over time as climate changes. It is therefore important to ensure that effort and resources are also directed towards gathering new information on species, especially to determine recovery potential as per the IUCN Green Status of Species methodology (Akçakaya et al., 2018). This new information must then be used to update and refine habitat maps. Effort and funding to reduce those uncertainties is required. Further, the existence of maps does not diminish the need for robust ground-truthing assessments in areas of uncertainty or where local knowledge exists that differs from what maps indicate.

We note that our analysis only covers species listed as of February 2023. Unfortunately, many additional species have since been added to the threatened list that would meet our criteria. For example, the Critically Endangered Fassiferm blind-snake *Anilios insperatus* is only known from the location of the holotype. Another example is the Victorian grassland earless dragon *Tympanocryptis pinguicolla*, which has declined severely, but was not recorded despite extensive searches for ca. 50 years until recently rediscovered, and is now known only from a single population on one property. It is now listed as Critically Endangered.

We recognise that the data used to develop these habitat maps describe contemporary occurrences only, with the assumption that presence is the main driver of habitat identification via species occurrence records. Mapping of presence-derived habitat does not guarantee the presence of a species throughout that habitat type. Additionally, in some cases, the mapping used here will not capture all areas where a species might occur, and may falsely give the impression of the distribution being $<$20,000 km^2 in extent. There are likely to be unmapped areas of habitat due to poor or limited survey data, poor historical knowledge of the species, or unoccupied or temporally dynamic habitats (e.g., ephemeral streams that sometimes support freshwater species). Some species (in particular, plants) can be present at a site but virtually undetectable (e.g., plants of genera like *Thismia* that reside almost entirely underground and/or are obscured by leaf litter) and many animals will not be detected if surveys are conducted at an inappropriate time of year or time of day. While this is less of a problem than underestimating, it can lead to sub-optimal allocation of resources, especially if the method used has excluded some highly restricted species, such as the southern bent-wing bat, which uses only two cave systems for breeding (a total area of $<$10 km^2) but has a far broader non-breeding distribution. We also note that not all patches for a restricted species are of equal conservation significance—some are critical but others may not be so. Nevertheless, we argue that mapping areas where such species have been detected is crucial until more accurate data become available.

Many countries are facing an extinction crisis, necessitating stronger conservation measures (Secretariat of the Convention on Biological Diversity, 2020). In Australia, an independent review of the EPBC Act (Samuel, 2020) highlighted the need for reform to establish legally enforceable National Environmental Standards, which will rely on mapping and seek to protect and manage habitats for threatened species. This approach aligns with global commitments to achieving 'Nature Positive' outcomes, which require identifying and safeguarding irreplaceable habitats. The refined habitat areas identified here for species most at risk of extinction provide a crucial first step in pinpointing vital conservation areas, particularly those outside protected zones. To prevent further biodiversity loss, future development should not occur or be highly regulated in these critical areas, and the areas should be prioritized for targeted conservation efforts. By adopting similar strategies, other countries can strengthen their conservation policies, contribute to global biodiversity protection, and advance their commitments to preventing species extinctions.

CRediT authorship contribution statement

Michelle Ward: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing. **Martine Maron:** Methodology, Writing – original draft, Writing – review & editing. **Jeremy S. Simmonds:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Mark Lintermans:** Investigation, Methodology, Writing – review & editing. **Nick S. Whiterod:** Data curation, Investigation, Methodology, Writing – review & editing. **David G. Chapple:** Data curation, Investigation, Writing – review & editing. **Hugh P. Possingham:** Data curation, Methodology, Writing – review & editing. **Sarah M. Legge:** Data curation, Methodology, Writing – original draft. **Rachael V. Gallagher:** Data curation, Investigation, Methodology, Supervision, Writing – review & editing. **Brendan A. Wintle:** Methodology, Writing – review & editing. **Samantha Vine:** Data curation, Methodology, Writing – original draft. **Kita Ashman:** Formal analysis, Methodology, Writing – review & editing. **Conrad J. Hoskin:** Data curation, Formal analysis, Investigation, Writing – review & editing. **Stephen T. Garnett:** Data curation, Investigation, Writing – review & editing. **John C.Z. Woinarski:** Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Ben C. Scheele:** Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Cerin Loane:** Project administration, Resources, Writing – original draft, Writing – review & editing. **James A. Fitzsimons:** Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Visualization, Writing – original draft, Writing – review & editing. **Romola R. Stewart:** Supervision, Writing – review & editing. **Ayesha I.T. Tulloch:** Investigation, Methodology, Writing – original draft. **Isabel T. Hyman:** Data curation, Investigation, Methodology, Writing – review & editing. **Kate Pearce:** Data curation, Investigation, Methodology. **Allan H. Burbidge:** Data curation, Investigation, Methodology, Writing – review & editing. **Tarmo A. Raadik:** Data curation, Methodology, Writing – review & editing. **Gerald Kuchling:** Data curation, Investigation, Writing – review & editing. **Arthur Georges:** Data curation, Formal analysis, Investigation, Writing – review & editing. **Matthew West:** Data curation, Formal analysis, Investigation, Writing – review & editing. **Vanessa M. Adams:** Methodology, Writing – review & editing. **J.P. Emery:** Data curation, Investigation, Writing – review & editing. **James E.M. Watson:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Michelle Ward reports financial support was provided by WWF Australia. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2025.111195.

Data availability

Data will be made available on request.

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