

NSW Threatened Species Scientific Committee

Conservation Assessment of the Shorter Rainforest Ground-beetle *Nurus brevis* Motschulsky, 1865 (Carabidae)

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Shorter Rainforest Ground-beetle *Nurus brevis* Motschulsky, 1865 (Carabidae)

Distribution: Endemic to rainforest habitat in the Lismore-Richmond Range region in northeast New South Wales (NSW).

Current EPBC Act Status: Not listed

Current NSW BC Act Status: Endangered

Proposed listing on NSW BC Act: Vulnerable

Reason for change: Discovery of additional sites has increased known population size, extent of occurrence and area of occupancy.

Summary of Conservation Assessment

The Shorter Rainforest Ground-beetle, *Nurus brevis*, was found to be eligible for listing as Vulnerable under Criterion B1ab(i, ii) + B2ab(i, ii).

The main reasons for this species being eligible are i) it has a highly restricted geographic range (Extent of Occupancy 1,106 km² and Area of Occupancy 68 km²); ii) it occurs at 7-9 locations; iii) there is an inferred continuing decline in the geographic distribution (Extent of Occurrence and Area of Occupancy) caused by the combined impact of weed infestation, stormwater discharge, extreme events associated with climate change, and the small size of some remnants leading to increased edge effects, microclimate change and susceptibility to stochastic events.

Description and Taxonomy

Nurus brevis (Motschulsky, 1865) is a large, flightless ground beetle from the family Carabidae. The species is broad-bodied, with a black pronotum that can contain some subtle metallic green. Overall length is 23.5–28.2 mm and greatest width of elytra is 9.5–11.6 mm (Will and Monteith 2018). It has prominent, straight jaws and a strong bite (G. Monteith pers. comm. January 2022). *Nurus brevis* can be distinguished from the closely related *Nurus popplei* by a pronotal basal margin which is distinctly concave and an elytra basal margin which is clearly sinuate. There are eight *Nurus* species and phylogenetic analyses show three well-supported clades. *Nurus brevis* is grouped with *N. popplei*, *Nurus latipennis* and *Nurus baehri*. The species ranges do not overlap. *Nurus latipennis* occurs to the north of *N. brevis* in the Queensland Border Ranges and to the south in the Gibraltar Range. *Nurus popplei* occurs to the south-west on an isolated granite plateau surrounding the township of Torrington. *Nurus baehri* is the most southerly species and occurs on high mountains surrounding the town of Ebor. Except for *Nurus moorei* and *N. perater*, the currently known distributions of *Nurus* species are mutually exclusive (Will and Monteith 2018).

Distribution and Abundance

Nurus brevis is only found in rainforest in the Lismore-Richmond Range region in northeast NSW. There are nine known sites, an increase from five following targeted surveys conducted in 2019. *Nurus brevis* has a highly disjunct distribution. The Richmond Range is the species' stronghold, containing most of the total population in five sites, as well as the majority of potential habitat. There are four other known sites approximately 50 km east of the Richmond Range in the Lismore–Bungabee area (Charley and Andren 2021). The sites around Lismore are small, fragmented rainforest remnants (8.8 - 22 ha) in an urban landscape. The nine known sites are likely to have limited or no connectivity, as *N. brevis* is flightless and there are barriers to dispersal. The four Lismore–Bungabee sites are separated from the five on the Richmond Range by 35.8 km of predominantly cleared rural land. The four eastern sites are individually separated by rural and/or urban land, with minimum separation distances of 11 km, 9.7 km, and 2.3 km. The Richmond Range sites are separated from north to south by 2.1 km, 12.7 km, 9.6 km, and 3.2 km (Charley and Andren 2021). All gaps include unsuitable habitat of drier sclerophyll forest and the northern three sites are separated from the southern two by cleared rural land and the Bruxner Highway. Based on limited dispersal ability and distance between sites *N. brevis* is likely to have 7-9 subpopulations. *Nurus brevis* beetles from Lismore–Bungabee are smaller and greener than their Richmond Range counterparts, and this may warrant taxonomic investigation (G. Monteith pers. comm. January 2022).

Nurus brevis has an 1,106 km² Extent of Occurrence (EOO), calculated as a minimal convex polygon containing all known occurrences, the method of assessment recommended by IUCN (2022). The Area of Occupancy (AOO) is estimated to be 68 km² based on 2 x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2022).

The *Nurus brevis* population is estimated to contain hundreds of thousands of mature individuals, based on burrow counts and density data collected for each known site and extrapolated across the area of suitable habitat (Charley and Andren 2021). Recording burrows is a highly accurate survey method for calculating *Nurus* population density. Each burrow is inhabited by one individual, and the beetles actively remove items that fall on their cleared hunting arenas. Therefore, burrows rapidly become covered with leaf litter and disappear from the landscape when they are unoccupied (G. Monteith pers. comm. January 2022). In 2019, Charley and Andren surveyed 15 sites, and recorded the number of *N. brevis* burrows found at each site. Where possible, the whole area of suitable habitat was surveyed. In other instances, only a portion was searched, and density was multiplied by the area of suitable habitat to estimate number of individuals. Burrows were recorded at nine of the 15 sites, which included four new sites. There were 330 burrows per hectare in the sampled portion of the Cambridge Plateau site. The plateau rainforest covers approximately 6,000–7,000 ha and the rainforest habitats occupied by *N. brevis* are diverse, highlighted by the occurrence of the species in the dry rainforests at Mallanganee NP, which contrasts with the wet rainforests of Richmond Range NP. (Charley and Andren 2021). Therefore, there may be hundreds of thousands of mature individuals in this single site

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(Charley and Andren 2021). There is a minimum of 566 mature individuals in the other eight sites (D. Charley pers. comm. December 2021).

Ecology

All species of *Nurus* are thought to have highly similar ecology and life history (G. Monteith pers. comm. January 2022), but little has been published on the genus. Sections of the following information are based on personal communication with G. Monteith (January 2022), who has spent many years researching and observing *Nurus* beetles. Some of the information about *Nurus brevis* is inferred from knowledge of other aspects of *Nurus* life history, and comparison with similar ground-dwelling carabid species.

Burrows

Nurus beetles use their mandibles to construct a fixed, deep burrow with a distinctive, cleared entrance stage where they ambush prey. Burrows are built under rocks, logs, and tree roots and are only found where there is an open understorey. They are generally absent from areas where there is deep or complete cover of leaf litter (Charley & Andren 2018). The burrows slope gently into the soil at a shallow gradient and broadly spiral down to a terminal chamber. Total burrow length is approximately 20–40 cm, and the entrance is 3–5 cm wide and 2 cm high. The two sexes live separately and only one individual occupies a burrow, which is used throughout its life. *Nurus* beetles are nocturnal and are presumed to spend the day in the terminal chamber (G. Monteith pers. comm. January 2022).

Dispersal

Nurus brevis is a flightless ground-beetle. Both sexes remain in their burrows for much of the year. During pitfall surveys, most *Nurus* beetles are caught in summer and many more males than females are detected. This is because males are more likely to be active outside of their burrows, particularly on warm, wet nights (Charley & Andren 2018). Likewise, newly emerged adults (i.e., with soft cuticle) of both sexes are taken in pitfall traps. These are assumed to be seeking burrow sites (G. Monteith pers. comm. January 2022.). Individuals rarely disperse more than a few hundred metres, as seen in other flightless carabids (Den Boer 1990). It is unlikely that there is substantial connectivity between sites (D. Charley pers. comm. December 2021).

Diet

Nurus brevis is predatory and feeds on leaf litter invertebrates (M. Andren pers. comm. December 2021). *Nurus* beetles typically only become active at their burrow entrances at night, where they wait for small passing prey. Any invertebrate that walks across the cleared hunting arena is potential prey, which *Nurus* beetles kill and consume using their long mandibles. Once killed, pieces of the prey item are dragged back into the burrow (G. Monteith pers. comm. January 2022). *Nurus* do not hunt in the wider landscape (Lloyd 2021). The remains of large millipedes have been observed at the entrances of burrows (Charley & Andren 2018) and form a major part of the their diet, likely because they are slow moving (G. Monteith pers. comm. January 2022).

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Life history

Adult lifespan is likely to be 2–4 years (G. Monteith pers. comm. January 2022), and the generation length is one year, as is seen in other carabid species (Lawrence & Slipinski 2013). *Nurus* beetles have an extraordinarily low reproductive output for an insect. Females lay a maximum of 10 large eggs (5–6 mm long) in the summer/wet season (G. Monteith pers. comm. January 2022). Each egg is laid inside an oval mud capsule, which is the same brood care strategy as described for the pterostichine genus *Percus* in Europe (Kavanaugh 1998). The eggs hatch within a few weeks, producing 5–10 larvae that are approximately half the length of a female. The larvae probably remain in the burrow for their first instar and then leave to become free-ranging predators in the leaf litter. Young larvae leave the burrow during the wet season, when they can take advantage of abundant prey. The larval period is unknown but is likely to be 3–6 months. It is assumed that larvae pupate in April–May and overwinter as pupae. The pupal period ends at the start of summer (i.e., the wet season), when soil is soft, enabling newly emerged adults to dig burrows. There is limited evidence for timing of the life cycle; the version presented here is supported by differences in burrow counts between seasons. In winter, burrow counts are generally low, as adult mortality is likely to be at its highest, reducing the number of adults surviving in the population. During summer, burrow counts are much higher, as they incorporate the newly emerged adults (G. Monteith pers. comm. January 2022).

Threats

Fragmentation and small remnant size

Decline is most likely in *Nurus brevis*, in the four small and isolated eastern sites around Lismore, that occur in a predominantly cleared landscape and are subject to multiple threats. Small sized remnants are susceptible to increased edge effects, microclimate change and to stochastic events including extreme events associated with climate change (such as extended drought or high severity fire) (D. Charley and M. Andren pers. comm. December 2021, Grimbacher *et al.* 2006). This is supported by *N. brevis* being abundant in large areas of habitat that are relatively undisturbed (e.g., Cambridge Plateau) and patchy in small, disturbed remnants such as Rotary Park (Charley and Andren 2021). Decline in carabid diversity has been documented in habitat remnants in urban and agricultural landscapes (Homburg *et al.*, 2019; Sadler *et al.*, 2006). Fragmentation and small remnant size can lead to high population densities of competing native and introduced species and exacerbate the negative impact of climate events such as drought, severe storms and localised flooding and environmental impacts such as stormwater

Competition and predation by Cane Toads

The introduced Cane Toad (*Rhinella marina*) is known to be present in the Lismore–Bungabee rainforest remnants and is considered a threat to *Nurus brevis*. Cane Toads are likely to compete with the species for food resources, as well as directly reducing the *N. brevis* population through predation (G. Monteith pers. comm. January 2022). *Nurus* adults have powerful chemical defence in form of strong-smelling spray from anal glands when disturbed. The common presence of *Nurus* adults in toad digestive

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tracks shows that this does not deter toad predation (G. Monteith pers. comm. January 2022). *Nurus brevis* is particularly vulnerable to predation by toads during two critical periods: 1) when adult males emerge on warm wet nights; and 2) after pupa hatch and young adults have not yet dug their burrow (Charley & Andren 2018). *Nurus brevis* has a low reproductive rate for an invertebrate, so predation of adult beetles by Cane Toads will reduce the population over time (G. Monteith pers. comm. January 2022). The threat of Cane Toads is most apparent for *N. brevis* at Rotary Park and Wilson Nature Reserve (Charley and Andren 2021). The Cambridge Plateau may be high enough that Cane Toads are not currently a threat to *N. brevis* in this area (G. Monteith pers. comm. January 2022).

While there is no direct evidence of Cane Toad mediated *Nurus brevis* declines, other *Nurus* species have disappeared from lowland places in Queensland where they used to be common (G. Monteith pers. comm. January 2022). This has been attributed to predation by Cane Toads, as *Nurus* remained abundant at high elevation sites where Cane Toads were not present (Newell 2011). Cane Toads have since invaded Bulburin and the Border Ranges National Park, and *Nurus* species have been detected in Cane Toad gut content from these locations. Similarly, the subtropical carabids of the genus *Pamborus* used to occur in extremely high abundance but disappeared from several lowland localities in southern Queensland following the arrival of the Cane Toad (G. Monteith pers. comm. January 2022).

Weeds

Wilson NR and Rotary Park have significant weed infestations, including *Ligustrum sinense* (Small-Leaved Privet), *Cinnamomum camphora* (Camphor Laurel) and *Dolichandra unguis-cati* (Cat's Claw Creeper). At both sites, *Nurus brevis* is rare or absent where these weeds dominate. As *Nurus brevis* requires an open understorey, weed infestations create unsuitable habitat conditions. (Charley and Andren 2021). Targeted weed control programs would help to mitigate this threat and secure populations.

Stormwater discharge

There are stormwater discharge issues at Mallanganee National Park and Rotary Park, reducing the area of suitable habitat and increasing the threat of inundation in these remnants. For example, at Mallanganee NP, *Nurus brevis* occurs immediately downslope of the Bruxner Highway and several drains discharge into the occupied habitat (Charley and Andren 2021).

Extreme events associated with climate change

Nurus beetles are sensitive to dry conditions and become more difficult to find during periods of drought (M. Andren pers. comm. December 2021). Droughts are predicted to become more frequent and intense under climate change in northern NSW (Herold *et al.* 2018). *Nurus brevis* may be impacted by drought in the small, fragmented rainforest remnants around Lismore because: 1) the critical thresholds of habitat availability and quality below which a decline in mature individuals is likely to occur increase with environmental change (Oliver *et al.* 2013; Travis 2003); 2) small areas

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of habitat are particularly sensitive to drying (Oliver & Morecroft 2014; Sutcliffe *et al.* 1997); 3) habitat fragmentation will prevent site recovery after drought, as an extirpated habitat patch is unlikely to be recolonised (Piessens *et al.* 2009) and; 4) food availability is likely to decline as leaf litter invertebrate numbers decrease and individual beetles in small, fragmented patches have reduced opportunity to seek food in other locations (Lindberg *et al.* 2002).

To date, fire has not had a negative effect on *Nurus brevis*. Four sites of the species have a history of fire. However, fire regimes are being modified by climate change and this represents a potential future threat, particularly when combined with increased frequency and intensity of drought. Increased evaporation and drier winter conditions are predicted in northern NSW (DECCW 2010), which will lead to seasonal changes in fire frequency and intensity. Many rainforest remnants could have sustained a ground fire during the 2019 drought (M. Andren pers. comm. June 2022), and fire can have severe consequences for rainforest species such as *N. brevis*, as they are not fire adapted (Berlinck and Batista 2020).

The Lismore-Richmond Range region is susceptible to flooding rains, and while *Nurus brevis* habitat is generally above the flood zone, prolonged rainfall could impact the species by inundating burrows (M. Andren pers. comm. June 2022). Rising average temperature in NSW is increasing the likelihood of extreme weather events such as heavy rainfall and thunderstorms (Hennessy *et al.* 2004). East coast lows are the main cause of extreme storms along the NSW coast and climate modelling predicts there will be an increase in extreme low-pressure systems during the warmer months (NSW Government 2022; IPCC 2021). However, currently there is no evidence to demonstrate flooding has any impact on the species.

Assessment against IUCN Red List criteria

For this assessment it is considered that the survey of *Nurus brevis* has been adequate and there is sufficient scientific evidence to support the listing outcome.

Criterion A *Population Size reduction*

Assessment Outcome: Not met.

Justification: It is unlikely that there has or will be a population size reduction large enough to categorise *Nurus brevis* as threatened under Criterion A in the past/next ten years. There is estimated to be hundreds of thousands of mature individuals on the Cambridge Plateau, and this site appears to be secure. The eastern sites in the Lismore-Bungabee region are relatively small and disjunct and are likely to experience ongoing loss of mature individuals as they are subject to numerous threats. However, this is unlikely to equate to a large enough total population reduction to assess the species as threatened under Criterion A given the presence of a large, robust site on the Cambridge Plateau.

Criterion B *Geographic range*

Assessment Outcome: Vulnerable under Criterion B1ab(i,ii) and B2ab(i, ii).

Justification: *Nurus brevis* has a best estimate 1,106 km² EOO (EOO <5,000 km² = EN), calculated as a minimal convex polygon containing all known occurrences, the

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method of assessment recommended by IUCN (2022). The AOO is best estimated to be 68 km² (AOO < 500 km² = EN) based on 2 x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2022). The EOO and AOO were estimated in GeoCAT (Bachman *et al.* 2011) using validated Bionet records. Both the EOO and AOO meet the thresholds for Endangered, however, the species falls within the Vulnerable threshold for number of locations under subcriterion a, therefore the overall threat category for Criterion B is Vulnerable, as the lowest category must be taken.

In addition to these thresholds, at least two of three other conditions must be met. These conditions are:

- a) The population or habitat is observed or inferred to be severely fragmented or there is 1 (CR), ≤5 (EN) or ≤10 (VU) locations.

Assessment Outcome: Sub criterion met for Vulnerable with 7-9 locations.

There are 7-9 locations when considering the most serious plausible threat of small remnant size. The number of locations has been calculated by adding the number of small remnants from the Lismore–Bungabee area (4) to the number of subpopulations in the Richmond Range (3-5), which currently show no evidence of impacts from any threats to the species. The species is not considered to be severely fragmented.

Justification: The most serious plausible threat to *N. brevis* is small remnant size which only affects the four Lismore-Bungabee sites. These sites occur in rainforest remnants separated by rural and urban land. In contrast, the subpopulations in the Richmond Range are estimated to contain hundreds of thousands of *N. brevis* beetles and there is no evidence to suggest that any of the threats to the species are impacting these subpopulations. According to the IUCN Guidelines (2022) when parts of the distribution are not affected by any threat, the following options will be appropriate under different circumstances: (a) number of locations is not used (i.e., the subcriteria that refer to the number of locations consequently are not met), especially if the unaffected area is more than half the taxon's range; (b) number of locations in the unaffected areas is set to the number of subpopulations in those areas, especially if there are several subpopulations; (c) the number of locations is based on the smallest size of locations in the currently affected areas; (d) the number of locations is based on the most likely threat that may affect the currently-unaffected areas in the future. For *N. brevis*, the number of locations in the unaffected area has been set to the number of subpopulations in those areas (3-5). The other options that could have been chosen in this situation have not been used because: (i) the unaffected area is not more than half of the taxon's range, (ii) the locations in the affected area are very small in comparison to the Richmond Range sites and would result in a number of location greater than 10 which does not meet the thresholds for this criteria and (iii) it is not clear what the most likely threat in the future is in the currently unaffected areas. As such, the total number of locations for *N. brevis* is 7-9, which qualifies as Vulnerable under this sub criterion.

The species is not considered to be severely fragmented. While there is unlikely to be substantial dispersal between sites and the sites in Lismore-Bungabee are

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small, isolated and may not persist in the future, 70% of the species AOO occurs in the Richmond Range, and sites in this region are considered robust (Charley and Andren 2021).

- b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or sites; (v) number of mature individuals

Assessment Outcome: Sub criterion met - continuing decline is inferred in (i) Extent of Occurrence (EOO) and Area of Occupancy (AOO)

There is inferred continuing decline in the EOO and AOO of *Nurus brevis*, from loss of small habitat remnants as a result of the compounding effects of weed infestation, stormwater discharge, extreme events associated with climate change (such as extended drought or high severity fire), and the small size of some remnants leading to increased edge effects microclimate change and susceptibility to stochastic events (D. Charley and M. Andren pers. comm. December 2021, Grimbacher *et al.* 2006). There is also some evidence suggesting decline in the number of mature individuals caused by Cane Toad competition and predation, fragmentation and isolation, and stormwater discharge at some sites (G. Monteith pers. comm. January 2022). This loss of individuals can be inferred as a decline of mature adults at the species level.

- c) Extreme fluctuations.

Assessment Outcome: Not met.

Justification: There is no direct evidence of extreme 10-fold fluctuations.

Criterion C Small population size and decline

Assessment Outcome: Not met.

Justification: The *Nurus brevis* population is estimated to contain hundreds of thousands of mature individuals, based on population density data collected for each known site, and extrapolated across the area of suitable habitat (D. Charley pers. comm. December 2021).

Criterion D Very small or restricted population

Assessment Outcome: Not met.

Justification: The *Nurus brevis* population is estimated to contain hundreds of thousands of mature individuals, based on population density data collected for each known site, and extrapolated across the area of suitable habitat (D. Charley pers. comm. December 2021). The species has a 68 km² Area of Occupancy, there are six locations, and there is no clear future threat to *N. brevis* that would contribute to the extinction of the species in a very short time. As a result, *N. brevis* does not meet the thresholds for listing under Criterion D.

To be listed as Vulnerable under D, a species must meet at least one of the two following conditions:

D1. Population size estimated to number fewer than 1,000 mature individuals

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Assessment Outcome: Not met.

Justification: The *Nurus brevis* population is estimated to contain hundreds of thousands of mature individuals, based on population density data collected for each known site, and extrapolated across the area of suitable habitat (D. Charley pers. comm. December 2021).

D2. Restricted Area of Occupancy (typically <20 km²) or number of locations (typically <5) with a plausible future threat that could drive the taxon to CR or EX in a very short time.

Assessment Outcome: Not met.

Justification: The area of occupancy is estimated to be 68 km², there are six locations, and there is no clear future threat to that would contribute to the extinction of the species in a very short time.

Criterion E Quantitative Analysis

Assessment Outcome: Data deficient

Justification: Sufficient data are not available to conduct a quantitative analysis.

Conservation and management actions

This species is currently listed on the NSW *Biodiversity Conservation Act 2016* and a conservation project has been developed by the NSW Department of Planning and Environment under the Saving our Species program. The conservation project identifies priority locations, critical threats and required management actions to ensure the species is extant in the wild in 100 years. *Nurus brevis* sits within the data deficient species management stream of the SoS program and the conservation project can be viewed here

(<https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10565>).

References

Berlinck C, Batista E (2020) Good fire, bad fire: It depends on who burns. *Flora* **268**, 151610.

Charley D, Andren M (2018) The distribution and conservation of the endangered atlas rainforest ground-beetle, *Nurus atlas* '(Laporte, 1867) (Coleoptera: Carabidae), in North-east New South Wales. *Australian Entomologist* **45**, 389–402.

Charley D, Andren M (2021) The distribution and conservation status of the shorter rainforest ground-beetle, *Nurus brevis* Motschulsky, 1865 (Coleoptera: Carabidae), in north-East New South Wales. *Australian Entomologist* **48(4)**, 384-396.

DECCW (2010) NSW Climate Impact Profile: The impacts of climate change on the biophysical environment of New South Wales. New South Wales Department of Environment, Climate Change and Water, Sydney, NSW.

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- Grimbacher PS, Catterall CP, Stork NE (2008) Do edge effects increase the susceptibility of rainforest fragments to structural damage resulting from a severe tropical cyclone?. *Austral Ecology*, **33**(4), 525–31.
- Hennessy K, Page C, McInnes K, Jones R, Bathols J, Collins D, Jones D (2004) *Climate Change in New South Wales*. CSIRO Atmospheric Research, Aspendale.
- Herold N, Ekström M, Kala J, Goldie J, Evans J (2018) Australian climate extremes in the 21st century according to a regional climate model ensemble: Implications for health and agriculture. *Weather Extreme Climates* **20**, 54–68.
- Homburg K, Drees C, Boutaud E, Nolte D, Schuett W, Zumstein P, von Ruschkowski E, Assmann T (2019) Where have all the beetles gone? Long-term study reveals carabid species decline in a nature reserve in Northern Germany. *Insect Conservation and Diversity* **12**, 268–277.
- IPCC (2021) *Climate Change 2021: The Physical Science Basis*. Cambridge University Press, Cambridge, United Kingdom.
- IUCN Standards and Petitions Subcommittee (2022) *Guidelines for Using the IUCN Red List Categories and Criteria*. Version 15.
https://nc.iucnredlist.org/redlist/content/attachment_files/RedListGuidelines.pdf
- Kavanaugh DH (1998) Field observations confirming brood care in *Percus passerinii* in the Tuscan Apennines, Italy (Coleoptera Carabidae). *Bollettino della Società Entomologica Italiana* **130**, 55–63.
- Lindberg N, Engtsson J, Persson T (2002) Effects of experimental irrigation and drought on the composition and diversity of soil fauna in a coniferous stand. *Journal of Applied Ecology* **39**, 924–936.
- Lloyd P (2021) *Woolgoolga to Ballina Pacific Highway Upgrade Invertebrate Monitoring Program Annual Report 2021, Year 1 Operation Phase Report*. BAAM Ecological Consultants, NSW.
- NSW Government (2022) 'Climate change impacts on storms and floods.' Available at:
<https://www.climatechange.environment.nsw.gov.au/storms-and-floods#:~:text=Several%20times%20each%20year%2C%20intense,and%20flood%20events%20more%20severe.> (accessed 30.06.2022).
- Oliver TH, Brereton T, Roy DB (2013) Population resilience to an extreme drought is influenced by habitat area and fragmentation in the local landscape. *Ecography* **36**, 579–586.
- Oliver TH, Morecroft MD (2014) Interactions between climate change and land use change on biodiversity: attribution problems, risks, and opportunities. *Wiley Interdisciplinary Reviews: Climate Change* **5**(3), 317–335.

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Piessens K, Adriaens D, Jacquemyn H, Honnay O (2009) Synergistic effects of an extreme weather event and habitat fragmentation on a specialised insect herbivore. *Oecologia* **159**, 117–126.

Sadler J, Small E, Fiszpan H, Telfer M, Niemelä J (2006) Investigating environmental variation and landscape characteristics of an urban–rural gradient using woodland carabid assemblages. *Journal of Biogeography* **33**, 1126–1138.

Travis J (2003) Climate change and habitat destruction: a deadly anthropogenic cocktail. *Proceedings of the Royal Society of London. Series B: Biological Sciences* **270** (1514), 467–473.

Will K, Monteith G (2018) Multi-locus phylogeny, taxonomic review and description of new species of Australian *Nurus* (*Sensu Stricto*) Motschulsky, 1865 (Coleoptera: Carabidae: Pterostichini). *Australian Entomologist* **45**, 353–388.

Expert Communications

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APPENDIX 1

Assessment against *Biodiversity Conservation Regulation 2017* criteria

The Clauses used for assessment are listed below for reference.

Assessment Outcome:

Nurus brevis was found to be Vulnerable under Clause 4.3 (c)(d)(e, ii).

Clause 4.2 – Reduction in population size of species

(Equivalent to IUCN criterion A)

Assessment Outcome: Data Deficient

| (1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon: | | | |
|--|-----|---|---|
| | (a) | for critically endangered species | a very large reduction in population size, or |
| | (b) | for endangered species | a large reduction in population size, or |
| | (c) | for vulnerable species | a moderate reduction in population size. |
| (2) - The determination of that criteria is to be based on any of the following: | | | |
| | (a) | direct observation, | |
| | (b) | an index of abundance appropriate to the taxon, | |
| | (c) | a decline in the geographic distribution or habitat quality, | |
| | (d) | the actual or potential levels of exploitation of the species, | |
| | (e) | the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites. | |

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**Clause 4.3 - Restricted geographic distribution of species and other conditions
(Equivalent to IUCN criterion B)**

Assessment Outcome: Vulnerable under Clause 4.3 (c)(d)(e, ii)

| The geographic distribution of the species is: | | | |
|--|-----|---|---|
| | (a) | for critically endangered species | very highly restricted, or |
| | (b) | for endangered species | highly restricted, or |
| | (c) | for vulnerable species | moderately restricted, |
| and at least 2 of the following 3 conditions apply: | | | |
| | (d) | the population or habitat of the species is severely fragmented or nearly all the mature individuals of the species occur within a small number of locations, | |
| | (e) | there is a projected or continuing decline in any of the following: | |
| | | (i) | an index of abundance appropriate to the taxon, |
| | | (ii) | the geographic distribution of the species, |
| | | (iii) | habitat area, extent or quality, |
| | | (iv) | the number of locations in which the species occurs or of populations of the species, |
| | (f) | extreme fluctuations occur in any of the following: | |
| | | (i) | an index of abundance appropriate to the taxon, |
| | | (ii) | the geographic distribution of the species, |
| | | (iii) | the number of locations in which the species occur or of populations of the species. |

**Clause 4.4 - Low numbers of mature individuals of species and other conditions
(Equivalent to IUCN criterion C)**

Assessment Outcome: Not met

| The estimated total number of mature individuals of the species is: | | | | |
|--|-----|---|-----------------------------------|----------------|
| | (a) | for critically endangered species | very low, or | |
| | (b) | for endangered species | low, or | |
| | (c) | for vulnerable species | moderately low, | |
| and either of the following 2 conditions apply: | | | | |
| | (d) | a continuing decline in the number of mature individuals that is (according to an index of abundance appropriate to the species): | | |
| | | (i) | for critically endangered species | very large, or |
| | | (ii) | for endangered species | large, or |
| | | (iii) | for vulnerable species | moderate, |
| | (e) | both of the following apply: | | |

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| | | | | | |
|--|--|------|---|-----------------------------------|-------------------|
| | | (i) | a continuing decline in the number of mature individuals (according to an index of abundance appropriate to the species), and | | |
| | | (ii) | at least one of the following applies: | | |
| | | (A) | the number of individuals in each population of the species is: | | |
| | | | (I) | for critically endangered species | extremely low, or |
| | | | (II) | for endangered species | very low, or |
| | | | (III) | for vulnerable species | low, |
| | | (B) | all or nearly all mature individuals of the species occur within one population, | | |
| | | (C) | extreme fluctuations occur in an index of abundance appropriate to the species. | | |

Clause 4.5 - Low total numbers of mature individuals of species

(Equivalent to IUCN criterion D)

Assessment Outcome: Not met

| | | | | | |
|--|--|-----|-----------------------------------|-------------------|--|
| The total number of mature individuals of the species is: | | | | | |
| | | (a) | for critically endangered species | extremely low, or | |
| | | (b) | for endangered species | very low, or | |
| | | (c) | for vulnerable species | low. | |

Clause 4.6 - Quantitative analysis of extinction probability

(Equivalent to IUCN criterion E)

Assessment Outcome: Data deficient

| | | | | | |
|---|--|-----|-----------------------------------|--------------------|--|
| The probability of extinction of the species is estimated to be: | | | | | |
| | | (a) | for critically endangered species | extremely high, or | |
| | | (b) | for endangered species | very high, or | |
| | | (c) | for vulnerable species | high. | |

Clause 4.7 - Very highly restricted geographic distribution of species–vulnerable species

(Equivalent to IUCN criterion D2)

Assessment Outcome: Not met

| | |
|-------------------------|--|
| For vulnerable species, | the geographic distribution of the species or the number of locations of the species is very highly restricted such that the species is prone to the effects of human activities or stochastic events within a very short time period. |
|-------------------------|--|