Australian Eucalypt Red List Assessments

Methodology for assessing the Red List status of Australian eucalypts

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1. Introduction

The 'eucalypts' comprise three related genera within the Myrtaceae family; *Eucalyptus*, *Corymbia* and *Angophora*, which collectively include more than 800 species and define the landscape of an entire continent. Almost all eucalypts are endemic to Australia, where they occupy a near-continuous distribution across almost all habitat types; from mesic forest to semi-desert and mountains. Australia has been subjected to rapid landscape transformation throughout 230 years, since European colonisation. This has resulted in, among other consequences, Australia being identified as having the highest rate of mammal extinction in the world, including many characteristic marsupials (Woinarski *et al*. 2012). An assessment of the threat status of the eucalypts will further highlight conservation issues at the continental-scale of Australia through the lens of the dominant tree genera.

The current most widely accepted framework for assessing extinction risk of biota is the International Union for Conservation of Nature's (IUCN) Red List Categories and Criteria (version 3.1) (IUCN 2012). These define extinction risk categories based on quantitative thresholds relating to geographic range, population size and rate of decline (Mace *et al*. 2008, IUCN 2012). Currently accepted State and Federal lists for threatened flora have a range of biases and currencies, and often do not align with the IUCN Red List methodologies (Brito *et al*. 2010). The IUCN Red List is out of step with listings under Australian jurisdictions and in 2019 (IUCN Red List 2019.2) only two assessments of eucalypts were included.

The Global Tree Assessment is an initiative led by Botanic Gardens Conservation International and the IUCN Species Survival Commission (SSC) Global Tree Specialist Group that aims to complete conservation assessments for all tree species worldwide by 2020 (Beech *et al*. 2017, Rivers 2017). As the third largest tree genus in the world (Beech *et al*. 2017), an assessment of *Eucalyptus* and its relatives will provide a major augmentation to this effort. In addition, there have been recent advances in conservation assessment procedures within Australia. Foremost, an emphasis has been placed on documenting species that have undergone significant declines relative to naturally rare species which lack conceivable past and future threats (McIntyre *et al*. 1992, Burgman 2002, Silcock *et al*. 2014). However, listing under IUCN Red List Criterion A has rarely been employed, as the time-series data required to undertake these analyses is often limited or unavailable (Brummitt *et al*. 2015). This tends to result in a preponderance for listing narrow-range species (assessed under criterion B) and species with small population sizes (assessed under criteria C or D) (Collen *et al*. 2016). This bias may be misleading for conservation decision-makers, as naturally narrow-range species often have pre-adaptations for survival in small populations (Flather and Sieg 2007, Yates *et al*. 2007, Bezemer *et al*. 2016) and common, widespread, yet rapidly declining species are overlooked due to apparent abundance (Lindenmayer *et al.* 2011). Emphasis on decline rather than rarity per se is reflected in the recent versions of the Red List procedures (IUCN 2012), but threatened species lists in Australia, typically have not been updated accordingly. There is an urgent need to identify methodologies that quantify past decline for assessment under criterion A and forecast future continuing declines under criteria A, B and C (Brummitt *et al*. 2015).

Assessing large and related groups of taxa, such as the eucalypts, overcomes the limitations of using variable methodologies over small, species-specific scales (Possingham *et al*. 2002). A continental assessment also allows regional conservation hotspots to be identified (Brummitt *et al*. 2015). Many eucalypts are also keystone species that provide the physical framework of the ecosystem where they occur; hollows for nesting and shelter, foliage for herbivores, pollen and nectar, nutrient cycling, and litter and fallen branches for ground-dwelling fauna. The current study aims to:

(i) provide Red List assessments of all *Eucalyptus*, *Corymbia* and *Angophora* species within Australia;
(ii) guide future conservation assessment methodologies emphasising genuine species' declines;
(iii) identify the range of threats to the eucalypts; and
(iv) identify regional hotspots for eucalypt conservation with recommendations to address conservation issues.

2. Methods

Eucalypts have relatively open breeding systems with considerable gene flow between related species (Potts and Wiltshire 1997). Hybrids are especially common within subgenera, and species regularly exhibit morphological gradations with intermediate characteristics. It is therefore inevitable that the taxonomic status of the eucalypts will continue to be reviewed. The list assessed here includes the 822 described species occurring in Australia accepted by the Australian Plant Census (Australian Plant Name Index, accessed May 2019), excluding clearly erroneous names (n = 24). Infraspecific taxa were not included.

Species' geographic ranges were determined by 'cleaning' herbarium specimen records in consultation with herbarium curators, other experts and reference to distribution maps (Brooker and Kleinig 1994, 2001, 2006; Williams and Potts 1996; French 2012; French and Nicolle 2019; Nicolle 2006a, 2013; French unpublished data). A 'geographic range' is defined here as the area encompassing the distribution of the species. Herbarium specimen data often includes errors associated with misidentified taxa, specimens representing species intergrading with other species and erroneous geocoding. Although there are numerous additional data sources, including field survey datasets, these were not utilised due to the difficulty of cleaning records that are not substantiated by a specimen. According to experts, specimen records generally represented species' geographic ranges. Specimen location data were converted to geographic ranges using either a convex polygon or a more-idiosyncratic polygon as guided by geographic features. For example, the distribution of lowland species often excluded areas that exceeded the highest altitude record. The 'geographic range' of a species is less than the extent of occurrence (EOO), which must be a minimum convex polygon (IUCN Red List Technical Working Group 2018), and often more than area of occupancy (AOO), which with adequate data represents the known area of the species measured using a 2 × 2 km grid.

The procedures adopted here follow the IUCN Red List Categories and Criteria, but are conservative, in that the estimations of generation length and decline are likely to underestimate threat status. This provides a high degree of certainty that the thresholds for threat criteria are satisfied but may have resulted in an underestimation of the threat status for some species under criterion A2.

2.1 Generation length

The generation length metric used for IUCN Red List assessments can be determined as age of first reproduction + z * length of reproductive period (IUCN Standards and Petitions Subcommittee 2017). While the time to seeding has not been quantified for many eucalypts, it can be as rapid as 40 months for species from Western Australia (Nicolle 2006b) and up to 20 years for the obligate-seeder *Eucalyptus regnans* (Ashton and Attiwill 1994). The lifespan of tropical eucalypts has been assessed by growth rates, which are reasonably independent of tree size (Cook *et al*. 2015, Fensham *et al*. 2017). Growth rates in the order of 1.5 to 2 mm per annum indicate a tree of 50 cm diameter at breast height is aged between 250 and 330 years (Murphy *et al*. 2010, Fensham *et al*. 2017). Some large *E. regnans* are estimated at 500 years old (Wood *et al*. 2010) and large lignotubers of other species are of similar age (Lacey and Head 1988) or older (Kennington and James 1997, Tyson *et al*. 1998). Values of z for a long-lived tree *Araucaria cunninghamii* have been calculated as 0.33 (Fung and Waples 2017). Using this z-value for all eucalypts appears to give a reasonable result. It is therefore assumed that a minimum value for generation length for eucalypts is 4 (minimum age of first reproduction) + 0.33 * 200 (minimum age of large tree) = 70 years. Criterion A of the IUCN assesses past decline relative to three generations. For eucalypts this is >210 years and thus prior to extensive clearance of eucalypts after 1810 following European colonisation.

2.2 Assessment of deforestation as a past threat

When assessing under criterion A it is necessary to estimate the population size reduction, either in the past (A1 and A2), future (A3) or a combination of the two (A4). For eucalypts in Australia, percentage declines over the past three generations (210 years) can be estimated by determining the extent of decline, assuming that populations were more or less stable prior to European colonisation. Land-use change from forest and woodland to agricultural crops, cleared pasture for livestock and urban and peri-urban development has been the most substantial cause of decline in eucalypt woodland (Yates and Hobbs 1997). Deforestation with this land-use change represents a decline in the quality of habitat (criterion A2c) because eucalypts are a dominant canopy tree species. The extent of deforestation was determined by intersecting the geographic range of a species with standardised land-use coverages developed for each Australian State and agglomerated for the entire Australian continent (Department of Agriculture and Water Resources 2019). The land-use categories were assigned as one of four types: ‘remnant’, deforestation due to ‘urbanisation’, deforestation due to ‘other intensive land-use’ or as ‘ambiguous deforestation’ (Table A1). The ‘ambiguous deforestation’ land-use categories (Table A1) include a mixture of deforested and non-deforested land and therefore need further examination to establish levels of deforestation within these areas (see below).

Eucalypt species are associated with certain habitats representing substrates or soil types. A species that grows on arable soils will have declined more than a species with a similar geographic range that occurs on rocky hills. The preferential deforestation of productive habitats has been demonstrated in Australia (Fensham and Fairfax 2003). Urbanisation is not dependent on soil productivity and does not occur with the same bias for arable soils. The habitat (soil/substrate) type of the eucalypt species were assigned as 'productive', 'moderately productive' or 'unproductive' (Table A2, Appendix 2).

To estimate population decline against criterion A2 the following sequence was used:

1) The geographic range of each eucalypt was intersected with the land-use coverage. The land-use cover was summarised as 'remnant' (no deforestation), 'unambiguous deforestation' and 'ambiguous deforestation' (Table A1). The extent of deforestation in the 'ambiguous deforestation' land-use categories was calculated using random points as 'less than 5% tree cover' (Table A1, Appendix 3).
2) For all species a 'preliminary estimate of population decline' population decline was determined by adding 'unambiguous deforestation' loss to the 'less than 5% cover' component of 'ambiguous deforestation' in their geographic range (Table A1, Appendix 2).
    a) For species occurring in 'productive' habitat (Table A2) the 'preliminary estimate of population decline' was used as the 'estimate of population decline'.
    b) For species occurring in 'moderately productive' habitat (Table A2), the 'estimate of population decline' was determined as 60% of the 'preliminary estimate of population decline' (see Appendix 2).
    c) Species occurring in habitat classified as 'unproductive' (Table A2), the 'preliminary estimate of population decline' was not used as an 'estimate of population decline'.
3) For any species with a significant decline (>8%) due to 'urbanisation', the 'estimate of population decline' was calculated using a modified procedure because decline associated with urbanisation occurs independent of habitat type (Appendix 4).

The application of 1) deforestation as less than 5% tree cover in the 'ambiguous deforestation' land-use categories, 2) the assumption that 'productive' habitats are only deforested to the same extent as general deforestation in an area, and 3) that 'moderately productive' habitats are only deforested by 60% relative to general deforestation will all result in a tendency for the 'estimate of population decline' to underestimate actual population decline due to deforestation.

2.3 Assessment using criteria B, C and D

Species with continuing declines, a restricted geographic range and ten or fewer 'locations' or showing severe fragmentation can be listed under criterion B (IUCN 2012). Species with a restricted range of AOO <2,000 km^2 and EOO <20,000 km^2 were listed as threatened under criterion B if the number of locations were also 10 or fewer. Expert elicitation and peer-reviewed literature was used to determine the presence of threats, ongoing population decline and population size. Some eucalypts may also qualify under criterion B with populations subject to 'severe fragmentation'. However, the viability of these populations in relation to fragmentation would require further assessment (see Fragmentation and genetic integrity below) and severe fragmentation was not invoked for any species. Extreme fluctuations (as defined by IUCN (2012) also did not apply.

Criterion C was used to assess species with <10,000 mature individuals coupled with continuing decline. Criterion D was used to assess species with <1,000 mature individuals. Population size was determined using data from field surveys (Department of Biodiversity, Conservation and Attractions 2012) or estimates from expert opinion. Criterion D2 was used to assess species with a potential future threat (where current threats are absent) and where their range was very restricted (AOO <20 km^2 or locations ≤5) and could drive the species to become Critically Endangered or Extinct within a very short time. For example, a species that occurs alongside inactive mining leases, geology with potential for mineral resource extraction and land tenure that does not preclude mining. The latter is assumed to be all tenures excluding areas classified in IUCN Protected Area Management Categories I to IV (Dudley 2008). The documentation for existing threatened species listings under Australian Federal and State jurisdictions were reviewed where available to assist in identifying future threats (Department of Biodiversity, Conservation and Attractions 2012, Office of Environment & Heritage 2015, Department of Environment 2019).

Some of the IUCN Red List Criteria are concerned with future threats and predicting future decline. While the fate of any species is difficult to predict, current threatening processes may inform future population trends. The general approach adopted here was to assess the response of eucalypts to past and present threats to inform their likely response to future threats.

2.3.1 Agriculture and pastoralism

The protection of native vegetation is addressed by legislation under all Australian State jurisdictions and clearing for agriculture and pastoralism has slowed substantially as a result of these measures (Evans 2016). It is recognised here that clearing of native vegetation is still occurring under some circumstances. However, there is also vegetation recovery occurring in some areas (Lunt *et al*. 2010). We assume vegetation clearance for cropping and pastoralism will remain regulated and have a greatly reduced impact on eucalypt population abundance compared to the past.

2.3.2 Urbanisation

Eucalypts were assessed for decline associated with urbanisation under criterion A2 using the footprint of Australian cities as indicated in the landuse coverages (Department of Agriculture and Water Resources 2019). Australian cities will continue to expand causing ongoing population declines for eucalypts. The scale of a threat was assessed relative to the number of 'locations' and where the scale of 'location' was the size of a typical Australian suburb (4 km^2). Wide-ranging species that may decline further because of urbanisation were not assessed under criteria A3 and A4 because the magnitude of decline is uncertain.

2.3.3 Mining

Mining was considered as a plausible threat that could cause ongoing population declines for eucalypts occurring on geological formations supporting existing mineral extraction. Where mining was the dominant threat to a species under criterion B, the scale was defined as the footprint of a typical mining development in that area. For example, where a gold mine within the geographic range of a species was 4 km^2, 'locations' were counted as the number of 4 km^2 occurrences for that species. Where species occurred on geology with potential for future mining, but no active mining, no continuing decline could be justified. These species were assessed under criterion D2 and qualified as threatened if they have a very restricted AOO (<20 km^2) and/or ≤5 locations (as calculated above) and could drive the species to qualify as Extinct or Critically Endangered in a very short time. Conservation reserves classified as IUCN Protected Management Categories I to IV (Dudley 2008), including National Parks, were assumed to be protected from mining threats.

2.3.4 Climate change

Climate change is an impending threat for biodiversity (Parmesan 2006) and species with limited capacity for dispersal may be disproportionately affected (Guisan and Thuiller 2005). Most eucalypts have poor seed dispersal and some have very restricted geographic ranges (Hughes *et al*. 2006). Species distribution modelling has predicted a substantial decline in the area of climatically-suitable space for many eucalypts (Hughes *et al*. 2006, Butt *et al*. 2013, González-Orozco *et al*. 2016). If the 'worst-case' scenario (RCP 8.5) of the IPCC predictions are realised (IPCC 2013), the available 'climate space' for small-range species will be reduced to 2.4% of their existing range and have no overlap with their current area of occupation (González-Orozco *et al*. 2016). However, this modelling approach has been questioned (Heads 2015, Peterson *et al*. 2018) and is problematic for eucalypts because i) other factors, notably the soil environment, determine the geographic limits of a species (Austin *et al*. 1997); ii) there is considerable ecotypic variability in many eucalypt taxa (Potts and Wiltshire 1997); iii) there is evidence that small populations of some rare taxa have persisted for long periods despite Pleistocene climatic fluctuations (Byrne and Hopper 2008, Hopper *et al*. 2016); and iv) the open breeding systems of eucalypts may allow for gene transfer and confer adaptive-capacity to future climate change (Fensham *et al*. 2014).

A likely influence of climate change is an increase in the intensity of drought events (Dai 2012, Mitchell *et al.* 2016), which may exacerbate mortality in eucalypt populations. These potential impacts should be assessed in relation to historical drought-induced mortality data (Fensham *et al.* 2019). One study has indicated the moisture limits of a species' range were poorly-related to drought-induced dieback symptoms for crown health (Fensham *et al*. 2014). In northeastern Australia, the most dominant and common species seem to be more susceptible to drought-induced mortality. These species apparently trade-off their vulnerability to drought for dominance and the capacity for population recovery (Fensham *et al*. 2015). Both studies strongly indicate that drought-intensification will be difficult to predict for individual species. Furthermore, it is even more difficult to apply Red List Criteria to predict decline under future climate change scenarios (Akçakaya *et al*. 2006).

Climate change may be detrimental to many eucalypt species in the future. However, the pioneering study identifying these impacts states that bio-climatic predictions cannot be used to reliably predict ‘either the future distributions, the survival or extinction of specific eucalypt species’ (Hughes *et al*. 2006, p. 27-28). Due to this uncertainty, such predictions were not included in the Red List assessments presented here.

2.3.5 Fire

Eucalypts have evolved in the most fire-prone continent and many have traits that allow them to survive fires. These adaptations include epicormic buds that instigate rapid crown re-development if the cambium is damaged (Burrows *et al*. 2008). Some species do not have substantial capacity for epicormic recovery but possess a lignotuber. This large, woody organ is insulated underground and is replete with buds allowing rapid post-fire recovery (Nicolle 2006b, Bowman *et al*. 2012). For some species, fire promotes seed-release from woody capsules that then germinate in the ash-bed (Henry and Florence 1966, Burrows *et al*. 1990, Ashton and Attiwill 1994), while other species regenerate from root suckers (Lacey 1974). The rarity of fire may be a key factor limiting recruitment in temperate woodlands (Orscheg *et al*. 2011).The Australian monsoon savanna dominated by *E. tetrodonta* and *E. miniata* have the highest frequency fire regimes in Australia (Russell-Smith *et al*. 2007, Bradstock *et al*. 2013). However, even in these extremely fire prone environments, only very minor areas are subject to extended periods of annual burning (Russell-Smith *et al*. 1998, 2003b) and long term experiments have not exhibited major changes to stand structure after application of very divergent fire treatments, including annual regimes relative to long unburnt treatments over 23 years (Russell-Smith *et al.* 2003a). Experimental studies for a range of eucalypts in other environments suggest that burning regimes have little impact on stand structure (Henry and Florence 1966, Russell-Smith *et al*. 2003a, Fensham *et al.* 2017). A review of the substantial body of research from tropical savanna concluded that ‘fire tolerance makes eucalypts relatively unresponsive to management-imposed reductions in fire frequency and intensity’ (Murphy *et al*. 2015). There is no published evidence that frequent burning within the range determined by natural fuel accumulation can cause population declines for any eucalypts that resprout from stems or lignotubers. However, extreme and prolonged fire regimes may result in changes in tree densities over three generations (Werner and Peacock 2019).

Some eucalypts are ‘obligate-seeders’ meaning that aboveground stems are typically killed by intense fire and germination from seed is the dominant form of regeneration (Nicolle 2006b). Theoretically, successive fires could cause significant population declines if the individuals that germinated after a fire were burnt again before they could produce seed (Bowman and Prior 2018). A subspecies of *E. delegatensis* from the Australian mainland is an obligate-seeder that has been assumed to produce ‘replacement’ quantities of viable seed after 20 years of age (Fagg *et al*. 2013). Across its range, successive fires have occurred at intervals <20 years (Doherty *et al*. 2017). A reduced rate of regeneration relative to the response after a single fire has been observed (Bowman *et al.* 2014). However, ‘precocious’ individuals can fruit set seed within six years (Doherty *et al*. 2017) and adults of this subspecies of *E. delegatensis* can survive burning at some sites (Bowman *et al*. 2014). The long-term population impacts over the entire range of this and other obligate seeders from similar high rainfall environments are yet to be understood.

In southwestern Western Australia, there is a concentration of obligate-seeders that occur in relatively dry landscapes (Nicolle 2006b, Gosper *et al*. 2019). It has been suggested that increased fire frequency, either through ignitions or climate change may be a significant future threat to these species (O'Donnell *et al.* 2011a). Germination occurs *en masse* after fire for these obligate-seeders, which then often form single-age cohorts (Gosper *et al*. 2018). As germination also occurs sporadically without fire, and as individuals become moribund and die, stands continue to develop as multi-age cohorts (Gosper *et al*. 2018). The time to seed production for obligate-seeders in southwestern Western Australia varies between 4.5 and 7.5 years (Nicolle 2006a), although seed volumes increase substantially after this time (Gosper *et al*. 2018). In low rainfall areas (<1,000 mm mean annual rainfall) where some of these obligate-seeder species occur, average fire intervals are ~400 years (O'Donnell *et al*. 2011b). Fuel loads in *E. salubris* woodlands take 35 years to peak (Gosper *et al*. 2013), suggesting that fires occurring at intervals substantially less than this are unlikely. While frequent burning could theoretically cause population declines for obligate-seeders, we are not aware of any observations where this has occurred in low rainfall environments. Further investigation is required to determine the vulnerability of obligate-seeders to future fire regimes, especially those with small populations and restricted ranges. As fire is rare in agricultural landscapes due to fire suppression (Shedley *et al*. 2018), the species considered most at risk of fire-related decline are those with restricted ranges that occurred outside intensive land-use areas. These species were listed under criterion D2 (if AOO of <20 km^2 or ≤5 locations). Locations were calculated according to the mean scale of a fire within the respective region (Shedley *et al*. 2018). Fire was not regarded as a threatening process for any other eucalypts.

2.3.6 Grazing

Cattle and sheep grazing are the primary land-use throughout many areas dominated by eucalypts. The stand structure of eucalypt woodlands is typically represented by a high density of small stems that declines to a low density of large stems (Burrows *et al.* 1990, Scanlan *et al*. 1996, Fischer *et al.* 2009). Intensive sheep grazing can effectively eliminate eucalypt regeneration in southeastern Australia and can result in broadscale decline of eucalypt woodlands as mature trees die (Dorrough and Moxham 2005, Weinberg *et al*. 2011). In these areas recruitment is insufficient to replace scattered paddock trees in grazed pastures (Fischer *et al*. 2009). However, provided that sheep grazing is not continuous, recruitment does occur in some situations (Semple and Koen 2001, Dorrough and Moxham 2005, Fischer *et al*. 2009). In tropical areas, cattle grazing can increase the mortality of small eucalypt trees relative to ungrazed areas (Scanlan *et al*. 1996), however, densities are not reduced below those required for stand replacement (Scanlan *et al*. 1996). Drought-induced mortality appears independent of livestock grazing and was similar between cattle-grazed areas and nearby ungrazed areas (Fensham 1998). Clearly, livestock grazing is a threatening process for eucalypt populations in intensively grazed areas. However, the mere coincidence of livestock grazing with eucalypt distributions was not accepted here as sufficient evidence of population decline, except where intensive grazing was a major land-use throughout the geographic range of a particular species and was observed to impede regeneration. Studies demonstrating the impacts of grazing for individual species are required to ascertain a causal relationship between grazing and future population declines.

2.3.7 Timber harvesting

Timber harvesting has been a pervasive land-use in eucalypt forests, especially in humid areas of temperate Australia, with species such as *E. delegatensis, E. diversicolor, E.*

fastigata, E. obliqua, E. marginata, E. nitens and *E. regnans* particularly affected. In some areas, native eucalypt forest has been replaced with plantations, often monocultures of a single species. Population decline is assessed under criterion A2 as deforestation in these areas. More generally, harvesting of native forest typically allows canopy trees to regenerate.

2.3.8 Dieback and absence of regeneration

Some species exhibit 'dieback' (death and crown damage) due to unspecified causes. *Eucalyptus gunnii* has exhibited substantial mortality and many populations have little regeneration (Calder and Kirkpatrick 2008, Sanger *et al*. 2011). Where this decline was characterised by substantial mortality of adults combined with minimal recruitment, the species was assumed to be undergoing ongoing decline and the scale of this decline was assessed at the scale of a population or the portion of the population affected.

2.3.9 Disease

Eucalypts can be susceptible to disease including the root pathogens *Phytophthora cinnamomi* (Davison 2018), *Armillaria* sp. (Kellas *et al*. 1987), Myrtle Rust *Austropuccinia psidii* (Berthon *et al*. 2018) and other galls and cankers (e.g. Paap *et al*. 2016). These diseases can have localised impacts, particularly in plantations, but were not regarded as major threats.

2.3.10 Fragmentation and genetic integrity

Fragmentation effects on genetic diversity may be profound for eucalypts with once large continuous geographical ranges (Prober 1996). Conversely, naturally fragmented species such as those endemic to disjunct habitats like rock outcrops may have evolved genetic mechanisms for surviving as small populations (Byrne and Hopper 2008, Bezemer *et al*. 2016, Hopper *et al*. 2016). Many widespread species have naturally occurring 'outlier' subpopulations that are probably genetically isolated from the core range. These persist apparently without being subject to effects of a small gene pool, e.g. inbreeding depression. Experimental studies are needed to ascertain the threats to genetic integrity, which may reveal unexpected resilience to fragmentation effects as has been established for *E. incrassata* (Breed *et al*. 2015). The reduced genetic variability of *E. argutifolia* has been attributed to events associated with the origin of the species rather than subsequent genetic bottle-necks (Kennington and James 1998). Therefore in the absence of evidence, fragmentation effects on genetic integrity were not considered a threatening process.

2.4 Assessment of Near Threatened taxa

There are no defined criteria for the Near Threatened (NT) category under the IUCN Red List Categories and Criteria (IUCN 2012). Rather, the species must be close to meeting the thresholds for a threatened category (IUCN 2012). In this assessment, a species was listed as Near Threatened under criterion A if it had undergone a past population decline of between 20 and 30%. Near Threatened species under criterion B had a restricted range (AOO <2,000 km^2 or EOO <20,000 km^2) with ongoing decline, but occurred at 11–

20 locations. For criterion C, a species was listed as Near Threatened if it had a small population (<10,000 mature individuals) with ongoing decline, but more than 1,000 mature individuals in each subpopulation. For criterion D1, a species was listed as Near Threatened if it had a population size of 1,000–2,000 mature individuals, or under D2, if it had a high extinction risk but occurred at 6–10 locations or had an AOO of 20–30 km^2 (IUCN Standards and Petitions Subcommittee 2017).

3. References

Akçakaya, R.H., Butchart, S.H.M., Mace, G.M., Stuart, S.N. and Hilton-Taylor, C. 2006. Use and misuse of the IUCN Red List Criteria in projecting climate change impacts on biodiversity. *Global Change Biology* 12: 2037–2043. https://doi.org/10.1111/j.1365-2486.2006.01253.x

Ashton, D.H. and Attiwill, P.M. 1994. Tall open-forests. In: R.H. Groves (ed.), *Australian Vegetation*, pp. 157–196. Cambridge University Press, Cambridge.

Austin, M.P., Pausas, J.G. and Noble, I.R. 1997. Modelling environmental and temproal niches of eucalypts. In: J. Williams and J. Woinarski (eds), *Eucalypt Ecology: Individuals to Ecosystems*, pp. 129–150. Cambridge University Press, Cambridge.

Beech, E., Rivers, M., Oldfield, S. and Smith, P.P. 2017. GlobalTreeSearch: The first complete global database of tree species and country distributions. *Journal of Sustainable Forestry* 36: 454–489. https://doi.org/10.1080/10549811.2017.1310049

Berthon, K., Esperon-Rodriguez, M., Beaumont, L.J., Carnegie, A.J. and Leishman, M.R. 2018. Assessment and prioritisation of plant species at risk from myrtle rust (*Austropuccinia psidii*) under current and future climates in Australia. *Biological Conservation* 218: 154–162. https://doi.org/10.1016/j.biocon.2017.11.035

Bezemer, N., Krauss, S.L., Phillips, R.D., Roberts, D.G. and Hopper, S.D. 2016. Paternity analysis reveals wide pollen dispersal and high multiple paternity in a small isolated population of the bird-pollinated *Eucalyptus caesia* (Myrtaceae). *Heredity* 117: 460–471. https://doi.org/10.1038/hdy.2016.61

Bowman, D., Murphy, B., Burrows, G. and Crisp, M. 2012. Fire regimes and the evolution of the Australian biota. In: R.A. Bradstock, A.M. Gill and R.J. Williams (eds), *Flammable Australia. Fire Regimes, Biodiversity and Ecosystems in a Changing World*, pp. 27–47. CSIRO Publishing, Collingwood.

Bowman, D. and Prior, L. 2018. Fire-driven loss of obligate seeder forests in the Alps. *Austral Ecology* 43(7): e16–e18. https://doi.org/10.1111/aec.12602

Bowman, D.M.J.S., Murphy, B.P., Neyland, D.L.J., Williamson, G.J. and Prior, L.D. 2014. Abrupt fire regime change may cause landscape-wide loss of mature obligate seeder forests. *Global Change Biology* 20: 1008–1015. https://doi.org/10.1111/gcb.12433

Bradstock, R.A., Williamson, G.J., Boer, M.M., Murphy, B.P., Russell-Smith, J., Fensham, R.J., Bowman, D.M.J.S., Cochrane, M.A., Cary, G.J. and Carter, J. 2013. Fire regimes of Australia: a pyrogeographic model system. *Journal of Biogeography* 40: 1048–1058. https://doi.org/10.1111/jbi.12065

Breed, M.F., Ottewell, K.M., Gardner, M.G., Marklund, M.H.K., Stead, M.G., Harris, J.B.C. and Lowe, A.J. 2015. Mating system and early viability resistance to habitat fragmentation in a bird-pollinated eucalypt. *Heredity* 115: 100–107. https://doi.org/10.1038/hdy.2012.72

Brito, D., Grace Ambal, R., Brooks, T., De Silva, N., Foster, M., Hao, W., Hilton-Taylor, C., Paglia, A., Paul Rodriguez, J. and Vicente Rodriguez, J. 2010. How similar are national red lists and the IUCN Red List? *Biological Conservation* 143: 1154–1158. https://doi.org/10.1016/j.biocon.2010.02.015

Brooker, M.I.H. and Kleinig, D.A. 1994. *Field Guide to Eucalypts. Volume 3*. Northern Australia. Inkata Press, Melbourne.

Brooker, M.I.H. and Kleinig, D.A. 2001. *Field Guide to Eucalypts. Volume 2*. South-western and southern Australia, Third edition. Bloomings Books, Melbourne.

Brooker, M.I.H. and Kleinig, D.A. 2006. *Field Guide to Eucalypts. Volume 1*. Southeastern Australia, Third edition. Bloomings Books, Melbourne.

Brummitt, N.A., Bachman, S.P., Griffiths-Lee, J., Lutz, M., Moat, J.F., Farjon, A., Donaldson, J.S., Hilton-Taylor, C., Meagher, T.R., Albuquerque, S., Aletrari, E., Andrews, A.K., Atchison, G., Baloch, E., Barlozzini, B., Brunazzi, A., Carretero, J., Celesti, M., Chadburn, H., Cianfoni, E., Cockel, C., Coldwell, V., Concetti, B., Contu, S., Crook, V., Dyson, P., Gardiner, L., Ghanim, N., Greene, H., Groom, A., Harker, R., Hopkins, D., Khela, S., Lakeman-Fraser, P., Lindon, H., Lockwood, H., Loftus, C., Lombrici, D., Lopez-Poveda, L., Lyon, J., Malcolm-Tompkins, P., McGregor, K., Moreno, L., Murray, L., Nazar, K., Power, E., Tuijtelaars, M.Q., Salter, R., Segrott, R., Thacker, H., Thomas, L.J., Tingvoll, S., Watkinson, G., Wojtaszekova, K. and Lughadha, E.M.N. 2015. Green plants in the red: A baseline global assessment for the IUCN Sampled Red List Index for Plants. *PLoS One* 10(8): e0135152. https://doi.org/10.1371/journal.pone.0135152

Burgman, M.A. 2002. Are listed threatened plant species actually at risk? *Australian Journal of Botany* 50: 1–13. https://doi.org/10.1071/BT01052

Burrows, G.E., Hornby, S.K., Waters, D.A., Bellairs, S.M., Prior, L.D. and Bowman, D.M.J.S. 2008. Leaf axil anatomy and bud reserves in 21 Myrtaceae species from Northern Australia. *International Journal of Plant Science* 169: 1174–1186. https://doi.org/10.1086/591985

Burrows, N., Gardiner, B. and Ward, B. 1990. Regeneration of *Eucalyptus wandoo* following fire. *Australian Forestry* 53(4): 248–258. https://doi.org/10.1080/00049158.1990.10676084

Butt, N., Pollock, L.J. and Mcalpine, C.A. 2013. Eucalypts face increasing climate stress. *Ecology and Evolution* 3(15): 5011–5022. https://doi.org/10.1002/ece3.873

Byrne, M. and Hopper, S.D. 2008. Granite outcrops as ancient islands in old landscapes: evidence from the phylogeography and population genetics of *Eucalyptus caesia* (Myrtaceae) in Western Australia. *Biological Journal of the Linnean Society* 93: 177–188. https://doi.org/10.1111/j.1095-8312.2007.00946.x

Calder, J.A. and Kirkpatrick, J.B. 2008. Climate change and other factors influencing the decline of the Tasmanian cider gum (*Eucalyptus gunnii*). *Australian Journal of Botany* 56: 684–692. https://doi.org/10.1071/BT08105

Collen, B., Dulvy, N.K., Gaston, K.J., Gärdenfors, U., Keith, D.A., Punt, A.E., Regan, H.M., Böhm, M., Hedges, S., Seddon, M., Butchart, S.H.M., Hilton-Taylor, C., Hoffmann, M., Bachman, S.P. and Akçakaya, H.R. 2016. Clarifying misconceptions of extinction risk assessment with the IUCN Red List. *Biology Letters* 12(4): 20150843 https://doi.org/10.1098/rsbl.2015.0843

Cook, G.D., Liedloff, A.C., Cuff, N.J., Brocklehurst, P.S. and Williams, R.J. 2015. Stocks and dynamics of carbon in trees across a rainfall gradient in a tropical savanna. *Austral Ecology* 40: 845–856. https://doi.org/10.1111/aec.12262

Dai, A. 2012. Increasing drought under global warming in observations and models. *Nature Climate Change* 3: 52–58. https://doi.org/10.1038/NCLIMATE1633

Davison, E.M. 2018. Relative importance of site, weather and *Phytophthora cinnamomi* in the decline and death of *Eucalyptus marginata* - jarrah dieback investigations in the 1970s to 1990s. *Australasian Plant Pathology* 47(3): 245–257. https://doi.org/10.1007/s13313-018-0558-8

Department of Agriculture and Water Resources. 2019. Catchment scale land use data [WWW Document]. URL http://www.agriculture.gov.au/abares/aclump/land-use/data-download (accessed 14 June 2019).

Department of Biodiversity, Conservation and Attractions. 2012. Biodiversity Assets [WWW Document]. URL https://biodiversity-audit.dbca.wa.gov.au/#assets (accessed 14 June 2019).

Department of Environment. 2019. Species profile and threats database [WWW Document]. URL https://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl (accessed 14 June 2019).

Doherty, M.D., Gill, A.M., Cary, G.J. and Austin, M.P. 2017. Seed viability of early maturing alpine ash (*Eucalyptus delegatensis* subsp. *delegatensis*) in the Australian Alps, south-eastern Australia, and its implications for management under changing fire regimes. *Australian Journal of Botany* 65(6): 517–523. https://doi.org/10.1071/BT17068

Dorrough, J. and Moxham, C. 2005. Eucalypt establishment in agricultural landscapes and implications for landscape-scale restoration. *Biological Conservation* 123: 55–66. https://doi.org/10.1016/j.biocon.2004.10.008

Dudley, N. (ed.). 2008. *Guidelines for Applying Protected Area Management Categories*. IUCN, Gland, Switzerland.

Evans, M.C. 2016. Deforestation in Australia: Drivers, trends and policy responses. *Pacific Conservation Biology* 22: 130–150. https://doi.org/10.1071/PC15052

Fagg, P., Lutze, M., Slijkerman, C., Ryan, M. and Bassett, O. 2013. Silvicultural recovery in ash forests following three large bushfires in Victoria. *Australian Forestry* 76(3-4): 140–155. https://doi.org/10.1080/00049158.2013.848610

Fensham, R.J. 1998. The influence of cattle grazing on tree mortality after drought in savanna woodland in north Queensland. *Australian Journal of Ecology* 83: 55–68. https://doi.org/10.1111/j.1442-9993.1998.tb00745.x

Fensham, R.J., Bouchard, D.L., Catterall, C.P. and Dwyer, J.M. 2014. Do local moisture stress responses across tree species reflect dry limits of their geographic ranges? *Austral Ecology* 39: 612–618. https://doi.org/10.1111/aec.12125

Fensham, R.J. and Fairfax, R.J. 2003. A land management history for central Queensland, Australia as determined from land-holder questionnaire and aerial photography. *Journal of Environmental Management* 68(4): 409–420. https://doi.org/10.1016/S0301-4797(03)00110-5

Fensham, R.J., Fraser, J., Macdermott, H.J. and Firn, J. 2015. Dominant tree species are at risk from exaggerated drought under climate change. *Global Change Biology* 21: 3777–3785. https://doi.org/10.1111/gcb.12981

Fensham, R.J., Freeman, M.E., Laffineur, B., Macdermott, H., Prior, L.D. and Werner, P.A. 2017. Variable rainfall has a greater effect than fire on the demography of the dominant tree in a semi-arid *Eucalyptus* savanna. *Austral Ecology* 42: 772–782. https://doi.org/10.1111/aec.12495

Fensham, R.J., Laffineur, B. and Allen, C.D. 2019. To what extent is drought-induced tree mortality a natural phenomenon? *Global Ecology and Biogeography* 28(3): 365–373. https://doi.org/10.1111/geb.12858

Fensham, R.J., McCosker, J.C. and Cox, M.J. 1998. Estimating clearance of *Acacia*-dominated ecosystems in central Queensland using land-system mapping data. *Australian Journal of Botany* 46(2): 305–319. https://doi.org/10.1071/BT96129

Fischer, J., Stott, J., Zerger, A., Warren, G., Sherren, K. and Forrester, R.I. 2009. Reversing a tree regeneration crisis in an endangered ecoregion. *PNAS* 106(25): 10386–10391. https://doi.org/10.1073/pnas.0900110106

Flather, C.H. and Sieg, C.H. 2007. Species rarity: definition, classification and causes. In: M. Raphael and R. Molina (eds), *Conservation of Rare or Little-Known Species: Biological, Social and Economic Considerations*, pp. 40–46. Island Press, Washington DC.

French, M. 2012. *Eucalypts of Western Australia's Wheatbelt*. Perth, Perth.

French, M. and Nicolle, D. 2019. *Eucalypts of Western Australia. The South-West Coast and Ranges*. Scott Print, Perth.

Fung, H.C. and Waples, R.S. 2017. Performance of IUCN proxies for generation length. *Conservation Biology* 31(4): 883–893. https://doi.org/10.1111/cobi.12901

González-Orozco, C.E., Pollock, L.J., Thornhill, A.H., Mishler, B.D., Knerr, N., Laffan, S.W., Miller, J.T., Rosauer, D.F., Faith, D.P., Nipperess, D.A., Kujala, H., Linke, S., Butt, N., Külheim, C., Crisp, M.D. and Gruber, B. 2016. Phylogenetic approaches reveal biodiversity threats under climate change. *Nature Climate Change* 6: 1110–1114. https://doi.org/10.1038/nclimate3126

Gosper, C.R., Hopley, T., Byrne, M., Hopper, S.D., Prober, S.M. and Yates, C.J. 2019. Phylogenomics shows lignotuber state is taxonomically informative in closely related eucalypts. *Molecular Phylogenetics and Evolution* 135: 236–248. https://doi.org/10.1016/j.ympev.2019.03.016

Gosper, C.R., Prober, S.M. and Yates, C.J. 2013. Multi-century changes in vegetation structure and fuel availability in fire-sensitive eucalypt woodlands. *Forest Ecology and Management* 310(15): 102–109. https://doi.org/10.1016/j.foreco.2013.08.005

Gosper, C.R., Yates, C.J., Cook, G.D., Harvey, J.M., Liedloff, A.C., McCaw, W.L., Thiele, K.R. and Prober, S.M. 2018. A conceptual model of vegetation dynamics for the unique obligate-seeder eucalypt woodlands of south-western Australia. *Austral Ecology* 43: 681–695. https://doi.org/10.1111/aec.12613

Guisan, A. and Thuiller, W. 2005. Predicting species distribution: offering more than simple habitat models. *Ecology Letters* 8(9): 993–1009. https://doi.org/10.1111/j.1461-0248.2005.00792.x

Heads, M. 2015. The relationship between biogeography and ecology: Envelopes, models, predictions. *Biological Journal of the Linnean Society* 115(2): 456–468. https://doi.org/10.1111/bij.12486

Henry, N.B. and Florence, R.G. 1966. Establishment and development of regeneration in spotted gum—ironbark forests. A*ustralian Forestry* 30, 304–316. https://doi.org/10.1080/00049158.1966.10675428

Hopper, S.D., Silveira, F.A.O. and Fiedler, P.L. 2016. Biodiversity hotspots and Ocbil theory. *Plant and Soil* 403(1/2): 167–216. https://doi.org/10.1007/s11104-015-2764-2

Hughes, L., Cawsey, E.M. and Westoby, M. 2006. Climatic range sizes of Eucalyptus species in relation to future climate change. *Global Ecology and Biogeography Letters* 5(1): 23. https://doi.org/10.2307/2997467

IPCC. 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M. (eds)]. Cambridge University Press, United Kingdom and New York, NY, USA.IUCN. 2012. *IUCN Red List Categories and Criteria, Version 3.1*. Second edition. IUCN, Gland, Switzerland and Cambridge, UK.

IUCN Red List Technical Working Group. 2018. Mapping Standards and Data Quality for the IUCN Red List Categories and Criteria. Version 1.16. [WWW Document] URL https://nc.iucnredlist.org/redlist/resources/files/1539098236-Mapping_Standards_Version_1.16_2018.pdf (accessed 14 June 2019).

IUCN Standards and Petitions Subcommittee. 2017. Guidelines for Using the IUCN Red List Categories and Criteria. Version 13. [WWW Document] URL http://www.iucnredlist.org/documents/RedListGuidelines.pdf (accessed 14 June 2019).

Kellas, J.D., Kile, G.A., Jarrett, R.G. and Morgan, B.J.T. 1987. The occurrence and effects of *Armillaria luteobubalina* following partial cutting in mixed eucalypt stands in the Wombat Forest, Victoria. *Australian Forest Research* 17: 263–276.

Kennington, W.J. and James, S.H. 1997. Contrasting patterns of clonality in two closely related malice species from Western Australia, *Eucalyptus argutifolia* and *E. obtusiflora* (Myrtaceae). *Australian Journal of Botany* 45: 679–689. https://doi.org/10.1071/BT96082

Kennington, W.J. and James, S.H. 1998. Allozyme and morphometric variation in two closely related mallee species from Western Australia, *Eucalyptus argutifolia* and *E. obtusifiora* (Myrtaceae). *Australian Journal of Botany* 46: 173–186. https://doi.org/10.1071/BT97009

Lacey, C.J. 1974. Rhizomes in tropical eucalypts and their role in recovery from fire damage. *Australian Journal of Botany* 22: 29–38. https://doi.org/10.1071/BT9740029

Lacey, C.J. and Head, M.J. 1988. Radiocarbon age-determinations from lignotubers. *Australian Journal of Botany* 36: 93. https://doi.org/10.1071/BT9880093

Lindenmayer, D., Wood, J., McBurney, L., MacGregor, C., Youngentob, K. and Banks, S. 2011. How to make a common species rare: A case against conservation complacency. *Biological Conservation* 144(5): 1663–1672. https://doi.org/10.1016/j.biocon.2011.02.022

Lunt, I.D., Winsemius, L.M., McDonald, S.P., Morgan, J.W. and Dehaan, R.L. 2010. How widespread is woody plant encroachment in temperate Australia? Changes in woody vegetation cover in lowland woodland and coastal ecosystems in Victoria from 1989 to 2005. *Journal of Biogeography* 37: 722–732. https://doi.org/10.1111/j.1365-2699.2009.02255.x

Mace, G.M., Collar, N.J., Gaston, K.J., Hilton-Taylor, C., Akçakaya, H.R., Leader-Williams, N., Milner-Gulland, E.J. and Stuart, S.N. 2008. Quantification of extinction risk: IUCN's system for classifying threatened species. *Conservation Biology* 22: 1424–1442. https://doi.org/10.1111/j.1523-1739.2008.01044.x

McIntyre, S., Barrett, G.W., Kitching, R.L. and Recher, H.F. 1992. Species triage - seeing beyond wounded Rhinos. *Conservation Biology* 6(4): 604–606. https://doi.org/10.1046/j.1523-1739.1992.06040604.x

Mitchell, P.J., O'Grady, A.P., Pinkard, E.A., Brodribb, T.J., Arndt, S.K., Blackman, C.J., Duursma, R.A., Fensham, R.J., Hilbert, D.W., Nitschke, C.R., Norris, J., Roxburgh, S.H., Ruthrof, K.X. and Tissue, D.T. 2016. An ecoclimatic framework for evaluating the resilience of vegetation to water deficit. *Global Change Biology* 22: 1677–1689. https://doi.org/10.1111/gcb.13177

Murphy, B.P., Liedloff, A.C. and Cook, G.D. 2015. Does fire limit tree biomass in Australian savannas? *International Journal of Wildland Fire* 24(1): 1–13. https://doi.org/10.1071/WF14092

Murphy, B.P., Russell-Smith, J. and Prior, L.D. 2010. Frequent fires reduce tree growth in northern Australian savannas: Implications for tree demography and carbon sequestration. *Global Change Biology* 16: 331–343. https://doi.org/10.1111/j.1365-2486.2009.01933.x

Nicolle, D. 2006a. *Eucalypts of Victoria and Tasmania*. Bloomings Books, Melbourne.

Nicolle, D. 2006b. A classification and census of regenerative strategies in the eucalypts (*Angophora, Corymbia* and *Eucalyptus* - Myrtaceae), with special reference to the obligate seeders. *Australian Journal of Botany* 54: 391–407. https://doi.org/10.1071/BT05061

Nicolle, D. 2013. *Native Eucalypts of South Australia*. Dean Nicolle, Adelaide.

O'Donnell, A.J., Boer, M.M., McCaw, W.L. and Grierson, P.F. 2011a. Climatic anomalies drive wildfire occurrence and extent in semi-arid shrublands and woodlands of southwest Australia. *Ecosphere* 2: 1–15. https://doi.org/10.1890/ES11-00189.1

O'Donnell, A.J., Boer, M.M., McCaw, W.L. and Grierson, P.F. 2011b. Vegetation and landscape connectivity control wildfire intervals in unmanaged semi-arid shrublands and woodlands in Australia. *Journal of Biogeography* 38: 112–124. https://doi.org/10.1111/j.1365-2699.2010.02381.x

Office of Environment & Heritage. 2015. Threatened species profile search [WWW Document]. URL https://www.environment.nsw.gov.au/threatenedSpeciesApp/ (accessed 14 June 2019).

Orscheg, C.K., Enright, N.J., Coates, F. and Thomas, I. 2011. Recruitment limitation in dry sclerophyll forests: Regeneration requirements and potential density-dependent effects in *Eucalyptus tricarpa* (L.A.S. Johnson) L.A.S. Johnson & K.D. Hill (Myrtaceae). Austral Ecology 36(8): 936–943. https://doi.org/10.1111/j.1442-9993.2010.02221.x

Paap, T., I, Calver, M., Mccomb, J., Shearer, B. and Hardy, G.E.S. 2016. A thirteen-year study on the impact of a severe canker disease of *Corymbia calophylla*, a keystone tree in Mediterranean-type forests. *Forest Pathology* 47(1): e12292. https://doi.org/10.1111/efp.12292

Parmesan, C. 2006. Ecological and evolutionary responses to recent climate change. *Annual Review of Ecology Evolution and Systematics* 37: 637–669. https://doi.org/10.1146/annurev.ecolsys.37.091305.110100

Peterson, A.T., Cobos, M.E. and Jiménez-García, D. 2018. Major challenges for correlational ecological niche model projections to future climate conditions. *Annals of the New York Academy of Sciences* 1429(1): 66–77. https://doi.org/10.1111/nyas.13873

Possingham, H.P., Andelman, S.J., Burgman, M.A., Medellín, R.A., Master, L.L. and Keith, D.A. 2002. Limits to the use of threatened species lists. *Trends in Ecology and Evolution* 17: 503–507. https://doi.org/10.1016/S0169-5347(02)02614-9

Potts, B.M. and Wiltshire, R.J.E. 1997. Eucalypt genetics and genecology. In: J.E. Williams and C.Z. Woinarski (eds), *Eucalypt Genetics and Genecology*, pp. 56–91. Cambridge University Press, Cambridge.

Prober, S.M. 1996. Conservation of the grassy white box woodlands: Rangewide floristic variation and implications for reserve design. *Australian Journal of Botany* 44: 57–77. https://doi.org/10.1071/BT9960057

Rivers, M. 2017. The Global Tree Assessment – red listing the world's trees. *BGjournal* 14: 16–19.

Royal Botanic Gardens and Domain Trust. 2019. PlantNET (The NSW Plant Information Network System) [WWW Document]. URL http://plantnet.rbgsyd.nsw.gov.au/floraonline.htm (accessed 14 June 2019).

Russell-Smith, J., Ryan, P., Klessa, D., Waight, G. and Harwood, R. 1998. Fire regimes, fire sensitive vegetation and fire management of the sandstone Arnhem Plateau, monsoonal northern Australia. *Journal of Applied Ecology* 35: 829–846. https://doi.org/10.1111/j.1365-2664.1998.tb00002.x

Russell-Smith, J., Whitehead, P.J., Cook, G.D. and Hoare, J.L. 2003a. Response of *Eucalyptus*-dominated savanna to frequent fires: lessons from Munmarlary, 1973–1996. *Ecological Monographs* 73: 349–375. https://doi.org/10.1890/01-4021

Russell-Smith, J., Yates, C., Edwards, A., Allan, G.E., Cook, G.D., Cooke, P., Craig, R., Heath, B. and Smith, R. 2003b. Contemporary fire regimes of northern Australia, 1997 - 2001: change since Aboriginal occupancy, challenges for sustainable management. *International Journal of Wildland Fire* 12(4): 283–297. https://doi.org/10.1071/wf03015

Russell-Smith, J., Yates, C.P., Whitehead, P.J., Smith, R., Craig, R., Allan, G.E., Thackway, R., Frakes, I., Cridland, S., Meyer, M.C.P. and Gill, M. 2007. Bushfires "down under": patterns and implications of contemporary Australian landscape burning. *International Journal of Wildland Fire* 16(4): 361–377. https://doi.org/10.1071/WF07018

Sanger, J.C., Davidson, N.J., O'Grady, A.P. and Close, D.C. 2011. Are the patterns of regeneration in the endangered *Eucalyptus gunnii* ssp. *divaricata* shifting in response to climate? *Austral Ecology* 36: 612–620. https://doi.org/10.1111/j.1442-9993.2010.02194.x

Scanlan, J.C., Pressland, A.J. and Myles, D.J. 1996. Grazing modifies woody and herbaceous component of North Queensland woodlands. *The Rangeland Journal* 18(1): 47–57. https://doi.org/10.1071/RJ9960047

Semple, W.S. and Koen, T.B. 2001. Growth rate and effect of sheep browsing on young eucalypts in an anthropogenic *Themeda* grassland. *The Rangeland Journal* 23(2): 182–193. https://doi.org/10.1071/RJ01005

Shedley, E., Burrows, N., Yates, C.J. and Coates, D.J. 2018. Using bioregional variations in fire history and fire response attributes as a basis for managing threatened flora in a fire-prone Mediterranean climate biodiversity hotspot. *Australian Journal of Botany* 66: 134–143. https://doi.org/10.1071/bt17176

Silcock, J.L., Healy, A.J. and Fensham, R.J. 2014. Lost in time and space: re-assessment of conservation status in an arid-zone flora through targeted field survey. *Australian Journal of Botany* 62: 674–688. https://doi.org/10.1071/BT14279

Tyson, M., Vaillancourt, R.E. and Reid, J.B. 1998. Determination of clone size and age in a mallee eucalypt using RAPDs. *Australian Journal of Botany* 46: 161–172. https://doi.org/10.1071/BT97003

Weinberg, A., Gibbons, P., Briggs, S.V. and Bonser, S.P. 2011. The extent and pattern of *Eucalyptus* regeneration in an agricultural landscape. *Biological Conservation* 144: 227–233. https://doi.org/10.1016/j.biocon.2010.08.020

Werner, P.A. and Peacock, S.J. 2019. Savanna canopy trees under fire: long-term persistence and transient dynamics from a stage-based matrix population model. *Ecosphere* 10: e02706. https://doi.org/10.1002/ecs2.2706

Western Australian Herbarium. 2018. FloraBase—the Western Australian Flora. Department of Biodiversity, Conservation and Attractions [WWW Document]. URL https://florabase.dpaw.wa.gov.au/ (accessed 14 June 2019).

Williams, K. and Potts, B. 1996. The natural distribution of *Eucalyptus* species in Tasmania. *Tasforests* 8: 39–149.

Woinarski, J., Burbidge, A. and Harrison, P. 2012. *The Action Plan for Australian Mammals 2012*. CSIRO, Clayton. https://doi.org/10.1071/9780643108745

Wood, S.W., Hua, Q., Allen, K.J. and Bowman, D.M.J.S. 2010. Age and growth of a fire prone Tasmanian temperate old-growth forest stand dominated by *Eucalyptus regnans*, the world's tallest angiosperm. *Forest Ecology and Management* 260(4): 438–447. https://doi.org/10.1016/j.foreco.2010.04.037

Yates, C.J. and Hobbs, R.J. 1997. Temperate eucalypt woodlands: A review of their status, processes threatening their persistence and techniques for restoration. *Australian Journal of Botany* 45: 949–973. https://doi.org/10.1071/BT96091

Yates, C.J., Ladd, P.G., Coates, D.J. and McArthur, S. 2007. Hierarchies of cause: Understanding rarity in an endemic shrub *Verticordia staminosa* (Myrtaceae) with a highly restricted distribution. *Australian Journal of Botany* 55: 194–205. https://doi.org/10.1071/BT06032

4. Appendices

4.1 Appendix 1

Land-use categories and their use for decline analysis

Table A1. Land-use descriptions as defined in the Australian Land Use and Management classification (Department of Agriculture and Water Resources 2019) and categorisation for analysis. The 'ambiguous deforestation' land-use categories were assessed using random points (see Appendix 3).

ALUM code	Land-use description	Decline analysis category
1.1.0	Nature conservation	Remnant
1.1.1	Strict nature reserves	Remnant
1.1.2	Wilderness area	Remnant
1.1.3	National park	Remnant
1.1.4	Natural feature protection	Remnant
1.1.5	Habitat/species management area	Remnant
1.1.6	Protected landscape	Remnant
1.1.7	Other conserved area	Remnant
1.2.0	Managed resource protection	Remnant
1.2.1	Biodiversity	Remnant
1.2.2	Surface water supply	Remnant
1.2.3	Ground water	Remnant
1.2.4	Landscape	Remnant
1.2.5	Traditional indigenous uses	Remnant
1.3.0	Other minimal use	Remnant
1.3.1	Defence land - natural areas	Remnant
1.3.2	Stock route	Remnant
1.3.3	Residual native cover	Remnant
1.3.4	Rehabilitation	Remnant
2.1.0	Grazing native vegetation	Ambiguous deforestation
2.2.0	Production forestry	Remnant
2.2.1	Wood production forestry	Remnant
2.2.2	Other forest production	Remnant
3.1.0	Plantation forests	Other intensive land-use
3.1.1	Hardwood plantation forestry	Other intensive land-use
3.1.2	Softwood plantation forestry	Other intensive land-use
3.1.3	Other forest plantation	Other intensive land-use
3.1.4	Environmental forest plantation	Other intensive land-use
3.2.0	Grazing modified pastures	Ambiguous deforestation
3.2.1	Native/exotic pasture mosaic	Ambiguous deforestation
3.2.2	Woody fodder plants	Other intensive land-use
3.2.3	Pasture legumes	Other intensive land-use

3.2.4	Pasture legume/grass mixtures	Other intensive land-use
3.2.5	Sown grasses	Other intensive land-use
3.3.0	Cropping	Other intensive land-use
3.3.1	Cereals	Other intensive land-use
3.3.2	Beverage and spice crops	Other intensive land-use
3.3.3	Hay and silage	Other intensive land-use
3.3.4	Oilseeds	Other intensive land-use
3.3.5	Sugar	Other intensive land-use
3.3.6	Cotton	Other intensive land-use
3.3.7	Alkaloid poppies	Other intensive land-use
3.3.8	Pulses	Other intensive land-use
3.4.0	Perennial horticulture	Other intensive land-use
3.4.1	Tree fruits	Other intensive land-use
3.4.2	Olives	Other intensive land-use
3.4.3	Tree nuts	Other intensive land-use
3.4.4	Vine fruits	Other intensive land-use
3.4.5	Shrub berries and fruits	Other intensive land-use
3.4.6	Perennial flowers and bulbs	Other intensive land-use
3.4.7	Perennial vegetables and herbs	Other intensive land-use
3.4.8	Citrus	Other intensive land-use
3.4.9	Grapes	Other intensive land-use
3.5.0	Seasonal horticulture	Other intensive land-use
3.5.1	Seasonal fruits	Other intensive land-use
3.5.2	Seasonal flowers and bulbs	Other intensive land-use
3.5.3	Seasonal vegetables and herbs	Other intensive land-use
3.5.4	Seasonal vegetables and herbs	Other intensive land-use
3.6.0	Land in transition	Other intensive land-use
3.6.1	Degraded land	Other intensive land-use
3.6.2	Abandoned land	Other intensive land-use
3.6.3	Land under rehabilitation	Other intensive land-use
3.6.4	No defined use	Other intensive land-use
3.6.5	Abandoned perennial horticulture	Other intensive land-use
4.0.0	Production from irrigated agriculture and plantations	Other intensive land-use
4.1.0	Irrigated plantation forestry	Other intensive land-use
4.1.1	Irrigated hardwood plantation forestry	Other intensive land-use
4.1.2	Irrigated softwood plantation	Other intensive land-use
4.1.3	Irrigated other forest plantation	Other intensive land-use
4.1.4	Irrigated environmental forest plantation	Other intensive land-use
4.2.0	Grazing irrigated modified pastures	Other intensive land-use
4.2.1	Irrigated woody fodder plants	Other intensive land-use
4.2.2	Irrigated pasture legumes	Other intensive land-use
4.2.3	Irrigated legume/grass mixtures	Other intensive land-use
4.2.4	Irrigated sown grasses	Other intensive land-use
4.3.0	Irrigated cropping	Other intensive land-use

4.3.1	Irrigated cereals	Other intensive land-use
4.3.2	Irrigated beverage and spice crops	Other intensive land-use
4.3.3	Irrigated hay and silage	Other intensive land-use
4.3.4	Irrigated oilseeds	Other intensive land-use
4.3.5	Irrigated sugar	Other intensive land-use
4.3.6	Irrigated cotton	Other intensive land-use
4.3.7	Irrigated alkaloid poppies	Other intensive land-use
4.3.8	Irrigated pulses	Other intensive land-use
4.3.9	Irrigated rice	Other intensive land-use
4.4.0	Irrigated perennial horticulture	Other intensive land-use
4.4.1	Irrigated tree fruits	Other intensive land-use
4.4.2	Irrigated olives	Other intensive land-use
4.4.3	Irrigated tree nuts	Other intensive land-use
4.4.4	Irrigated vine fruits	Other intensive land-use
4.4.5	Irrigated shrub berries and fruits	Other intensive land-use
4.4.6	Irrigated perennial flowers and bulbs	Other intensive land-use
4.4.7	Irrigated perennial vegetables and herbs	Other intensive land-use
4.4.8	Irrigated citrus	Other intensive land-use
4.4.9	Irrigated grapes	Other intensive land-use
4.5.0	Irrigated seasonal horticulture	Other intensive land-use
4.5.1	Irrigated seasonal fruits	Other intensive land-use
4.5.2	Irrigated seasonal flowers and bulbs	Other intensive land-use
4.5.3	Irrigated seasonal vegetables and herbs	Other intensive land-use
4.5.4	Irrigated turf farming	Other intensive land-use
4.5.5	Irrigated turf farming	Other intensive land-use
4.6.0	Irrigated land in transition	Other intensive land-use
4.6.1	Degraded irrigated land	Other intensive land-use
4.6.2	Abandoned irrigated land	Other intensive land-use
4.6.3	Irrigated land under rehabilitation	Other intensive land-use
4.6.4	No defined use - irrigation	Other intensive land-use
4.6.5	Abandoned irrigated perennial horticulture	Other intensive land-use
5.0.0	Intensive uses	Other intensive land-use
5.1.0	Intensive horticulture	Other intensive land-use
5.1.1	Production nurseries	Other intensive land-use
5.1.2	Shadehouses	Other intensive land-use
5.1.3	Glasshouses	Other intensive land-use
5.1.4	Glasshouses - hydroponic	Other intensive land-use
5.1.5	Abandoned intensive horticulture	Other intensive land-use
5.2.0	Intensive animal production	Other intensive land-use
5.2.1	Dairy sheds and yards	Other intensive land-use
5.2.2	Feedlots	Other intensive land-use
5.2.3	Poultry farms	Other intensive land-use
5.2.4	Piggeries	Other intensive land-use
5.2.5	Aquaculture	Other intensive land-use
5.2.6	Horse studs	Other intensive land-use

5.2.7	Saleyards/stockyards	Other intensive land-use
5.2.8	Abandoned intensive animal production	Other intensive land-use
5.2.9	Abandoned intensive animal husbandry	Other intensive land-use
5.3.0	Manufacturing and industrial	Urbanisation
5.3.1	General purpose factory	Urbanisation
5.3.2	Food processing factory	Urbanisation
5.3.3	Major industrial complex	Urbanisation
5.3.4	Bulk grain storage	Urbanisation
5.3.5	Abattoirs	Urbanisation
5.3.6	Oil refinery	Urbanisation
5.3.7	Sawmill	Urbanisation
5.3.8	Abandoned manufacturing and industrial	Urbanisation
5.4.0	Residential and farm infrastructure	Urbanisation
5.4.1	Urban residential	Urbanisation
5.4.2	Rural residential with agriculture	Urbanisation
5.4.3	Rural residential without agriculture	Urbanisation
5.4.4	Remote communities	Urbanisation
5.4.5	Farm buildings/infrastructure	Urbanisation
5.4.6	Land in transition to residential/infrastructure	Urbanisation
5.5.0	Services	Urbanisation
5.5.1	Commercial services	Urbanisation
5.5.2	Public services	Urbanisation
5.5.3	Recreation and culture	Urbanisation
5.5.4	Defence facilities - urban	Urbanisation
5.5.5	Research facilities	Urbanisation
5.6.0	Utilities	Urbanisation
5.6.1	Fuel powered electricity generation	Urbanisation
5.6.2	Hydro-electricity generation	Urbanisation
5.6.3	Wind electricity generation	Urbanisation
5.6.4	Electricity substations and transmission	Urbanisation
5.6.5	Electricity substations and transmission	Urbanisation
5.6.6	Gas treatment, storage and transmission	Urbanisation
5.6.7	Water extraction and transmission	Urbanisation
5.7.0	Transport and communication	Urbanisation
5.7.1	Airports/aerodromes	Urbanisation
5.7.2	Roads	Urbanisation
5.7.3	Railways	Urbanisation
5.7.4	Ports and water transport	Urbanisation
5.7.5	Navigation and communication	Urbanisation
5.8.0	Mining	Other intensive land-use
5.8.1	Mines	Other intensive land-use
5.8.2	Quarries	Other intensive land-use
5.8.3	Tailings	Other intensive land-use
5.8.4	Extractive Industry not in use	Other intensive land-use

5.9.0	Waste treatment and disposal	Urbanisation
5.9.1	Effluent pond	Urbanisation
5.9.2	Landfill	Urbanisation
5.9.3	Solid garbage	Urbanisation
5.9.5	Sewage/sewerage	Urbanisation
6.0.0	Water	Remnant
6.1.0	Lake	Remnant
6.1.1	Lake - conservation	Remnant
6.1.2	Lake - production	Remnant
6.1.3	Lake - intensive use	Other intensive land-use
6.1.4	Lake - saline	Remnant
6.2.0	Reservoir/dam	Other intensive land-use
6.2.1	Reservoir	Other intensive land-use
6.2.2	Water storage - intensive use/farm dams	Other intensive land-use
6.2.3	Evaporation basin	Other intensive land-use
6.3.0	River	Remnant
6.3.1	River - conservation	Remnant
6.3.2	River - production	Remnant
6.3.3	River - intensive use	Other intensive land-use
6.4.0	Channel/aqueduct	Other intensive land-use
6.4.1	Supply channel/aqueduct	Other intensive land-use
6.4.2	Drainage channel/aqueduct	Other intensive land-use
6.4.3	Stormwater	Other intensive land-use
6.5.0	Marsh/wetland	Remnant
6.5.1	Marsh/wetland - conservation	Remnant
6.5.2	Marsh/wetland - production	Remnant
6.5.3	Marsh/wetland - intensive use	Other intensive land-use
6.5.4	Marsh/wetland - saline	Remnant
6.6.0	Estuary/coastal waters	Remnant
6.6.1	Estuary/coastal waters - conservation	Remnant
6.6.2	Estuary/coastal waters - production	Remnant
6.6.3	Estuary/coastal waters - intensive use	Other intensive land-use

4.2 Appendix 2

The use of habitat type in the assessment of deforestation

Habitat type for species with >8% of their range classified as ‘unambiguous deforestation’ was derived from available sources (Nicolle 2006a, 2013; French 2012; Western Australian Herbarium 2018; Royal Botanic Gardens and Domain Trust 2019). Deforestation is selective depending on habitat productivity in Australia (Fensham and Fairfax 2003). The habitat terms listed as ‘productive’ habitat (Table A2) were assumed to be accurately reflected by the ‘preliminary estimate of population decline’ (Appendix

3), as these are the types of habitat that have been extensively deforested for agriculture. This probably represents an underestimate of deforestation for the eucalypts in these habitats because they are likely to have been preferentially deforested relative to the ‘preliminary estimate of population decline’, which represents decline across all the habitats within the entire geographic range of a species. The habitat terms included as ‘moderately productive’ habitats (Table A4) have declined but at a lower rate than ‘productive’ habitats and thus are likely to be more intact than the ‘preliminary estimate of population decline’. For these habitats, the actual extent of decline was assumed to be 60% of the ‘preliminary estimate of population decline’. The application of this factor assumes that ‘moderately productive’ habitats are deforested to 60% of the area indicated by the ‘preliminary estimate of population decline’ and biases of this magnitude have been documented in other estimates of deforestation in landscapes of variable productivity (Fensham *et al*. 1998). This probably represents an underestimate of deforestation for the eucalypts in these habitats but ensures that species are not listed as threatened in a category higher than their actual decline. Habitat terms listed as ‘unproductive’ habitats were assessed as Least Concern as these are preferentially uncleared in agricultural landscapes and it is not appropriate to use the ‘preliminary estimate of population decline’ as any indication of actual decline.

Table A2. Habitat terms used to assess decline in cropping and pastoral lands in terms of agricultural productivity.

Productive habitats	Moderately productive habitats	Unproductive habitats
alluvial soils	decomposed granite	acid volcanics
basaltic soils	gravelly sands	arid areas
broad depressions	gravelly soils	breakaways
calcareous loams	higher landscapes	granite outcrops
clay-loams	poorly-drained	laterite
clays (heavy)	salt-lake margins	outcrops
deep	sandplains	rocky ridges
drainage lines	sands	rocky soils
fertile	sandy-loams	shallow soils
fresh-water lake margins	swamps	skeletal soils
loams	water-logged soils	soils over sandstone
low-lying landscapes	light soils	stony rises
moderately fertile		
soils over limestone		
alkaline soils		

4.3 Appendix 3

Random points to assess deforestation in the ‘ambiguous deforestation’ land-use categories

Four thousand random points were generated within the three ‘ambiguous deforestation’ land-use categories throughout the combined geographic ranges of the species with >8% of their range classified as ‘unambiguous deforestation’ (Appendix 1), and not occurring in ‘unproductive’ habitat (Appendix 2). The value of 8% was applied to ensure that the distribution of random points aligned with the geographic range of species most affected by deforestation. The random points occur in linear proportion to the number of species occurring at that location. Thus if a random point informs twelve species it is six times more likely to be selected than if it only informs one species. This bias and the 8% cut-off concentrates random points in regions where intensive land-use was occurring but also provided a less concentrated coverage of random points within the ‘ambiguous deforestation’ land-use categories in other regions of the Australian continent (Figure A1).

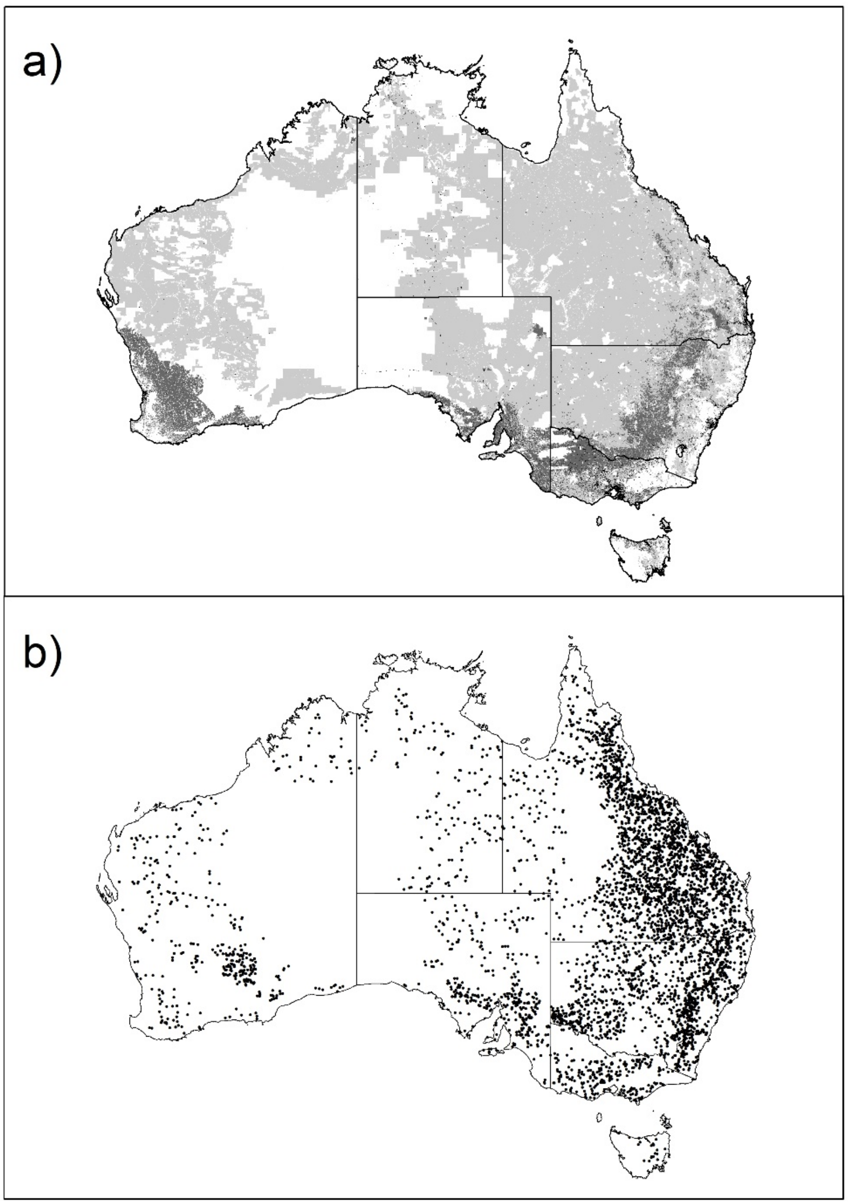

Figure A1. **a)** Land-use categories representing 'urbanisation' (black), land-use categories representing 'unambiguous deforestation' (dark grey), land-use categories representing 'ambiguous deforestation' (light grey) and areas of 'remnant' vegetation (white); **b)** distribution of random points associated with 'ambiguous' land-use categories (2.1.0 Grazing native vegetation, 3.2.0 Grazing modified pastures, 3.2.1 Native/exotic pasture mosaic).

Each random point was buffered with a 50 m radius and attributed using World Imagery (accessed March 2019) for the presence of tree clearance and tree cover <5%. Points were classified as 'deforestation' where tree clearing was present and tree cover was <5%. All other points were classified as 'remnant' habitat. A pilot exercise for *E. albens* indicated that 210 random points were required to be 90% confident that the proportion of deforested points was within 10% of a stable solution (Figure A2). Where there were less than 210 random points within the range of a species, the proportion of random points representing each of the three 'ambiguous deforestation' categories (see Table A1 above) was calculated. The nearest random points outside the range of the species were then selected according to the proportion of each of the three individual 'ambiguous deforestation' categories within the range of a species. For example, for a species range with 110 random points within its range, where 70% of the 110 random points intersected category 3.2.1 and the remaining 30% intersected category 2.1.0. The 70 nearest points intersecting category 3.2.1 and the 30 nearest points intersecting category 2.1.0 were selected (for a total of 210) to calculate the proportion of deforestation within the 'ambiguous deforestation' categories.

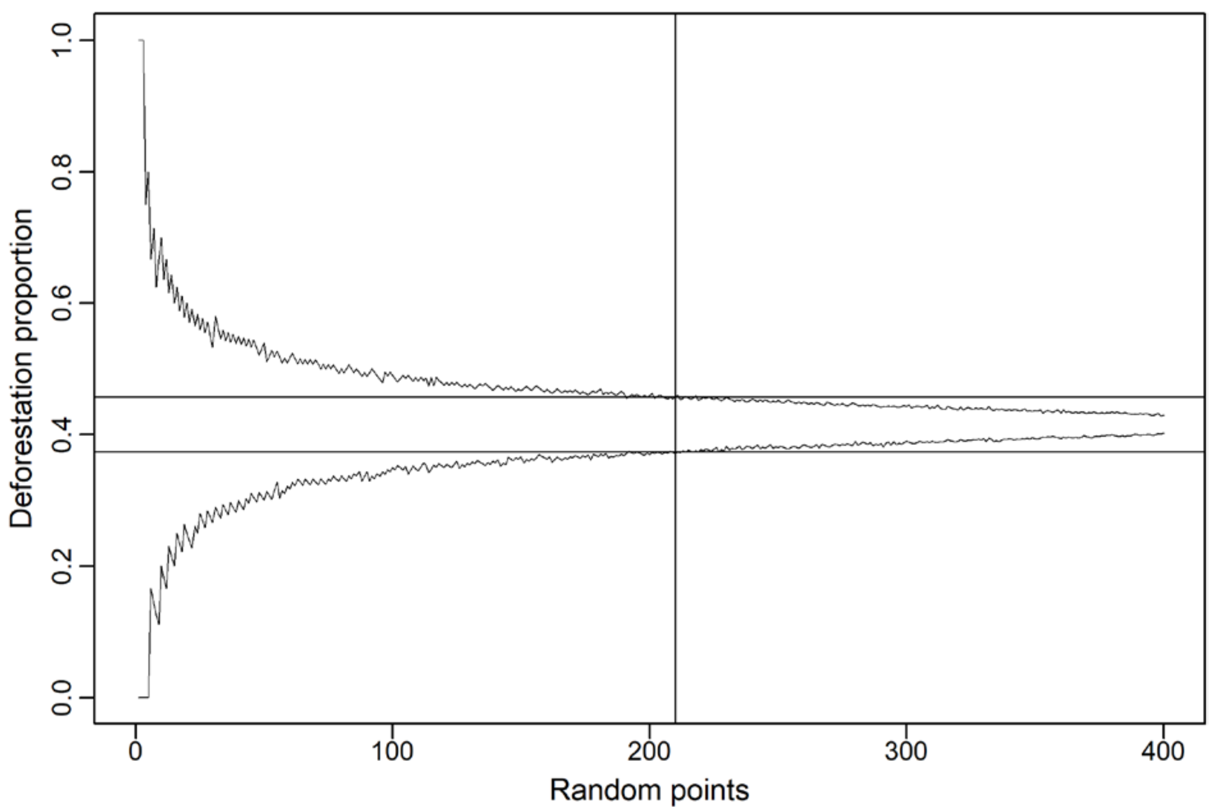

Figure A2. Bootstrapping exhibiting the 5th and 95th percentile for the proportion of deforested points (tree clearing present; tree cover <5%) with increasing frequency of random points within the geographic range of *E. albens*. The horizontal lines indicate the band within 10% of a stable solution. The vertical line indicates 210 random points are required to be within 10% of the stable value with 90% confidence.

The proportion of deforestation indicated by the random points was applied to the three ‘ambiguous deforestation’ land-use categories for each species. This area was added to the area of the ‘unambiguous deforestation’ land-use categories for each species. The total proportion of deforestation relative to the total geographic range provided a ‘preliminary estimate of population decline’.

4.4 Appendix 4

Assessing deforestation with urbanisation

Unlike land-use change associated with agriculture, decline due to urbanisation occurs independently of habitat type. The following procedure was employed to account for a species having declined due to both habitat-independent (‘urbanisation’) and habitat-dependent (‘other deforestation’) decline. ‘Other deforestation’ includes ‘other intensive land-use’ areas (see Appendix 1) and the ‘ambiguous deforestation’ land-use areas assigned as ‘less than 5% tree cover’ using random points (see Appendix 3). The method was only applied to species with >8% of their range classified as ‘urbanisation’ (see Methods Step 3; Appendix 1). For species occurring on ‘unproductive’ habitats (Appendix 2), only the proportion of decline due to ‘urbanisation’ was used to assess decline. This procedure assumes that the species’ populations in areas affected by ‘other deforestation’ would be otherwise intact because ‘unproductive’ habitats are not extensively deforested for agriculture. For species occurring on ‘productive’ habitats, the ‘preliminary estimate of population decline’ (including the ‘urbanisation’ component) was used to assess decline. This assumed the species’ habitat had undergone decline due to both urbanisation and agriculture. For species occurring on ‘moderately productive habitats’, the portion of decline due to ‘other deforestation’ was reduced by 60% (see Methods Step 2b; Appendix 2). This moderated portion was added to the ‘urbanisation’ component and provided the ‘estimate of population decline’ in the urban context. Thus for the species occupying ‘moderately productive habitat’ decline was calculated as:

$$\frac{(U + (O \times 0.6))}{R}$$

Where U was ‘urbanisation’ (km^2); O was ‘other deforestation’ (km^2); R was the total geographic range of the species (km2). The outcome of the abovementioned procedure for 21 species where the geographic range was represented by >8% ‘urbanisation’ and the species were listed as Endangered (EN) or Vulnerable (VU) under the Red List procedure (Table A3).

Table A3. Criterion A2 Red List Category for species with a geographic range (GR) represented by >8% 'urbanisation' and listed as EN or VU under criterion A2, after augmentation depending on habitat preference. Where habitat was classified as 'productive' habitat (P) the combination of 'urbanisation' (Urban) and 'other deforestation' (OD) represented decline. For species occurring on 'unproductive' habitat (U), 'urbanisation' alone represented decline. For species occurring on 'moderately productive' habitat (M) the 'other intensive land-use' is reduced by 60% and added the area of 'urbanisation' to determine the 'estimate of population decline'.

Species	GR (km^2)	Urban (km^2)	OD (km^2)	Habitat	Decline (%)	IUCN listing
E. arenicola	2,286	196	1,097	M	37.4	VU
E. aromaphloia	10,289	1,315	4,528	M	39.2	VU
E. aurifodina	1,030	167	541	M	49.1	VU
E. baueriana	955	1,075	1,986	P	32.1	VU
E. cadens	95	9	35	P	46.4	VU
E. camfieldii	487	156	8	M	32.9	VU
E. cephalocarpa	25,871	4,950	10,169	M	42.7	VU
E. conglomerata	330	112	68	M	46.4	VU
E. fulgens	1,508	384	552	P	62.1	EN
E. glaucina	3,234	266	992	P	39.0	VU
E. gomphocephala	5,733	1,057	1,238	M	31.4	VU
E. goniocalyx	106,196	8,577	41,163	M	31.3	VU
E. haemastoma	6,065	2,296	502	U	37.9	VU
E. ignorabilis	6,636	1,595	1,959	M	42.5	VU
E. lane-poolei	2,798	310	1,137	M	35.5	VU
E. litoralis	46	20	4	M	48.5	VU
E. longifolia	16,484	3,037	1,913	P	30.0	VU
E. luehmanniana	1,249	508	25	U	40.7	VU
E. ovata	159,345	13,357	62,502	P	47.6	VU
E. strzeleckii	6,479	766	3,556	P	66.7	EN
E. yarraensis	13,670	3,319	5,267	P	62.8	EN