Resilient Landscapes

National Environmental Science Program

Queensland Threatened Lizard Survey

Final report for Project 1.8

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Australia has a rich and diverse squamate reptile fauna (lizards and snakes), which account for approximately 10% of the world's species. In 2017, researchers conducted comprehensive conservation assessments of the Australian squamate fauna, and indicated that one species was extinct, 2 were extinct in the wild, and a further 65 were threatened with extinction. A subsequent structured expert elicitation process was conducted to determine the threatened squamate species that were most likely to go extinct by 2040. Of the 20 most imperilled squamate species in Australia, 55% were endemic to Queensland.

This Queensland Threatened Lizard Survey research project (2021 – 2026) focused on conducting surveys and fieldwork on the priority threatened Queensland squamate species. The surveys and fieldwork conducted in this project resulted in the rediscovery of Lyon's grassland striped skink, which had not been seen since 1981 (42 years). The surveys also found a new site for the McIlwraith Range Leaf-tailed Gecko, which was formerly known from a handful of sightings at one site. Importantly, our fieldwork and surveys on 7 other threatened Queensland squamate species resulted in improved knowledge of the distribution of these species, and the threats that they face. In contrast, our survey work was not able to detect either the Fassifern blind snake (not seen since 1992), or the Gravel-downs Ctenotus (not recorded since 1984). Overall, this project has improved our knowledge of the conservation status of the most imperilled squamate species in Queensland.

Figure 1: The limbless fine-lined slider (*Lerista ameles*) is one of the 11 imperilled lizard and snake species from Queensland that this report focuses on. Image: Angus Emmott

Introduction

Australia is a hotspot for reptile diversity, hosting the largest number of species of any country in the world, and approximately 10% of all known species globally (Tingley et al. 2019; Chapple et al. 2019). The Australian reptile fauna is very distinctive, with 96% of species being endemic (Chapple et al. 2019). However, the taxonomy of Australian reptile fauna is poorly resolved, with the presence of many cryptic lineages (species that are morphologically similar but genetically distinct) (Melville et al. 2021). By global standards, there is a very high ongoing rate of description of new species (32% of the Australian squamate fauna has taxonomic uncertainty, or undescribed species; Melville et al. 2021), many of which have traits that make them susceptible to extinction (Meiri 2016).

Despite mounting evidence of ongoing global declines of reptile species (Böhm et al. 2013; Tingley et al. 2016; Saha et al. 2018), reptiles are typically neglected in conservation planning (Cox et al. 2022). This is primarily because many species are poorly known, there is limited understanding of population trends, and in many cases detection is difficult, making monitoring unfeasible (Tingley et al. 2016; Woinarski 2018; Chapple et al. 2019). The lack of, or limited, monitoring for most threatened reptiles is a major impediment to conservation recovery (Woinarski 2018; Chapple et al. 2019). Without adequate monitoring, the impacts of threats are poorly understood, and managers may lose opportunities to prevent extinctions because precipitous declines are not detected with sufficient time to respond (Woinarski 2018).

As part of the International Union for Conservation of Nature's (IUCN) first Global Reptile Assessment, 2 workshops were held in 2017 to undertake assessments of the conservation status of all Australian terrestrial squamates (snakes and lizards) against IUCN categories and criteria (Chapple et al. 2019; Tingley et al. 2019). This was the first comprehensive assessment of the conservation status of Australian lizards and snakes since 1993 (Cogger et al. 1993), and identified 68 species as either threatened or extinct. Using these assessments as a starting point, Geyle et al. (2021) used a structured expert elicitation approach for 60 lizard and snake species with the highest IUCN Red List threat category to determine the species most likely to go extinct over the next 20 years (an arbitrary period over which change might reasonably be assessed, and which might reasonably be influenced by policy changes made today). In the resultant list of the 20 most imperilled lizard and snake species in Australia, 55% were endemic to Queensland (Geyle et al. 2021; note that this assessment preceded the 2019–20 Australian megafires, which worsened the conservation outlook for many species).

One of the key aims of the Geyle et al. (2021) squamate 'Reptiles on the brink' exercise was prioritise and direct resourcing of management to better prevent future extinctions. As 55% of the top 20 imperilled species were endemic to Queensland, funding was sought through the National Environmental Science Program (NESP) Emerging Priorities scheme to conduct the necessary field surveys and interventions for the priority threatened squamate species in Queensland.

The Queensland Threatened Lizard Survey project (NESP Project 1.8) was administered by the NESP Resilient Landscapes Hub, and focused on 11 imperilled lizard and snake species from Queensland (Table 1). The project aimed to support conservation efforts to help reptiles struggling to adapt to human activities and changing environmental conditions. The project involved fieldwork and surveys with historic records, and new potential sites and surrounding habitats. The project involved personnel from Monash University (Prof David Chapple, Associate Professor Jane Melville), James Cook University (Associate Professor Conrad Hoskin), the Queensland Museum (Patrick Couper, Dr Andrew Amey), and

the Queensland Department of Environment, Tourism, Science and Innovation (DETSI) (Adrian Borsboom).

Table 1. The threatened Queensland lizard and snake species included in this project. The conservation status (IUCN Red List, QLD, Environment Protection and Biodiversity Conservation [EPBC] Act 1999) of each species is listed, along with its ranking in the 'Reptiles on the brink' exercise by Geyle et al. (2021). LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered.

Species	**IUCN Red List**	**QLD**	***EPBC Act***	**Threatened Rank**
Anilios insperatus (Fassifern blind snake)	CR	CR	CR	2nd
Austroablepharus barrylyoni (Lyon's grassland striped skink)	CR	CR	CR	3rd
Ctenotus serotinus (Gravel-downs ctenotus)	CR	CR	CR	6th
Lerista allanae (Retro slider)	CR	EN	EN	7th
Lerista ameles (limbless fine-lined slider)	EN	NT	—	10th
Lerista storri (Mt Surprise fine-lined skink)	NT	LC	—	20th
Oedura lineata (Arcadia velvet gecko)	CR	CR	CR	—
Orraya occultus (McIlwraith leaf-tailed gecko)	VU	CR	CR	11th
Phyllurus pinnaclensis (Pinnacles leaf-tailed gecko)	CR	CR	CR	12th
Saltuarius eximius (Cape Melville leaf-tailed gecko)	EN	CR	CR	9th
Tympanocryptis condaminensis (Condamine earless dragon)	EN	EN	EN	13th

1 Summary of surveys and fieldwork

1.1 *Anilios insperatus* (Fassifern blind snake)

Figure 2: The only known specimen of the Fassifern blind snake, *Anilios insperatus.* There are no images of the live species in existence. Image: © Peter Waddington, Queensland Museum.

The Fassifern blind snake is known only from a single specimen collected in 1992 (31 years ago) on a property in south-eastern Queensland that is used for cattle grazing. The delay in describing the species was due to the hope that additional specimens could be collected prior to description of the species. However, additional searches of the region by experienced herpetologists, including at least 7 searches between 2014 and 2015 (Venchi et al. 2015), did not detect the species.

Survey effort by the Queensland Museum (Andrew Amey, Patrick Couper, Adrian Borsboom [QLD DESI]) during this project consisted of eight days of hand searching under rocks, logs and leaf litter, 3 days of pitfall trapping, and one night of slow road driving. This search effort was spread over 4 sites, and 4 separate periods between December 2021 and February 2023.

The Fassifern blind snake was not recorded during the surveys. The field surveys were effective at sampling a range of other reptile species (including other species of blindsnake), and the methods widely accepted as the most effective for blind snakes. The cryptic habits of blind snakes make them possibly the most enigmatic and poorly understood of Australia's reptile fauna. Several other species are also known from very few or single individuals, for example, *Anilios batillus* (Waite, 1894), *Anilios longissimus* (Aplin, 1998) and *Anilios robertsi* (Couper, Covacevich and Wilson, 1998).

The Fassifern Blind Snake stands out in its proximity to one of the most densely populated regions of Australia, the greater Brisbane area, and it is surprising that it was not discovered until 1992. Its only known locality is not a protected area. On the contrary, the area has been grazed by cattle since at least the 1920s and is extensively modified. The original specimen was found near relictual (remnant) habitat on a rocky hillside. Whether this remnant vegetation is a significant refuge for this species cannot be determined from the single data point we currently have, and we can make no conclusions concerning its true conservation status.

1.2 *Austroablepharus barrylyoni* (Lyon's grassland striped skink), *Lerista ameles* (limbless fine-lined slider), and *Lerista storri* (Mt Surprise fine-lined skink)

Figure 3: The first *Austroablepharus barrylyoni* seen in 42 years, and the first individual ever photographed in life. Image: Conrad Hoskin.

Figure 4: The Mt Surprise fine-lined skink (*Lerista storri*). Image: © Steve Wilson.

Lyon's Grassland Skink, *Austroablepharus barrylyoni* (Couper et al. 2010) was described from material collected between 1979 and 1981. It is a 5-fingered, 5-toed, surface-active skink. All specimens were collected from one locality in open natural grassland on Springfield Station, north Queensland. Despite targeted searches in a broader area, between 1979 and 1984, no other specimens were found. By the time of its description, changes in the habitat, brought about by cattle grazing and weed invasion, led to fears that the species may already be extinct (Couper et al. 2010). In 2017, it was assessed on the IUCN Red List as Critically Endangered. It is also listed as Critically Endangered in Queensland, and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act).

The limbless fine-lined Slider, *Lerista ameles* Greer, 1979, was described from a single specimen found under a rock in a shallow, soil-filled depression on a granite outcrop beside the Gulf Developmental Road, about 35 km east of Mount Surprise township in north Queensland, close to Undara Volcanic National Park. It is a small, elongate skink with no limbs. It is cryptic, found only in loose soil associated with rocky habitats. Since its description, it has been found at a few other localities, including one record within Undara Volcanic NP. Although the Atlas of Living Australia lists some localities around Mount Surprise and even further to the west, scrutiny of these records suggests they are unreliable, leaving the species confined to Undara Volcanic NP and adjacent properties. It is considered Endangered under the IUCN Red List and Near Threatened under the *Queensland Nature Conservation Act 1992*. It has not been assessed under the EPBC Act; however, Geyle et al. (2021) considered it to be the 10th most imperilled squamate in Australia.

The Mount Surprise slider, *Lerista storri* Greer et al., 1983, was described from 4 specimens from 2 different localities. The holotype was collected on Springfield Station, approximately halfway between Undara Volcanic NP and Mount Surprise, while two of the paratypes were collected from near Chillagoe, 70 km further north. Amey et al. (2019) demonstrated that the northern population was a distinct species more closely related to the limbless fine-lined slider and named it as *Lerista parameles*. They also showed that a population found to the west, in and around Bulleringa NP, was also specifically distinct naming it *Lerista alia*. This restricted the Mount Surprise Slider to a single locality on Springfield Station. This species is also a small, elongate skink. However, in contrast to the totally limbless fine-lined slider, it possesses a pair of very small hind limbs with no claws. It also differs in its habitat requirements, being found in sandy soils with open woodland. No populations other than the type population are known to exist. The IUCN Red List listed *L. storri* as Near Threatened, but this was done before the taxonomic revision of 2019 greatly reduced its Extent of Occurrence (EOO). The Queensland Government considers the species of Least Concern, and it has not been assessed under the EPBC Act. However, Geyle et al. (2021) considered it to be the 20th most imperilled squamate in Australia.

A fieldwork team from the Queensland Museum (Andrew Amey, Patrick Couper, Martin Ambrose, Angus Emmott) and James Cook University (Conrad Hoskin) conducted fieldwork for the species from the 20th-29th April 2023. The two *Lerista* species were targeted using hand searching under rocks and logs, and through leaf litter and mulch. Lyon's Grassland skink was targeted with pitfall trapping. Lyon's grassland skink was found at all 3 pit trap sites, for a total of 5 specimens. Four specimens of the limbless fine-lined slider were found, but the species was not found within the Undara Volcanic NP. Five specimens of the Mount Surprise fine-lined skink were found, but only within 5 km of the type locality.

The results of this survey indicate that the distribution of the limbless fine-lined slider is substantially smaller than that given in previous reports for the species that included the erroneous westerly records for the species (Vanderduys et al. 2018, Wellbelove et al. 2021). The Mount Surprise fine-lined skink is still only known from Springfield Station. These surveys recorded the first specimens of Lyon's grassland striped skink in 42 years. Its habitat is open grassland with sparse tree cover on heavy cracking blacksoil. With the thick grass cover and cracking soil, visual surveying is ineffective and pitfall trapping is required to successfully detect its presence. The species occurs entirely outside of protected areas.

1.3 *Ctenotus serotinus* (gravel-downs ctenotus)

The gravel-downs Ctenotus, *Ctenotus serotinus* Czechura, 1986, is known from 2 individuals, a holotype collected in 1984 and a paratype collected in 1981 (Czechura 1986). The specimens were collected in and adjacent to Diamantina National Park in south-western Queensland. There have been no confirmed observations since these specimens were collected. Fauna surveys conducted since its description have failed to locate any individuals, leading to fears it has declined greatly in abundance, perhaps to extinction (Geyle et al. 2021), although it is important to note that none of the previous surveys have specifically targeted the gravel-downs ctenotus. The gravel-downs ctenotus is considered Critically Endangered under Queensland legislation, the EPBC Act and the IUCN Red List of Threatened Species.

A fieldwork team from the Queensland Museum (Andrew Amey, Patrick Couper, Martin Ambrose, Angus Emmott) conducted fieldwork for the species from 30 September 2022 through to the 3 October 2022. Pitfall trapping was conducted at 2 sites, and 5 additional sites were surveyed visually. No gravel-downs ctenotus were recorded during the surveys, although a number of stout ctenotus (*Ctenotus hebetior*) were recorded during the surveys. Although this survey was unsuccessful at locating specimens of the gravel-downs ctenotus, we believe it has improved our understanding of the species' likely habitat and location. Any further targeted surveys will benefit from this.

1.4 *Lerista allanae* (Retro slider)

Lerista allanae (Retro slider) is a reduced-limb lizard that is listed as endangered under Queensland legislation and the EPBC Act (Borsboom & Ferguson 2015). This lizard was rediscovered north of Capella in Central Queensland in late 2009, after there had been no records for nearly 50 years (Borsboom et al. 2010). Since rediscovery, it has been recorded at a further 5 sites in the Capella area (Borsboom et al. 2010; Borsboom 2012; Borsboom & Ferguson 2015). The most southerly of these sites was on freehold land southeast of Capella. This site record was based on the landowner's photographs of a *Lerista*, which subsequently was identified as *L. allanae*. The photographed lizard was in a coarse woody debris, rock and soil pile from past clearing that was removed from a cultivated field. The aims of this survey were to capture one or more *L. allanae* to confirm identification at this location, and obtain habitat details for any capture sites.

The fieldwork was contacted by the Queensland Department of Environment, Tourism, Science and Innovation (Adrian Borsboom, Melanie Venz) between the 27 and 30 March 2022. The fieldwork involved diurnal surveys, using rakes to search leaf litter under trees and shrubs, and surface soils beneath this litter. In addition, rocks were turned, logs rolled and woody debris such as exfoliated bark was lifted and surface soil beneath these raked. At some roadside sites, cut grass mats were also

lifted. Eight areas were searched during the survey. Two Retro sliders were recorded during the survey (one captured, and one seen). This confirms the presence of the species at the new site.

1.5 *Oedura lineata* (Arcadia velvet gecko)

Figure 5: An *Oedura lineata* located during surveys in the Arcadia Valley. Image: Conrad Hoskin.

Oedura lineata was described in 2019 (Hoskin 2019), and hence was not considered as part of the Geyle et al. (2021) 'Reptiles on the brink' exercise. However, it has been listed as Critically Endangered on the IUCN Red List, and under Queensland legislation, due to occurring at 2 locations (brigalow remnant fragments) and being at severe risk due to fire (Hoskin 2021). In December 2023, it was listed as Critically Endangered under the EPBC Act. Hoskin (2019) pointed out that more detailed surveys of brigalow in the Arcadia Valley region were required to try find more populations and to better assess density and population sizes in the 2 known populations.

In November 2022 and May 2023, Conrad Hoskin and Nicholas Bail (both from James Cook University) completed a fieldtrip for the species in the Arcadia Valley region, Queensland. The Arcacia velvet gecko was found at one of the 2 known sites (Lonesome National Park). It was found more broadly at that site, but at lower density than previous surveys (probably a result of extreme drought at the time). It was not found at the other known site (Nuga Nuga National Park), despite detailed surveys, and may now be extinct there. Possible extinction at this site may be attributable to a decline in habitat quality at this site. It was, however, found in 4 small brigalow fragments in the southern Arcadia Valley. These new sites are very small brigalow fragments, not in protected areas, and the species remains highly threatened. The surveys were valuable for finding more sites, for better establishing habitat requirements (mature brigalow forest), and for assessing persistence and density at sites. The surveys have paved the way for further surveys and for conservation genetic analysis of the remaining populations.

1.6 *Tympanocryptis condaminensis* (Condamine earless dragon)

The Condamine earless dragon was described in 2014 (Melville et al. 2014), and it has a restricted distribution in south-eastern Queensland. The species is threatened by habitat loss and disturbance, generally from agricultural activities. The Condamine earless dragon is listed as Endangered under the IUCN Red List, Queensland legislation, and the EPBC Act.

A research team from Monash University, led by Associate Professor Jane Melville, undertook fieldwork in the Darling Downs region from the 24 September to 2 October 2022. They visited previous locations of the Condamine earless dragon in the Pittsworth area. It had been a very wet winter and there was still deep water along road verges. In addition, the team noted removal of road verges for cropping and also use of road verges as turn-around spots for large tilling machinery – leaving large and deep furrows in *Tympanocryptis* habitat. Nine Condamine earless dragons were caught during the fieldtrip, including at a known site as well as a new site.

1.7 *Phyllurus pinnaclensis* (Pinnacles leaf-tailed gecko)

Figure 6: The Pinnacles Leaf-tailed Gecko (*Phyllurus pinnaclensis*). Image: Conrad Hoskin.

This species was considered one of Australia's most threatened reptile species in the Geyle et al. (2021) 'Reptiles on the brink' exercise. It was known from just 3 sites at the time of description (Hoskin et al. 2019). In November 2021, Conrad Hoskin (James Cook University) surveyed one of the known sites to confirm persistence and better estimate population size. The survey was similar to 2 prior surveys of this site in finding very few individuals, despite detailed survey effort. Three individuals were found, and the population at that site is estimated to be fewer than 25 individuals. A second site was surveyed by Conrad Hoskin in February 2022 but no *P. pinnaclensis* were found. Suitable rainforest was present at the site but the rock is metamorphic (not granite) and probably not sufficiently layered for the species. Further surveys are required for this species, and are planned for the near future.

1.8 *Phyllurus fimbriatus* (Scawfell Island leaf-tailed gecko)

Figure 7: The Scawfell Island Leaf-tailed Gecko (*Phyllurus fimbriatus*). Image: Conrad Hoskin.

Phyllurus fimbriatus was described in 2023 (Hoskin 2023), and hence was not considered as part of the Geyle et al. (2021) 'Reptiles on the brink' exercise. However, it is believed to be restricted to small areas of a single island (Scawfell Island) off Mackay in mid-east Queensland. At the time of description, the species was considered potentially threatened, but data deficient due to a lack of detailed surveys and assessment of potential threats (fire and invasive geckos). In November 2023, Conrad Hoskin (James Cook University) and John Augusteyn (Queensland Parks & Wildlife Service, Queensland Department of Environment, Tourism, Science and Innovation) surveyed new areas of Scawfell Island (with the assistance of Brett Turnbull, Queensland Parks and Wildlife Service) and 2 adjacent islands. The objectives were to assess whether *P. fimbriatus* is also distributed in rainforest gullies on the southern and eastern side of Scawfell Island and whether the species is also present on nearby St Bees and Keswick Islands.

The surveys found *P. fimbriatus* to be patchy, but moderately common, in 2 new areas on the southern side of Scawfell Island. This extends the known distribution of this species across Scawfell Island and suggests it probably occurs in other areas of deep rock with a rainforest canopy on the island. The surveys failed to find *P. fimbriatus* on St Bees or Keswick Islands, despite good survey effort in rainforest gullies. This adds to previous effort by Hoskin (2023) on other nearby islands, and suggests the species is indeed endemic to Scawfell Islands.

The introduced house gecko (*Hemidactylus frenatus*) was also searched for on the surveys of these three islands. The invasive species was found to be present and locally common on St Bees and Keswick Islands. *Hemidactylus frenatus* had previously been found in a localised area on the north-west of Scawfell Island and is deemed a potential threat to *P. fimbriatus* (Hoskin 2023). The surveys in the south-east did not find *H. frenatus*, showing that they are not yet on that side of the island. A survey trip was conducted on the 9-13th October 2024 to assess spread of *H. frenatus* in the area on the north-west of Scawfell Island, with a focus on how close the invasive gecko is to the endemic leaf-tailed gecko habitat. This survey was a collaboration with Queensland Parks & Wildlife Service, including training of the Airlie Beach team in gecko surveys. The surveys found that *H. frenatus* has spread rapidly and extensively in the north-west of the island, including well away from the beach scrub and into rainforest and rock areas. The invasive gecko has spread to the edge of the leaf-tailed

gecko habitat at one site and close to leaf-tail gecko habitat at another. This is concerning (due to potential competition from the abundant invasive gecko) and future monitoring will assess continued spread and impacts, with an eye to whether management is required and what form it could take.

1.9 *Orraya occultus* (McIlwraith leaf-tailed gecko)

Figure 8: An *Orraya occultus* found during the survey of eastern McIlwraith Range. Image: Conrad Hoskin.

This species was considered one of Australia's most threatened reptile species in the Geyle et al. (2021) 'Reptiles on the brink' exercise. It is known from a single site in McIlwraith Range, on the Cape York Peninsula of Far North Queensland (Couper et al. 2000) and very few individuals have been found at this site. The key knowledge gap for this species is whether it is distributed elsewhere in the McIlwraith Range. In late August and early September 2023, Conrad Hoskin (James Cook University) planned a survey trip of several new areas in the central and eastern McIlwraith Range. However, the trip was cancelled due to a range of factors (including Tropical Cyclone Jasper). The field survey was then completed from 24 to 26 August 2024. The objective was to survey 2 creeklines, and associated boulder slopes, on the central eastern McIlwraith Range, at mid elevations. Assessment of imagery suggested promising, deeply-piled boulder habitat in these catchments, well away from all previous records in the Peach Creek catchment. The survey was conducted as a collaboration with the Traditional Custodian group Kalan Enterprises, to share knowledge and train rangers in reptile and frog surveys on their lands.

Helicopter assessment of the sites found only one of the 2 catchments had a nearby suitable site to land. Given the extremely difficult terrain and vegetation, we decided to focus on that catchment. The trip was a great success in locating a new site for *Orraya occultus*. Two individuals were found in close proximity to each other in deep boulder-field, with the site being approximately 12 km straight-

line distance to the only other known site (Peach Creek). Only 2 individuals were found (within 10 m of each other), despite many hours of survey effort over three nights, and covering a large area of boulder habitat. This suggests that, as for the Peach Creek site, the species is very rare in this area. The other alternative is that the species is not rare but very difficult to find in the deep boulder habitat. However, the 2 individuals that were found were found quite easily while surveying their particular area of boulder habitat, and both were in typical locations in the habitat for saxicoline leaf-tailed geckos. This suggests that the species is rare at the site rather than being unusually hard to find.

The results are a big positive in adding another, disjunct site to the known distribution of *Orraya occultus* but add to concern over apparent very low density in suitable habitat. While flying around in the helicopter, other areas of potential boulder habitat were seen through the canopy, providing targets for future surveys for the species. Many other species were observed during the surveys, including abundant individuals of the endemic McIlwraith Range Ring-tailed Gecko (*Cyrtodactylus pronarus*).

1.10 *Saltuarius eximius* (Cape Melville leaf-tailed gecko)

Figure 9: The Cape Melville Leaf-tailed Gecko (*Saltuarius eximius*). Image: Conrad Hoskin.

This species was considered one of Australia's most threatened reptile species in the Geyle et al. (2021) 'Reptiles on the brink' exercise. *Saltuarius eximius* is known from a very small area of the Melville Range uplands of Far North Queensland, in very small numbers, (Hoskin & Couper 2013) and is potentially threatened by climate change and invasive species. Surveys to date have focussed on the highest elevation areas in the central area of Melville Range. Surveys were planned for this species, particularly for the northern uplands of the Melville Range, which have not been surveyed to date. However, these surveys were not conducted due to a range of issues regarding access. These surveys are are now planned for mid-2025. Future surveys will attempt to increase the known distributional area of this highly localised species and better estimate population size.

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