Conservation Assessment of the Lord Howe Island Wood-feeding Cockroach *Panesthia lata* Walker, 1868 (Blaberidae)

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NSW Threatened Species Scientific Committee

Lord Howe Island Wood-feeding Cockroach *Panesthia lata* Walker, 1868
Distribution: Endemic to Lord Howe Island (NSW)
Current EPBC Act Status: Not Listed
Current NSW BC Act Status: Endangered
Proposed listing on NSW BC Act: Critically Endangered

Reason for change

Genuine change based on increasing threat of habitat decline due to weed invasion and increasing hydrological deficit as a result of climate change.

Summary of Conservation Assessment

The Lord Howe Island Wood-feeding Cockroach *Panesthia lata* was found to be eligible for listing as Critically Endangered under B1ab(iii).

The main reasons for this listing are i) It has a very highly restricted geographic range (AOO = 16km^2, EOO = 62.19km^2); ii) It is severely fragmented, found in small genetically isolated subpopulations which are scattered across four islands in the Lord Howe Group; and, iii) There is inferred continuing decline in habitat quality as a consequence of weed encroachment and increased hydrological deficit driven by climate change.

Review of status was conducted as the current Endangered status was assigned under previous NSW legislation (*NSW Threatened Species Conservation Act 1995*) where the highest threat category available at the time of listing (2001) was Endangered.

Description and Taxonomy

The Lord Howe Island Wood-feeding Cockroach *Panesthia lata* is a large, flightless, burrowing cockroach endemic to the Lord Howe Island Group of New South Wales (NSW). *Panesthia lata* was initially described by Walker (1868), and then subsequently by Roth (1977) as part of a broad taxonomic revision of cockroaches of the sub-family Panesthiinae (Roth, 1977). Roth 1977 describes *P. lata* as:

Male: Head punctulate, ocellar spots not round, vertex not foveolate, exposed. Pronotum convex, anterior margin very slightly concave, incrassate, with a small mesal rounded elevation; anterior half moderately depressed, the floor sparsely roughened and with fine transverse striae; laterally finely and sparsely punctate, mesal disc tubercles represented by low, rounded mounds. Meso- and metanotum with very few, fine punctations. Mesonotum not reaching the margin of the body, the anterior half, or the entire lateral margin, covered by the tegmina. Tegmina lateral, reaching slightly beyond hind margin of mesonotum. Wings absent. Tergites hairless, shallowly punctate, the punctations more numerous on posterior segments; anterolateral corners of T5-T7 with small holes lacking setae, the opening on T5 very small. Lateral margin of segment 7 practically straight, the caudal angle short, stout, directed caudad. Supranal plate densely punctate, hind margin arcuate, entire, the lateral angle

short, rounded. Sternites shallowly punctate, punctations most numerous on S7 whose hind margin is concave. Cercus subrectangular, dorsoapical surface punctulate but lacking setae, ventrally with a setose swelling below apex. Anteroventral margin of front femur with 1–2 spines and a small distal spine, hind margin with a large distal spine. Genital phallomeres well developed. Total length 33–40 mm; pronotum length x width 7.8–9 x 13–14.5 mm; tegmen length x width 4.5–5.7 x 2.8–3.6 mm.

Colouration: somewhat metallic, shiny. Head reddish to black, apex of clypeus and base of labrum tawny, remainder of labrum brownish, the apex darker. Pronotum with disc blackish, blending into reddish. Meso- and metanotum and anterior abdominal tergites blackish. Mesal edge of tegmen pale. Abdominal sternites black, legs reddish.

Female: Female differs from male as follows: Anterior pronotal margin slightly concave, but not incrassate and lacking the mesal elevation. Anterior half of the pronotum less depressed and punctate and without elevated mounds of tubercles; in their place may be a pair of round, slight depressions. The female is generally blacker than the male, showing less of the reddish tinge and lacking the metallic shine. The apical clypeal band is also much narrower than in the male. Anteroventral margin of front femur with 2 spines. Total length 32.5–41 mm; pronotal length x width 7.5–9.2 x 12.5–16 mm; tegmen length x width 5–6.4 x 3–3.8 mm.

Nymph: The female nymph (18 mm) has meso- and metanotum and abdominal tergites densely punctate, holes in anterolateral corners of T5-T7, and hind margin of the supranal plate entire'.

Genetics, sub-populations, and fragmentation

Genetic studies support the original description of *Panesthia lata* as representing a single species across the Lord Howe Island Group, despite restricted gene flow between islands (Adams, 2023; Lo et al., 2016). A preliminary 2016 study incorporating a single individual from each of Blackburn and Roach islands found there was evidence to support the idea that subpopulations on different islands may have diverged sufficiently to constitute species level classification (Lo et al., 2016). However, a follow-up study by the same lab in 2023 examined a larger sample from a broader range of subpopulations (Lord Howe n=10, Blackburn n=15, Roach n=21, Balls n=2), finding that although subpopulations showed divergence between islands, this divergence is relatively recent (17.0 to 43.7 ka), and not sufficient to warrant species level reclassification (Adams, 2023).

Adams (2023) highlights that some uncertainty remains around the subpopulation on Ball's pyramid, for which there is evidence of both morphological and genetic divergence from the other islands that could constitute reclassification at a sub-species or species level (Adams, 2023). However, *Panesthia lata* has not been sighted or collected on Ball's Pyramid since 1969, including following an intensive survey by the Australian Museum in 2017, so the number of available samples for genetic analysis was low (n=2), and these samples were both juveniles from a museum collection, making assessment of morphological differences difficult (Adams, 2023; Flemons et al., 2018). As a result, the level of genetic and morphological divergence of the Ball's Pyramid subpopulation from the rest of the Lord Howe Island Group is still unclear, and there is currently not enough information to support listing of the Ball's Pyramid subpopulation as a separate species (Adams, 2023).

Results of this study show *Panesthia lata* is fragmented across its range, with little to no gene flow between islands over at least the last 10-50 thousand years (Adams,

2023). Adams (2023) found that while subpopulations did not diverge to a species level, there was significant divergence between the subpopulations on each island, and little evidence of recent gene flow. Each island then supports a distinct subpopulation as per the IUCN (2022) definition.

Panesthia lata is flightless and appears to show high site fidelity, and as a result is extremely unlikely to easily or regularly cross even the smallest bodies of ocean between islands. Some terrestrial invertebrates, including *Panesthia* species, have been observed or suggested to 'raft' over large areas of ocean, floating on collections of debris blown from one island to another, and leading to possible colonisation or bolstering of subpopulations on new islands (Bartlett et al., 2021; Cowie, 2001; Lindo, 2020; Maekawa & Matsumoto, 2002; Yeh et al., 2018). However, while this mechanism may help explain the distribution of *P. lata* across islands in the Lord Howe Group, the genetic evidence suggests this would be extremely uncommon, and does not support any meaningful, ongoing genetic flow between islands.

Distribution and Abundance

Panesthia lata is known from 4 sites, Blackburn Island, Roach Island, Lord Howe Island and Balls Pyramid, each of which can be regarded as a subpopulation (Adams 2023). There is a possible sighting on Muttonbird Island and there are other potential areas of occurrence on Lord Howe Island and offshore small islands.

Panesthia lata is endemic to the subtropical Lord Howe Island Group, NSW. Lord Howe Island (also 'the main island' or LHI) (-31.553, 159.082) is the largest of a collection of small volcanic islands in the Tasman Sea, 760 km northeast of Sydney (Department of Environment and Climate Change (NSW), 2007). The island is approximately 11 km long, 2.8 km at its widest point, with a total area of 1455 hectares and a maximum elevation of 875 m at its highest peak, Mount Gower (Department of Environment and Climate Change (NSW), 2007). The Lord Howe Island Group was colonised by lineages of flora and fauna from mainland Australia, New Zealand, and New Caledonia, and this diversity of sources combined with the island group's isolation has led to the evolution of a high number of endemic species and unique ecosystems (Auld & Leishman, 2015). There is a small town on the main island, however development and tourism are strictly controlled; 75% of the main island, and all other islands in the Lord Howe Island Group are conservation protected, and the island group is UNESCO world heritage listed (Department of Environment and Climate Change (NSW), 2007).

The Lord Howe Island Group contains 28 islands in total. The most southerly island is Ball's Pyramid (-31.754, 159.251), around 23km from the main island. One kilometre to the north of the main island lies a collection of small islands known as the Admiralty Group, of which Roach Island is the largest (-31.500, 159.069). On the west side of Lord Howe lies Blackburn Island (also known as Rabbit Island, -31.535, 159.060), while to the east lies Muttonbird Island (-31.540, 159.108) (Carlile et al., 2018; Department of Environment and Climate Change (NSW), 2007). These smaller islands are uninhabited, but are irregularly visited by tourists, conservation workers and researchers.

Distribution across islands in the Lord Howe Island Group

Panesthia lata has been collected from four islands in the Lord Howe Island Group; Lord Howe Island (-31.553, 159.082), Roach Island (-31.499, 159.068), Blackburn Island (-31.535, 159.060), and Ball's Pyramid (-31.754, 159.250). Experts also suggest it may also occur on a further four islands in the group; Muttonbird Island (-31.541, 159.108), South Island (-31.502, 159.073), Soldiers Cap (-31.509, 159.063), and Tenth of June (-31.495, 159.071) (Carlile et al., 2018).

Lord Howe Island apparent extirpation and rediscovery

Two very small (estimated 1000-2000 individuals each) groups of *Panesthia lata* were rediscovered on Lord Howe Island in 2022, following the rodent eradication program on the island (Adams, 2023). *Panesthia lata* was historically present on the main island but appeared to have been extirpated following the introduction of ship rats (*Rattus rattus;* also commonly called black rats) in 1918, and was believed to be extinct on the island since at least the 1930s (Adams, 2023; Carlile et al., 2018).

Lord Howe Island has been the focus of decades of extensive and ongoing invertebrate surveys, however *Panesthia lata* was not rediscovered until 2022, following the rodent eradication program (Adams, 2023; M. Adams *in litt*. July, 2023). This recent rediscovery of *P. lata* on Lord Howe Island suggests this subpopulation has persisted at an undetectable density under rodent pressure and has increased in the absence of rats.

This rediscovered subpopulation is known from the ground under two Australian banyan trees (*Ficus macrophylla* forma *columnaris*) separated by 400 m. So far specimens have not been found between the banyans or under any of the other surveyed banyans on the island (Adams, 2023; M. Adams *in litt*. July, 2023).

It is possible that this subpopulation represents the only remnant subpopulation on Lord Howe Island, as no other specimens have been found in the decades of invertebrate surveys prior to 2022, or in other targeted surveys since 2022 (Adams, 2023; Carlile et al., 2018; M. Adams in litt. July, 2023). However, in the absence of rodent pressure it is possible that other previously undetectable subpopulations may return to detectable densities, given that banyan dominated habitat is widespread in the lowlands (Sheringham *et al*. 2016).

Blackburn Island

Blackburn Island is a very small (2.4 hectare) island situated in a lagoon, 720m to the west of the main Lord Howe Island (Carlile et al., 2018; Department of Environment and Climate Change (NSW), 2007).

The island is dominated (>70%) by exotic Rhodes grass (*Chloris gayana*), which provides very low-quality habitat for *Panesthia lata*, as well as about 12 small trees of sallywood (*Lagunaria patersonia*), and a single large Australian banyan tree (*Ficus macrophylla* forma *columnaris*) (Carlile et al., 2018). This Australian banyan tree is the single source of high-quality habitat available to *P. lata* on Blackburn Island, and despite only covering ~8% of the area of the island supports 60 - 90% of that island's total population of cockroaches (Carlile et al., 2018). Rodents are unknown from Blackburn Island (Carlile *et al*. 2018), and so *P. lata* on Blackburn Island has been free of the predation that led to the near extinction of cockroaches on the main island.

Blackburn Island is the most accessible of the small islands in the Lord Howe Group, and as a result the subpopulation of *Panesthia lata* on Blackburn is the best surveyed subpopulation in the island group. Carlile *et al*. (2018) conducted a variety of surveys

for *P. lata* on Blackburn Island, examining their presence across different habitat types. While the authors caution that these were only preliminary surveys, they provide the most thorough and recent estimates of population size and distribution for the subpopulation on Blackburn Island.

Roach Island

Roach Island lies about 1,100 m from Lord Howe Island and is the largest (14.5 ha) of the Admiralty group, a small group of islands to the north of Lord Howe Island. Roach Island is uninhabited and difficult to access. Consequently, while tourism and research surveys are legally permitted, Roach Island is rarely visited (Carlile et al., 2013). In their 2013 seabird survey of the island Carlile, Priddel, and Bower report that:

"Human trampling could have significant impact on burrowing species due to the fragility of the skeletal soils on Roach Island. Tourism, although permitted under licence, is very limited due to the difficulty of access and the need for calm sea conditions to allow safe landings. Visits to conduct scientific studies occur infrequently…"

Roach island is dominated by habitat considered low quality by Carlile et al (2018) but has one large (1500m2) patch of leafy flat sedge (*Cyperus lucidus*). leafy flat sedge is considered by Carlile et al (2018) to be a key habitat type for *Panesthia lata*, although the cockroach occurs in far lower densities in this habitat than under the Australian banyan tree on Blackburn Island (Carlile et al., 2018). Beyond the sedge patch, Carlile *et al*. (2018) noted few specimens amongst rocks and plant debris, and low numbers in other known but low-quality habitat types.

Rodents have not been recorded from Roach Island, with *Panesthia lata* there free of the predation that led to the near extinction of cockroaches on the main island.

Ball's Pyramid

Ball's Pyramid is a small volcanic stack around 23 km to the south of Lord Howe Island, which is notable for supporting the last known population of the Lord Howe Phasmid (*Dryococelus australis*). Ball's Pyramid shares a variety of endemic invertebrate species with the main Lord Howe Island Group (Department of Environment and Climate Change (NSW), 2007). Two specimens of *Panesthia lata* collected in 1969 were first attributed to 'Lord Howe Island', however these have subsequently been attributed to Ball's Pyramid, which was also visited on the 1969 survey, and indicate that a subpopulation is likely to persist there (Adams, 2023; Carlile et al., 2018). Rodents have not been recorded from Balls Pyramid, and so *P. lata* on Ball's Pyramid has been free of the predation by rodents that led to the near extinction of cockroaches on Lord Howe Island.

There have been no targeted surveys for *Panesthia lata* on Ball's Pyramid since the last specimens were collected in 1969. Ball's Pyramid is extremely difficult to access, rising over 500m straight from the ocean with no place to safely land boats, primarily composed of sheer cliffs, and only accessible by challenging rock-climbing (Flemons et al., 2018). The island also supports very little vegetation and soil offering suitable invertebrate habitat, further confounding survey efforts. Because of these challenges, surveys of Ball's Pyramid are difficult and uncommon. The last expedition to Ball's Pyramid was conducted by The Australian Museum in 2017 to monitor the population of *Dryococelus australis* and survey for other invertebrate species, but no *P. lata* were detected (Flemons et al., 2018; C. Reid in litt. December, 2021). However, researchers

noted that drought conditions may have reduced invertebrate populations, making them harder to detect in this already challenging field site, and so failure to detect them during this survey does not mean they are not present on the island (Flemons et al., 2018; C. Reid in litt. December, 2021).

Panesthia lata may also occur on other smaller islands in the Lord Howe Island group with suitable habitat and which have been free from rodents, in particular Muttonbird Island, Tenth of June, South Island, and Soldiers Cap, however there have been no surveys for *P. lata* at these sites. There is a single observation of a probable *P. lata* on Muttonbird Island, but targeted surveys and collection are required to confirm this observation (H. Bower *in litt.* January, 2022).

Extent of Occurrence and Area of Occupancy

Extent of Occurrence (EOO) and Area of Occupancy (AOO) were calculated based on locations drawn from surveys of Roach and Blackburn islands conducted by Carlile *et al* (2018), and discussion of Ball's Pyramid collections and recently rediscovered subpopulations on Lord Howe Island in Adams (2023). The very small size of these islands means there is generally only one GPS coordinate associated with each subpopulation. This yielded a total of 5 points; one each for Ball's Pyramid, and Blackburn and Roach islands, and two for the subpopulation on Lord Howe Island (North Bay and North Head).

EOO and AOO were estimated in GeoCAT (Bachman et al. 2011). Area of Occupancy (AOO) was calculated by overlaying 2 km x 2 km grid cells over the known occurrence and is the spatial scale of assessment recommended by IUCN (IUCN Standards and Petitions Committee 2022). Extent of Occurrence (EOO) is based on a minimum convex polygon enclosing all known occurrences of the species, the method of assessment recommended by the IUCN (2022).

AOO for *Panesthia lata* is 16 km^2. The entire population of *P. lata* occurs in an area that can be contained within four 2 km x 2 km grid squares, which is the smallest standard grid resolution recommended for assessments of AOO under the IUCN Standards and Petitions Committee (2022). *Panesthia lata* has only been recorded from three tiny islands in the Lord Howe Group (Roach Island, 14.5 ha; Blackburn Island, 2.4 ha, and Ball's Pyramid 3.3 ha), each of which fit entirely in a 2 km x 2 km grid cell, and two recently discovered sites on Lord Howe Island restricted to the area beneath two Australian banyan trees (M. Adams *in litt*. July, 2023). The two sites on Lord Howe Island are close to each other (400m), covered by a single 2 km x 2 km grid cell.

EOO for *Panesthia lata* is 62.189 km^2. The subpopulations on Blackburn, Roach, and Lord Howe islands are all closely clustered, and with these subpopulations alone EOO is much smaller, at only 4.498 km^2. However, the subpopulation on Ball's Pyramid is ~23 km from the main island, which contributes to the much larger final EOO for the species of 62.189 km^2. *Panesthia lata* is still considered to be present on Ball's Pyramid despite not being collected since 1969, however if future surveys determined that this subpopulation was extinct this would have a significant impact on the EOO for the species.

With the exception of the four possible subpopulations discussed above, regular invertebrate surveys and ongoing research projects across the Lord Howe Island

Group means these estimates of EOO and AOO are likely to reasonably reflect distribution of *Panesthia lata* across the group and are appropriate for assessment under the IUCN (2022) criteria.

Population Estimates

Combining results from surveys across all confirmed subpopulations provides a minimum total mature population estimate of 12,410 (Blackburn, 9,809; Roach, 601, Lord Howe Island, 2,000), and a maximum of 50,556 (Blackburn, 40,445; Roach, 6,111, Lord Howe Island, 4,000). No population estimate is available for Ball's Pyramid.

Blackburn Island

Extrapolating from plot surveys across the island's three habitat types, there is an estimated total minimum population on Blackburn Island of 9809; Australian banyan (1515 m^2), 5939; sallywood (480 m^2), 384; and Rhodes Grass (17,430 m^2), 3486. On Blackburn Island most individuals were observed in high densities under the single large Australian banyan tree, with low density on the rest of the island.

Informed by mark-recapture Carlile *et al.* (2018) also estimated a maximum population of 24,745 ± 11,830 for the subpopulation living underneath the Australian banyan. However, the authors highlight that this estimate has a very high level of uncertainty, with standard error around 50% of the total population number. Using this estimate combined with plot surveys for the other two habitat types, there is an estimated maximum adult population on Blackburn Island of 40,445 (Australian Banyan, 36,575; Sallywood, 384; Rhodes Grass, 3486). Given the level of uncertainty this estimate should be treated with caution.

Roach Island

Carlile et al. (2018) estimated a minimum of 3356 ± 2755 individuals on Roach Island. This estimate was drawn from a survey in leafy flat sedge where *Panesthia lata* was judged to be most likely to occur. However, the authors also noted incidental sightings in unsurveyed habitat types. Again, this estimate represents a preliminary survey only with a high level of uncertainty.

Lord Howe Island

A total population of 2000 - 4000 was estimated for *Panesthia lata* on the main island, based on estimates of 1000-2000 at each of the two sites (Adams, 2023; M. Adams *in litt*. July, 2023). These sites are extremely localised (100 m^2), restricted entirely to habitat under two Australian banyan trees, and *P. lata* has not been found in the area immediately adjacent to this habitat, or under any other surveyed Australian banyan trees on Lord Howe Island (Adams, 2023; M. Adams *in litt*. July, 2023).

Ball's Pyramid

Lack of vegetation mapping and specimen collection means that no population estimate could be produced for Ball's Pyramid. However, the general lack of habitat on the island, and the lack of sightings or collection since 1969, suggests that the subpopulation on Ball's Pyramid is likely to be extremely small, and would be very unlikely to affect the population assessment thresholds for the species.

Ecology

Carlile *et al*. (2018) provide the only formal study into the ecology of *Panesthia lata*. However, authors caution that this was a preliminary study and does not provide a thorough description of the ecology of the species. Exact details concerning life cycle, diet, habitat use, population dynamics and behaviour remain generally unexplored, although *P. lata* appears dependant on moist soil and decaying vegetation for habitat and food, in common with other wood-eating cockroaches (Carlile et al., 2018; Lo et al., 2016; Rugg & Rose, 1990).

Life History

There is no formal description of the life cycle of *Panesthia lata*. Cockroaches (Blattodea) typically have three life stages; eggs are deposited into an ootheca, eggs hatch as nymphs, nymphs moult several times eventually becoming adults. However, some species of cockroach have evolved to become ovoviviparous (eggs are hatched inside the body of the parent) or viviparous (live-bearing), with offspring incubated internally rather than deposited into an ootheca (Roth, 1977). All other members of Panesthiniie are ovoviviparous, and this has been used as an identifying taxonomic feature of the group, so this is likely in *P. lata* (Roth, 1977).

Related mainland species *Panesthia australis* and *Panesthia cribrata* appear to live in 'family groups', with a pair of adults accompanied by up to 20 nymphs (Roth, 1977). This may also be true of *Panesthia lata*, with observers noting adults accompanied by juveniles (Carlile et al., 2018).

Panesthia species and other large cockroaches can be relatively long lived, and it is possible that this is also true of *Panesthia lata*. Laboratory studies in *Panesthia cribrata* found individuals could take up to 6 years to reach maturity and live for over 10 years in total (Rugg & Rose, 1990).

There is no information available about dispersal in *Panesthia lata,* however adults appear to show high site fidelity and low mobility. A tracking experiment found that individuals appear to rely on fixed daytime refuges, only moving short distances from their refuge to forage (Carlile et al., 2018).

Carlile et al. (2018) did not examine movement in juveniles, amongst sexes or seasonal differences in dispersal behaviour. However, studies in other flightless cockroaches have generally found limited dispersal over relatively short distances (Schal et al., 1984). Apparently high site fidelity suggests *Panesthia lata* may be unlikely to easily move between subpopulations or colonise new sites even where suitable habitat exists.

Habitat

Australian Banyans as high-quality habitat

Australian banyan trees appear to provide the highest quality habitat for *Panesthia lata*. These trees drop thick layers of leaf litter, providing food and the moist environment on which *P. lata* are likely to depend. The footprint of the single Australian banyan tree on Blackburn Island supports the largest surveyed subpopulation of *P. lata* known, contributing 48 - 72% of the total minimum and maximum estimated population for *P. lata* across all islands, despite forming only around 1% (1515 m^2) of the total estimated occupied habitat area for *P. lata* across its range (137,110 m^2). Similarly, the two sites recently rediscovered on Lord Howe Island are entirely

restricted to the footprint (~100 m^2) of two Australian banyans, with no individuals observed outside this area, despite targeted surveys in surrounding low-quality habitat, and beneath other banyans on the island (Adams, 2023; M. Adams in litt. July, 2023).

Banyan is a major element of several lowland forest types on the main island (Sheringham et al. 2016), which may offer high quality habitat for *Panesthia lata*, with the several trees within 200m of the known subpopulation, and the furthest 7 km away in the southern mountains region. However, surveys have not found *P. lata* at these sites, and the high site fidelity displayed by *P. lata,* and the distance between these patches and known populations is likely to pose a challenge to colonisation of this habitat, even in the absence of rodents. Except for the single tree on Blackburn Island, banyans are absent from the rest of the island group.

This evidence strongly indicates that Australian banyan trees form the most significant habitat component for *Panesthia lata* across its range, and any degradation or loss of these trees would be likely to contribute to population decline in *P. lata*.

Sub-optimal and low quality habitat

Panesthia lata persists at moderate densities in sub-optimal leafy flat sedge (*Cyperus lucidus*). Leafy flat sedge is considered by Carlile et al (2018) to be a key habitat type for *P. lata*, although the cockroach occurs in far lower densities in this habitat (2.3+/-1.8 per m2) than in preferred habitat under the Australian banyan trees (Carlile et al., 2018). Banyans and other trees are absent from the smaller islands in the group, including Roach island, while leafy flat sedge is broadly distributed across the group, and is likely to constitute the crucial habitat for *P. lata* where it occurs on these islands.

Panesthia lata also persist in lower-quality habitat on Roach and Blackburn islands, in particular Rhodes grass and sallywood. However, density in these habitats is comparatively extremely low, contributing as little as ~30% of the total *P. lata* population despite forming almost 99% of the habitat in which *P. lata* has been observed (Carlile et al., 2018). *Panesthia lata* is likely to struggle to move through thick grass and may not find suitable food or shelter in sparse and rocky environments.

Diet

Diet in *Panesthia lata* has not been thoroughly explored, however they appear to feed on moist vegetable matter, particularly leaves, and in one case on cardboard (Carlile et al., 2018). On Blackburn Island *P. lata* were observed to preferentially feed on leaf matter from Australian banyan trees, and this may be a contributing factor in their general restriction to the footprint of Australian banyan trees on both Blackburn and Lord Howe Islands (Carlile et al., 2018).

Threats

There are 15 Key Threatening Processes listed on the NSW *Biodiversity Conservation Act 2016* considered relevant to the security of biodiversity on Lord Howe Island (Department of Environment and Climate Change (NSW), 2007). Of these '*Predation by the Ship Rat on Lord Howe Island*', '*Anthropogenic Climate Change*', '*Invasion of native plant communities by exotic perennial grasses*', and *'Dieback caused by the root-rot fungus Phytophthora cinnamomi'* pose an immediate threat to the ongoing security of *Panesthia lata.* Additionally, predation by or competition with exotic

invertebrates poses a threat across subpopulations. Invertebrates that pose a potential threat should they make it to Lord Howe Island include, but are not limited to, Red Imported Fire Ants (*Solenopsis invicta*) and Yellow Crazy Ants (*Anoplolepis gracilipes*), both of which are described in KTPs under the NSW *Biodiversity Conservation Act* 2016 and the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999.

Low mobility suggests *Panesthia lata* is unlikely to easily recolonise sites from which they have been lost or colonise new habitat that may become available as a result of habitat shift, where climate change affects moisture availability, plant communities, or habitat structure.

Hydrological deficit and resulting habitat loss as a consequence of climate change

Wood-eating cockroaches like *Panesthia lata* are generally dependant on moist soil and decaying leaf-litter for habitat and food (Carlile et al., 2018; Lo et al., 2016; Rugg & Rose, 1990). As a result, any reduction in available moisture is likely to impact habitat quality, extent, and food availability for *P. lata*. However, *P. lata* occurs in some of the most exposed and therefore driest habitats in the Lord Howe Archipelago, so soil moisture may not be a major factor for this species.

While there is broad uncertainty in the projected range and severity of climate impacts on Lord Howe Island and across the group, Auld and Leishman (2015) determined that there was evidence for an ongoing increase in temperature and a decrease in overall rainfall on Lord Howe Island over the last 50 years, stating that:

"…sea level temperatures around Lord Howe Island have risen by some 0.6°C since 1940… average annual air temperature on Lord Howe Island is expected to rise (compared with 1990 levels) by 1.3 ± 0.6°C by 2030, although there is much uncertainty around such estimates…For annual rainfall, we found over the last 50 years there had been a decline of 31% (95% CL 4–79%)…Both minimum and maximum temperatures at sea level increased in the last 50 years…"

As well as directly affecting *Panesthia lata* through reduction in moist habitat and decaying leaf-litter, a hotter, drier climate is likely to affect plant communities across the Lord Howe Group, further affecting habitat for *P. lata*. The majority of plants endemic to Lord Howe Island are reliant on high moisture availability and are threatened by an increasingly dry environment (Auld & Leishman, 2015). An environment with less available moisture will likely favour the less specialised invasive weed species that already compete with habitat plants, and may further impact the distribution of food plant availability and moist soil on which *P. lata* relies (Auld & Leishman, 2015; Carlile et al., 2018).

The small EOO for *Panesthia lata* means that changes in weather and climate are likely to affect all islands and subpopulations, as highlighted by the 2018-2019 drought which affected all islands in the group, including Ball's Pyramid (Reid et al. 2020; Reid & Hutton 2019).

Drought

Of particular concern for *Panesthia lata* is the impact of increasing aridity and drought on the welfare of the island group's Australian banyan trees, upon which the majority of individuals on Lord Howe and Blackburn Islands (and consequently the vast majority of the total population of *P. lata* in the island group) appear to rely for high quality habitat and food (Carlile et al., 2018). In 2018-2019 the banyan on Blackburn Island

was severely affected by drought, with a loss in overall canopy cover, and drought and ongoing increases in temperature remain an ongoing concern for the welfare of this tree.

This acute drought from 2018-2019 severely impacted multiple plant species and communities in the Lord Howe Group, including Australian banyan trees, and demonstrated that drought is a severe and ongoing threat for species in the Lord Howe Group (International Union for Conservation of Nature and Natural Resources, 2020; NSW Government Saving our Species, 2021b). Specific modelling of drought risk for the Lord Howe Group and surrounding Pacific region is not available, however droughts across the Australian continent are becoming more severe as background climate becomes more arid (Abram et al., 2021). This information, combined with observations of increased temperature and reduced rainfall, suggests drought is projected to pose a threat to endemic Lord Howe Island species, reducing available habitat and food for *Panesthia lata*.

Introduced rodents and the rodent eradication project

Introduced rodents, in particular the ship rat *Rattus rattus*, have had a devastating effect on the native fauna of Lord Howe Island. Since their introduction following a shipwreck in 1918, ship rats have been a driving factor in the extinction of at least 5 bird species and decline in other vertebrates on the main island (Department of Environment and Climate Change (NSW), 2007). Ship rats have been implicated in the decline and extinction of at least 10 invertebrates, and their continued consumption of plants and seeds has driven habitat change (Department of Environment and Climate Change (NSW), 2007). As well as ship rats, the introduction of house mice (*Mus musculus*) in the 1860s may have also contributed to decline and extinction in endemic species, however, the scale of impact by this species is unclear (Department of Environment and Climate Change (NSW), 2007).

In response to this threat, an extensive program of rodent eradication on the main island was undertaken in 2019 (Harper et al. 2020). This program appears to have been successful and rodents (rats and mice) are currently considered to be eradicated from the island, with preliminary evidence suggesting corresponding increases in some invertebrate species previously severely impacted by rodent predation (T. Auld *in litt*. December, 2021). However, formal examination of the success of rodent eradication is ongoing, and its effectiveness and impact may not be clear for a number of years as species affected by rodent predation recover.

While rodents appear to have been eradicated from Lord Howe Island, there is an ongoing risk of reintroduction to the main island, and others in the island group. Rodents are frequently introduced onto islands having stowed away in boats or being inadvertently introduced in packing materials and supplies. Lord Howe Island's small permanent town, and tourist and kentia palm industries, are entirely dependent on shipping for supplies, posing an ongoing biosecurity risk. In response there is a stringent, ongoing biosecurity program for the island group, incorporating intensive surveillance of both mainland and Lord Howe Island ports and ships with networks of cameras, traps, and other detection devices, and specialised sniffer dogs (Lord Howe Island Board 2023).

Rodents on Blackburn and Roach Islands, Ball's Pyramid, and other islands

Accidental introduction of rodents onto islands on which *Panesthia lata* is present is one of the most severe potential threats to these subpopulations. Rats may stow away

in boats used to access these islands by tourists or researchers, and strict quarantine must continue to be practiced by all visitors to the Lord Howe Island Group.

Both Blackburn and Roach islands are close enough to the main island that rats may also swim or be swept out to them (Carlile et al., 2018; Russell et al., 2019). Blackburn Island is only 700m from the main island, and Roach Island 900m, both within known ocean travelling distance for rats; individuals swim up to 800 m and survive being swept to sea for over 1km (Russell et al., 2019). Ongoing risk of invasion highlights the importance of quarantine and rodent control on the main island.

There are no records of rodents on Ball's Pyramid, but visits by researchers pose a low but ongoing risk of introduction. Ball's Pyramid is located too far from the main Lord Howe Group for rats to swim, however rats and mice are frequently inadvertently introduced to islands having stowed away on boats, and this poses a risk to Ball's Pyramid.

Habitat degradation as a consequence of weed invasion

Invasive weeds pose an ongoing threat to the habitat of *Panesthia lata* across the Lord Howe Group (Lord Howe Island Board, 2016). Weeds encroach on the habitat of *P. lata* on every island, changing habitat composition and availability, outcompeting native plants for resources and space, and inhibiting native plant recruitment by reducing the likelihood seeds will find sufficient space and resources to germinate (Lord Howe Island Board, 2016).

48-72% of the total estimated adult population for *Panesthia lata* live in the high-quality habitat provided by Australian banyans, despite this habitat forming only around 1% (1·5 ha) of the total estimated occupied habitat area for *P. lata* across its range (137 ha). In contrast, *P. lata* only occurs at extremely low densities in habitat dominated by invasive species, in particular Rhodes grass, and so any encroachment of weed species into the footprint of these Australian banyans or patches of leafy flat sedge is likely to have severe consequences for the quality and availability for *P. lata* across its range, and lead to significant decline in the species.

Of particular concern are Rhodes grass (*Chloris gayana*), *Ageratina adenophora* (crofton weed)*, Lilium formosanum* (formosan lily)*, Cenchrus clandestinus* (Kikuyu grass), and *Asparagus aethiopicus* (ground asparagus) (Lord Howe Island Board, 2016; T. Auld pers. comm. 2022). These weed species remain common across the Lord Howe Group, and threaten multiple endemic plants and communities, including those on Lord Howe, Blackburn, and Roach Islands (Carlile et al., 2018; Lord Howe Island Board, 2016a, 2016b).

Risk of weed spread is primarily due to movement of people, equipment, and resources between islands. While there are a variety of stringent biosecurity measures used to reduce spread of weeds, pests and disease across the Lord Howe Island group, these methods are not always effective, and human movement remains a vector for spread of weeds.

Birds are a common vector for the spread of weed species, primarily through droppings containing undigested seed (Coleman et al., 2011; Twigg et al., 2009). The general proximity of islands in the Lord Howe group means birds of many species are likely to be able to move freely and spread seed across and between islands. Spread of weeds by birds is generally very hard to monitor or manage (Coleman et al., 2011; Twigg et al., 2009).

Weeds on Lord Howe Island

Up to 2020 there had been a reduction of 90% in mature weed plants on Lord Howe Island since intensive weed eradication efforts began in 2004, and in 2020/21 only 0.01% of weeds removed in the Southern Mountains region were mature (Lord Howe Island Board, 2016a, 2016b; NSW Government Office of Environment and Heritage, 2017; NSW Government Saving our Species, 2021b). However, there is evidence that the overall number of juvenile weeds may be increasing; in 2020/21 63 weeds were controlled per hectare, compared to 43 per hectare in 2019/20 (NSW Government Saving our Species, 2019, 2021b, 2021a). This increase is likely driven by the removal of rodents, and exacerbated by increasing aridity, with generalist weed species on Lord Howe Island likely more successful than endemics in changing environments, (Lord Howe Island Board, 2016b; NSW Government Saving our Species, 2021a). The increase in juvenile weeds highlights the severe ongoing threat of weed infestation and ecosystem decline in the absence of effective control.

Weeds on Blackburn Island

Invasive plants pose a threat to the small area of remaining high-quality habitat on Blackburn Island, where the largest known subpopulation of *Panesthia lata* occurs. While originally covered in woody plants, invasive grasses now dominate, in particular Rhodes Grass (*Chloris gayana*) (Sheringham et al., 2020). *Panesthia lata* occurs in low density in the Rhodes Grass which dominates the island, where they likely struggle to navigate and find food in the thick, matted substrate (Carlile et al., 2018). Decline in the health of Australian banyans and subsequent expansion of invasive grasses into their footprint would dramatically reduce the available high-quality habitat on the island and have negative consequences for the total population size and resilience of *P. lata*. Fire may also be a potential threat, especially in areas dominated by Rhodes grass.

Dieback caused by the root-rot fungus Phytophthora cinnamomi

Phytophthora cinnamomi is an introduced fungal pathogen that has had a devastating effect on plant communities world-wide, causing catastrophic dieback in many species, and is listed as a Key Threatening Process 'Dieback caused by the root-rot fungus *Phytophthora cinnamomi*' under both the NSW BC Act, and Commonwealth EPBC Act. *Phytophthora cinnamomi* affects a huge variety of plants, including *Ficus* species like the Australian banyans on Blackburn and Lord Howe Island (Türkölmez et al., 2019; Weste, 1974; Weste et al., 1973). *Panesthia lata* on Lord Howe and Blackburn Islands are dependent on Australian banyan trees for high quality habitat and food, so infection and death of these trees would have severe consequences for the ongoing security of *P. lata*. *Phytophthora cinnamomi* was detected in a small orchard on Lord Howe Island in 2003 and is now considered a resident threat on the island (Auld & Hutton, 2004). It has so far been contained, however the movement of residents and tourists across and between islands poses an ongoing risk of further spread.

Exotic invertebrates

The introduction of exotic invertebrates, in particular ant species, is a severe future threat to species across the Lord Howe Island Group, including *Panesthia lata*. Numerous species are of concern (for example yellow crazy ant, *Anoplolepis gracilipes*; African big-headed ant, *Pheidole megacephala*, and red imported fire ant, *Solenopsis invicta*) which heavily predate and compete with native terrestrial invertebrates, posing a severe extinction risk for species like *P. lata* (Wetterer, 2012).

Introduced invertebrates have been devastating for other island groups worldwide, causing extinction in native invertebrates through catastrophic predation, and are a key concern for the conservation of endangered species in the Lord Howe Island Group (Department of Environment and Climate Change (NSW), 2007; Hoffmann et al., 2017; Wetterer, 2012).

A 2017 survey of ant species on Lord Howe Island found 27 introduced species, most likely inadvertently introduced in goods transported to Lord Howe from the Australian mainland (Hoffmann et al., 2017). While these 27 species have not had the devastating effects associated with ant species of concern like those listed above, they highlight the ongoing and frequent introduction of invasive ants onto the island, and the risk that one of these introductions may be of a more devastating species in the future. An invasion of African big-headed ants was successfully eradicated from the main island in 2018 following an intensive 6-year project, however there is always an ongoing threat of reinvasion.

An introduced huntsman spider (*Heteropoda sp.*) has also become extremely common in lowland forest on Lord Howe Island and is likely to pose a threat to *Panesthia lata* (Reid & Hutton, 2019b). These spiders are likely to prey on *P. lata,* and to restrict expansion of subpopulations from banyans into and across lowland forest. This spider is currently uncontrolled.

While the threat of introduced invertebrates is most severe on the main island, introduced species threaten known and possible subpopulations of *Panesthia lata* across the entire Lord Howe Group, where even infrequent movement of tourists or researchers may inadvertently facilitate the spread of invasive species (Department of Environment and Climate Change (NSW), 2007)

Assessment against IUCN Red List criteria

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

Criterion A *Population Size reduction*

Assessment Outcome: Data Deficient

Justification: There are insufficient data on life history, generation length, historic population size, or population decline in *Panesthia lata* to apply Criterion A. Although *P. lata* has been recorded in the Lord Howe Island Group for over 100 years, the first and only formal study of ecology and population size for the species was not conducted until 2018. While there has been an observed severe historic decline as a result of rodent introduction on the main island, no data exists to determine the scale and timeframe of this decline. As a result, there are insufficient data on historic range, population size, and life history to make an assessment against A.

Criterion B *Geographic range*

Assessment Outcome: Critically Endangered under B1ab(iii) and Endangered under B2ab(iii)

Justification: *Panesthia lata* is only positively recorded on four small islands in the Lord Howe Group. These islands are all relatively closely clustered, and as a result both EOO (62.189 km^2) and AOO (16 km^2) for the species are very small. EOO for the

species meets the threshold for listing as Critically Endangered under B1 (EOO <100 km^2), and AOO meets the threshold for listing as Endangered for B2 (AOO < 500 km^2).

In addition to these thresholds, at least two of three other conditions must be met to qualify for listing under Criterion B. 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: Met for Critically Endangered

   Justification: All known subpopulations of *Panesthia lata* fall within a single threat-defined location, meeting the threshold for Critically Endangered for this condition. *Panesthia lata* is only known from five sites across a small area (EOO 62.189 km^2) with a small total AOO of 16 km^2. This highly restricted range means that increased hydrological deficit and drought associated with climate change are likely to affect all subpopulations, and as a result this threat describes a single threat location for the species, posing a threat to habitat for *P. lata* across its entire range. There is no evidence that the species is severely fragmented.

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 subpopulations; (v) number of mature individuals

   Assessment Outcome: Met for (iii) – inferred decline in area, extent or quality of habitat.

   Justification: Observed and projected reduction in rainfall driven by climate change, and associated weed encroachment compounded by removal of rodents are inferred to reduce the quality of the habitat available to *Panesthia lata* across its range. This is a particularly severe threat where subpopulations are dependent on Australian banyans, which are severely impacted by hydrological deficit and drought, and where weed encroachment into the footprint of these trees is likely to severely affect the availability of high-quality habitat, and greatly reduce the carrying capacity of these areas.

   While there is broad uncertainty in the projected range and severity of climate impacts on Lord Howe Island and across the group, Auld and Leishman (2015) determined that there was evidence for an ongoing increase in air and sea temperature and a decrease in overall rainfall on Lord Howe Island over the last 50 years. Habitat is likely to become increasingly arid and less suitable for *P. lata* as rainfall declines, and high-quality habitat more susceptible to the threat of encroachment by generalist weed species.

   Wood-eating cockroaches like *Panesthia lata* are generally dependant on moist soil and decaying leaf-litter for habitat and food. As a result, reduction in available moisture is likely to impact habitat quality, extent, and food availability for *P. lata*. A hotter, drier climate is likely to affect plant communities across the Lord Howe Group, further affecting habitat for *P. lata*. The majority of plants endemic to Lord Howe Island are reliant on high humidity, and are threatened by an increasingly dry environment (Auld & Leishman, 2015). A less humid environment will likely favour the less specialised invasive weed species that already compete with habitat plants,

and may further impact the distribution of food plant availability and moist soil on which *P. lata* relies (Auld & Leishman, 2015; Carlile et al., 2018).

The small EOO (62.189 km^2) and AOO (16 km^2) for *Panesthia lata* means that reduction in rainfall and humidity is likely to affect all islands and subpopulations, as highlighted by the 2018-2019 drought which affected all islands in the group, including Ball's Pyramid (Reid et al., 2020; Reid & Hutton, 2019a).

c) Extreme fluctuations.

Assessment Outcome: Not Met

Justification: There is no evidence for extreme population fluctuations in *Panesthia lata*. Carlile et al. (2018) briefly address the idea that differences in population counts in different months may be due to population fluctuations but argue that this is unlikely. Other *Panesthia* species are long lived and take years to reach maturity, making them less likely to undergo large population fluctuations, which is likely also true of *P. lata* (Rugg & Rose, 1990).

Criterion C Small population size and decline

Assessment Outcome: Not Met

Justification: The minimum estimated population size for *Panesthia lata* is 12,410 mature individuals, exceeding the threshold for listing under C.

At least one of two additional conditions must be met. These are:

C1. An observed, estimated or projected continuing decline of at least: 25% in 3 years or 1 generation (whichever is longer) (CR); 20% in 5 years or 2 generations (whichever is longer) (EN); or 10% in 10 years or 3 generations (whichever is longer) (VU).

Assessment Outcome: Data Deficient

Justification: There are insufficient data on life history, generation length, historic population size, or population decline in *Panesthia lata* to apply Criterion C1. Although *P. lata* has been recorded in the Lord Howe Island Group for over 100 years, the first and only formal study of ecology and population size for the species was not conducted until 2018. While there has been an observed severe historic decline as a result of rodent introduction on the main island, no data exists to determine the scale and timeframe of this decline. As a result, there are insufficient data on historic range, population size, and life history to make an assessment against C1.

C2. An observed, estimated, projected or inferred continuing decline in number of mature individuals.

Assessment Outcome: Data Deficient

Justification: There are insufficient data on decline in mature individuals for *Panesthia lata* to apply criterion C2. There is no ongoing monitoring of individuals in any subpopulation, with population estimates based on extrapolations of density data provided in a single study. As a result, there are insufficient data to make an assessment against C2.

In addition, at least 1 of the following 3 conditions:

a (i).Number of mature individuals in each subpopulation ≤50 (CR); ≤250 (EN) or ≤1000 (VU).

Assessment Outcome: Not Met

Justification: The minimum estimated population size for *Panesthia lata* on Blackburn Island is 9,809 mature individuals, exceeding the threshold for listing under this condition.

a (ii). % of mature individuals in one subpopulation is 90-100% (CR); 95-100% (EN) or 100% (VU)

Assessment Outcome: Not Met

Justification: No single subpopulation comprises 90-100% of the total mature population of *Panesthia lata*. The subpopulation beneath the banyan on Blackburn island currently represents 48-72% of the total estimated population for *P. lata*, and so the loss of any other subpopulation would likely increase this percentage to a threshold that would meet this criteria.

b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Not Met

Justification: There is no evidence for extreme population fluctuations in *Panesthia lata*. Carlile *et al*. (2018) briefly address the idea that differences in population counts in different months may be due to population fluctuations but argue that this is unlikely. Other *Panesthia* species are long lived and take years to reach maturity, making them unlikely to undergo large population fluctuations, and this is likely also true of *P. lata* (Rugg & Rose, 1990).

Criterion D Very small or restricted population

Assessment Outcome: Met for Vulnerable D2

Justification: The minimum estimated population size for *Panesthia lata* is 12,410 mature individuals, exceeding the threshold for listing under 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

Assessment Outcome: Not Met

Justification: The minimum estimated population size for *Panesthia lata* is 12,410 mature individuals, exceeding the maximum threshold of 1000 mature individuals for listing under D1.

D2. Restricted area of occupancy (typically <20 km^2) 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: Met for Vulnerable

Justification: *Panesthia lata* is only known from five sites across a small area (EOO 62.189km^2) with a small total AOO of 16km^2. The small EOO and AOO for *P. lata* means that changes in climate are likely to be the same across all islands and subpopulations, as highlighted by the 2018–2019 drought which affected all islands in the group, including Ball's Pyramid (Reid et al., 2020; Reid & Hutton, 2019a). Severe or prolonged drought associated with anthropogenic climate change describes a single location for the species, posing a threat to habitat which could drive the species to become critically endangered or extinct in a very short period of time.

Additionally, with the vast majority of the subpopulation of *Panesthia lata* on Blackburn Island confined to the small footprint of the Australian banyan, introduction of ants or rats could also rapidly cause the extinction of this subpopulation and drive the species to critically endangered. Rodents and ants have been inadvertently introduced to the main island and may be inadvertently spread through travel between islands. Blackburn Island is commonly visited by researchers, workers, and tourists from the main island, posing an ongoing biosecurity risk.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient

Justification: No population viability analysis is available for *Panesthia lata.*

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Hank Bower – Lord Howe Island Board

Conservation and Management Actions

Panesthia lata is currently listed as Endangered 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. *Panesthia lata* sits within the site-managed management stream of the SoS program.

Activities to assist this species currently recommended by the SoS program include:

Habitat loss, disturbance and modification

- Broad-scale weed control continuing across the Lord Howe Island Group under the Lord Howe Island Weed Management Strategy.
- Broad-scale biosecurity monitoring and control for invasive ants across the Lord Howe Island Group.
- Ongoing monitoring for rodent re-invasion following the completion of the Lord Howe Island Rodent Eradication Project.

Survey and monitoring

- Ongoing surveying of *Panesthia lata* on Blackburn Island
- Thorough and ongoing surveys of recently rediscovered subpopulations on Lord Howe Island
- Identify and estimate *Panesthia lata* subpopulations outside of monitoring sites
- Opportunistic monitoring and surveys of *Panesthia lata* on other islands in the Lord Howe Island Group
- Continue monitoring trends in weed invasion and biosecurity threats across the Lord Howe Island Group

APPENDIX 1

Assessment against *Biodiversity Conservation Regulation 2017* criteria
The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome: *Panesthia lata* was found to be Critically Endangered under Clause 4.3(a)(d)(eiii)

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.	

Clause 4.3 - Restricted geographic distribution of species and other conditions (Equivalent to IUCN criterion B)
Assessment Outcome: Critically Endangered under Clause 4.3(a)(d)(eiii)

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:				
		(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

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: Vulnerable under Clause 4.7

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.