ARE MANAGEMENT SITES FOR THREATENED SPECIES IN NSW RESILIENT TO CLIMATE CHANGE?

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The style and formatting of this thesis are in the form of a journal article following the author guidelines of *Ecography*. Although the thesis has been prepared for manuscript submission, some sections have additional information for the purposes of clarification.

Declaration

I certify that all the research described in this thesis is my own original work.

Elissa McFarlane

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TABLE OF CONTENTS

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ABSTRACT

Anthropogenic climate change is already having substantial impacts on species, with numerous species undergoing shifts to their range margins. However, many threatened species are restricted to fragmented bushland remnants, and are highly unlikely to be able to shift their range to track the movement of climate zones. In New South Wales, around 440 threatened species have been designated as 'site-managed species': their populations are located at discrete sites that require management to ensure the species' security beyond 2100. Unfortunately, the selection of managed sites did not consider whether climate will remain suitable for species over this time frame. This project interrogated maps of climate suitability under 12 plausible climate scenarios for 238 of these threatened species to (a) assess whether managed sites are likely to retain suitable habitat from now to 2070, and (b) identify whether populations outside of managed sites may be better candidates for site-management, based on the longevity of suitable habitat. Given cumulative threats from climate change and land use change, identifying areas where investment of finite resources will have greatest impact is vital to ensuring the survival of these species.

1. INTRODUCTION

Since 1910, mean annual temperature across Australia has warmed ~1°C, and the duration, frequency and intensity of extreme weather events has increased over large parts of the continent (CSIRO and BoM 2016, CSIRO and BoM 2015). Precipitation patterns have also altered over recent decades. Since the mid-1990s, there has been a decline of around 11 per cent in the April–October growing season rainfall in the southeast of continental Australia (CSIRO and BoM 2016). Southwest Australia has also experienced substantial drying (CSIRO and BoM 2016). In addition, increased temperatures and drying have contributed to a rise in extreme fire weather, and a longer fire season, across large parts of Australia since the 1970s (CSIRO and BoM 2016). As the 21st century progresses, these trends are projected to continue: temperatures may increase 1.8-3.4°C by 2070, leading to more extremely hot days and fewer extremely cool days (CSIRO and BoM 2016, CSIRO 2007). Significant declines in rainfall and increases in evaporation are likely across large areas of Australia, including lower winter and spring rainfall across southern continental Australia, with more time spent in drought (CSIRO and BoM 2016, CSIRO and BoM 2015). The number of days with weather conducive to fire in southern and eastern Australia is also projected to increase (CSIRO and BoM 2016).

These climatic changes are resulting in shifts in the arrangement of climate zones, which define the structure and composition of ecosystems (Parmesan 2006). Increasing evidence shows that climate change is already causing alterations to phenology, distribution and abundance of plants and animals, as well as changes in the composition of communities and interactions between species (Cabrelli et al. 2015, Bellard et al. 2012, Parmesan 2006, Fischlin et al. 2007, Rosenzweig 2008). The timing of spring events has advanced by a mean of 2.3 days per decade during the twentieth century (Parmesan & Yohe 2003). Australian studies have shown a strong trend towards advanced spring phenology associated with increases in temperature over the last century (Beaumont et al. 2015, Gallagher et al. 2013). In contrast, decreases in precipitation over the same timeframe have been shown to play a role in causing later onset of spring phenology in some species, primarily those in arid or semi-arid regions (Beaumont et al. 2015, Chambers et al. 2013). Similarly, a global study revealed that distributions of species have shifted to higher elevations at a median rate of 11.0 metres per a decade, and to higher latitudes at a median rate of 16.9 kilometres per decade, within the last 25 years (Chen et al. 2011).

The rate of climate change will become increasingly problematic for species and communities as normal patterns of temperature and humidity continue to shift in the future (Thuiller 2007). A mounting body of evidence shows that climate change is occurring at a pace that may exceed the adaptive potential of many populations and species (IPCC 2014). Therefore, the most immediate responses to changes in climatic zones are shifts in species' geographical range, with continuing and increasing relocation of species projected for the near future (Thomas et al. 2004; Walther et al. 2002). At 2°C warming globally, climatically determined geographic range losses of > 50% are projected for 16% of plants and 8% of vertebrates (Warren et al. 2018).

To date, widespread land transformation, associated habitat fragmentation, invasive species and introduced diseases have been the primary drivers of declines in biodiversity (Sala et al. 2000). However, as the century progresses, these factors may interact with projected climate change to further threaten biodiversity. Hence, the impacts of climate are predicted to become increasingly important relative to other factors such as habitat destruction and biotic exchange over a longer timescale (Thuiller 2007). Sala et al. (2000) estimated that by 2100, land-use change and climate change will have the largest effect on biodiversity, followed by nitrogen deposition, biotic exchange, and elevated carbon dioxide concentration.

Fragmentation of habitat in human-altered landscapes creates barriers to the migration of species, preventing population shifts to suitable environments as organisms are unable to track spatial shifts in climate zones (Vos et al. 2008, Collingham & Huntley 2000, Malanson & Armstrong 1996). This is particularly problematic for threatened species, which may be predisposed to negative future impacts due to restricted geographic ranges, and existing degradation and fragmentation of their habitats (Hughes 2011). Threatened species often have traits that reduce dispersal abilities, which mean that organisms may not be able to track changes in optimum environmental conditions (Hughes 2011). Relatively intact landscapes may also be a risk factor where landscape heterogeneity is low, forcing species to relocate over larger distances to track suitable climatic conditions (Mantyka-Pringle et al. 2015).

As a result of the above interactions, higher estimates of climate change correspond to higher projected rates of future extinction. The IPCC Fifth Assessment Report described alternative future climate scenarios using representative concentration pathways (RCPs), which were selected to represent the full range of emissions scenarios in the peer-reviewed literature (Jantz et al. 2015). RCP 8.5, which serves as the "business-as-usual scenario," i.e. a radiative forcing of 8.5 W/m^2, leading to a greenhouse gas concentration scenario of approximately 1370 ppm of CO_2 by the end of the century, is predicted to result in 3,300-20,000 plant species and

250-1,500 tetrapod species committed to extinction by 2100 (Jantz et al. 2015, van Vuuren et al. 2011).

In the state of New South Wales (NSW), Australia, the Saving Our Species (SoS) program currently underpins State Government conservation efforts. There are currently almost 1000 species listed on the schedules of the NSW *Biodiversity Conservation Act 2016*. As part of the SoS program, each species has been placed into one of six management streams to better target their management (OEH 2013). Of these, 439 threatened species are currently designated as "site-managed species" (OEH 2018). These species consist of populations which are located at discrete sites, that require immediate management to ensure the species' long-term survival in the wild beyond 2100 (OEH 2013, OEH 2016a). Site-managed species are those for which critical threats at sites have been identified and are able to be feasibly managed, and the mitigation of these threats is likely (with 95% probability) to secure viable populations for the next 100 years (OEH 2013, OEH 2016a). Due to insufficient funding to allow management of all populations of these species, a subset of populations was selected, representing the minimum number of managed sites that would ensure the above target be met for each species (OEH 2013, OEH 2016a). Each species within this stream has between 1-7 sites being managed.

Unfortunately, the selection of sites managed for each species neglected to consider whether climate across these locations will remain suitable for the species in the long term. Species within this management stream are generally restricted to fragmented bushland remnants, preventing shifts in range and making them highly susceptible to a changing climate. Fragmentation surrounding these identified sites interrupts ecological flows and prevents species from shifting their distribution as climate changes, as well as increasing exposure to other negative human impacts (Beaumont & Duursma 2012). Understanding of the potential impacts of climate change specifically for site-managed species is currently limited. However, habitat suitability models (HSMs) can be used to estimate these impacts.

HSMs are common tools used to assess the distribution of suitable habitat under current and future climates. HSMs determine the environmental conditions currently corresponding to species' distributions, and use models of future climate to predict where suitable conditions for each species may occur, based on species' responses to environmental gradients (Harris et al. 2014, Thuiller 2007, Elith et al. 2006). These tools have a strong history of use in conservation planning and for assessing potential impacts of climate change on biodiversity (Thomas et al. 2004, Guisan & Thuiller 2005). Projecting HSMs onto a range of future climate scenarios explicitly incorporates climate uncertainty by representing the plausible range of impacts

(Beaumont et al. 2018). This allows identification of areas that are more, or less, likely to provide suitable habitat for species into the future (Beaumont et al. 2018).

A recent project funded by NSW Office of Environment and Heritage (OEH) focussed on assessing changes to the distribution of suitable habitat for a subset of site-managed species (n = 238). Using the presence-only HSM, Maxent (Elith et al. 2011, Phillips et al. 2006), suitable habitat for each species was assessed under a number of plausible climate scenarios for each decade from 2010-2070. The goals of the present study are (a) to couple these projections to the locations of managed sites for the modelled species to assess the likelihood that each site will retain suitable habitat from now to 2070, and (b) to assess the relationship between other populations of the target species and the longevity of suitable habitat to assess whether there is the potential for other populations to become 'site managed'. This information will quantify the impact of projected climate change on the distribution of suitable climate for site-managed species, currently not accounted for in the Saving Our Species program. As such, it will directly inform decision-making for the conservation of NSW biodiversity in the face of uncertain climate change.

2. METHODS

2.1 Study area

The area of this study is the state of New South Wales (NSW) in south-eastern Australia, which covers an area of ~809,440 km^2. NSW can broadly be described as being in the temperate zone, however, the climate is highly variable depending on proximity to the coast and to mountains (OEH 2016b, EPA 1997). Annual precipitation varies widely throughout the state, with the north-western arid region receiving, on average, ~200 mm of precipitation per year, while the eastern coastal fringe receives up to ~1,500 mm per year (OEH 2016b, EPA 1997). Mean summer maximum temperatures range from ~15 °C in the alpine region to ~35 °C in the north-west, while mean winter minimum temperatures range from ~-5 °C in high altitude areas, to ~7–10 °C along the east coast (<www.bom.gov.au>). Site-managed species are primarily found along the eastern coastal fringe of NSW, with suitable habitat predominately located in the Sydney Basin and North Coast (Beaumont et al. 2018).

2.2 Site-managed species

This study utilised output of habitat suitability models (HSMs) calibrated for 238 species (34 vertebrates and 204 plants) (Beaumont et al 2018), out of 440 species within the site-managed stream of the Saving our Species program (https://drive.google.com/open?id=1v9w1i-rwjVLIGUwWyyfLM3ERII7RFrBf). These consisted of 13 Critically Endangered, 125 Endangered and 100 Vulnerable species, classified under the *Biodiversity Conservation Act 2016* (NSW). Site-managed species are threatened species that are located at discrete sites that require management to ensure their long-term survival in the wild. These species occur within NSW and, in many cases, throughout Australia, however, all species within this management stream have at least 10% of their populations within NSW (OEH 2013). Although 439 species are currently included in this stream, many were excluded from Beaumont et al. (2018) due to insufficient occurrence records to calibrate HSMs. Below I briefly outline the approach undertaken by Beaumont et al. (2018) to calibrate HSMs for site-managed species, and then detail my methodology for assessing the vulnerability of species' sites to climate change.

2.3 Habitat suitability models

Point occurrences (latitude and longitude) describing the distribution of each species were downloaded from (a) OEH Atlas; (b) the Victorian Biodiversity Atlas; and (c) the Australasian

Virtual Herbarium (AVH) hub of the Atlas of Living Australia (ALA). Records that were spatial outliers or had poor spatial accuracy were then removed (see additional details in Beaumont et al, 2018). The remaining records were further reduced to a single point per species at a spatial resolution of 1 × 1 km. This resulted in an average of 194 point locations per species (ranging from 20 to 8,462).

Current and future climate data were generated by the NSW and ACT Regional Climate Modelling (NARCliM) project (Evans et al. 2014). Future climate data spanned 12 scenarios (four global climate models (GCMs) downscaled using three Regional Climate Model (RCM) configurations), encompassing a range of equally plausible future climate scenarios for south-eastern Australia (Evans et al. 2014). Although the GCMs were based upon the SRES A2 emissions scenario (Nakicenovic et al. 2000), which was the only scenario available for this region, this is a high emission which approximates RCP 8.5 in terms of projected radiative forcing and global mean annual temperature (IPCC 2013). The GCMs used are outlined in Table 2.1.

Climate data were statistically downscaled to 0.01 degrees (~1 km). These were then summarised to 19 bioclimatic (BIOCLIM) variables using ANUCLIM version 6.1.1 (Xu & Hutchinson 2011). These variables were generated for all three NARCliM time periods: baseline climate (1990–2009), near-future (2020–2039) and far future (2060–2079), representative of the long-term average climate around their midpoints, i.e. 2000, 2030, and 2070. In addition, scenarios for intervening decades (2010, 2020, 2040, 2050, 2060) were linearly interpolated from the NARCliM data. Beaumont et al. (2018) then used seven of the variables in Maxent models: (1) mean diurnal temperature range; (2) temperature seasonality (the coefficient of variation of weekly mean temperature); (3) maximum temperature of the warmest week; (4) minimum temperature of the coldest week; (5) precipitation of the wettest week; (6) precipitation of the driest week; and (7) precipitation seasonality (the coefficient of variation of weekly total precipitation). These represent a common set of climatic variables that influence ecophysiological functions, and hence, species distributions (Table 2.2). Finally, climate data were transformed to the Australian Albers Equal-Area Conic projection (EPSG:3577) at 1 × 1 km resolution.

In addition to the climate variables, three static environmental datasets were obtained (outlined in Table 2.3), and aggregated to 1 × 1 km. These layers were assumed to remain static for the projections of future habitat suitability.

Beaumont et al. (2018) used Maxent version 3.3.3k (Elith et al. 2011, Phillips et al. 2006) to model habitat suitability. This is a machine learning approach that is rated among the highest performing techniques in a comparative study of presence-only modelling approaches (Elith et al. 2006). Maxent produces a continuous probability surface, with higher values indicating a greater habitat suitability for the modelled species (Phillips & Dudik 2008, Phillips et al. 2006). The models were fit primarily using default settings, although threshold and hinge features were disabled. This assists with minimising locally-overfit response curves. Background samples were selected from up to 100,000 cells randomly selected from all cells that met two criteria: (a) contained occurrence records for native fauna or flora (for animal and plant target species, respectively) and (b) fell within 200 km of records for the target species (Elith & Leathwick 2009, Phillips & Dudik 2008). This targeted background approach reduces the impact of sampling bias associated with ad hoc collection of species occurrence records.

For each species, habitat suitability was estimated for the baseline period (2000), and the 12 alternative future climates for each decade from 2010 to 2070. Continuous suitability predictions (where values range from 0 (unsuitable) to 1 (most suitable)) were then converted to binary layers using the threshold that maximised the sum of sensitivity and specificity, an approach that reflects the prevalence of the modelled species well (Liu et al. 2016, Liu et al. 2013, Jiménez-Valverde & Lobo 2007). All modelling and calculation of statistics were performed in R version 3.1.2 (R Development Core Team 2014).

2.4 Model results

Results of HSMs and projected changes to suitable habitat are outlined in Beaumont et al. (2018). The average test AUC (area under the receiver operating characteristic curve) score across the 238 site-managed species was 0.952 (SD = 0.044), with scores ranging from 0.778 (SD = 0.005) (*Hibbertia* sp. Bankstown) to 0.999 (SD < 0.001) (*Eucalyptus canobolensis*). These results indicate high classifier performance, with areas predicted by Maxent to be the most bioclimatically suitable also generally being highly correlated with the occurrence location points that were omitted from training each model (Swets 1988).

2.5 Vulnerability of species to climate change

I obtained the model output described above, and undertook the following steps to determine vulnerability to climate change for (a) individual sites managed for each species, and (b) other populations of site-managed species, found beyond managed-sites.

For each species I used custom R code to stack the 12 binary habitat suitability surfaces (based on the four GCMs downscaled using three RCMs) for each decade from 2010-2070, to quantify the number of scenarios for which a grid cell was projected to retain suitable habitat (i.e. cell values ranged from 0 to 12). Cells with values of 12 represent areas projected to remain suitable irrespective of future climate. The resulting grid is henceforth referred to as the 'consensus grid'. The decision-making process used to determine the level of climate change threat for each species is outlined in Sections 2.7.1 and 2.72 below, and in Figure 2.1. In addition, I stacked the three grids corresponding to each GCM, to enable comparisons to be made across the four GCM scenarios. In doing so, a cell was classified as "suitable" if it was suitable under all RCM scenarios, having "limited suitability" if it was suitable under one or two RCM scenarios, or "unsuitable" if it was not suitable under any of the RCM scenarios.

Suitability is presented for 2030 and 2070, both coupled and uncoupled from suitability in previous decades. Coupled suitability is considered because, in a given time period, suitability may decline resulting in the species undergoing local extinction. In a following time period, suitability may return to an extent that a lost population could be re-established, provided extant populations of the species were retained within dispersal distance in the interim.

All analyses of models presented in this study were performed in R version 3.1.2 (R Development Core Team 2014). The raster (Hijmans 2015), sp (Pebesma & Bivand 2005), gdalUtils (Greenberg & Mattiuzzi 2015), rgeos (Bivand & Rundel 2016), rnaturalearth (South 20170, rgdal (Bivand 2018), tidyr (Wickham 2018), dplyr (Wickham 2018), lattice (Sarkar 2017) and rasterVis (Perpinan Lamigueiro & Hijmans 2018) packages were used for manipulation and extraction of spatial data.

2.5.1 Managed sites

A shapefile of all managed sites was obtained from NSW OEH (OEH 2018), and reprojected to the Australian Albers Equal-Area Conic projection (EPSG:3577). Of the 238 species, seven species lacked sites within the study area and were excluded from the following analysis. For the remaining 231 species, each species' consensus grid and suitability projections for the four GCM scenarios were overlaid with the species' respective managed sites. This enabled suitability for each site to be quantified where grid cells were weighted by their area contribution to the site. From here I identified sites which fell into the following classes:

a) Suitable: ≥ 90% of the site's area was projected to have suitable habitat under all 12 scenarios for a given decade. This represents a very cautious approach to the identification of suitable habitat, based on complete consensus across the plausible climate scenarios;

b) Limited suitability: ≥ 90% of the site's area was projected to have suitable habitat under 1-12 scenarios for a given decade, however <90% of the area was suitable under all 12 scenarios. This allows sites that may be unsuitable under some future scenarios to be flagged as areas that may require reassessment as the magnitude and direction of climate change becomes more apparent;

c) Unsuitable: >10% of the site's area was not projected to be suitable under any of the 12 scenarios for a given decade. These sites are likely to be the most vulnerable to climate change.

Next, each species was placed into one of four categories, depending upon the proportion of its managed sites that fell into the above classes:

i) All sites suitable: All managed sites fall into Class (a) low vulnerability to climate change;

ii) Some sites suitable: Some managed sites fall into Class (a), and have low vulnerability to climate change;

iii) Limited suitability: All managed sites fall into Class (b) and have some vulnerability to climate change, or managed sites fall into both Class (b) i.e. some vulnerability to climate change and Class (c) i.e. high vulnerability to climate change;

iv) No suitability: All managed sites fall into class (c), and therefore are highly vulnerable to climate change.

2.5.2 Occurrence records

The second aim of this study was to identify populations that are located outside of managed sites that are projected to have low vulnerability to climate change. To this end, the set of occurrence records originally used to calibrate species' models was obtained from Beaumont et al (2018). These records had been subjected to an intensive data cleaning process to exclude records with poor spatial accuracy or that may represent taxonomic errors. From this dataset, records representing populations on mainland NSW that were outside of managed sites were extracted for analysis. Of the 238 species, five species lacked records beyond their managed sites and were excluded from the following analysis.

For the remaining 233 species, a 1 km buffer was placed around each occurrence record. Each species' consensus grid and suitability projections for the four GCM scenarios were then overlaid with their respective buffered occurrence records. From here, I identified occurrence records that fell into the following classes:

a) Low vulnerability to climate change: At least one grid cell overlapping the occurrence buffer was projected to be suitable under all 12 scenarios for a given decade.

b) Some vulnerability to climate change: At least one grid cell overlapping the occurrence buffer was projected to be suitable under 1-11 scenarios, and no grid cells overlapping the occurrence buffer were projected to be suitable under 12 scenarios, for a given decade.

c) High vulnerability to climate change: No grid cells overlapping the occurrence buffer were projected to be suitable under any of the 12 scenarios for a given decade.

Again, each species was then placed into one of four classes, depending on the proportion of occurrence records that fell into the above classes, i.e. (i) all occurrences retain suitable conditions; (ii) some occurrences remain suitable; (iii) limited suitability; (iv) no suitability.

2.5.3 Statistical analyses

For both occurrence buffers and sites, I tested whether there was a significant difference in the median suitable area for species of different conservation statuses (Vulnerable, Endangered and Critically Endangered) and for plants versus animals, under baseline conditions and for 2030 and 2070. As data were non-parametric, a Kruskal-Wallis one-way analysis of variance was undertaken for each of the above in Minitab 18.1 (Minitab Inc. 2017).

2.5.4 Code availability

Code used to extract suitability for managed sites is available at:
https://drive.google.com/open?id=1Uie78W0apoBiTgZPO7xJkP0x4H0iexk7

Code used to extract suitability for occurrences records is available at:
https://drive.google.com/open?id=1Xc1R63RKXrug0XrUMUO8p9LrrGuAOUJH

Code used to produce maps overlaying managed sites and occurrence records on habitat suitability raster stacks for each species are available at:
https://drive.google.com/open?id=1HCpWsNF3eZPftwpEQpwo3y0bCyikSEWs

Table 2.1 Climate futures used in this study. GCMs assumed the SRES A2 emissions scenario (Nakicenovic et al. 2000).

Climate Future	GCM	Represents a future that is:
Warmer/Wetter	MIROC3.2(medres)	Warmer and wetter than present, particularly in NE NSW, although alpine regions are projected to become drier.
Hotter/Little Change in Precipitation	ECHAM5/MPI-OM	Has the greatest increase in temperature of the four scenarios. Precipitation trend varies across the state (slightly wetter in the NE and coastal regions, slightly drier elsewhere).
Hotter/Wetter	CCCMA CGCM3.1(T47)	Warmer than MIROC, and wetter across most of the state, although areas in NW and SE of the state may be slightly drier.
Warmer/Drier	CSIRO-Mk3.0	Warmer than present, and the driest of the four models.

Table 2.2 Set of bioclimatic predictors derived from BIOCLIM used for modelling.

Variable	**Definition**
Mean Diurnal Temperature Range (MDR)	Mean of weekly (Tmax – Tmin) (°C)
Temperature Seasonality (TS)	Standard Deviation of weekly Tmean × 100 (°C)
Maximum Temperature of Warmest Week (TmaxWW)	Highest Tmax across weeks (°C)
Minimum Temperature of Coldest Week (TminCW)	Lowest Tmin across weeks (°C)
Precipitation of Wettest Week (PrWW)	Highest weekly rainfall (mm)
Precipitation of Driest Week (PrDW)	Lowest weekly rainfall (mm)
Precipitation Seasonality (PS)	Coefficient of variation of weekly rainfall (mm)

Table 2.3 Set of static environmental predictors used for modelling.

Variable	**Definition**
Soil data	First three principal components (soil1, soil2 and soil3) from a principal components analysis performed on spectral characteristics of soil samples from across Australia (Viscarra Rossel & Chen 2011).
Weathering Intensity Index (WII)	Key characteristic of soil/regolith (Wilford 2012).
Topographic characteristics	Topographic Position Index (TPI; Gallant & Austin 2012a) classifies cells into classes corresponding to upper, mid and lower slopes; Topographic Wetness Index (TWI; Gallant & Austin 2012b) estimates the relative wetness within a catchment.

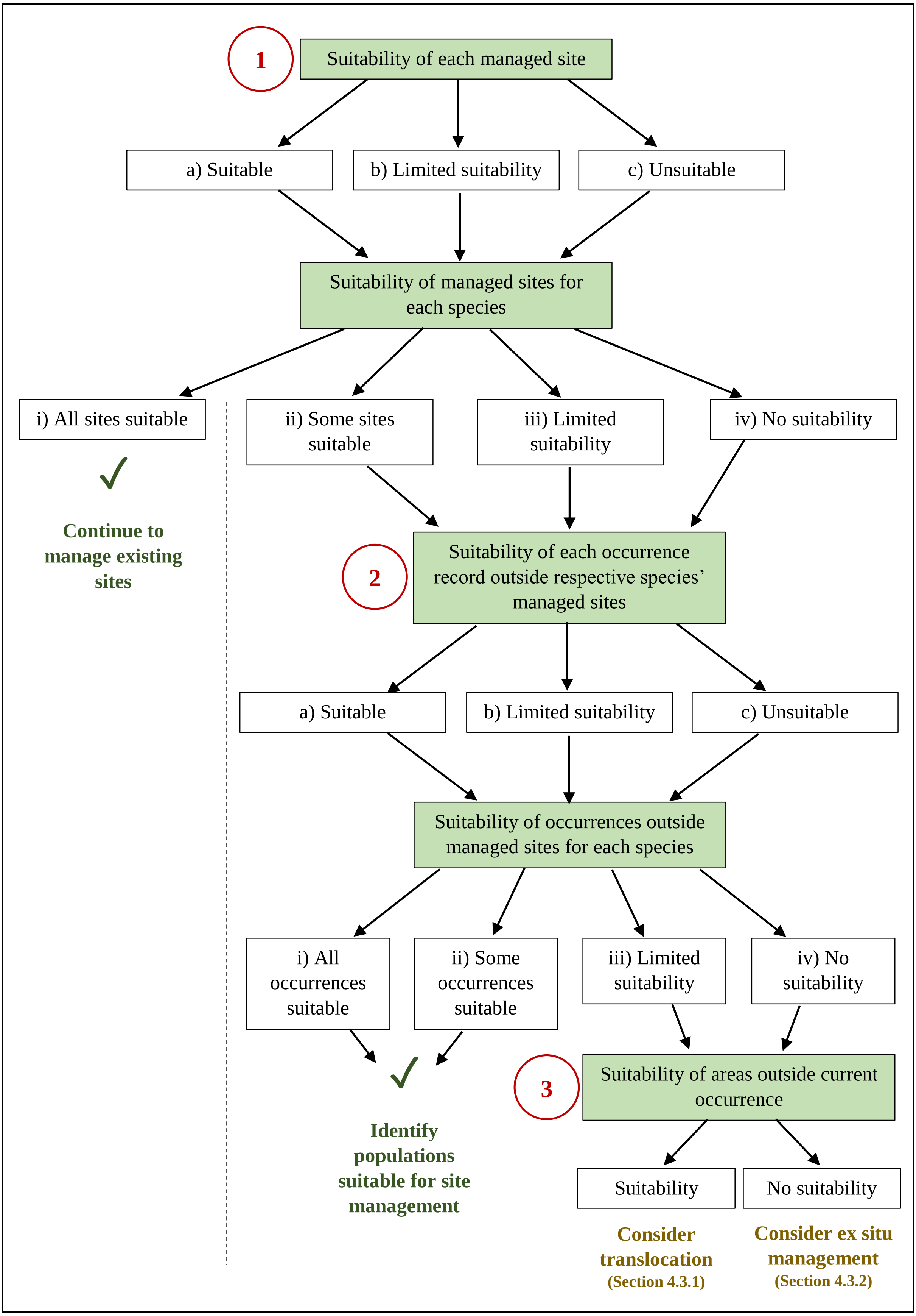

Figure 2.1 A framework for identifying site-managed species with greatest vulnerability to climate change and determining appropriate management actions.

3. RESULTS

For the baseline period (2000) and under all climate scenarios for 2030 and 2070, I assessed (a) the proportion of each managed site that was projected to be climatically suitable, and (b) whether the buffer regions surrounding occurrence records that lie beyond managed sites overlapped with climatically suitable habitat. Species for which all managed sites are projected to retain suitable conditions irrespective of the future climate scenario are likely to be less vulnerable to climate change – at least across their respective sites. Species for which suitable conditions are projected within 1 km buffers surrounding occurrence records are likely to have potential alternative management sites.

3.1 Managed site suitability

3.1.1 General site suitability

Across all managed sites, 84.0% (± 31.5 (mean ± SD)) of the area of each site was projected to be above the species' suitability threshold under baseline climate conditions (Table S1). When suitability is uncoupled from previous decades, the average area suitable under all scenarios is projected to decrease to 24.7 ± 38.8% by 2030, and 22.3 ± 38.0% by 2070.

Site suitability is projected to decline more rapidly for plant species than animal species. For plants, the median site area projected to be suitable under all scenarios declines from 100.0% (Interquartile Range (IQR): 94.1–100.0%) under baseline conditions, to 0.0% (IQR: 0.0–43.7%) by 2030, and 0.0% (IQR: 0.0–14.0%) by 2070. Among animals, median suitable site area is projected to decline from 94.1% (IQR: 59.9–99.9%) under baseline conditions, to 8.8% by 2030 (IQR: 0.0–65.2%), and 5.1% (IQR: 0.0–77.0%) by 2070. These differences between plants and animals are significant (2000: $H = 54.68$, $p < 0.001$; 2030: $H = 25.24$, $p < 0.001$; 2070: $H = 31.98$, $p < 0.001$).

For the baseline period, site suitability was significantly lower for Critically Endangered species than Endangered and Vulnerable species, with a median suitable site area of 86.8% (IQR: 32.8–99.8%) for Critically Endangered species, in comparison to 100.0% for Endangered (IQR: 91.4–100.0%) and Vulnerable (IQR: 92.6–100.0%) species ($H_2 = 29.48$, $p < 0.001$) (Table S3). However, by 2030 and 2070, there was no longer a significant difference in site suitability based on conservation status ($p = 0.690$; $p = 0.278$).

3.1.2 Site suitability for particular species

My analysis of the models developed by Beaumont et al. (2018) suggests that, by 2030, only six (i.e. 4.8%) of the 125 Endangered species with sites included in this study are projected to retain suitable conditions across all their respective sites under all considered climate scenarios, when suitability is coupled to previous decades (*Angophora exul, Caladenia concolor, Diuris pedunculata, Eucalyptus largeana, Eucalyptus magnificata* and *Hibbertia superans*) (Table 3.7, Figure 3.4). When site suitability is uncoupled from previous decades (i.e. sites are considered suitable regardless of suitability in previous decades), an additional Endangered species (*Caladenia arenaria*) is projected to retain suitable conditions across all of its sites. All sites for five (i.e. 5.4%) of the 93 Vulnerable species (*Acacia bakeri, Acacia phasmoides, Bertya opponens, Prostanthera densa* and *Pseudomys pilligaensis*) are also projected to remain suitable under all scenarios.

By 2070, only three (i.e. 2.4%) Endangered species (*Caladenia concolor*, *Eucalyptus largeana* and *Hibbertia superans*), and two (i.e. 2.2%) Vulnerable species (*Bertya opponens* and *Prostanthera densa*), retain suitable conditions across all of their sites under all climate scenarios (Table 3.7, Figure 3.4). Again, when suitability is uncoupled from previous decades, an additional six Endangered species (*Acacia gordonii, Caladenia arenaria, Genoplesium baueri, Lindsaea incisa, Prostanthera junonis* and *Sophora tomentosa*), and one vulnerable species (*Crinia sloanei*), retain suitability across all sites. None of the 13 Critically Endangered species are projected to have all sites suitable in 2030 or 2070.

In contrast, two (i.e. 15.4%) Critically Endangered (*Myriophyllum implicatum* and *Pterostylis despectans*), six (i.e. 4.8%) Endangered (*Burramys parvus*, *Caladenia tessellata, Cullen parvum*, *Eucalyptus microcodon*, *Persoonia hindii* and *Pomaderris cocoparrana*), and three (i.e. 3.2%) Vulnerable (*Eucalyptus alligatrix* subsp. *alligatrix*, *Eucalyptus cannonii* and *Eucalyptus oresbia*) species are highly vulnerable to climate change, with no currently managed sites projected to have suitable habitat under any climate scenarios by 2030, when suitability is uncoupled from previous decades (Table 3.7, Figure 3.4). When suitability is coupled to previous decades, an additional eight Endangered (*Boronia repanda, Caesalpinia bonduc, Callitris baileyi, Eucalyptus camphora* subsp. *relicta, Isoodon obesulus obesulus, Lepidium peregrinum, Pultenaea pedunculata* and *Senecio spathulatus*), and four Vulnerable (*Darwinia glaucophylla, Olearia cordata, Pterostylis cobarensis* and *Swainsona plagiotropis*) species are projected to have no managed sites remain suitable under any of the climate scenarios by 2030. By 2070, this increases to two (i.e. 15.4%) Critically Endangered (*Myriophyllum implicatum* and *Pterostylis despectans*), 26 (i.e. 20.8%) Endangered (*Acacia* *acanthoclada, Acacia meiantha, Acacia terminalis* subsp. *terminalis, Allocasuarina defungens, Boronia repanda, Burramys parvus, Caladenia tessellata, Ctenophorus mirrityana, Cullen parvum, Dampiera fusca, Diuris aequalis, Epacris hamiltonii, Eucalyptus microcodon, Euphrasia scabra, Grevillea obtusiflora, Grevillea renwickiana, Hakea dohertyi, Hibbertia puberula, Olearia flocktoniae, Persoonia bargoensis, Persoonia hindii, Pilularia novae-hollandiae, Plectranthus alloplectus, Polytelis anthopeplus monarchoides, Pomaderris cocoparrana* and *Prasophyllum affine*), and 18 (i.e. 19.4%) Vulnerable (*Eucalyptus aggregata, Eucalyptus benthamii, Eucalyptus cannonii, Eucalyptus canobolensis, Eucalyptus oresbia, Eucalyptus rubida* subsp. *barbigerorum, Grevillea rhizomatosa, Hakea archaeoides, Leionema ralstonii, Leucopogon exolasius, Macadamia tetraphylla, Prostanthera stricta, Phyllota humifusa, Swainsona plagiotropis, Symplocos baeuerlenii, Tasmannia glaucifolia, Veronica blakelyi* and *Zieria tubercultata*) species projected to lose suitability across all currently managed sites by 2070, under all climate scenarios, when suitability is uncoupled from previous decades (Table 3.7). When suitability is coupled to previous decades, an additional nine Endangered (*Caesalpinia bonduc, Callitris baileyi, Carex raleighii, Eucalyptus camphora* subsp. *relicta, Homopholis belsonii, Isoodon obesulus obesulus, Lepidium peregrinum, Pultenaea pedunculata* and *Senecio spathulatus*) and four Vulnerable (*Darwinia glaucophylla, Eucalyptus alligatrix* subsp. *alligatrix, Olearia cordata* and *Pterostylis cobarensis*) species are projected to have no managed sites retain suitable conditions under any climate scenario by 2070 (Table 3.7).

Maps overlaying managed sites on habitat suitability for each species are available at: https://drive.google.com/open?id=1wn3cu7aD2FRCaz2rME2jw_CLpa3EvRFl. Habitat suitability rasters are stacked to indicate the number of climate scenarios each 1km grid cells is projected to be suitable under for each decade. Areas of suitable habitat are provided in the legend of each site map.

3.2 Occurrence record suitability

3.2.1 General occurrence suitability

Across all locations with occurrence records, outside of currently managed sites, on average 84.6± 33.3% (mean ± SD) of the area of each 1km occurrence record buffer was projected to be above the species' suitability threshold under baseline climate conditions (Table S4). By 2030, the average area of each occurrence record buffer suitable under all plausible scenarios is projected to decrease to 33.1 ± 44.3% by 2030, and 31.6 ± 44.5% by 2070.

Occurrence record suitability is projected to decline more rapidly for plant species than animal species. For plants, the median buffer area projected to be suitable under all scenarios declines from 100.0% (IQR: 100.0–100.0%) under baseline conditions, to 0.0% (IQR: 0.0–35.0%) by 2030, and 0.0% (IQR: 0.0–0.0%) by 2070. Among animals, median suitable site area is projected to decline from 100.0% (IQR: 99.5–100.0%) under baseline conditions, to 39.8% by 2030 (IQR: 0.0–100.0%), and 68.79% (IQR: 0.0–100.0%) by 2070. These differences between plants and animals are significant (2000: $H = 5.84$, $p = 0.016$; 2030: $H = 1009.67$, $p < 0.001$; 2070: $H = 1738.49$, $p < 0.001$).

For the baseline period, suitability around occurrence locations was lower for Critically Endangered species in comparison to Endangered and Vulnerable species, with a median suitable site area of 86.8% (IQR: 61.6–100.0%) for Critically Endangered species, in comparison to 100.0% (IQR: 97.4–100.0%) for Endangered species, and 100.0% (IQR: 100.0–100.0%) for Vulnerable species ($H_2 = 126.57$, $p < 0.001$) (Table S6). However, by 2030 and 2070 suitability around occurrences was lower for Endangered species and Vulnerable species in comparison to Critically Endangered species, with a median suitable site area of 0.0% (IQR: 0.0–100.0%) by 2030 and 0.0% (IQR: 0.0–100.0%) by 2070 for Critically Endangered species, in comparison to 0.0% (IQR: 0.0–90.0%) by 2030 and 0.0% (IQR: 0.0–97.7%) by 2070 for Endangered species, and 0.0% (IQR: 0.0–100.0%) by 2030 and 0.0% (IQR: 0.0–94.0%) by 2070 for Vulnerable species (2030: $H_2 = 30.05$, $p < 0.001$; 2070: $H_2 = 66.99$, $p < 0.001$).

3.2.2 Occurrence suitability for particular species

Of the 23 species projected to have highest vulnerability to climate change by 2030 (i.e. none of their managed sites are projected to retain suitable climate under any climate scenarios when suitability is coupled to previous decades), two (i.e. 8.7%) (*Darwinia glaucophylla* and *Lepidium peregrinum*) are likely to have suitable conditions across all other regions where there are occurrence records, based on suitability of 1km buffers around each occurrence record (Table 3.8). Seven (i.e. 30.4%) (*Eucalyptus camphora* subsp. *relicta, Eucalyptus cannonii, Eucalyptus microcodon, Isoodon obesulus obesulus, Olearia cordata, Pterostylis cobarensis* and *Pultenaea pedunculata*) are projected to retain suitability in some regions with occurrences (Table 3.8). Hence, there are potentially other populations less vulnerable to climate change that could be managed.

For 2070, nine (i.e. 15.3%) (*Carex raleighii, Darwinia glaucophylla, Eucalyptus aggregata, Eucalyptus camphora* subsp. *relicta, Eucalyptus cannonii, Isoodon obesulus*

obesulus, Olearia cordata, Pterostylis cobarensis and *Pultenaea pedunculata*) of the 59 species projected to no longer have suitable climate within their managed sites under any climate scenarios are likely to have some other populations for which conditions remain suitable (Table 3.8). None, however, are likely to have suitable conditions across all other regions where there are occurrence records.

In contrast, of the species projected to have no managed sites retaining suitable climate under any of the scenarios by 2030, all other populations for eight species (i.e. 34.8%) (*Burramys parvus, Caesalpinia bonduc, Callitris baileyi, Cullen parvum, Eucalyptus alligatrix* subsp. *alligatrix, Persoonia hindii, Pomaderris cocoparrana* and *Swainsona plagiotropis*) are also projected to no longer have suitable climate under any climate scenarios. This is projected to increase to 23 species (i.e. 39.0%) (*Allocasuarina defungens, Burramys parvus, Caesalpinia bonduc, Caladenia tessellata, Callitris baileyi, Diuris aequalis, Eucalyptus alligatrix* subsp. *alligatrix, Eucalyptus benthamii, Eucalyptus cannonii, Euphrasia scabra, Grevillea obtusiflora, Grevillea renwickiana, Grevillea rhizomatosa, Hakea dohertyi, Olearia flocktoniae, Persoonia bargoensis, Persoonia hindii, Phyllota humifusa, Plectranthus alloplectus, Pomaderris cocoparrana, Prostanthera stricta, Swainsona plagiotropis* and *Veronica blakelyi*) by 2070.

Maps overlaying occurrences on habitat suitability for each species are available at: https://drive.google.com/open?id=1L3DQybT0yuyL9GsxkAoJtDmr_KW1uY0E. Habitat suitability rasters are stacked to indicate the number of climate scenarios each 1km grid cells is projected to be suitable under for each decade. Proportions of occurrence records within suitable habitat are provided in the legend of each species' map.

3.3 Climate scenarios

When the climate scenarios are considered individually, coupled to climatic suitability in previous decades, more managed sites are projected to remain suitable under the warmer/wetter scenario (2030: 323 of 759 sites; 2070: 208 sites) (Figure 3.5). Fewer managed sites are projected to be suitable under the warmer/drier scenario (2030: 302 sites; 2070: 193 sites) and the hotter/little precipitation change scenarios (2030: 244 sites; 2070: 189 sites), and the lowest number of sites are projected to be suitable under the hotter/wetter scenario (2030: 214 sites; 2070: 138 sites).

3.4 Biomes

I also assessed the vulnerability of regions in mainland NSW to climate change. The vast majority of both managed sites (693 of 759 sites) and occurrence records (11,448 of 12,205 occurrence records) lie within the Temperate Broadleaf & Mixed Forests (TBMF) biome. Within this biome, 16.7% of sites (116 of 693 sites) and 40.8% of occurrence locations (4,669 of 11,448 occurrence records) are projected to remain suitable under all climate scenarios by 2030, when suitability is coupled to previous decades (Figure 3.6). By 2070, only 10.8% of sites (75 sites) and 31.3% of occurrence locations (3,581 occurrence locations) within this biome are projected to remain suitable under all climate scenarios.

Other biomes with a proportion of managed sites projected to remain suitable under all climate scenarios are Temperate Grasslands, Savannas & Shrublands (TGSS) (2030: 9.1% of sites; 2070: 9.1% of sites), Tropical/Subtropical Grasslands, Savannas & Shrublands (TrGSS) (2030: 16.7% of sites; 2070: 8.3% of sites), and Montane Grasslands & Shrublands (MGS) (2030: 9.1% of sites). By 2030, no sites within the Deserts & Xeric Shrublands (DXS) or Mediterranean Forests, Woodlands & Shrublands (MFWS) are suitable, and additionally, by 2070, no sites within the Montane Grasslands & Shrublands (MGS) biome are suitable under all climate scenarios.

Biomes with the greatest proportion of occurrence records projected to remain suitable under all climate scenarios are TrGSS (2030: 43.7% of occurrence records; 2070: 40.2% of occurrence records), TGSS (2030: 25.7% of occurrence records; 2070: 18.7% of occurrence records), and MGS (2030: 49.3% of occurrence records; 2070: 2.8% of occurrence records) (Figure 3.12). By 2070, no occurrence records within MFWS are suitable under all climate scenarios.

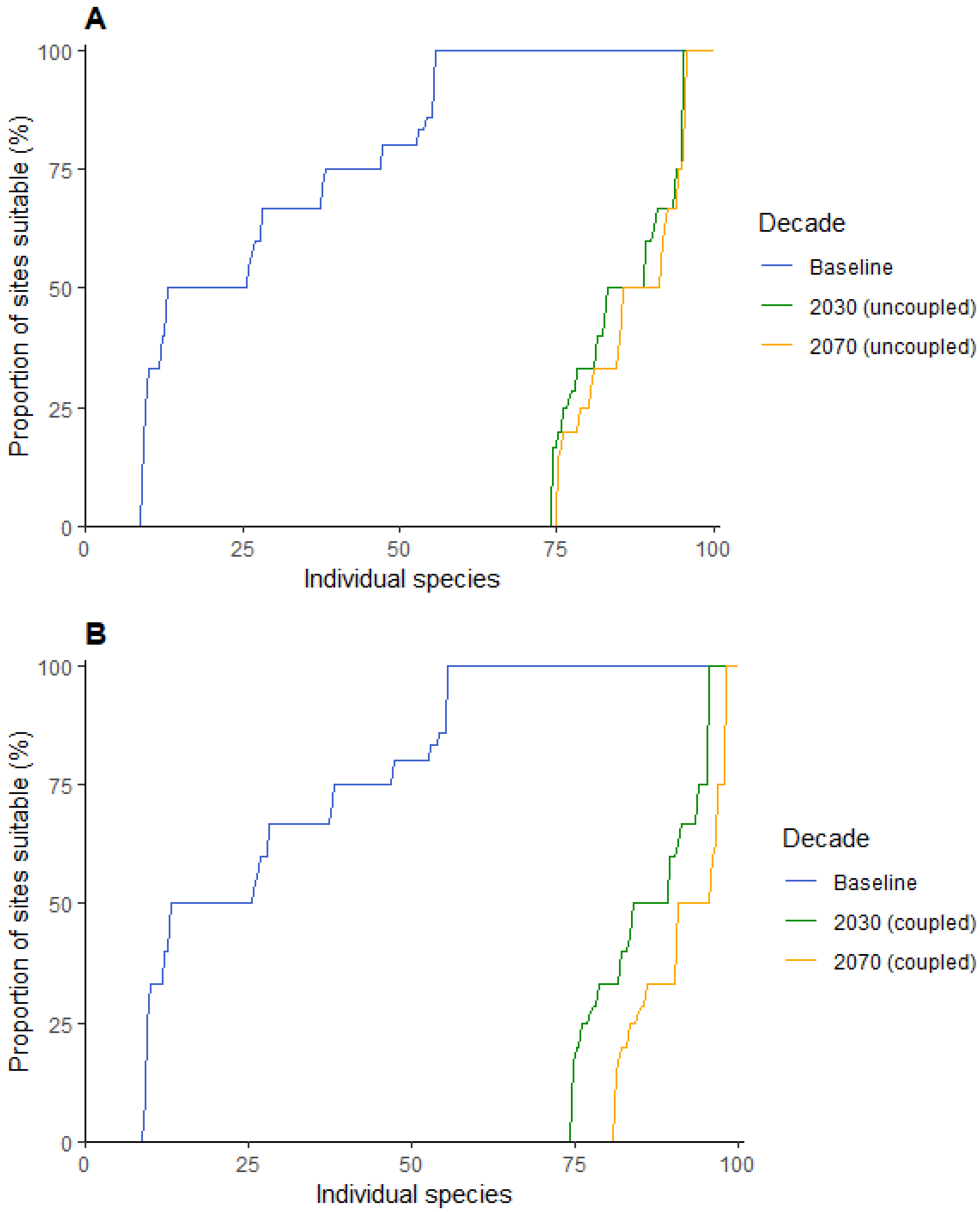

Figure 3.1 Proportion of managed sites for threatened species projected to be suitable (i.e. ≥ 90% of area suitable under baseline modelled conditions or under all 12 future climate scenarios) under baseline conditions, and in 2030 and 2070 (n = 231). X axis represents the 0th to 100th percentile of species arranged in order of increasing proportion of sites suitable, normalised by the number of species modelled.

(A) Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions.

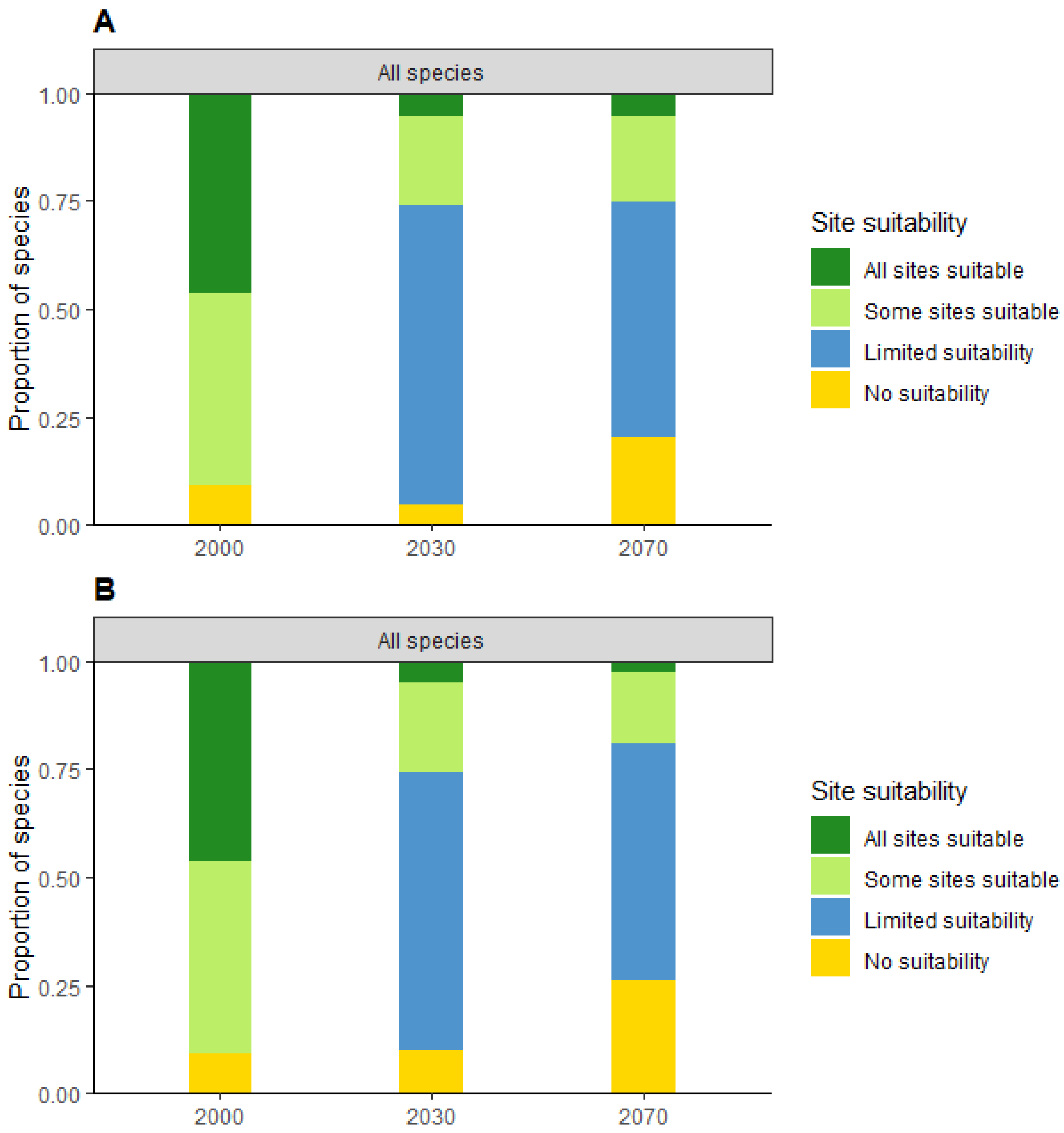

Figure 3.2 The proportion of modelled site managed species that are projected to have (i) all their respective managed sites retain climatically suitable habitat in all climate scenarios; (ii) some of their respective managed sites retain climatically suitable habitat in all climate scenarios; (iii) climatically suitable habitat for all or some sites under some climate scenarios; or (iv) no suitability for all sites under any scenario, under baseline conditions, and for 2030 and 2070.
(A) Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions.

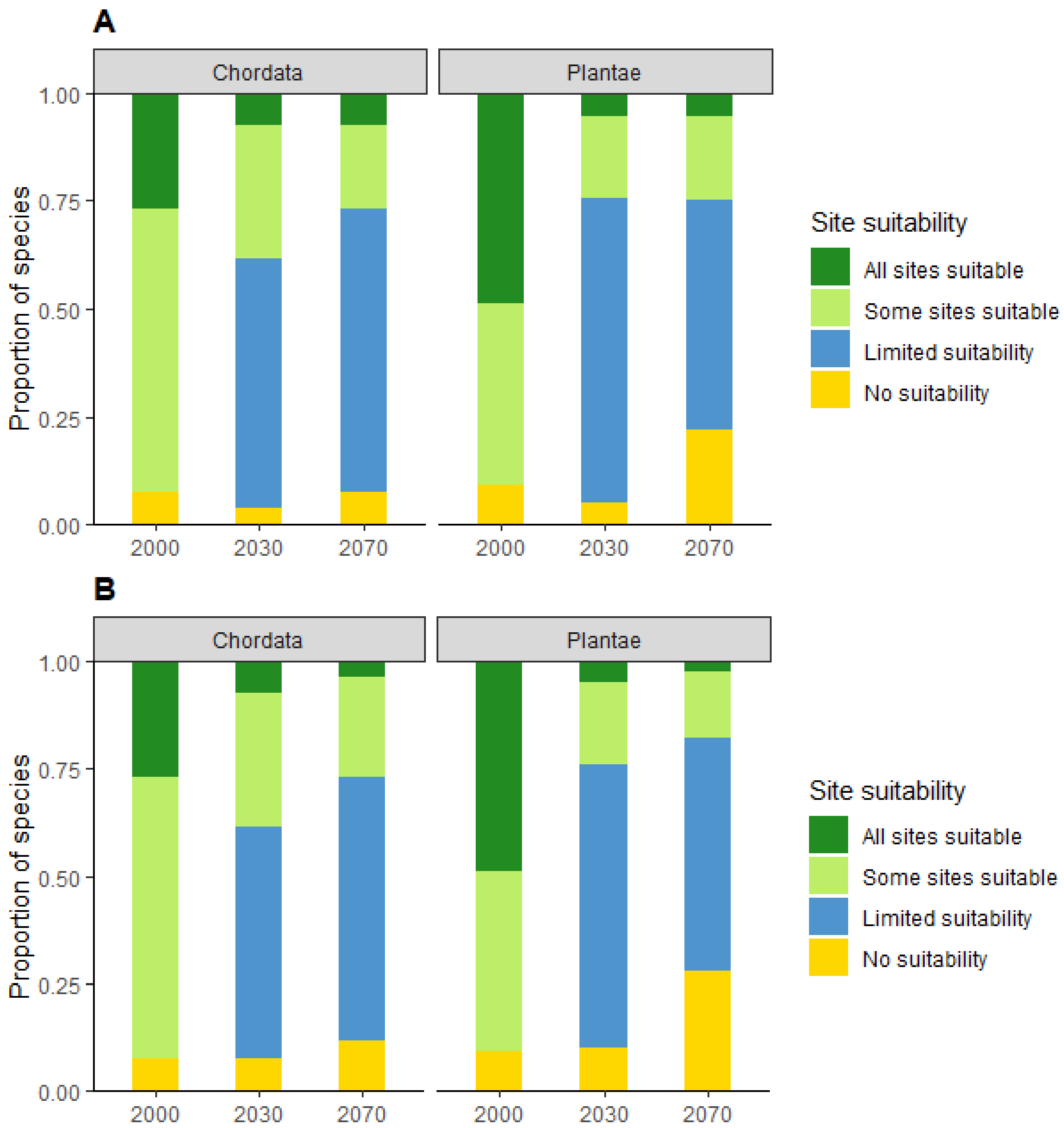

Figure 3.3 The proportion of modelled chordate and plant species that are projected to have (i) all their respective managed sites retain climatically suitable habitat in all climate scenarios; (ii) some of their respective managed sites retain climatically suitable habitat in all climate scenarios; (iii) climatically suitable habitat for all or some sites under some climate scenarios; or (iv) no suitability for all sites under any scenario, under baseline conditions, and for 2030 and 2070.

(A) Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions.

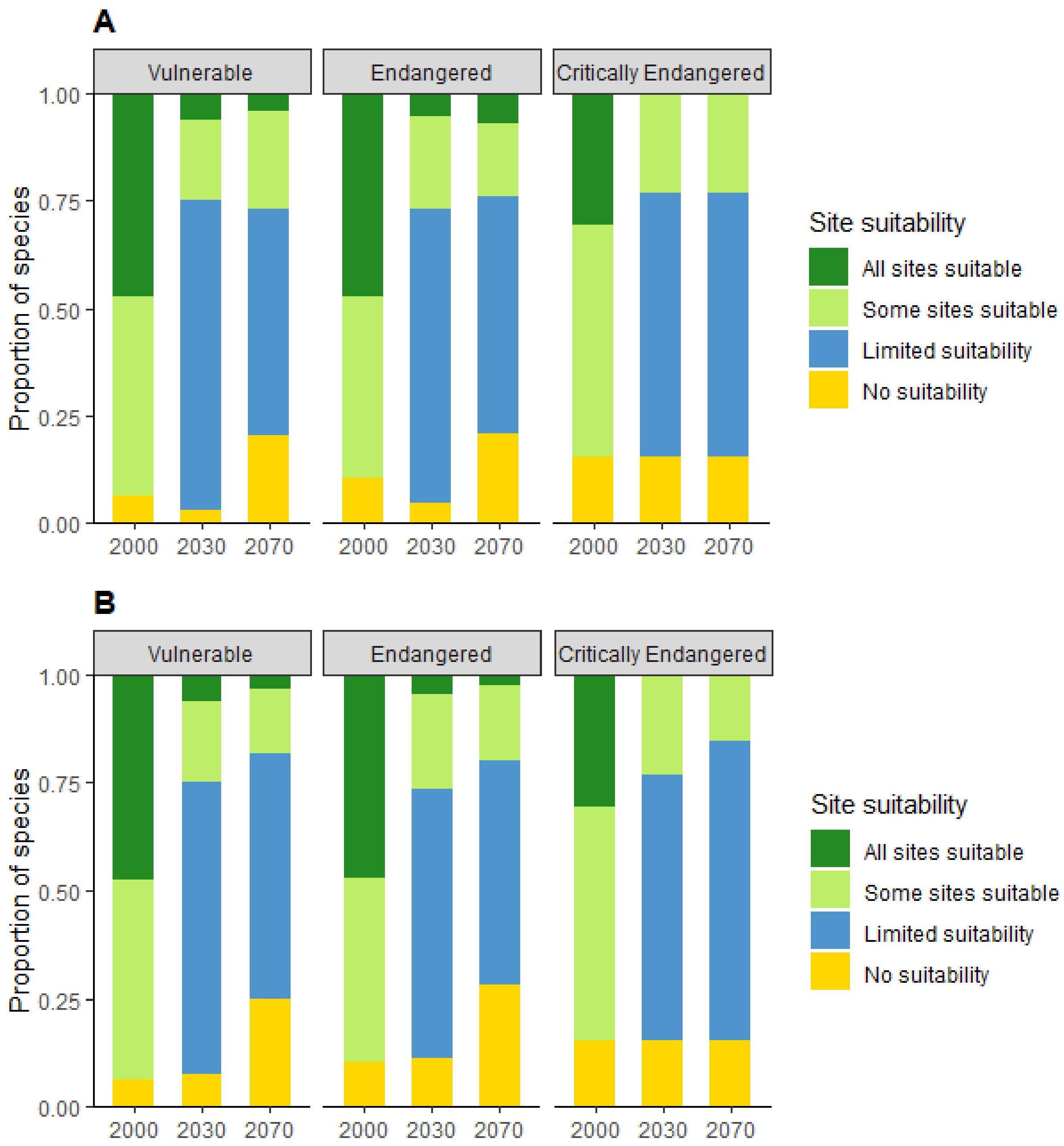

Figure 3.4 The proportion of modelled Vulnerable, Endangered and Critically Endangered species that are projected to have (i) all their respective managed sites retain climatically suitable habitat in all climate scenarios; (ii) some of their respective managed sites retain climatically suitable habitat in all climate scenarios; (iii) climatically suitable habitat for all or some sites under some climate scenarios; or (iv) no suitability for all sites under any scenario, under baseline conditions, and for 2030 and 2070. **(A)** Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions.

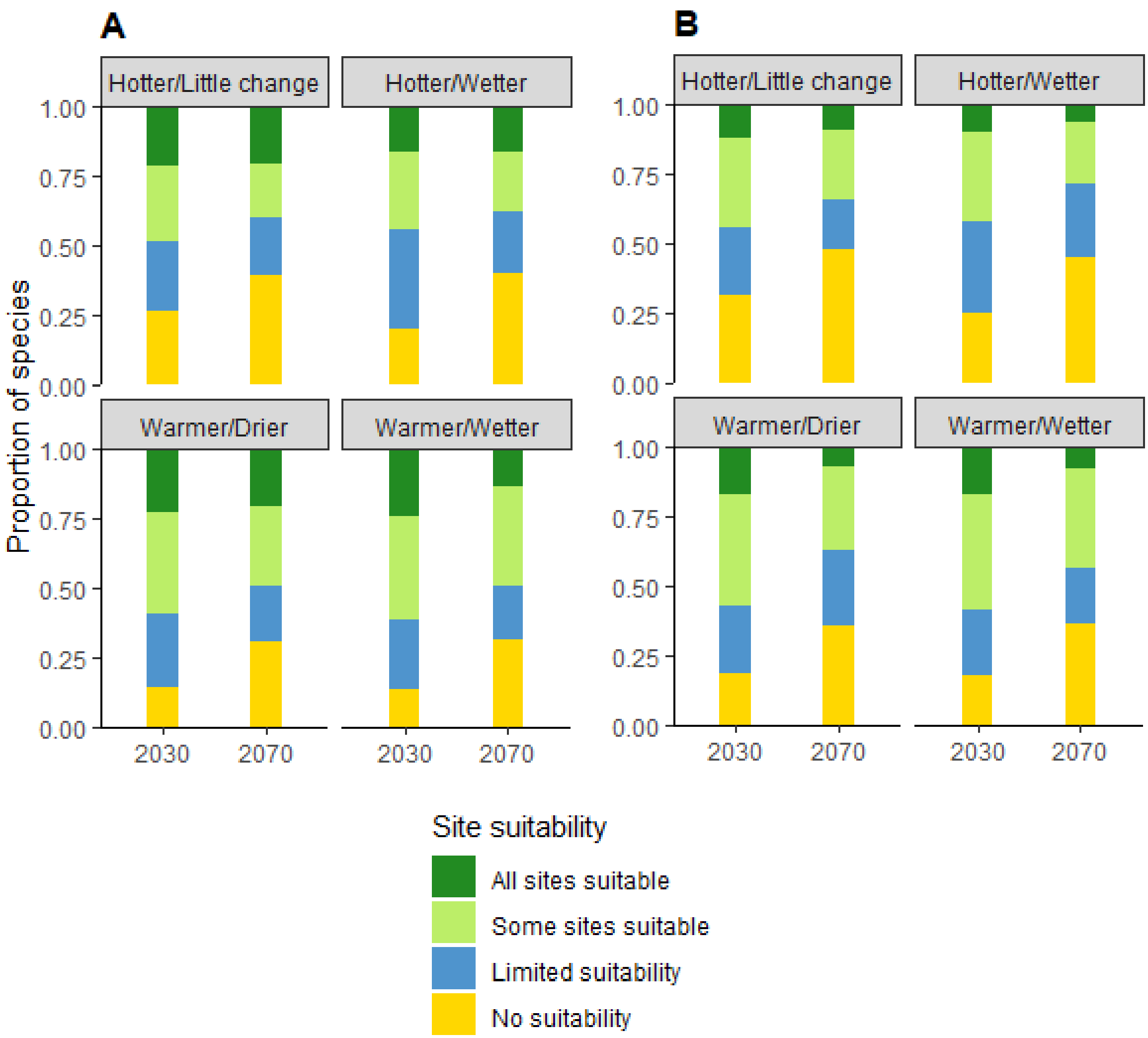

Figure 3.5 The proportion of modelled site managed species that are projected to have (i) all their respective managed sites retain climatically suitable habitat under each Global Climate Model (GCM); (ii) some of their respective managed sites retain climatically suitable habitat under each GCM; (iii) climatically suitable habitat for all or some sites under some climate scenarios for each GCM; or (iv) no suitability for all sites under each GCM, for 2030 and 2070.

(A) Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions.

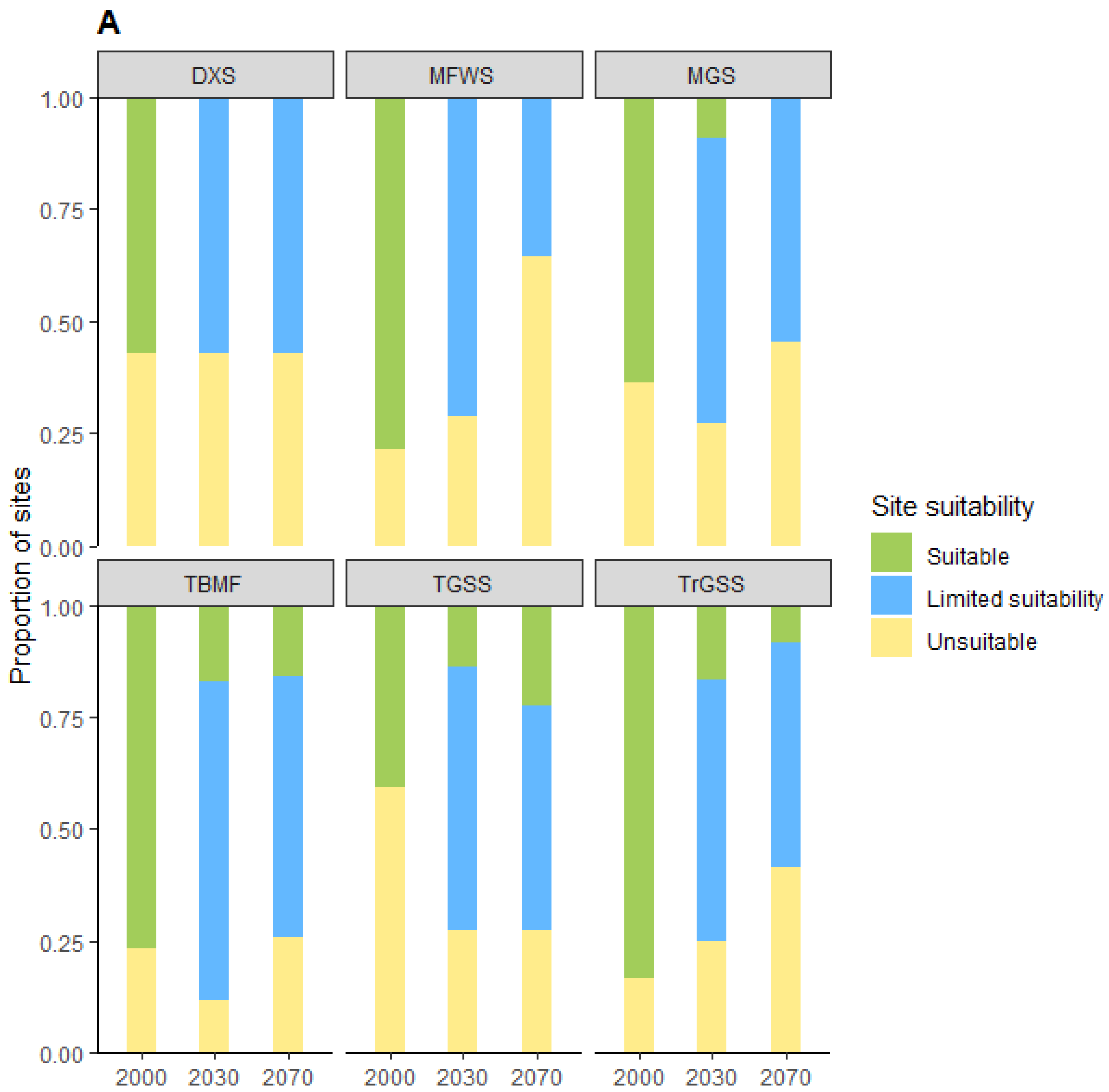

Figure 3.6 The proportion of sites (n = 759) within each of six NSW biomes that are projected to retain climatically suitable habitat under (a) all climate scenarios; (b) some climate scenarios; or (c) no climate scenarios, under baseline conditions, and for 2030 and 2070.

DXS: Deserts & Xeric Shrublands

MFWS: Mediterranean Forests Woodlands & Shrublands

MGS: Montane Grasslands & Shrublands

TBMF: Temperate Broadleaf & Mixed Forests

TGSS: Temperate Grasslands Savannas & Shrublands

TrGSS: Tropical/Subtropical Grasslands Savannas & Shrublands

(A) Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions. (Continued overleaf)

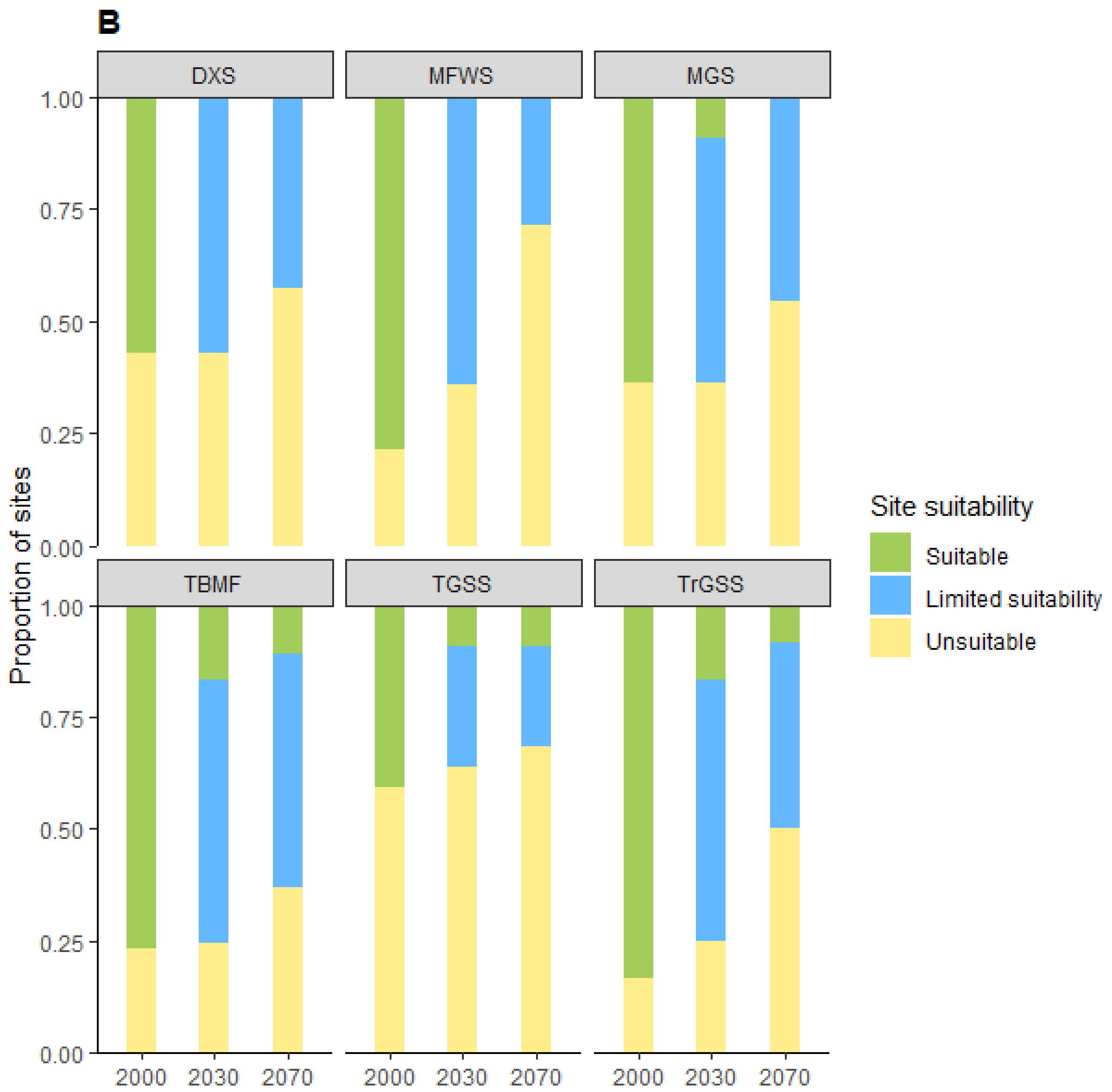

Figure 3.6 (Continued)

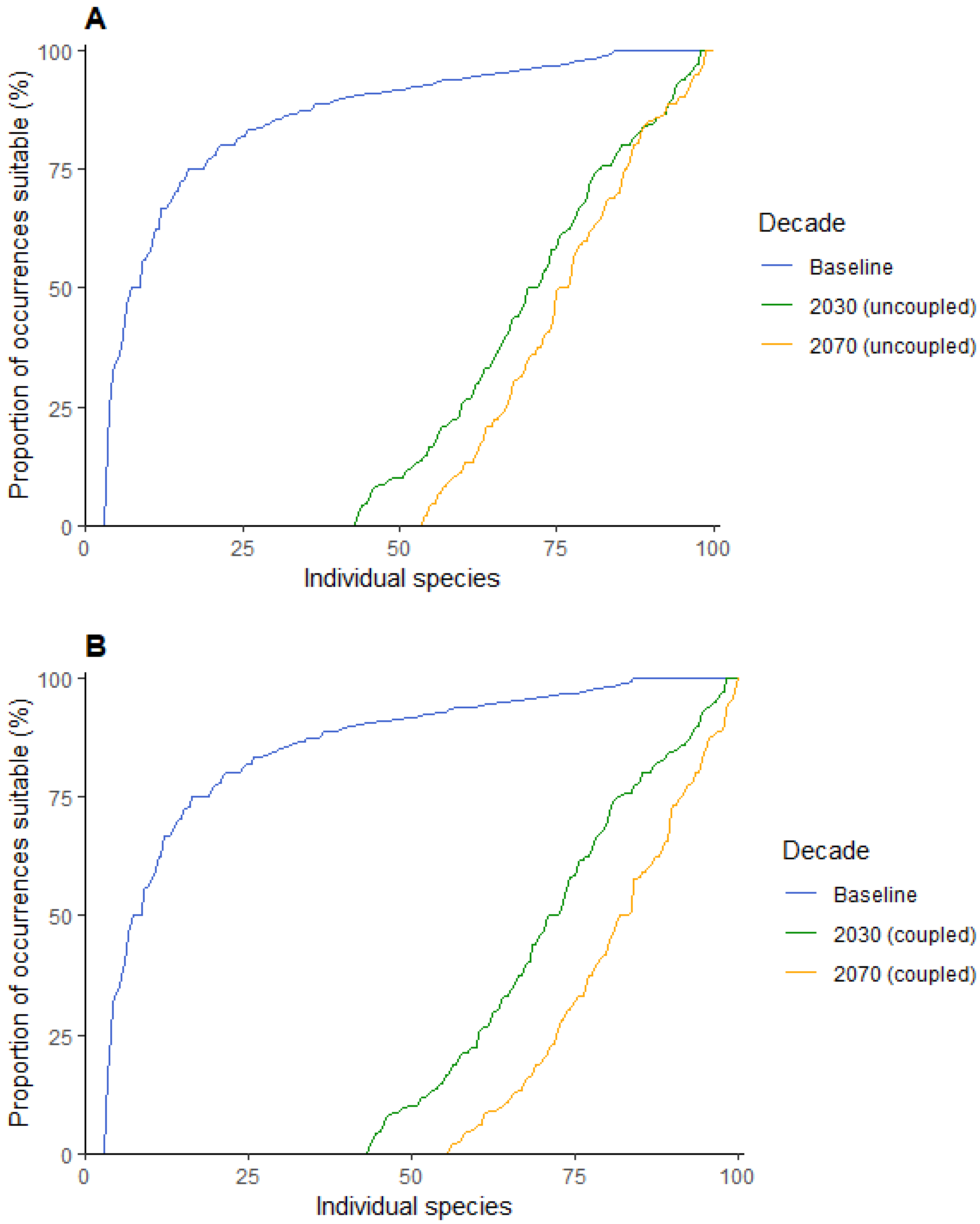

Figure 3.7 Proportion of occurrence records for threatened species projected to be suitable (i.e. at least one grid cell within 1km buffer of occurrence suitable under baseline modelled conditions or under all 12 future climate scenarios) under baseline conditions, and in 2030 and 2070 (n = 233). X axis represents the 0^{th} to 100^{th} percentile of species arranged in order of increasing proportion of records suitable, normalised by the number of species modelled.

(A) Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions.

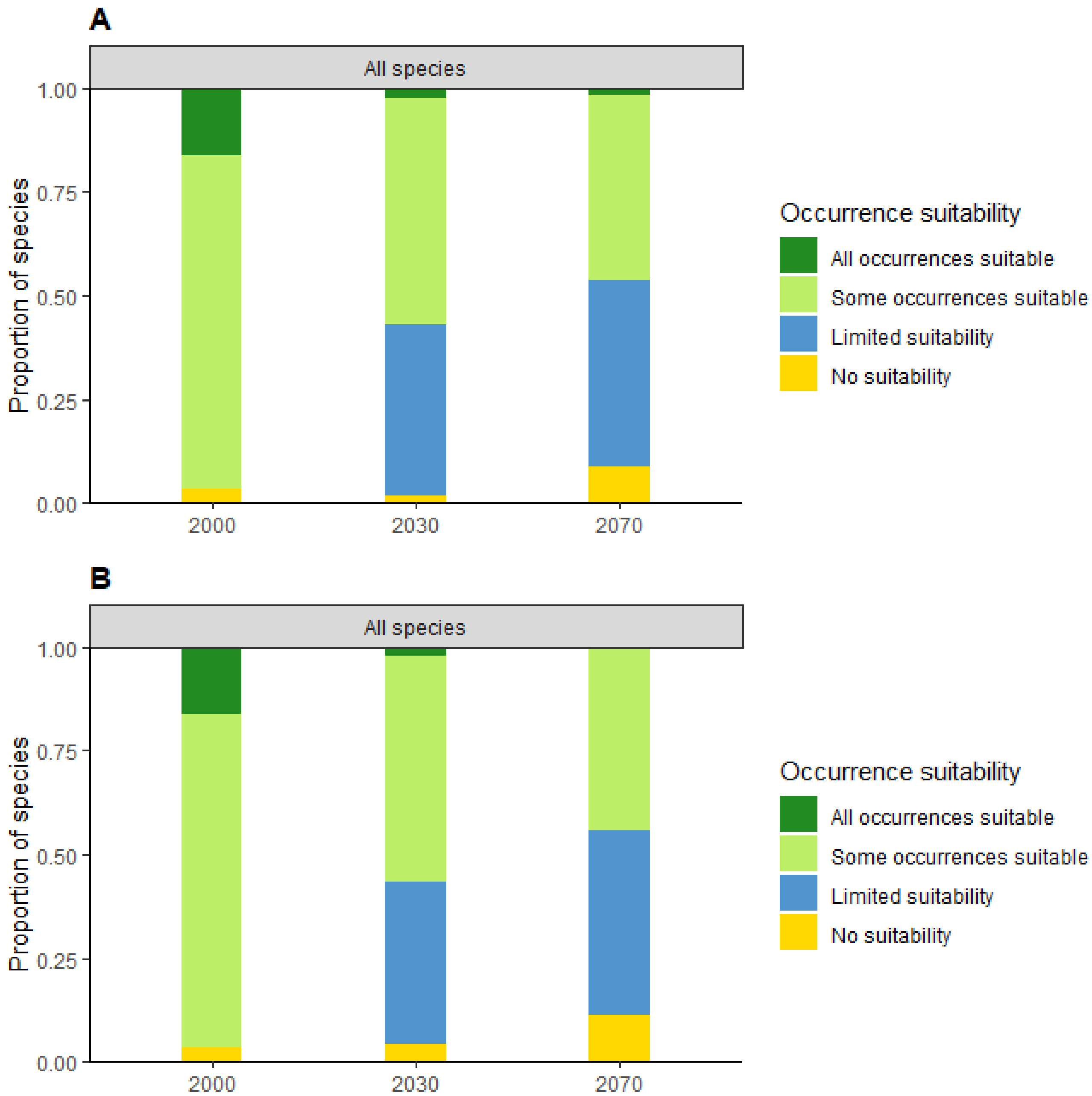

Figure 3.8 The proportion of modelled site managed species that are projected to have (i) all their respective occurrence records retain climatically suitable habitat in all climate scenarios; (ii) some of their respective occurrence records retain climatically suitable habitat in all climate scenarios; (iii) climatically suitable habitat for all or some occurrence records under some climate scenarios; or (iv) no suitability for all occurrence records under any scenario, under baseline conditions, and for 2030 and 2070.

(A) Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions.

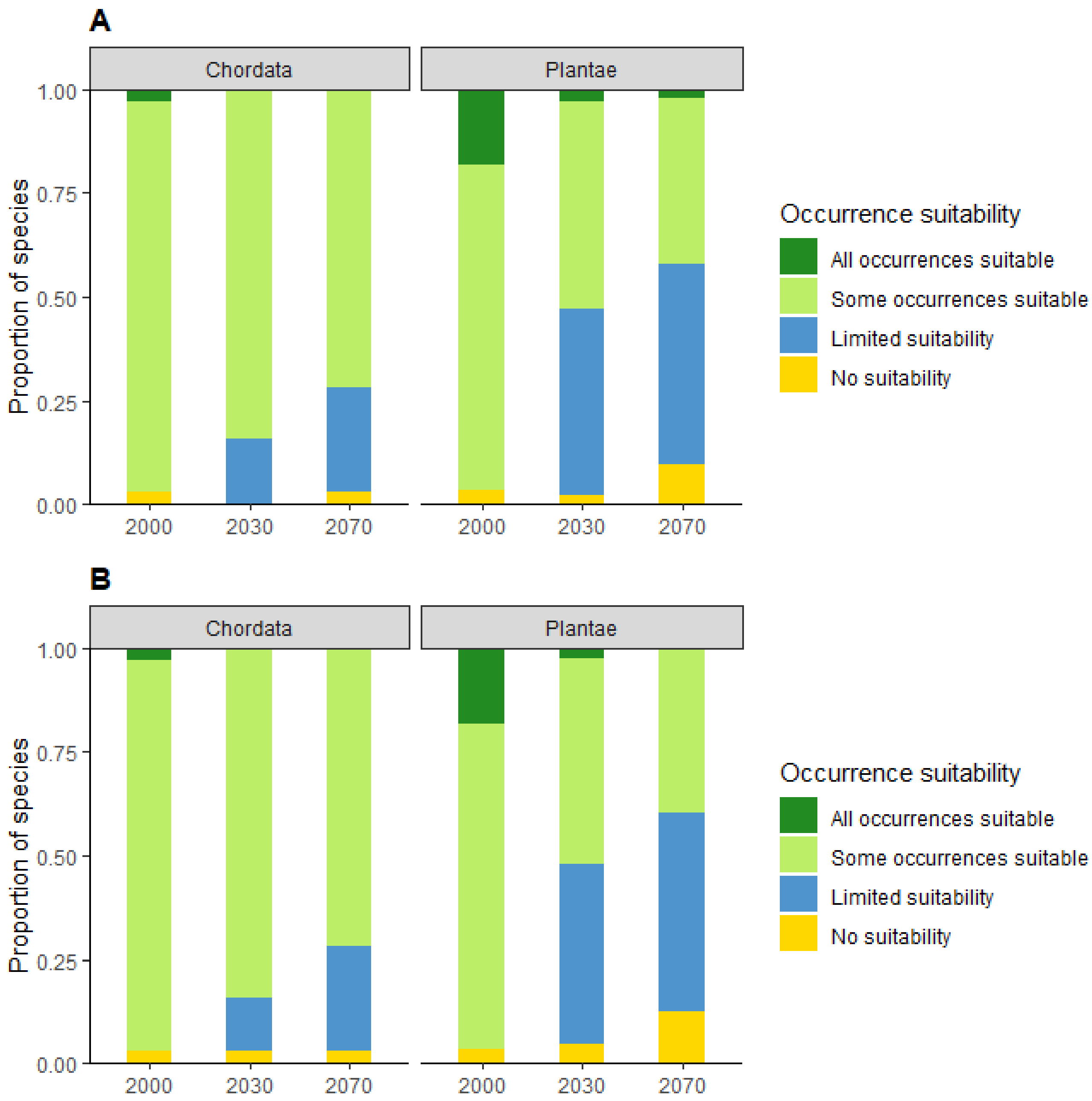

Figure 3.9 The proportion of modelled chordate and plant species that are projected to have (i) all their respective occurrence records retain climatically suitable habitat in all climate scenarios; (ii) some of their respective occurrence records retain climatically suitable habitat in all climate scenarios; (iii) climatically suitable habitat for all or some occurrence records under some climate scenarios; or (iv) no suitability for all occurrence records under any scenario, under baseline conditions, and for 2030 and 2070.

(A) Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions.

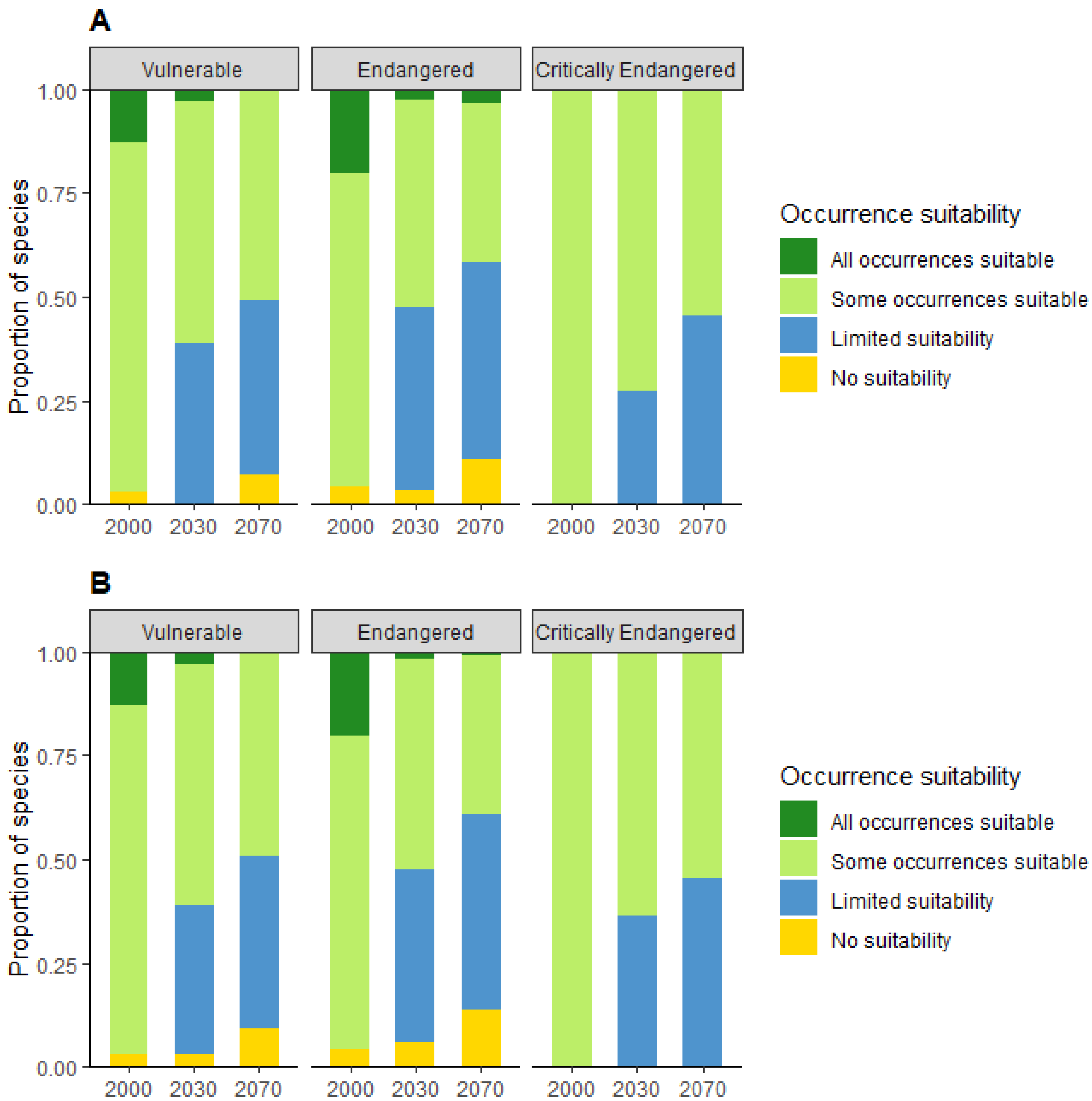

Figure 3.10 The proportion of modelled Vulnerable, Endangered and Critically Endangered species that are projected to have (i) all their respective occurrence records retain climatically suitable habitat in all climate scenarios; (ii) some of their respective occurrence records retain climatically suitable habitat in all climate scenarios; (iii) climatically suitable habitat for all or some occurrence records under some climate scenarios; or (iv) no suitability for all occurrence records under any scenario, under baseline conditions, and for 2030 and 2070.

(A) Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions.

Figure 3.11 The proportion of modelled site managed species that are projected to have (i) all their respective occurrence records retain climatically suitable habitat under each Global Climate Model (GCM); (ii) some of their respective occurrence records retain climatically suitable habitat under each GCM; (iii) climatically suitable habitat for all or some occurrence records under some climate scenarios for each GCM; or (iv) no suitability for all occurrence records under each GCM, for 2030 and 2070. **(A)** Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions.

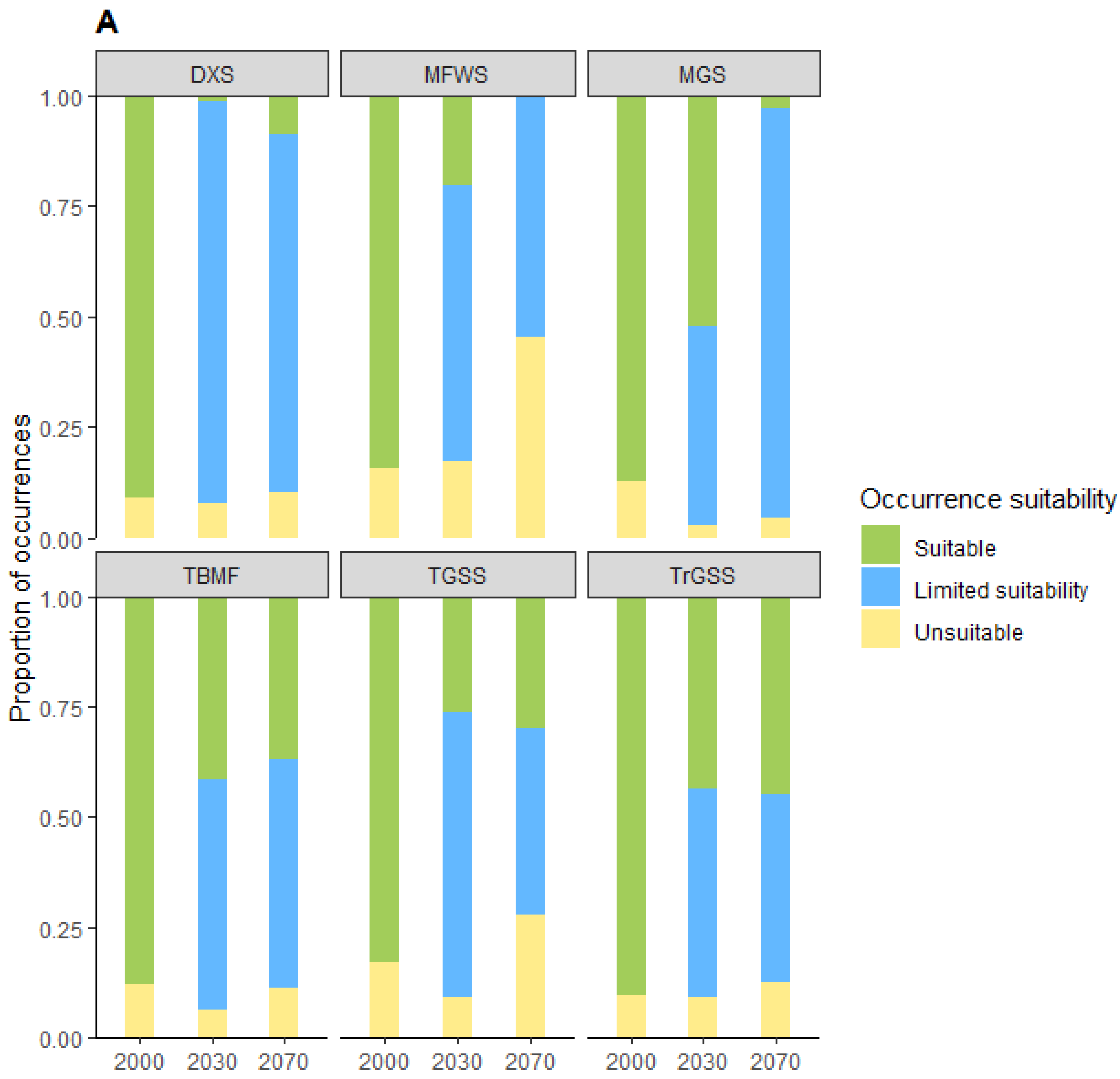

Figure 3.12 The proportion of occurrence records (n = 12,714) within each of six NSW biomes that are projected to retain climatically suitable habitat under (a) all climate scenarios; (b) some climate scenarios; or (c) no climate scenarios, under baseline conditions, and for 2030 and 2070.

DXS: Deserts & Xeric Shrublands

MFWS: Mediterranean Forests Woodlands & Shrublands

MGS: Montane Grasslands & Shrublands

TBMF: Temperate Broadleaf & Mixed Forests

TGSS: Temperate Grasslands Savannas & Shrublands

TrGSS: Tropical/Subtropical Grasslands Savannas & Shrublands

(A) Uncoupled: Suitability of each site is independent of suitability in previous decades and under baseline conditions. **(B)** Coupled: Suitability of each site is dependent on suitability in previous decades and under baseline conditions. (Continued overleaf)

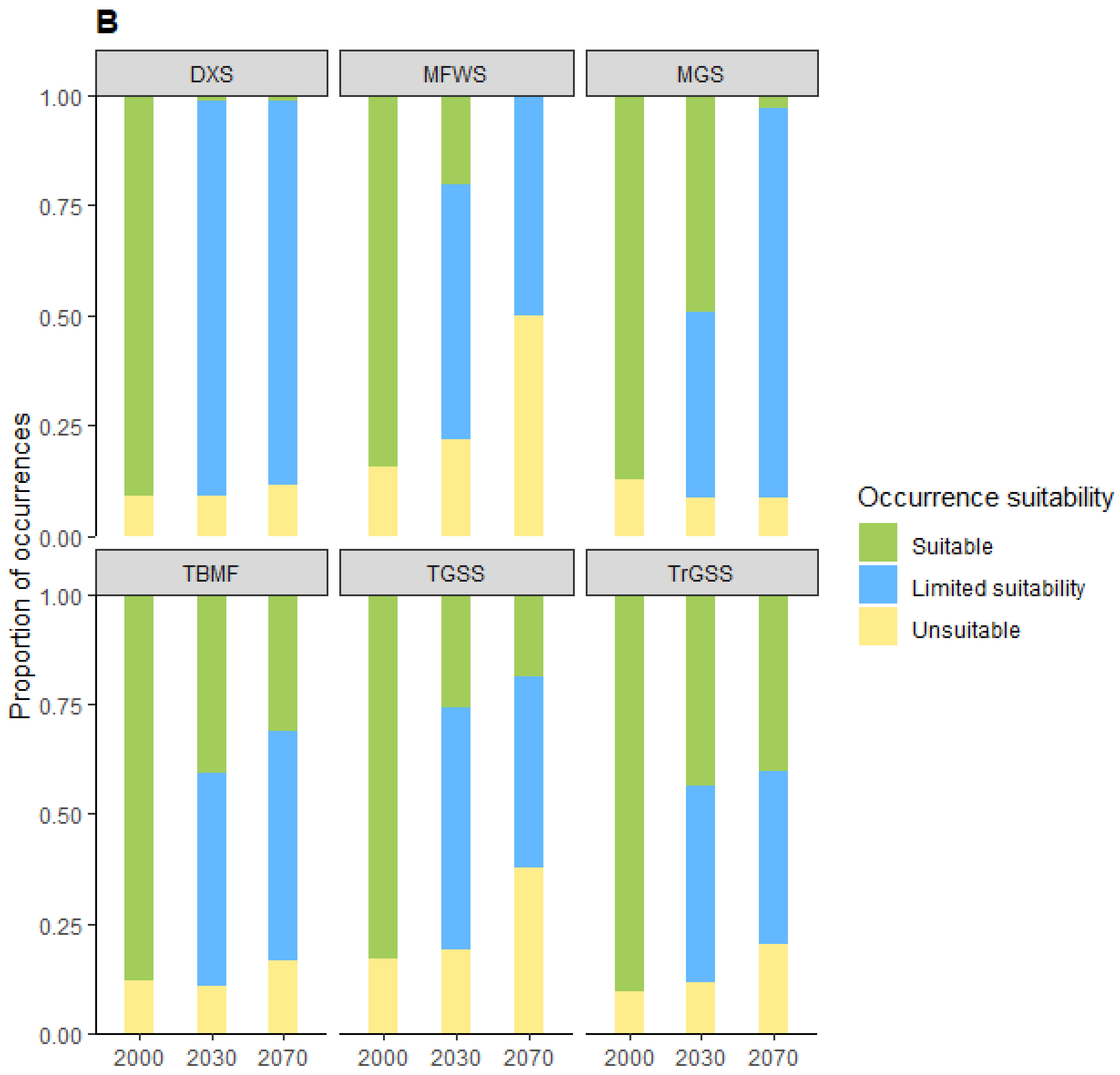

Figure 3.12 (Continued)

Table 3.7 Threatened species that are projected to have (i) all of their respective managed sites retain climatically suitable habitat in all climate scenarios; (ii) some of their respective managed sites retain climatically suitable habitat in all climate scenarios; (iii) climatically suitable habitat for all or some sites under *some* climate scenarios; or (iv) no suitability for all sites under *any* scenario, when climate suitability is coupled to previous decades for 2030 and 2070. Coupled suitability refers to dependence of suitability for each decade on suitability in all previous decades, i.e. if a site falls below the threshold for suitability for a decade, then returns to above this threshold in succeeding decades, it will be considered unsuitable for those succeeding decades. ***Higher suitability when climate suitability is uncoupled from previous decades.**

		2030		
i) All sites suitable	**ii) Some sites suitable**	**iii) Limited suitability**		**iv) No suitability**
Critically Endangered				
	Anthochaera phrygia	*Eucalyptus* sp. Cattai		*Myriophyllum implicatum*
	Esacus magnirostris	*Genoplesium littorale*		*Pterostylis despectans*
	Litoria castanea	*Grevillea caleyi*		
		Hibbertia sp. Bankstown		
		Pachycephala rufogularis		
		Pseudomys fumeus		
		Pseudophryne pengilleyi		
		Thinornis rubricollis		
Endangered				
Angophora exul	*Acacia bynoeana*	*Acacia acanthoclada*	*Irenepharsus trypherus*	***Boronia repanda***
Caladenia concolor	*Acacia gordonii*	*Acacia meiantha*	*Isoglossa eranthemoides*	*Burramys parvus*
Diuris pedunculata	*Aldrovanda vesiculosa*	*Acacia pubifolia*	*Lepidium monoplocoides*	***Caesalpinia bonduc***
Eucalyptus largeana	***Caladenia arenaria***	*Acacia terminalis* subsp. *terminalis*	*Lindernia alsinoides*	*Caladenia tessellata*
Eucalyptus magnificata	*Cassia brewsteri* var. *marksiana*	*Acronychia littoralis*	*Litoria aurea*	***Callitris baileyi***
Hibbertia superans	*Chamaesyce psammogeton*	*Alexfloydia repens*	*Litoria booroolongensis*	*Cullen parvum*
	Davidsonia johnsonii	*Allocasuarina defungens*	*Litoria raniformis*	***Eucalyptus camphora* subsp. *relicta***
	Diospyros mabacea	*Amytornis barbatus barbatus*	*Melichrus hirsutus*	*Eucalyptus microcodon*
	Diploglottis campbellii	*Astrotricha roddii*	*Micromyrtus minutiflora*	***Isoodon obesulus obesulus***
	Diuris arenaria	*Austrostipa nullanulla*	*Mixophyes fleayi*	***Lepidium peregrinum***
	Elaeocarpus williamsianus	*Carex raleighii*	*Ochrosia moorei*	*Persoonia hindii*
	Eleocharis tetraquetra	*Coatesia paniculata*	*Olearia flocktoniae*	*Pomaderris cocoparrana*
	Endiandra floydii	*Commersonia prostrata*	*Ozothamnus vagans*	***Pultenaea pedunculata***
	Genoplesium baueri	*Corchorus cunninghamii*	*Persoonia bargoensis*	***Senecio spathulatus***
	Grevillea guthrieana	*Ctenophorus mirrityana*	*Persoonia glaucescens*	
	Haematopus longirostris	*Dampiera fusca*	*Persoonia mollis* subsp. *maxima*	
	Leucopogon fletcheri subsp. *fletcheri*	*Daphnandra johnsonii*	*Persoonia nutans*	
	Lindsaea incisa	*Dasyornis brachypterus*	*Phaius australis*	
	Melaleuca irbyana	*Davidsonia jerseyana*	*Pilularia novae-hollandiae*	
	Persoonia hirsuta	*Digitaria porrecta*	*Plectranthus alloplectus*	
	Phyllanthus microcladus	*Dillwynia glaucula*	*Polytelis anthopeplus monarchoides*	
	Pimelea spicata	*Diuris aequalis*	*Pomaderris brunnea*	
	Pomaderris cotoneaster	*Epacris hamiltonii*	*Prasophyllum affine*	
	Randia moorei	*Eucalyptus macarthurii*	*Prostanthera askania*	
	Senna acclinis	*Eucalyptus parvula*	*Prostanthera junonis*	
	Sophora tomentosa	*Eucalyptus saxatilis*	*Pultenaea parviflora*	
	Sternula albifrons	*Eucalyptus scoparia*	*Quassia* sp. Mooney Creek	
		Euphrasia scabra	*Rutidosis leptorrhynchoides*	

		Gossia fragrantissima	*Sclerolaena napiformis*	
		Grevillea hilliana	*Solanum celatum*	
		Grevillea masonii	*Swainsona recta*	
		Grevillea obtusiflora	*Syzygium paniculatum*	
		*Grevillea parviflora subsp. _supplicans_	*Triplarina nowraensis*	
		Grevillea renwickiana	*Tylophora woollsii*	
		Hakea dohertyi	*Tympanocryptis pinguicolla*	
		Hibbertia puberula	*Uromyrtus australis*	
		Hibbertia stricta subsp. *furcatula*	*Xylosma terrae-reginae*	
		Homopholis belsonii	*Zieria granulata*	
		Indigofera baileyi	*Zieria involucrata*	
Vulnerable				
Acacia bakeri	*Astrotricha crassifolia*	*Acacia ausfeldii*	*Grevillea rhizomatosa*	**_*Darwinia glaucophylla_**
Acacia phasmoides	*Callitris oblonga*	*Acacia carneorum*	*Hakea archaeoides*	*Eucalyptus alligatrix* subsp. *alligatrix*
Bertya opponens	*Calotis glandulosa*	*Acacia courtii*	*Kunzea rupestris*	*Eucalyptus cannonii*
Prostanthera densa	*Crinia sloanei*	*Acacia curranii*	*Leionema ralstonii*	*Eucalyptus oresbia*
Pseudomys pilligaensis	*Darwinia peduncularis*	*Acacia pubescens*	*Lepiderema pulchella*	**_*Olearia cordata_**
	Dichanthium setosum	*Acrophyllum australe*	*Leucopogon exolasius*	**_*Pterostylis cobarensis_**
	Dodonaea procumbens	*Allocasuarina simulans*	*Macadamia tetraphylla*	**_*Swainsona plagiotropis_**
	Eucalyptus camfieldii	*Amytornis striatus*	*Melaleuca biconvexa*	
	Euphrasia ciliolata	*Archidendron hendersonii*	*Micromyrtus blakelyi*	
	Lasiopetalum joyceae	*Asperula asthenes*	*Owenia cepiodora*	
	Melaleuca deanei	*Boronia deanei*	*Persoonia acerosa*	
	Persicaria elatior	*Bossiaea oligosperma*	*Persoonia marginata*	
	Potorous tridactylus	*Brachyscome muelleroides*	*Pezoporus wallicus wallicus*	
	Pseudomys gracilicaudatus	*Cryptostylis hunteriana*	*Phyllota humifusa*	
	Pterodroma leucoptera leucoptera	*Darwinia biflora*	*Picris evae*	
	Rutidosis leiolepis	*Desmodium acanthocladum*	*Pimelea curviflora* var. *curviflora*	
	Tetratheca glandulosa	*Discaria nitida*	*Pomaderris pallida*	
	Zieria murphyi	*Diuris praecox*	*Pomaderris parrisiae*	
		Epacris purpurascens var. *purpurascens*	*Prostanthera stricta*	
		Eucalyptus aggregata	*Pultenaea glabra*	
		Eucalyptus benthamii	*Pultenaea maritima*	
		Eucalyptus canobolensis	*Sarcochilus hartmannii*	
		Eucalyptus glaucina	*Sophora fraseri*	
		Eucalyptus kartzoffiana	*Symplocos baeuerlenii*	
		Eucalyptus langleyi	*Syzygium hodgkinsoniae*	
		Eucalyptus pulverulenta	*Syzygium moorei*	
		Eucalyptus rubida subsp. *barbigerorum*	*Tasmannia glaucifolia*	
		Eucalyptus sturgissiana	*Tinospora tinosporoides*	
		Floydia praealta	*Veronica blakelyi*	
		Gentiana wissmannii	*Wilsonia backhousei*	
		Grevillea juniperina subsp. *juniperina*	*Zieria tuberculata*	
		Grevillea quadricauda		

2070				
i) All sites suitable	**ii) Some sites suitable**	**iii) Limited suitability**		**iv) No suitability**
Critically Endangered				
	Anthochaera phrygia	*Eucalyptus* sp. Cattai		*Myriophyllum implicatum*
	Esacus magnirostris	*Genoplesium littorale*		*Pterostylis despectans*
		Grevillea caleyi		
		*Hibbertia sp. Bankstown		
		Litoria castanea		
		Pachycephala rufogularis		
		Pseudomys fumeus		
		Pseudophryne pengilleyi		
		Thinornis rubricollis		
Endangered				
Caladenia concolor	*Acacia bynoeana*	*Acacia pubifolia*	*Litoria raniformis*	*Acacia acanthoclada*
Eucalyptus largeana	**_*Acacia gordonii_**	*Acronychia littoralis*	*Melichrus hirsutus*	*Acacia meiantha*
Hibbertia superans	*Aldrovanda vesiculosa*	*Alexfloydia repens*	*Micromyrtus minutiflora*	*Acacia terminalis* subsp. *terminalis*
	*Caladenia arenaria	*Amytornis barbatus barbatus*	*Mixophyes fleayi*	*Allocasuarina defungens*
	Chamaesyce psammogeton	*Angophora exul*	*Ochrosia moorei*	*Boronia repanda*
	Davidsonia johnsonii	*Astrotricha roddii*	*Ozothamnus vagans*	*Burramys parvus*
	Diploglottis campbellii	*Austrostipa nullanulla*	*Persoonia glaucescens*	**_*Caesalpinia bonduc_**
	Diuris arenaria	*Cassia brewsteri* var. *marksiana*	*Persoonia mollis* subsp. *maxima*	*Caladenia tessellata*
	Elaeocarpus williamsianus	*Coatesia paniculata*	*Persoonia nutans*	**_*Callitris baileyi_**
	Eleocharis tetraquetra	*Commersonia prostrata*	*Phaius australis*	**_*Carex raleighii_**
	Endiandra floydii	*Corchorus cunninghamii*	*Pimelea spicata*	*Ctenophorus mirrityana*
	*Genoplesium baueri	*Daphnandra johnsonii*	*Pomaderris brunnea*	*Cullen parvum*
	Grevillea guthrieana	*Dasyornis brachypterus*	*Pomaderris cotoneaster*	*Dampiera fusca*
	Haematopus longirostris	*Davidsonia jerseyana*	**_*Prostanthera askania_**	*Diuris aequalis*
	Leucopogon fletcheri subsp. *fletcheri*	*Digitaria porrecta*	**_*Prostanthera junonis_**	*Epacris hamiltonii*
	*Lindsaea incisa	*Dillwynia glaucula*	*Pultenaea parviflora*	**_*Eucalyptus camphora_ subsp. _relicta_**
	Melaleuca irbyana	**_*Diospyros mabacea_**	*Quassia* sp. Mooney Creek	*Eucalyptus microcodon*
	Persoonia hirsuta	*Diuris pedunculata*	*Randia moorei*	*Euphrasia scabra*
	Phyllanthus microcladus	*Eucalyptus macarthurii*	*Rutidosis leptorrhynchoides*	*Grevillea obtusiflora*
	Senna acclinis	*Eucalyptus magnificata*	*Sclerolaena napiformis*	*Grevillea renwickiana*
	*Sophora tomentosa	*Eucalyptus parvula*	*Solanum celatum*	*Hakea dohertyi*
	Sternula albifrons	*Eucalyptus saxatilis*	*Swainsona recta*	*Hibbertia puberula*
		Eucalyptus scoparia	*Syzygium paniculatum*	**_*Homopholis belsonii_**
		Gossia fragrantissima	*Triplarina nowraensis*	**_*Isoodon obesulus obesulus_**
		*Grevillea hilliana	*Tylophora woollsii*	**_*Lepidium peregrinum_**
		Grevillea masonii	*Tympanocryptis pinguicolla*	*Olearia flocktoniae*
		Grevillea parviflora subsp. *supplicans*	*Uromyrtus australis*	*Persoonia bargoensis*
		Hibbertia stricta subsp. *furcatula*	*Xylosma terrae-reginae*	*Persoonia hindii*
		Indigofera baileyi	*Zieria granulata*	*Pilularia novae-hollandiae*
		Irenepharsus trypherus	*Zieria involucrata*	*Plectranthus alloplectus*
		Isoglossa eranthemoides		*Polytelis anthopeplus monarchoides*
		Lepidium monoplocoides		*Pomaderris cocoparrana*
		Lindernia alsinoides		*Prasophyllum affine*
		Litoria aurea		**_*Pultenaea pedunculata_**
		Litoria booroolongensis		**_*Senecio spathulatus_**

Vulnerable				
Bertya opponens	_Acacia phasmoides_	_Acacia ausfeldii_	_Gentiana wissmannii_	**_*Darwinia glaucophylla_**
Prostanthera densa	_Astrotricha crassifolia_		**_*Grevillea juniperina_ subsp.**	
		Acacia bakeri	**_juniperina_**	_Eucalyptus aggregata_
	Callitris oblonga			**_*Eucalyptus alligatrix_ subsp.**
		Acacia carneorum	_Grevillea quadricauda_	**_alligatrix_**
	Calotis glandulosa	_Acacia courtii_	_Kunzea rupestris_	_Eucalyptus benthamii_
	*Crinia sloanei	**_*Acacia curranii_**	_Lepiderema pulchella_	_Eucalyptus cannonii_
	Darwinia peduncularis	**_*Acacia pubescens_**	_Melaleuca biconvexa_	_Eucalyptus canobolensis_
	Dicanthium setosum	_Acrophyllum australe_	**_*Melaleuca deanei_**	_Eucalyptus oresbia_
	Dodonaea procumbens	_Allocasuarina simulans_	_Micromyrtus blakelyi_	_Eucalyptus rubida_ subsp. _barbigerorum_
	Euphrasia ciliolata	_Amytornis striatus_	_Owenia cepiodora_	_Grevillea rhizomatosa_
	Lasiopetalum joyceae	_Archidendron hendersonii_	_Persoonia acerosa_	_Hakea archaeoides_
	Persicaria elatior	_Asperula asthenes_	_Persoonia marginata_	_Leionema ralstonii_
	Pseudomys gracilicaudatus	_Boronia deanei_	_Pezoporus wallicus wallicus_	_Leucopogon exolasius_
	Pterodroma leucoptera leucoptera	_Bossiaea oligosperma_	_Picris evae_	_Macadamia tetraphylla_
	Tetratheca glandulosa	_Brachyscome muelleroides_	**_*Pimelea curviflora_ var. _curviflora_**	_Prostanthera stricta_
	Zieria murphyi	_Cryptostylis hunteriana_	_Pomaderris pallida_	**_*Olearia cordata_**
		*Darwinia biflora	_Pomaderris parrisiae_	_Phyllota humifusa_
		Desmodium acanthocladum	_Potorous tridactylus_	**_*Pterostylis cobarensis_**
		Discaria nitida	_Pseudomys pilligaensis_	_Swainsona plagiotropis_
		*Diuris praecox	_Pultenaea glabra_	_Symplocos baeuerlenii_
		Epacris purpurascens var.		_Tasmannia glaucifolia_
		purpurascens	_Pultenaea maritima_	
		Eucalyptus camfieldii	_Rutidosis leiolepis_	_Veronica blakelyi_
		Eucalyptus glaucina	_Sarcochilus hartmannii_	_Zieria tuberculata_
		Eucalyptus kartzoffiana	_Sophora fraseri_	
		Eucalyptus langleyi	_Syzygium hodgkinsoniae_	
		*Eucalyptus pulverulenta	_Syzygium moorei_	
		Eucalyptus sturgissiana	_Tinospora tinosporoides_	
		Floydia praealta	_Wilsonia backhousei_	

Table 3.8 Threatened species that are projected to have (i) all of their respective occurrence records retain climatically suitable habitat in all climate scenarios; (ii) some of their respective occurrence records retain climatically suitable habitat in all climate scenarios; (iii) climatically suitable habitat for all or some occurrence records under *some* climate scenarios; or (iv) no suitability for all occurrence records under *any* scenario, when climate suitability is coupled to previous decades for 2030 and 2070. Coupled suitability refers to dependence of suitability for each decade on suitability in all previous decades, i.e. if an occurrence record falls below the threshold for suitability for a decade, then returns to above this threshold in succeeding decades, it will be considered unsuitable for those succeeding decades. ***Higher suitability when climate suitability is uncoupled from previous decades.**

2030			
All occurrence records suitable	**Some occurrence records suitable**	**Limited suitability**	**No suitability**
Critically Endangered			
	Anthochaera phrygia	*Genoplesium littorale*	
	Esacus magnirostris	***Grevillea caleyi**	
	Eucalyptus sp. Cattai	*Pachycephala rufogularis*	
	Hibbertia sp. Bankstown	*Pseudomys fumeus*	
	Litoria castanea		
	Pseudophryne pengilleyi		
	Thinornis rubricollis		
Endangered			
Caladenia arenaria	*Acacia acanthoclada*	*Acacia meiantha*	***Burramys parvus**
Lepidium peregrinum	*Acacia bynoeana*	*Acacia pubifolia*	***Caesalpinia bonduc**
	Acacia gordonii	*Acacia terminalis* subsp. *terminalis*	***Callitris baileyi**
	Aldrovanda vesiculosa	*Acronychia littoralis*	*Cullen parvum*
	Amytornis barbatus barbatus	*Alexfloydia repens*	*Olearia flocktoniae*
	Angophora exul	*Allocasuarina defungens*	*Persoonia hindii*
	Caladenia concolor	*Astrotricha roddii*	*Pomaderris cocoparrana*
	Carex raleighii	*Austrostipa nullanulla*	
	Cassia brewsteri var. *marksiana*	*Caladenia tessellata*	
	Chamaesyce psammogeton	*Coatesia paniculata*	
	Commersonia prostrata	*Corchorus cunninghamii*	
	Dasyornis brachypterus	*Ctenophorus mirrityana*	
	Davidsonia johnsonii	*Dampiera fusca*	
	Digitaria porrecta	*Daphnandra johnsonii*	
	Diospyros mabacea	*Davidsonia jerseyana*	
	Diploglottis campbellii	*Dillwynia glaucula*	
	***Diuris arenaria**	*Diuris aequalis*	
	Diuris pedunculata	*Elaeocarpus williamsianus*	
	Eleocharis tetraquetra	*Eucalyptus macarthurii*	
	Endiandra floydii	*Eucalyptus parvula*	
	Epacris hamiltonii	*Eucalyptus scoparia*	
	Eucalyptus camphora subsp. *relicta*	*Euphrasia scabra*	
	Eucalyptus largeana	*Gossia fragrantissima*	
	Eucalyptus magnificata	*Grevillea obtusiflora*	
	Eucalyptus microcodon	*Grevillea renwickiana*	
	Eucalyptus saxatilis	*Hakea dohertyi*	
	Genoplesium baueri	*Hibbertia puberula*	

	Grevillea guthrieana	*Hibbertia stricta* subsp. *furcatula*	
	Grevillea hilliana	*Homopholis belsonii*	
	Grevillea masonii	*Irenepharsus trypherus*	
	Grevillea parviflora subsp. *supplicans*	*Isoglossa eranthemoides*	
	Haematopus longirostris	*Lindernia alsinoides*	
	Hibbertia superans	*Melichrus hirsutus*	
	Indigofera baileyi	*Micromyrtus minutiflora*	
	Isoodon obesulus obesulus	*Mixophyes fleayi*	
	Lepidium monoplocoides	*Ochrosia moorei*	
	Leucopogon fletcheri subsp. *fletcheri*	*Persoonia bargoensis*	
	Lindsaea incisa	*Persoonia mollis* subsp. *maxima*	
	Litoria aurea	*Persoonia nutans*	
	Litoria booroolongensis	*Phaius australis*	
	Litoria raniformis	*Pilularia novae-hollandiae*	
	Melaleuca irbyana	*Plectranthus alloplectus*	
	Ozothamnus vagans	*Polytelis anthopeplus monarchoides*	
	Persoonia glaucescens	*Pomaderris brunnea*	
	Persoonia hirsuta	*Rutidosis leptorrhynchoides*	
	Phyllanthus microcladus	*Senecio spathulatus*	
	Pimelea spicata	*Solanum celatum*	
	Pomaderris cotoneaster	*Swainsona recta*	
	Prostanthera askania	*Triplarina nowraensis*	
	Prostanthera junonis	*Tylophora woollsii*	
	Pultenaea parviflora	*Zieria involucrata*	
	Pultenaea pedunculata		
	Quassia sp. Mooney Creek		
	Randia moorei		
	Sclerolaena napiformis		
	Senna acclinis		
	Sophora tomentosa		
	Sternula albifrons		
	Syzygium paniculatum		
	Uromyrtus australis		
	Xylosma terrae-reginae		
	Zieria granulata		
Vulnerable			
Acacia curranii	*Acacia bakeri*	*Acacia ausfeldii*	***Eucalyptus alligatrix* subsp. *alligatrix***
Acacia phasmoides	*Acacia pubescens*	*Acacia carneorum*	***Swainsona plagiotropis***
Darwinia glaucophylla	*Aepyprymnus rufescens*	*Acacia courtii*	
	Amytornis striatus	*Acrophyllum australe*	
	Ardenna carneipes	*Allocasuarina simulans*	
	Astrotricha crassifolia	*Archidendron hendersonii*	
	Bertya opponens	*Asperula asthenes*	
	Bossiaea oligosperma	*Boronia deanei*	
	Callitris oblonga	*Brachyscome muelleroides*	
	Calotis glandulosa	*Cryptostylis hunteriana*	
	Crinia sloanei	*Desmodium acanthocladum*	
	Darwinia biflora	*Eucalyptus benthamii*	
	Darwinia peduncularis	*Eucalyptus canobolensis*	

Dichanthium setosum
Discaria nitida
Diuris praecox
Dodonaea procumbens
Epacris purpurascens var. *purpurascens*
Eucalyptus aggregata
Eucalyptus camfieldii
Eucalyptus cannonii
Eucalyptus pulverulenta
Eucalyptus rubida subsp. *barbigerorum*
Euphrasia ciliolata
Floydia praealta
Grevillea juniperina subsp. *juniperina*
Grevillea quadricauda
Lasiopetalum joyceae
Lepiderema pulchella
Melaleuca biconvexa
Melaleuca deanei
Micromyrtus blakelyi
Olearia cordata
Persicaria elatior
Persoonia acerosa
Persoonia marginata
Pezoporus wallicus wallicus
Phaethon rubricauda
Pimelea curviflora var. *curviflora*
Potorous tridactylus
Prostanthera densa
Pseudomys gracilicaudatus
Pseudomys pilligaensis
Pterodroma leucoptera leucoptera
Pterodroma nigripennis
Pterodroma solandri
Pterostylis cobarensis
Puffinus assimilis
Pultenaea glabra
Pultenaea maritima
Rutidosis leiolepis
Sarcochilus hartmannii
Sula dactylatra
Syzygium hodgkinsoniae
Syzygium moorei
Tetratheca glandulosa
Wilsonia backhousei
Zieria murphyi
Eucalyptus glaucina
Eucalyptus kartzoffiana
Eucalyptus langleyi
Eucalyptus oresbia
Eucalyptus sturgissiana
Gentiana wissmannii
Grevillea rhizomatosa
Hakea archaeoides
Kunzea rupestris
Leionema ralstonii
Leucopogon exolasius
Macadamia tetraphylla
Owenia cepiodora
Phyllota humifusa
Picris evae
Pomaderris pallida
Pomaderris parrisiae
Prostanthera stricta
Sophora fraseri
Symplocos baeuerlenii
Tasmannia glaucifolia
Tinospora tinosporoides
Veronica blakelyi
Zieria tuberculata

2070			
All occurrence records suitable	**Some occurrence records suitable**	**Limited suitability**	**No suitability**
Critically Endangered			
	Anthochaera phrygia	*Genoplesium littorale*	
	Esacus magnirostris	*Grevillea caleyi*	
	Eucalyptus sp. Cattai	*Pachycephala rufogularis*	
	Hibbertia sp. Bankstown	*Pseudomys fumeus*	
	Litoria castanea	*Pseudophryne pengilleyi*	
	Thinornis rubricollis		
Endangered			
Caladenia arenaria	*Acacia bynoeana*	*Acacia acanthoclada*	*Acacia meiantha*
	Acacia gordonii	*Acacia pubifolia*	*Allocasuarina defungens*
	Aldrovanda vesiculosa	*Acacia terminalis* subsp. *terminalis*	*Burramys parvus*
	Amytornis barbatus barbatus	*Acronychia littoralis*	***Caesalpinia bonduc**
	Angophora exul	*Alexfloydia repens*	***Caladenia tessellata**
	Caladenia concolor	*Astrotricha roddii*	***Callitris baileyi**
	Carex raleighii	*Austrostipa nullanulla*	*Cullen parvum*
	Cassia brewsteri var. *marksiana*	*Coatesia paniculata*	*Diuris aequalis*
	Chamaesyce psammogeton	*Corchorus cunninghamii*	*Euphrasia scabra*
	Commersonia prostrata	*Ctenophorus mirrityana*	*Grevillea obtusiflora*
	Dasyornis brachypterus	*Dampiera fusca*	*Grevillea renwickiana*
	Davidsonia johnsonii	*Daphnandra johnsonii*	***Hakea dohertyi**
	Digitaria porrecta	*Davidsonia jerseyana*	*Olearia flocktoniae*
	Diospyros mabacea	*Dillwynia glaucula*	*Persoonia bargoensis*
	Diploglottis campbellii	***Elaeocarpus williamsianus**	*Persoonia hindii*
	***Diuris arenaria**	*Epacris hamiltonii*	*Plectranthus alloplectus*
	Diuris pedunculata	*Eucalyptus macarthurii*	*Pomaderris cocoparrana*
	Eleocharis tetraquetra	*Eucalyptus magnificata*	
	Endiandra floydii	*Eucalyptus microcodon*	
	Eucalyptus camphora subsp. *relicta*	*Eucalyptus parvula*	
	Eucalyptus largeana	*Eucalyptus scoparia*	
	Eucalyptus saxatilis	*Gossia fragrantissima*	
	Genoplesium baueri	*Grevillea masonii*	
	Grevillea guthrieana	*Grevillea parviflora* subsp. *supplicans*	
	Grevillea hilliana	*Hibbertia puberula*	
	Haematopus longirostris	*Hibbertia stricta* subsp. *furcatula*	
	Hibbertia superans	*Homopholis belsonii*	
	Isoodon obesulus obesulus	*Indigofera baileyi*	
	Leucopogon fletcheri subsp. *fletcheri*	*Irenepharsus trypherus*	
	Lindsaea incisa	*Isoglossa eranthemoides*	
	Litoria aurea	*Lepidium monoplocoides*	
	Litoria booroolongensis	*Lepidium peregrinum*	
	Litoria raniformis	*Lindernia alsinoides*	
	Melaleuca irbyana	*Melichrus hirsutus*	
	Persoonia hirsuta	*Micromyrtus minutiflora*	

	*Phyllanthus microcladus	*Mixophyes fleayi*	
	Pimelea spicata	*Ochrosia moorei*	
	Pomaderris cotoneaster	*Ozothamnus vagans*	
	Prostanthera askania	*Persoonia glaucescens*	
	Prostanthera junonis	*Persoonia mollis* subsp. *maxima*	
	Pultenaea pedunculata	*Persoonia nutans*	
	Quassia sp. Mooney Creek	*Phaius australis*	
	Randia moorei	*Pilularia novae-hollandiae*	
	Senna acclinis	*Polytelis anthopeplus monarchoides*	
	Sophora tomentosa	*Pomaderris brunnea*	
	Sternula albifrons	*Pultenaea parviflora*	
	Uromyrtus australis	*Rutidosis leptorrhynchoides*	
		Sclerolaena napiformis	
		Senecio spathulatus	
		Solanum celatum	
		Swainsona recta	
		*Syzygium paniculatum	
		Triplarina nowraensis	
		Tylophora woollsii	
		Xylosma terrae-reginae	
		Zieria granulata	
		*Zieria involucrata	
Vulnerable			
	Acacia bakeri	**_*Acacia carneorum_**	*Acacia ausfeldii*
	Acacia curranii	*Acacia courtii*	**_*Eucalyptus alligatrix_ subsp. _alligatrix_**
	Acacia phasmoides	*Acrophyllum australe*	*Eucalyptus benthamii*
	Acacia pubescens	*Allocasuarina simulans*	*Eucalyptus cannonii*
	Aepyprymnus rufescens	*Amytornis striatus*	*Grevillea rhizomatosa*
	Ardenna carneipes	*Archidendron hendersonii*	**_*Phyllota humifusa_**
	Astrotricha crassifolia	*Asperula asthenes*	*Prostanthera stricta*
	Bertya opponens	*Boronia deanei*	*Swainsona plagiotropis*
	Bossiaea oligosperma	*Brachyscome muelleroides*	*Veronica blakelyi*
	Callitris oblonga	*Cryptostylis hunteriana*	
	Calotis glandulosa	**_*Darwinia biflora_**	
	Crinia sloanei	*Desmodium acanthocladum*	
	Darwinia glaucophylla	*Discaria nitida*	
	Darwinia peduncularis	*Epacris purpurascens* var. *purpurascens*	
	Dichanthium setosum	*Eucalyptus canobolensis*	
	Diuris praecox	*Eucalyptus glaucina*	
	Dodonaea procumbens	*Eucalyptus kartzoffiana*	
	Eucalyptus aggregata	*Eucalyptus langleyi*	
	Eucalyptus camfieldii	*Eucalyptus rubida* subsp. *barbigerorum*	
	Eucalyptus pulverulenta	*Eucalyptus oresbia*	
	Euphrasia ciliolata	*Eucalyptus sturgissiana*	
	Floydia praealta	*Gentiana wissmannii*	
	Grevillea juniperina subsp. *juniperina*	*Hakea archaeoides*	

Grevillea quadricauda
Lasiopetalum joyceae
Melaleuca deanei
Micromyrtus blakelyi
Olearia cordata
Persicaria elatior
Persoonia acerosa
Pezoporus wallicus wallicus
Pimelea curviflora var. *curviflora*
Potorous tridactylus
Prostanthera densa
Pseudomys gracilicaudatus
Pseudomys pilligaensis
Pterodroma leucoptera leucoptera
Pterodroma nigripennis
Pterodroma solandri
Pterostylis cobarensis
Pultenaea maritima
Rutidosis leiolepis
Sarcochilus hartmannii
Sula dactylatra
Syzygium hodgkinsoniae
Syzygium moorei
Tetratheca glandulosa
Wilsonia backhousei
Zieria murphyi
Kunzea rupestris
Leionema ralstonii
Lepiderema pulchella
Leucopogon exolasius
Macadamia tetraphylla
Melaleuca biconvexa
Owenia cepiodora
Persoonia marginata
Phaethon rubricauda
Picris evae
Pomaderris pallida
Pomaderris parrisiae
Puffinus assimilis
Pultenaea glabra
Sophora fraseri
Symplocos baeuerlenii
Tasmannia glaucifolia
Tinospora tinosporoides
Zieria tuberculata

4. DISCUSSION

4.1 Why identify suitable climate for site-managed species?

This study demonstrates how interpreting habitat suitability models (HSMs) in relation to existing management practices can provide insight into potential conservation implications for threatened species. This approach is the first step to prioritising allocation of resources and resulting management actions according to the level of vulnerability of a species or site to climate change, a key priority for conservation policy-makers (Gallagher et al. 2015). The high level of threat to site-managed species including cumulative impacts from climate change and land use change, along with limited resources, has put a premium on identifying areas where investment will have greatest impact.

To allow for management decision-making based on climate change impacts assessments, and given uncertainty in the magnitude of warming and direction of precipitation trends, potential impacts to species' ranges need to be forecast, summarised and visualised across the range of plausible climate futures (Baumgartner et al. 2018, Beaumont et al. 2018). From a conservation perspective, areas where habitat suitability is projected under all plausible climate scenarios are a sensible priority for management. These areas are likely to be robust to future variation in regional climate, leading to greater confidence in the stability in habitat suitability for the species currently managed at these locations. My approach therefore provides valuable information for decision-makers, allowing them to visualise areas of vulnerability and security for site-managed species in NSW.

4.2 Climatic suitability for site-managed species

My results show how species restricted to fragmented patches of habitat, such as site-managed species, may be placed at risk by climate change when suitable climate shifts outside of their existing range. These types of changes are problematic for these species, since they are unlikely to shift their range to track the movement of climate zones. While my study focussed on site-managed species in NSW, the approach can be readily extended to other species and locations.

4.2.1 Which areas are likely to retain suitable habitat?

My analysis indicates that varying areas of suitable habitat will persist over species current ranges under all 12 plausible climate scenarios for 105 of the 238 species included in this study, i.e. suitable habitat is projected to be present under all climate scenarios at some or all sites and some or all occurrence locations for 2070. However, of these 105 species, only five (*Bertya opponens* (V), *Caladenia concolor* (E), *Eucalyptus largeana* (E), *Hibbertia superans* (E) and *Prostanthera densa* (V)) are projected to retain suitable habitat at *all sites under all climate scenarios*, and only one species (*Caladenia arenaria* (E)) is projected to retain suitable habitat at *all occurrence locations* outside of managed sites *under all climate scenarios*, by 2070. No Critically Endangered species are projected to retain suitability at all sites or all occurrence locations. Further, the species listed above are all plants: none of the 33 animal species included in this study were found to have suitable habitat across all managed sites or occurrence locations under all 12 climate scenarios for 2070. Overall results show a trend towards higher suitability for animal species in comparison to plant species: by 2070, on average 33.1% (± 40.8) of the area of sites managed for animal species is projected to remain suitable, compared to 20.2% (± 37.2) of the area for plant sites.

Across the 238 species included in this study, none were projected to retain suitable habitat at all sites and all occurrence locations under all plausible climate scenarios up to 2030 or 2070. Areas of greatest climatic stability differ when considering current managed sites in comparison to occurrence locations within NSW, indicating that no species are projected to remain completely secure across their range, under all plausible climate scenarios.

When considering GCM projections individually for 2070, suitability across species' ranges was generally highest under the Hotter/Little precipitation change scenario for managed-sites, and highest under the Warmer/Wetter scenario for locations with occurrence records. In general, suitability across species' ranges is likely to be more extensive in the temperate broadleaf (TBMF) and temperate and tropical grassland (TGSS, TrGSS) ecoregions (i.e. relatively high proportion of sites and occurrence records suitable within each biome) to 2070.

4.2.2 Which areas are most vulnerable to climate change?

Areas with suitable habitat are projected to contract for many species, shifting away from currently managed sites and other regions where these species have established populations. Shifts in habitat suitability may increase the likelihood of population extirpations due to poor habitat connectivity. This, in turn, may alter the ecological communities in which the threatened species currently occur.

By 2070, the species with greatest vulnerability to climate change are those projected to have no suitable habitat across any managed site or other regions with occurrences. Nineteen species fall within this category: *Acacia meiantha* (E), *Allocasuarina defungens* (E), *Burramys parvus* (E), *Cullen parvum* (E), *Diuris aequalis* (E), *Eucalyptus benthamii* (V), *Eucalyptus cannonii* (V), *Euphrasia scabra* (E), *Grevillea obtusiflora* (E), *Grevillea renwickiana* (E), *Grevillea rhizomatosa* (V), *Olearia flocktoniae* (E), *Persoonia bargoensis* (E), *Persoonia hindii* (E), *Plectranthus alloplectus* (E), *Pomaderris cocoparrana* (E), *Prostanthera stricta* (V), *Swainsona plagiotropis* (V) and *Veronica blakelyi* (V). Of these, only one is a fauna species (*Burramys parvus*); the remainder are plants. In addition, one fauna species, *Puffinus assimilis* (V), had no managed sites within the study area, and was projected to have no suitable habitat across any regions with occurrences. Four flora species, with no occurrence records remaining that were outside of current sites and in NSW, were also projected to have no suitable habitat at their respective sites under any of the plausible climate scenarios (*Boronia repanda* (E), *Myriophyllum implicatum* (CE), *Prasophyllum affine* (E) and *Pterostylis despectans* (CE)).

In general, the Hotter/Wetter scenario corresponded to the lowest suitability across managed sites and regions with occurrence records (i.e. the species' range within NSW) for 2070. The Mediterranean Forest (MFWS) ecoregion is projected to be the most vulnerable to climate change, with lowest retained suitability across species' ranges (i.e. lowest proportion of sites and occurrence locations suitable within this biome) to 2070.

4.3 What are the management implications of this study?

A key strength of my approach is that it identifies the areas within each species' range that are most likely to retain suitability under a range of plausible climate scenarios, whilst considering and conveying climate uncertainty (Baumgartner et al. 2018). The small number of species with all sites or occurrence locations remaining suitable to 2070 indicates that changes to management will be required for the majority of site-managed species. Varying levels of suitability are projected for the majority of species, ranging from suitability under limited numbers of future climate scenarios to complete consensus for some sites. The plasticity of these species to climate change should be assessed, and, if necessary, alternative or additional sites should be identified, based on future climatic suitability of regions with other populations, as well as consideration of other threats at the site level.

A minority of species (24) are projected to have no suitability under all climate scenarios at any sites or occurrence records by 2070. Of these species, 16 (*Allocasuarina defungens* (E), *Boronia repanda* (E), *Cullen parvum* (E), *Eucalyptus benthamii* (V), *Eucalyptus cannonii* (V), *Euphrasia scabra* (E), *Grevillea rhizomatosa* (V), *Myriophyllum implicatum* (CE), *Olearia flocktoniae* (E), *Persoonia bargoensis* (E), *Plectranthus alloplectus* (E), *Pomaderris cocoparrana* (E), *Prasophyllum affine* (E) *Prostanthera stricta* (V), *Puffinus assimilis* (V), *Swainsona plagiotropis* (V)) are projected to have suitable habitat outside of their current range up to 2070, while eight (*Acacia meiantha* (E), *Burramys parvus* (E), *Diuris aequalis* (E), *Grevillea obtusiflora* (E), *Grevillea renwickiana* (E), *Persoonia hindii* (E), *Pterostylis despectans* (CE), *Veronica blakelyi* (V)) have no suitable habitat projected in the study area. These species are highly vulnerable to climate change. Alternative management actions for these species are outlined below.

4.3.1 Assisted colonisation

Species with no projected climatic suitability within their current range could be considered as candidates for assisted colonisation, a form of conservation translocation which introduces species at risk of extinction to new habitats, in anticipation of higher habitat suitability (Gallagher et al. 2015, Rout et al. 2013, McDonald-Madden et al. 2011). Species at risk from climate change may, in some cases, adapt *in situ* or migrate (Hughes 2000), however, species lacking dispersal capability, with narrow distribution, or small effective population sizes, may be suitable candidates for assisted colonisation (Gallagher et al. 2015). It has been argued that failure to extend the range of species threatened by climate change will lead to their extinction (McLachlan et al. 2007, Hoegh-Guldberg et al. 2008, Thomas 2011). However, assisted colonisation involves risks, such as lack of knowledge of species ecology and potential invasiveness, and is likely to be costly in financial terms (Hancock & Gallagher 2014, Hewitt et al. 2011, Ricciardi & Simberloff 2009, Seddon et al. 2009).

4.3.2 *Ex situ* conservation

Species which have no projected climatic suitability within the study area may be best suited to *ex situ* conservation. However, further assessment would be required to determine whether these species possess suitable habitat outside of the study area. *Ex situ* conservation may be carried out by zoos, aquaria, botanical gardens, arboreta and seedbanks which breed animals or plants directly for conservation purposes, including reintroduction and population augmentation (Pritchard et al. 2011). This approach can be a useful tool to help recover threatened species (Bowkett 2009, Conde et al. 2011), however, it is also contentious due to the long-term commitment and financial investment required to achieve management objectives, and the resulting need to balance generation of revenue from visitors with achieving direct conservation (Canessa et al. 2015, Pritchard et al. 2011). As well as high costs, *ex situ* programs have been found to have low success rates, and may be unsuitable for species facing continuing threats, such as amphibian species threatened by disease (Fischer & Lindenmayer 2000, Tapley et al. 2015, Zippel et al. 2011). However, shifts in habitat suitability to outside protected areas may undermine the principle of *in situ* conservation for many species as the century progresses (Pritchard et al. 2011).

4.4 What are the strengths and limitations of this study?

This study analyses HSMs produced by a previous study (Beaumont et al. 2018), which determined habitat suitability for threatened species within the site-management stream of the Saving our Species program. Suitability was considered under a range of qualitatively distinct, but plausible climate futures, allowing selection of populations and managed sites that are relatively robust to uncertainty surrounding future climate change. Setting conservation priorities based on these results relies on the assumption that species will persist if their respective sites are projected to remain suitable across all plausible climate scenarios, since sites for each species were selected on the basis that they ensure the survival of species for the next 100 years (OEH 2013).

Estimating the environmental suitability for species relies on the assumption that the environmental tolerances and preferences of species are described by the location of their current populations (Elith & Leathwick 2009). This assumes that species are currently at equilibrium with their environment, without consideration of historical impacts on species, which means that extrapolating current correlations between species distributions and the environment into the future may lead to biased predictions (Barry & Elith 2006, Guisan & Thuiller 2005). Removal of populations with low spatial accuracy as part of the data cleaning process may result in underestimation of the number of populations that are projected to remain within suitable habitat for an individual species. However, this data cleaning process meant that the models used were likely to be of a high quality (Beaumont et al. 2018).

HSMs also exclude different dispersal scenarios and biotic interactions, both of which may change, leading to problems for predicting future distributions (Ashcroft 2010, Barry & Elith 2006). Responses of individual species are likely to occur at different rates, leading to changes in the composition of ecological communities that currently support site-managed species, which may result in cumulative impacts on these species (Ackerley 2003, Gallagher et al. 2013, Urban et al. 2012). Conversely, HSMs do not account for plasticity of species responses and adaptation to climate change, and therefore may overestimate the impacts of projected climate change on species. This study also assumed that species will be unable to disperse as the climate changes. Site-managed species are managed in this way because they are located at discrete sites with limited connectivity and therefore are unlikely to disperse significantly to track climate change. However, intrinsic traits that shape species' capacity to respond to climate change should be considered when determining appropriate management strategies (Butt & Gallagher 2018).

My results may also be sensitive to limitations inherent in the model used. Binary suitability values under each climate scenario were based on a subjective threshold for each species. While my choice of threshold minimises the combined omission and commission errors suffered by binary classifiers (Franklin 2010), this may be inconsistent with decision-makers' objectives, and other thresholds could be explored. Further, thresholding produced a value of zero or one for baseline conditions, and a range of values from zero to 12 when all plausible climate scenarios were considered for successive decades. As a result, suitability appears to drop between baseline conditions and succeeding decades, since areas that have low suitability may be excluded when a binary threshold is used.

This study bases suitability of sites on complete consensus under four GCMs, since scenarios are currently considered equally plausible (Evans et al. 2014). However, given that scenarios simulate different conditions, it is likely that suitability is underestimated by this study, and better estimates will be possible once it becomes apparent which scenario the climate will most closely track. An additional caveat is that HSMs may underestimate climate impact on species, since the HSM was calibrated with long-term averages in climate, and do not provide any indication of the likelihood nor impacts of extreme weather conditions e.g. extreme heat or drought, which will increase in frequency with climate change.

4.5 Future research directions

This study only included 238 of the approximately 440 site-managed species in NSW, since species were excluded from habitat suitability modelling for a variety of reasons including low numbers of occurrence records. An app is currently being developed by James Lawson which will provide an index of vulnerability of populations to climate change, based on the projected temperature and precipitation anomaly (R. Gallagher, pers. comm.). This will allow assessment of species with less than 20 occurrence records, and therefore comparison and reassessment of all managed sites, although HSMs provide a more detailed assessment of the impact of climate change on habitat suitability.

Previous studies undertaken with the support of the Office of Environment and Heritage (Gallagher et al. 2015, Hancock & Gallagher 2014) have considered potential for translocation of threatened species, including those which are predicted to lose all habitat within their existing range. However, translocation only contributes to conservation of individual species, and does not address broader scale conservation efforts focussing on conserving ecological communities. Responses of species to climate change are likely to vary, leading to changes in the composition of ecological communities, which translocation of individual species based on current research would not address (Urban et al. 2012, Gilman et al. 2010, Lavergne et al. 2010).

In addition, this research provides valuable information for decision-makers on areas of vulnerability for site-managed species. However, species included in this study are subject to historical and continuing threatening processes of varying extent and severity, e.g. land clearing, invasive species, and pathogens, in addition to climate change (OEH 2013). Habitat quality of sites and ecological knowledge for each species must also be considered when making decisions surrounding site-management and translocation of species, since these factors influence resilience to the stress of climate change (Field et al. 2014). Lack of knowledge of species biology and ecology has been identified as an impediment to decision-making surrounding conservation (Hancock & Gallagher 2014), and therefore research on individual threatened species is vital to application of climatic suitability research to these species.

5. CONCLUSION

The effective conservation of threatened species requires knowledge of where climatically suitable habitat is likely to persist under future climate change. Species which are unable to keep pace with shifting climatic zones through migration or adaptation, such as species with low dispersal potential or population sizes, are particularly vulnerable to climate change (Hoffman & Sgro 2011, Loarie et al. 2009). The approach undertaken in this study provides information that can be used to prioritise conservation actions for species at high risk, whilst explicitly incorporating climate uncertainty. I found that, as the century progresses, climatic suitability of habitat within species' respective ranges is projected to decline to varying degrees for the majority of site-managed species included in this study. However, the wide range of projected suitability values across managed sites and species' ranges highlights that reassessment of managed sites should be carried out on a species-by-species basis.

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SUPPLEMENTARY MATERIAL

Table S1 Descriptive statistics for all managed sites for 231 species listed under the *Biodiversity Conservation Act 2016,* in New South Wales. Complete consensus refers to the proportion of the managed site that is classified as climatically suitable under 12 scenarios of future climate. *For 2000, statistics reflect the proportion of site that is (1) suitable or (2) unsuitable under baseline conditions.

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
1) Proportion of site that has complete consensus (%)	2000*	84.02	1.14	31.45	0.00	89.41	100.00	100.00	100.00
	2010	59.40	1.57	43.34	0.00	0.01	82.21	100.00	100.00
	2020	37.51	1.56	43.27	0.00	0.00	5.44	91.39	100.00
	2030	24.71	1.40	38.81	0.00	0.00	0.00	48.63	100.00
	2040	30.55	1.49	41.37	0.00	0.00	0.00	76.03	100.00
	2050	30.27	1.51	41.78	0.00	0.00	0.00	77.23	100.00
	2060	26.38	1.45	40.10	0.00	0.00	0.00	55.47	100.00
	2070	22.26	1.37	38.03	0.00	0.00	0.00	38.25	100.00
2) Proportion of site that is suitable under no scenarios (%)	2000*	15.47	1.13	31.23	0.00	0.00	0.00	8.66	100.00
	2010	10.702	0.986	27.303	0.00	0.00	0.00	0.785	100.00
	2020	9.885	0.969	26.816	0.00	0.00	0.00	0.025	100.00
	2030	8.896	0.928	25.697	0.00	0.00	0.00	0.00	100.00
	2040	11.91	1.05	29.18	0.00	0.00	0.00	0.66	100.00
	2050	15.24	1.17	32.26	0.00	0.00	0.00	4.15	100.00
	2060	18.64	1.30	35.91	0.00	0.00	0.00	8.28	100.00
	2070	21.00	1.37	37.85	0.00	0.00	0.00	17.98	100.00
3) Median number of suitable scenarios across site	2010	9.644	0.141	3.907	0.000	9.000	12.000	12.000	12.000
	2020	8.520	0.144	3.996	0.000	6.000	10.000	12.000	12.000
	2030	7.682	0.144	3.988	0.000	5.000	9.000	11.000	12.000
	2040	7.526	0.156	4.323	0.000	4.000	9.000	12.000	12.000
	2050	7.180	0.164	4.548	0.000	3.000	8.000	12.000	12.000
	2060	6.773	0.168	4.645	0.000	2.000	7.500	12.000	12.000
	2070	6.375	0.167	4.626	0.000	1.000	7.000	11.000	12.000
4) Mean number of suitable scenarios across site	2010	9.407	0.135	3.738	0.000	8.197	11.476	12.000	12.000
	2020	8.364	0.138	3.825	0.000	5.951	9.672	11.810	12.000
	2030	7.564	0.139	3.850	0.000	4.612	8.489	11.000	12.000
	2040	7.421	0.150	4.162	0.000	3.892	8.390	11.502	12.000
	2050	7.066	0.159	4.396	0.000	3.000	8.015	11.509	12.000
	2060	6.666	0.162	4.495	0.000	2.194	7.335	11.058	12.000
	2070	6.276	0.162	4.479	0.000	1.595	6.661	10.796	12.000

Table S2 Descriptive statistics for all managed sites for 26 animal species and 205 plant species listed under the *Biodiversity Conservation Act 2016*, in New South Wales. Complete consensus refers to the proportion of the managed site that is classified as climatically suitable under 12 scenarios of future climate. *For 2000, statistics reflect the proportion of site that is (1) suitable or (2) unsuitable under baseline conditions.

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
Animals									
1) Proportion of site that has complete consensus (%)	2000*	76.21	3.07	33.76	0.00	59.91	94.08	99.91	100.00
	2010	63.31	3.40	37.40	0.00	28.32	78.45	98.04	100.00
	2020	43.38	3.56	39.15	0.00	0.80	38.10	86.16	100.00
	2030	31.57	3.46	38.06	0.00	0.00	8.80	65.15	100.00
	2040	35.12	3.55	39.00	0.00	0.00	15.02	76.09	100.00
	2050	35.98	3.65	40.18	0.00	0.00	16.44	80.46	100.00
	2060	35.23	3.70	40.67	0.00	0.00	9.65	82.48	100.00
	2070	33.13	3.71	40.80	0.00	0.00	5.13	76.97	100.00
2) Proportion of site that is suitable under no scenarios (%)	2000*	22.37	3.00	33.03	0.00	0.00	4.08	36.93	100.00
	2010	19.75	2.97	32.72	0.00	0.00	1.08	25.22	100.00
	2020	18.02	2.91	31.98	0.00	0.00	0.39	17.68	100.00
	2030	16.17	2.81	30.88	0.00	0.00	0.09	13.66	100.00
	2040	15.92	2.81	30.86	0.00	0.00	0.06	13.63	100.00
	2050	15.81	2.82	31.06	0.00	0.00	0.03	15.12	100.00
	2060	15.41	2.83	31.12	0.00	0.00	0.02	11.49	100.00
	2070	15.10	2.78	30.63	0.00	0.00	0.00	9.77	100.00
3) Median number of suitable scenarios across site	2010	9.325	0.421	4.616	0.000	9.125	12.000	12.000	12.000
	2020	8.446	0.405	4.441	0.000	5.250	10.000	12.000	12.000
	2030	7.679	0.390	4.275	0.000	4.000	9.000	12.000	12.000
	2040	7.792	0.397	4.353	0.000	4.125	9.000	12.000	12.000
	2050	7.787	0.399	4.369	0.000	4.125	9.000	12.000	12.000
	2060	7.625	0.403	4.412	0.000	4.000	9.000	12.000	12.000
	2070	7.338	0.407	4.457	0.000	3.625	8.000	12.000	12.000
4) Mean number of suitable scenarios across site	2010	8.758	0.376	4.137	0.000	6.368	10.949	11.898	12.000
	2020	8.075	0.368	4.049	0.000	5.295	9.433	11.625	12.000
	2030	7.432	0.360	3.960	0.000	4.673	8.140	11.105	12.000
	2040	7.547	0.367	4.037	0.000	4.403	8.296	11.318	12.000
	2050	7.459	0.372	4.096	0.000	4.340	8.378	11.318	12.000
	2060	7.277	0.375	4.130	0.000	4.037	7.917	11.400	12.000
	2070	7.057	0.380	4.185	0.000	3.886	7.874	11.186	12.000

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
Plants									
1) Proportion of site that has complete consensus (%)	2000*	85.49	1.21	30.81	0.00	94.08	100.00	100.00	100.00
	2010	58.66	1.75	44.35	0.00	0.00	83.11	100.00	100.00
	2020	36.41	1.73	43.94	0.00	0.00	0.00	95.18	100.00
	2030	23.42	1.53	38.84	0.00	0.00	0.00	43.65	100.00
	2040	29.69	1.64	41.77	0.00	0.00	0.00	75.95	100.00
	2050	29.20	1.65	42.02	0.00	0.00	0.00	76.19	100.00
	2060	24.72	1.57	39.81	0.00	0.00	0.00	50.40	100.00
	2070	20.22	1.46	37.17	0.00	0.00	0.00	14.04	100.00
2) Proportion of site that is suitable under no scenarios (%)	2000*	14.18	1.21	30.73	0.00	0.00	0.00	5.08	100.00
	2010	9.00	1.02	25.84	0.00	0.00	0.00	0.00	100.00
	2020	8.36	1.00	25.47	0.00	0.00	0.00	0.00	100.00
	2030	7.531	0.960	24.392	0.000	0.000	0.000	0.000	100.00
	2040	11.16	1.13	28.82	0.00	0.00	0.00	0.00	100.00
	2050	15.13	1.28	32.50	0.00	0.00	0.00	2.69	100.00
	2060	19.25	1.45	36.73	0.00	0.00	0.00	7.48	100.00
	2070	22.10	1.53	38.97	0.00	0.00	0.00	21.84	100.00
3) Median number of suitable scenarios across site	2010	9.704	0.148	3.762	0.000	9.000	12.000	12.000	12.000
	2020	8.533	0.154	3.911	0.000	6.000	10.000	12.000	12.000
	2030	7.682	0.155	3.935	0.000	5.000	9.000	11.000	12.000
	2040	7.477	0.170	4.319	0.000	4.000	9.000	12.000	12.000
	2050	7.067	0.180	4.575	0.000	3.000	8.000	12.000	12.000
	2060	6.615	0.184	4.673	0.000	1.000	7.000	11.000	12.000
	2070	6.195	0.183	4.638	0.000	1.000	6.500	11.000	12.000
4) Mean number of suitable scenarios across site	2010	9.529	0.144	3.649	0.000	8.446	11.582	12.000	12.000
	2020	8.418	0.149	3.783	0.000	5.994	9.691	11.874	12.000
	2030	7.589	0.151	3.831	0.000	4.611	8.556	11.000	12.000
	2040	7.398	0.165	4.187	0.000	3.855	8.390	11.547	12.000
	2050	6.992	0.175	4.449	0.000	2.845	8.000	11.546	12.000
	2060	6.552	0.179	4.555	0.000	1.835	7.000	11.046	12.000
	2070	6.129	0.178	4.520	0.000	1.150	6.467	10.601	12.000

Table S3 Descriptive statistics for all managed sites for 13 Critically Endangered species, 125 Endangered species and 93 Vulnerable species listed under the *Biodiversity Conservation Act 2016*, in New South Wales. Complete consensus refers to the proportion of the managed site that is classified as climatically suitable under 12 scenarios of future climate. *For 2000, statistics reflect the proportion of site that is (1) suitable or (2) unsuitable under baseline conditions.

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
Critically Endangered									
1) Proportion of site that has complete consensus (%)	2000*	64.16	5.76	38.65	0.00	32.81	86.79	99.79	100.00
	2010	45.34	6.03	40.43	0.00	0.93	33.72	92.17	100.00
	2020	31.72	5.91	39.62	0.00	0.00	5.43	69.01	100.00
	2030	26.53	5.68	38.09	0.00	0.00	0.00	52.55	100.00
	2040	33.76	6.09	40.83	0.00	0.00	5.33	76.26	100.00
	2050	33.02	5.99	40.18	0.00	0.00	1.98	71.01	100.00
	2060	29.19	5.90	39.55	0.00	0.00	1.94	57.97	100.00
	2070	26.30	6.09	40.88	0.00	0.00	0.00	59.90	100.00
2) Proportion of site that is suitable under no scenarios (%)	2000*	35.28	5.76	38.63	0.00	0.08	13.21	67.17	100.00
	2010	30.43	5.74	38.48	0.00	0.00	3.40	57.41	100.00
	2020	28.24	5.68	38.07	0.00	0.00	1.40	50.33	100.00
	2030	25.59	5.52	37.00	0.00	0.00	0.59	45.51	100.00
	2040	24.67	5.52	37.01	0.00	0.00	0.06	40.55	100.00
	2050	23.91	5.51	36.94	0.00	0.00	0.05	36.38	100.00
	2060	23.53	5.52	37.04	0.00	0.00	0.03	35.54	100.00
	2070	23.69	5.50	36.91	0.00	0.00	0.11	42.62	100.00
3) Median number of suitable scenarios across site	2010	7.322	0.781	5.239	0.000	0.000	10.000	12.000	12.000
	2020	6.744	0.731	4.903	0.000	1.000	8.000	12.000	12.000
	2030	6.433	0.706	4.739	0.000	2.000	6.000	11.750	12.000
	2040	6.733	0.726	4.872	0.000	2.000	7.000	12.000	12.000
	2050	6.878	0.735	4.929	0.000	1.500	8.000	12.000	12.000
	2060	6.622	0.722	4.844	0.000	1.000	8.000	12.000	12.000
	2070	6.256	0.709	4.756	0.000	0.500	6.000	12.000	12.000
4) Mean number of suitable scenarios across site	2010	7.167	0.672	4.510	0.000	3.591	8.209	11.646	12.000
	2020	6.725	0.655	4.393	0.000	2.727	8.060	11.033	12.000
	2030	6.354	0.651	4.365	0.000	2.527	6.329	10.974	12.000
	2040	6.620	0.678	4.549	0.000	2.359	6.438	11.315	12.000
	2050	6.590	0.690	4.629	0.000	1.133	7.635	11.037	12.000
	2060	6.380	0.674	4.519	0.000	1.034	7.451	11.001	12.000
	2070	6.039	0.665	4.460	0.000	1.143	4.940	10.066	12.000

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
Endangered									
1) Proportion of site that has complete consensus (%)	2000*	85.36	1.42	29.83	0.00	91.37	100.00	100.00	100.00
	2010	59.65	2.06	43.42	0.00	0.00	83.11	100.00	100.00
	2020	37.64	2.07	43.67	0.00	0.00	2.69	92.74	100.00
	2030	24.88	1.86	39.10	0.00	0.00	0.00	49.22	100.00
	2040	30.95	1.99	41.86	0.00	0.00	0.00	77.64	100.00
	2050	30.56	2.01	42.31	0.00	0.00	0.00	80.14	100.00
	2060	25.73	1.91	40.24	0.00	0.00	0.00	53.85	100.00
	2070	22.27	1.83	38.43	0.00	0.00	0.00	35.99	100.00
2) Proportion of site that is suitable under no scenarios (%)	2000*	14.10	1.41	29.71	0.00	0.00	0.00	6.92	100.00
	2010	9.84	1.25	26.26	0.00	0.00	0.00	0.01	100.00
	2020	9.46	1.26	26.42	0.00	0.00	0.00	0.00	100.00
	2030	9.29	1.26	26.61	0.00	0.00	0.00	0.00	100.00
	2040	12.68	1.45	30.46	0.00	0.00	0.00	0.68	100.00
	2050	16.09	1.58	33.28	0.00	0.00	0.00	7.27	100.00
	2060	17.97	1.68	35.36	0.00	0.00	0.00	7.16	100.00
	2070	19.52	1.74	36.73	0.00	0.00	0.00	10.49	100.00
3) Median number of suitable scenarios across site	2010	9.708	0.183	3.843	0.000	9.000	12.000	12.000	12.000
	2020	8.489	0.190	3.997	0.000	6.000	10.000	12.000	12.000
	2030	7.580	0.189	3.976	0.000	5.000	8.000	11.000	12.000
	2040	7.435	0.206	4.327	0.000	4.000	9.000	12.000	12.000
	2050	7.117	0.214	4.505	0.000	3.000	8.000	12.000	12.000
	2060	6.726	0.216	4.556	0.000	3.000	7.000	12.000	12.000
	2070	6.371	0.216	4.547	0.000	2.000	6.500	11.000	12.000
4) Mean number of suitable scenarios across site	2010	9.448	0.175	3.686	0.000	8.346	11.502	12.000	12.000
	2020	8.315	0.182	3.823	0.000	5.871	9.604	11.833	12.000
	2030	7.470	0.182	3.831	0.000	4.751	8.000	11.000	12.000
	2040	7.327	0.197	4.145	0.000	3.838	8.000	11.538	12.000
	2050	6.999	0.206	4.343	0.000	3.291	7.777	11.538	12.000
	2060	6.612	0.210	4.410	0.000	2.889	7.000	11.000	12.000
	2070	6.273	0.209	4.402	0.000	2.000	6.372	10.690	12.000

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
Vulnerable									
1) Proportion of site that has complete consensus (%)	2000*	85.11	1.90	31.73	0.00	92.58	100.00	100.00	100.00
	2010	61.27	2.60	43.40	0.00	0.97	88.21	100.00	100.00
	2020	38.25	2.60	43.29	0.00	0.00	8.00	94.03	100.00
	2030	24.15	2.31	38.58	0.00	0.00	0.00	48.77	100.00
	2040	29.40	2.44	40.76	0.00	0.00	0.00	63.54	100.00
	2050	29.37	2.48	41.30	0.00	0.00	0.00	71.72	100.00
	2060	26.96	2.40	40.08	0.00	0.00	0.00	61.61	100.00
	2070	21.59	2.22	36.99	0.00	0.00	0.00	34.99	100.00
2) Proportion of site that is suitable under no scenarios (%)	2000*	14.46	1.88	31.30	0.00	0.00	0.00	6.95	100.00
	2010	8.89	1.54	25.61	0.00	0.00	0.00	0.38	100.00
	2020	7.60	1.45	24.12	0.00	0.00	0.00	0.00	100.00
	2030	5.57	1.23	20.50	0.00	0.00	0.00	0.00	100.00
	2040	8.62	1.49	24.79	0.00	0.00	0.00	0.00	100.00
	2050	12.47	1.77	29.49	0.00	0.00	0.00	1.34	100.00
	2060	18.92	2.20	36.66	0.00	0.00	0.00	7.65	100.00
	2070	22.91	2.38	39.74	0.00	0.00	0.00	23.60	100.00
3) Median number of suitable scenarios across site	2010	9.921	0.219	3.644	0.000	9.000	12.000	12.000	12.000
	2020	8.857	0.226	3.761	0.000	6.000	11.000	12.000	12.000
	2030	8.047	0.230	3.836	0.000	5.000	9.000	11.250	12.000
	2040	7.801	0.253	4.216	0.000	4.000	9.500	12.000	12.000
	2050	7.329	0.274	4.566	0.000	3.000	9.000	12.000	12.000
	2060	6.874	0.286	4.767	0.000	1.000	8.000	12.000	12.000
	2070	6.399	0.285	4.747	0.000	1.000	7.000	11.000	12.000
4) Mean number of suitable scenarios across site	2010	9.704	0.214	3.574	0.000	8.964	11.685	12.000	12.000
	2020	8.706	0.220	3.671	0.000	6.124	10.032	11.835	12.000
	2030	7.909	0.225	3.756	0.000	5.000	9.000	11.012	12.000
	2040	7.701	0.247	4.114	0.000	4.051	9.071	11.501	12.000
	2050	7.249	0.267	4.448	0.000	2.826	8.544	11.537	12.000
	2060	6.799	0.278	4.637	0.000	1.361	8.000	11.324	12.000
	2070	6.318	0.277	4.616	0.000	1.000	7.160	11.000	12.000

Table S4 Descriptive statistics for all occurrence records for 233 species listed under the *Biodiversity Conservation Act 2016*, in New South Wales. Complete consensus refers to the proportion of the 1km buffer that is classified as climatically suitable under 12 scenarios of future climate. *For 2000, statistics reflect the proportion of site that is (1) suitable or (2) unsuitable under baseline conditions.

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
1) Proportion of buffer that has complete consensus (%)	2000*	84.551	0.295	33.257	0.00	100.00	100.00	100.00	100.00
	2010	66.487	0.385	43.431	0.00	4.682	100.00	100.00	100.00
	2020	46.388	0.414	46.736	0.00	0.00	29.094	100.00	100.00
	2030	33.119	0.393	44.339	0.00	0.00	0.00	98.095	100.00
	2040	38.402	0.407	45.881	0.00	0.00	0.00	100.00	100.00
	2050	38.263	0.409	46.119	0.00	0.00	0.00	100.00	100.00
	2060	35.265	0.404	45.598	0.00	0.00	0.00	100.00	100.00
	2070	31.604	0.395	44.491	0.00	0.00	0.00	99.683	100.00
2) Proportion of buffer that is suitable under no scenarios (%)	2000*	15.449	0.295	33.257	0.00	0.00	0.00	0.00	100.00
	2010	11.303	0.261	29.421	0.00	0.00	0.00	0.00	100.00
	2020	9.61	0.244	27.518	0.00	0.00	0.00	0.00	100.00
	2030	9.06	0.238	26.864	0.00	0.00	0.00	0.00	100.00
	2040	10.783	0.258	29.128	0.00	0.00	0.00	0.00	100.00
	2050	12.413	0.274	30.929	0.00	0.00	0.00	0.00	100.00
	2060	14.203	0.292	32.907	0.00	0.00	0.00	0.00	100.00
	2070	15.408	0.303	34.151	0.00	0.00	0.00	0.00	100.00
3) Median number of suitable scenarios across buffer	2010	9.7527	0.0363	4.0886	0.00	10.00	12.00	12.00	12.00
	2020	8.9002	0.0362	4.0822	0.00	7.00	11.00	12.00	12.00
	2030	8.1544	0.0363	4.0953	0.00	5.00	10.00	12.00	12.00
	2040	8.0932	0.0383	4.3156	0.00	5.00	10.00	12.00	12.00
	2050	7.8511	0.0397	4.4774	0.00	4.00	10.00	12.00	12.00
	2060	7.5192	0.0405	4.5692	0.00	3.00	9.00	12.00	12.00
	2070	7.2063	0.0408	4.5995	0.00	3.00	8.00	12.00	12.00
4) Mean number of suitable scenarios across buffer	2010	9.6358	0.0349	3.9306	0.00	9.00	12.00	12.00	12.00
	2020	8.8136	0.0352	3.9688	0.00	6.5714	10.857	12.00	12.00
	2030	8.0886	0.0354	3.9924	0.00	5.1667	9.50	11.875	12.00
	2040	8.027	0.0374	4.216	0.00	4.75	9.7143	12.00	12.00
	2050	7.7935	0.0388	4.3783	0.00	4.00	9.5278	12.00	12.00
	2060	7.4794	0.0396	4.4696	0.00	3.375	9.00	12.00	12.00
	2070	7.1676	0.0399	4.5014	0.00	3.00	8.2222	11.889	12.00

Table S5 Descriptive statistics for all occurrence records for 32 animal species and 201 plant species listed under the *Biodiversity Conservation Act 2016*, in New South Wales. Complete consensus refers to the proportion of the 1km buffer that is classified as climatically suitable under 12 scenarios of future climate. *For 2000, statistics reflect the proportion of site that is (1) suitable or (2) unsuitable under baseline conditions.

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
Animals									
1) Proportion of buffer that has complete consensus (%)	2000*	82.55	0.502	35.505	0.00	99.485	100.00	100.00	100.00
	2010	71.398	0.597	42.228	0.00	25.744	100.00	100.00	100.00
	2020	57.989	0.656	46.344	0.00	0.00	94.249	100.00	100.00
	2030	48.376	0.666	47.11	0.00	0.00	39.796	100.00	100.00
	2040	51.357	0.669	47.271	0.00	0.00	59.031	100.00	100.00
	2050	52.422	0.671	47.42	0.00	0.00	69.149	100.00	100.00
	2060	52.65	0.675	47.684	0.00	0.00	73.482	100.00	100.00
	2070	51.77	0.677	47.875	0.00	0.00	68.79	100.00	100.00
2) Proportion of buffer that is suitable under no scenarios (%)	2000*	17.45	0.502	35.505	0.00	0.00	0.00	0.515	100.00
	2010	14.26	0.464	32.794	0.00	0.00	0.00	0.00	100.00
	2020	12.174	0.436	30.786	0.00	0.00	0.00	0.00	100.00
	2030	11.088	0.419	29.648	0.00	0.00	0.00	0.00	100.00
	2040	11.248	0.422	29.821	0.00	0.00	0.00	0.00	100.00
	2050	10.936	0.416	29.425	0.00	0.00	0.00	0.00	100.00
	2060	10.215	0.404	28.563	0.00	0.00	0.00	0.00	100.00
	2070	9.339	0.386	27.27	0.00	0.00	0.00	0.00	100.00
3) Median number of suitable scenarios across buffer	2010	9.6406	0.0625	4.4182	0.00	10.5	12.00	12.00	12.00
	2020	9.1312	0.0615	4.3497	0.00	7.00	12.00	12.00	12.00
	2030	8.6602	0.0613	4.3305	0.00	6.00	11.00	12.00	12.00
	2040	8.7311	0.0618	4.3709	0.00	6.00	12.00	12.00	12.00
	2050	8.7019	0.0625	4.4185	0.00	5.00	12.00	12.00	12.00
	2060	8.6839	0.0623	4.4058	0.00	5.00	12.00	12.00	12.00
	2070	8.6573	0.0619	4.3751	0.00	5.00	12.00	12.00	12.00
4) Mean number of suitable scenarios across buffer	2010	9.5647	0.0598	4.2304	0.00	9.2222	12.00	12.00	12.00
	2020	9.07	0.0595	4.2081	0.00	7.00	11.75	12.00	12.00
	2030	8.6104	0.0595	4.2033	0.00	5.875	11.00	12.00	12.00
	2040	8.6762	0.0602	4.2528	0.00	5.8571	11.00	12.00	12.00
	2050	8.6592	0.0608	4.2998	0.00	5.4444	11.2	12.00	12.00
	2060	8.642	0.0608	4.2968	0.00	5.125	11.25	12.00	12.00
	2070	8.6155	0.0604	4.2688	0.00	5.00	11.25	12.00	12.00

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
Plants									
1) Proportion of buffer that has complete consensus (%)	2000*	85.846	0.36	31.652	0.00	100	100	100.00	100.00
	2010	63.308	0.5	43.903	0.00	0.00	97.152	100.00	100.00
	2020	38.876	0.517	45.437	0.00	0.00	0.00	100.00	100.00
	2030	23.24	0.449	39.417	0.00	0.00	0.00	35.031	100.00
	2040	30.014	0.489	42.924	0.00	0.00	0.00	83.599	100.00
	2050	29.095	0.488	42.832	0.00	0.00	0.00	81.528	100.00
	2060	24.007	0.46	40.384	0.00	0.00	0.00	40.095	100.00
	2070	18.546	0.417	36.654	0.00	0.00	0.00	0.00	100.00
2) Proportion of buffer that is suitable under no scenarios (%)	2000*	14.154	0.36	31.652	0.00	0.00	0.00	0.00	100.00
	2010	9.387	0.306	26.843	0.00	0.00	0.00	0.00	100.00
	2020	7.949	0.285	25.04	0.00	0.00	0.00	0.00	100.00
	2030	7.747	0.282	24.81	0.00	0.00	0.00	0.00	100.00
	2040	10.481	0.326	28.669	0.00	0.00	0.00	0.00	100.00
	2050	13.369	0.362	31.831	0.00	0.00	0.00	0.00	100.00
	2060	16.786	0.401	35.199	0.00	0.00	0.00	0.00	100.00
	2070	19.338	0.426	37.427	0.00	0.00	0.00	1.6	100.00
3) Median number of suitable scenarios across buffer	2010	9.8253	0.0439	3.8588	0.00	9.50	12.00	12.00	12.00
	2020	8.7507	0.0443	3.8923	0.00	6.50	10.5	12.00	12.00
	2030	7.8268	0.0444	3.901	0.00	5.00	9.00	11.00	12.00
	2040	7.6801	0.0481	4.2287	0.00	4.00	9.00	12.00	12.00
	2050	7.3001	0.0504	4.429	0.00	3.00	8.00	12.00	12.00
	2060	6.7649	0.0514	4.5147	0.00	2.50	7.00	11.00	12.00
	2070	6.2667	0.0512	4.4961	0.00	2.00	6.00	11.00	12.00
4) Mean number of suitable scenarios across buffer	2010	9.6818	0.0424	3.7231	0.00	8.875	11.857	12.00	12.00
	2020	8.6475	0.0432	3.7968	0.00	6.4286	10.167	12.00	12.00
	2030	7.7508	0.0434	3.8121	0.00	5.00	8.6667	11.111	12.00
	2040	7.6066	0.0471	4.1384	0.00	4.3333	8.6667	11.667	12.00
	2050	7.233	0.0494	4.3375	0.00	3.3333	8.00	11.667	12.00
	2060	6.7266	0.0503	4.418	0.00	2.5714	7.1429	11.00	12.00
	2070	6.23	0.0501	4.3987	0.00	2.00	6.375	10.75	12.00

Table S6 Descriptive statistics for all occurrence records for 11 Critically Endangered species, 122 Endangered species and 100 Vulnerable species listed under the *Biodiversity Conservation Act 2016*, in New South Wales. Complete consensus refers to the proportion of the 1km buffer that is classified as climatically suitable under 12 scenarios of future climate. *For 2000, statistics reflect the proportion of site that is (1) suitable or (2) unsuitable under baseline conditions.

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
Critically Endangered									
1) Proportion of buffer that has complete consensus (%)	2000*	76.27	1.22	39.17	0.00	61.57	100.00	100.00	100.00
	2010	58.94	1.45	46.61	0.00	0.00	98.43	100.00	100.00
	2020	48.27	1.50	47.99	0.00	0.00	37.29	100.00	100.00
	2030	40.94	1.48	47.39	0.00	0.00	0.00	100.00	100.00
	2040	43.62	1.49	47.95	0.00	0.00	0.00	100.00	100.00
	2050	45.22	1.50	48.02	0.00	0.00	3.05	100.00	100.00
	2060	44.56	1.50	48.04	0.00	0.00	0.00	100.00	100.00
	2070	42.35	1.50	48	0.00	0.00	0.00	100.00	100.00
2) Proportion of buffer that is suitable under no scenarios (%)	2000*	23.73	1.22	39.17	0.00	0.00	0.00	38.43	100.00
	2010	17.16	1.07	34.42	0.00	0.00	0.00	3.73	100.00
	2020	12.868	0.959	30.777	0.00	0.00	0.00	0.00	100.00
	2030	10.992	0.898	28.81	0.00	0.00	0.00	0.00	100.00
	2040	11.923	0.925	29.692	0.00	0.00	0.00	0.00	100.00
	2050	11.905	0.937	30.084	0.00	0.00	0.00	0.00	100.00
	2060	9.631	0.843	27.059	0.00	0.00	0.00	0.00	100.00
	2070	7.244	0.734	23.565	0.00	0.00	0.00	0.00	100.00
3) Median number of suitable scenarios across buffer	2010	8.723	0.15	4.809	0.00	5.00	12.00	12.00	12.00
	2020	8.167	0.144	4.637	0.00	4.00	11.00	12.00	12.00
	2030	7.806	0.14	4.506	0.00	4.00	10.00	12.00	12.00
	2040	7.869	0.144	4.625	0.00	4.00	10.75	12.00	12.00
	2050	7.85	0.147	4.72	0.00	3.00	11.00	12.00	12.00
	2060	7.891	0.142	4.563	0.00	3.00	10.00	12.00	12.00
	2070	7.881	0.137	4.412	0.00	4.00	10.00	12.00	12.00
4) Mean number of suitable scenarios across buffer	2010	8.647	0.142	4.57	0.00	5.00	11.866	12.00	12.00
	2020	8.11	0.139	4.471	0.00	4.202	10.69	12.00	12.00
	2030	7.765	0.137	4.381	0.00	4.00	9.50	12.00	12.00
	2040	7.828	0.14	4.504	0.00	3.741	10.00	12.00	12.00
	2050	7.803	0.143	4.599	0.00	3.138	10.225	12.00	12.00
	2060	7.838	0.14	4.478	0.00	3.333	10.00	12.00	12.00
	2070	7.842	0.135	4.332	0.00	3.625	9.625	12.00	12.00

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
Endangered									
1) Proportion of buffer that has complete consensus (%)	2000*	83.301	0.454	34.2	0.00	97.436	100.00	100.00	100.00
	2010	62.828	0.587	44.193	0.00	0.00	97.143	100.00	100.00
	2020	43.9	0.613	46.178	0.00	0.00	17.778	100.00	100.00
	2030	32.017	0.577	43.481	0.00	0.00	0.00	89.985	100.00
	2040	36.419	0.599	45.098	0.00	0.00	0.00	100.00	100.00
	2050	36.978	0.604	45.488	0.00	0.00	0.00	100.00	100.00
	2060	33.884	0.597	44.981	0.00	0.00	0.00	100.00	100.00
	2070	31.415	0.588	44.313	0.00	0.00	0.00	97.774	100.00
2) Proportion of buffer that is suitable under no scenarios (%)	2000*	16.699	0.454	34.2	0.00	0.00	0.00	2.564	100.00
	2010	13.072	0.415	31.297	0.00	0.00	0.00	0.00	100.00
	2020	11.343	0.392	29.526	0.00	0.00	0.00	0.00	100.00
	2030	10.835	0.385	28.989	0.00	0.00	0.00	0.00	100.00
	2040	12.753	0.415	31.291	0.00	0.00	0.00	0.00	100.00
	2050	14.282	0.435	32.787	0.00	0.00	0.00	0.00	100.00
	2060	15.54	0.453	34.104	0.00	0.00	0.00	0.00	100.00
	2070	16.416	0.461	34.717	0.00	0.00	0.00	0.00	100.00
3) Median number of suitable scenarios across buffer	2010	9.4952	0.0564	4.2458	0.00	9.00	12.00	12.00	12.00
	2020	8.545	0.0562	4.2309	0.00	6.00	11.00	12.00	12.00
	2030	7.7651	0.0561	4.2295	0.00	5.00	9.00	12.00	12.00
	2040	7.6833	0.0588	4.4269	0.00	4.00	9.00	12.00	12.00
	2050	7.4698	0.0606	4.5694	0.00	3.00	9.00	12.00	12.00
	2060	7.1467	0.0617	4.6457	0.00	3.00	8.00	12.00	12.00
	2070	6.8834	0.062	4.6708	0.00	2.00	7.50	12.00	12.00
4) Mean number of suitable scenarios across buffer	2010	9.3641	0.0538	4.0515	0.00	8.25	11.857	12.00	12.00
	2020	8.4469	0.0541	4.0773	0.00	6.00	10.143	12.00	12.00
	2030	7.6943	0.0543	4.0909	0.00	4.6667	8.7143	11.691	12.00
	2040	7.6121	0.057	4.2944	0.00	4.125	8.8571	12.00	12.00
	2050	7.408	0.0589	4.4392	0.00	3.4286	8.5714	12.00	12.00
	2060	7.1068	0.0599	4.5122	0.00	3.00	7.875	12.00	12.00
	2070	6.8383	0.0603	4.5455	0.00	2.625	7.3333	11.857	12.00

Variable	year	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
Vulnerable									
1) Proportion of buffer that has complete consensus (%)	2000*	87.151	0.398	30.869	0.00	100.00	100.00	100.00	100.00
	2010	71.24	0.537	41.591	0.00	30.928	100.00	100.00	100.00
	2020	48.416	0.606	46.936	0.00	0.00	40.836	100.00	100.00
	2030	32.821	0.574	44.476	0.00	0.00	0.00	100.00	100.00
	2040	39.381	0.596	46.157	0.00	0.00	0.00	100.00	100.00
	2050	38.284	0.597	46.28	0.00	0.00	0.00	100.00	100.00
	2060	34.976	0.588	45.572	0.00	0.00	0.00	100.00	100.00
	2070	29.941	0.565	43.783	0.00	0.00	0.00	93.968	100.00
2) Proportion of buffer that is suitable under no scenarios (%)	2000*	12.849	0.398	30.869	0.00	0.00	0.00	0.00	100.00
	2010	8.626	0.338	26.223	0.00	0.00	0.00	0.00	100.00
	2020	7.413	0.318	24.642	0.00	0.00	0.00	0.00	100.00
	2030	7.052	0.312	24.157	0.00	0.00	0.00	0.00	100.00
	2040	8.725	0.344	26.673	0.00	0.00	0.00	0.00	100.00
	2050	10.733	0.376	29.117	0.00	0.00	0.00	0.00	100.00
	2060	13.724	0.42	32.589	0.00	0.00	0.00	0.00	100.00
	2070	15.855	0.451	34.956	0.00	0.00	0.00	0.00	100.00
3) Median number of suitable scenarios across buffer	2010	10.173	0.0482	3.737	0.00	11.00	12.00	12.00	12.00
	2020	9.3616	0.0487	3.7749	0.00	8.00	11.00	12.00	12.00
	2030	8.582	0.0496	3.843	0.00	6.00	10.00	12.00	12.00
	2040	8.5191	0.053	4.1096	0.00	6.00	10.50	12.00	12.00
	2050	8.2117	0.0557	4.3148	0.00	5.00	10.00	12.00	12.00
	2060	7.8073	0.0577	4.471	0.00	4.00	10.00	12.00	12.00
	2070	7.3957	0.0586	4.5403	0.00	3.00	9.00	12.00	12.00
4) Mean number of suitable scenarios across buffer	2010	10.062	0.0469	3.632	0.00	10.222	12.00	12.00	12.00
	2020	9.2807	0.0479	3.7113	0.00	7.75	11.125	12.00	12.00
	2030	8.5168	0.0488	3.7798	0.00	6.125	10.00	12.00	12.00
	2040	8.4531	0.0522	4.0458	0.00	5.875	10.333	12.00	12.00
	2050	8.1562	0.0548	4.2495	0.00	5.1111	10.00	12.00	12.00
	2060	7.7701	0.0568	4.4013	0.00	4.1667	9.4286	12.00	12.00
	2070	7.3632	0.0576	4.4643	0.00	3.25	8.6667	11.833	12.00