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Further records and breeding of the Eyrean Grasswren *Amytornis goyderi* in New South Wales

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Abstract. Eyrean Grasswrens *Amytornis goyderi* have generally been considered habitat specialists associated with Sandhill Canegrass *Zygochloa paradoxa* on the dunes of inland Australian deserts in the Lake Eyre Basin. Following above-average rainfall in 2020–2022 and an associated vegetation response in the Strzelecki Desert, Eyrean Grasswrens were observed at 39 locations south-east of their known distribution, with sites up to 11 km inside New South Wales, well beyond the extent of previous easterly records on the New South Wales–South Australia border. Further, two sites were north of the New South Wales–Queensland border, confirming the species 380 km south of previous Queensland records. Nine sites were within feral-free exclosures at the Wild Deserts project site in Sturt National Park, New South Wales. Repeated observations between May 2021 and August 2022 suggest persistence for at least 16 months in ephemeral vegetation on sand dunes supporting no Sandhill Canegrass. Two instances of breeding were recorded, with juvenile birds and feeding by an adult male observed. We explore possible drivers for this apparent range expansion and future scenarios around persistence inside landscape-scale exclosures, within which theorised threats from feral predators and overabundant herbivores are absent, presenting an opportunity to assess the relevancy of these drivers on the ecology of Eyrean Grasswrens.

Introduction

The Eyrean Grasswren *Amytornis goyderi* occupies some of the most remote, arid, and climatically variable parts of the Australian continent. The species' first discovery to Western science was in 1875, followed by an 87-year hiatus of records before its rediscovery in 1961 (Morgan *et al*. 1961). Current understanding of its status and distribution suggests that it is moderately abundant in its core range across the Simpson, Tirari and Strzelecki Deserts in South Australia, the corner of western Queensland, and the Northern Territory (Figure 1 inset Map A; Black & Gower 2017). Grasswrens *Amytornis* spp. generally are known as habitat specialists and several sources suggest that Eyrean Grasswrens are typically associated with stands of Sandhill Canegrass *Zygochloa paradoxa* (Parker *et al*. 1978; Higgins *et al*. 2001; Black & Gower 2017), a perennial plant species widespread in the dunefield deserts that the birds occupy (Cunningham *et al*. 2011).

In April 2016, Eyrean Grasswrens were discovered on Winnathee Station in New South Wales adjacent to the South Australian border in habitat that did not include Sandhill Canegrass (McAllan *et al*. 2017). These records were the first for the species in New South Wales. Within the eastern flank of the Strzelecki Desert that extends into New South Wales, Sandhill Canegrass is mainly absent and found only in small, isolated patches a few hectares in extent (McAllan *et al*. 2017).

Further, Dingoes *Canis familiaris dingo* are excluded from New South Wales by the Dog Fence, which runs along the state border, creating a different 'ecological universe' (Newsome *et al*. 2001) to areas outside the Dog Fence in South Australia and Queensland where Eyrean Grasswrens commonly occur. In the absence of Dingoes, New South Wales generally has had much higher grazing pressure from kangaroos *Osphranter* and *Macropus* spp. (Rees *et al*. 2017), Domestic Sheep *Ovis aries* and Feral Goats *Capra hircus*, and higher numbers of invasive mesopredators, namely Feral Cats *Felis catus* and Red Foxes *Vulpes vulpes* (Letnic & Koch 2010). Areas outside the Dog Fence in South Australia and Queensland support grazing by Domestic Cattle *Bos taurus* but have no sheep or goats, very low kangaroo densities, and higher densities of European Rabbits *Oryctolagus cuniculus* (Newsome *et al*. 2001). McAllan *et al*. (2017) suggested that easing of grazing pressure and predation in far north-western New South Wales could allow Eyrean Grasswrens to occupy much of the sand dune habitat in that area.

Here we document further records of the Eyrean Grasswren from far north-western New South Wales, including evidence of breeding and persistence over a sustained period in habitats without Sandhill Canegrass. We explore possible drivers for this apparent range expansion and future scenarios around persistence that may help to shed light on the ecology of and threats to this species.

Study area and methods

Study area, and opportunistic and structured ecological monitoring

The study area encompassed the far north-western corner of Sturt National Park and adjacent pastoral properties in far north-western New South Wales. Within this area, Wild Deserts – a partnership between the University of New South Wales (UNSW) Sydney, Ecological Horizons and the NSW National Parks and Wildlife Service – manages a 35,000-ha area for ecosystem restoration through control and exclusion of feral species and overabundant

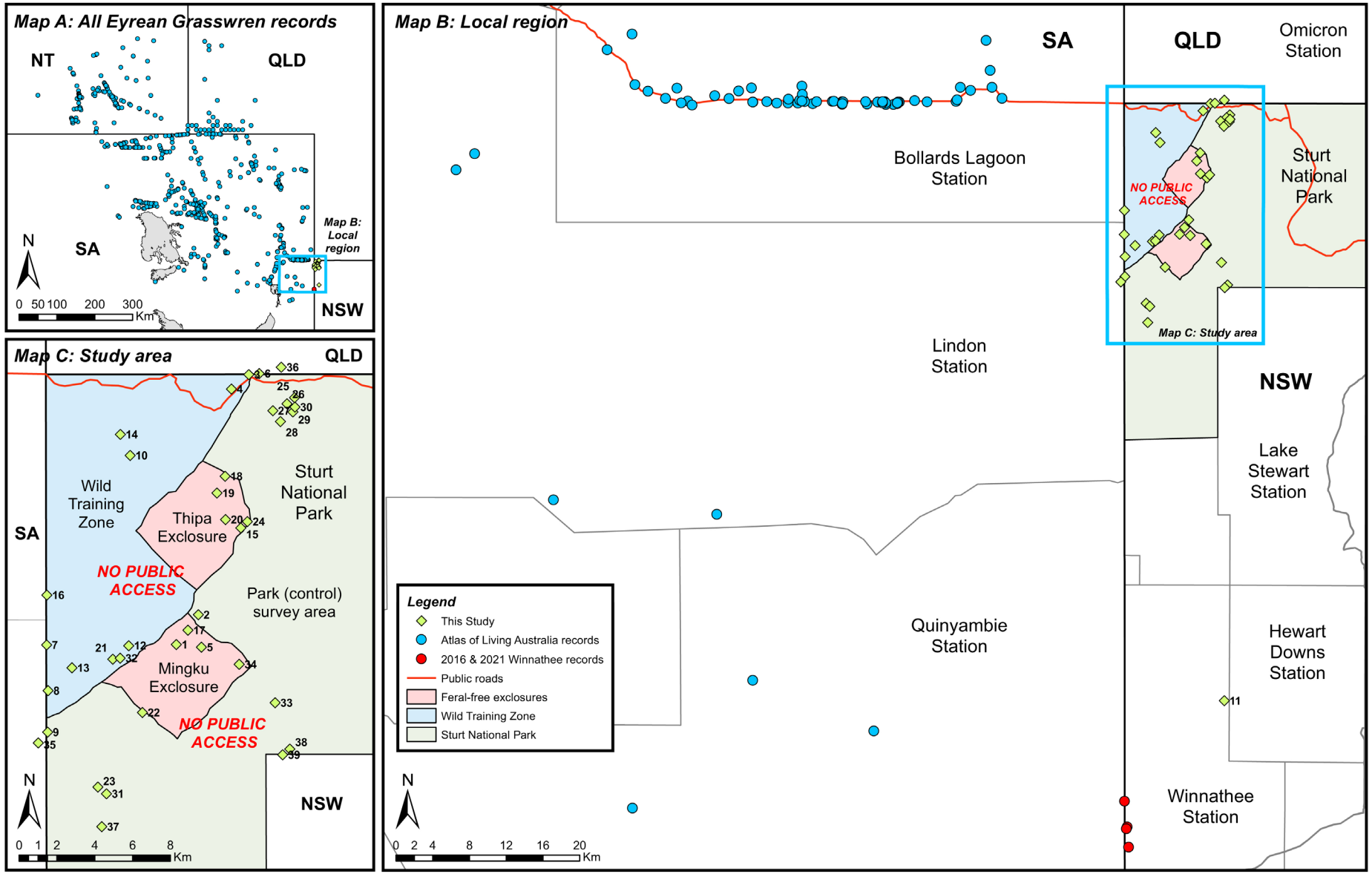

Figure 1. Record locations of Eyrean Grasswrens (coloured symbols) beyond their previously known distribution, showing Atlas of Living Australia (2022) records (circles in blue, filtered for suspect records/those with >10,000 m uncertainty), the first two records from New South Wales from McAllan *et al.* (2017) and two follow-up records (Rehberg 2021) on Winnathee Station (circles in red), and the 39 new sites (1–39) documented in this study (diamonds in green). Map A shows the distribution of all Eyrean Grasswren records across Central Australia, Map B shows records in the local region, and Map C shows the extent of the study area. NSW = New South Wales, NT = Northern Territory, Qld = Queensland, and SA = South Australia.

native herbivores and the reintroduction of locally extinct mammals. In 2018–2019, Wild Deserts established a 50-km network of feral-exclusion fences, which includes the Thipa and Mingku Exclosures, encompassing a 4000-ha area (Pedler *et al*. 2018). These exclosures have been maintained free of rabbits, cats, foxes and kangaroos since early 2019. A larger 10,000-ha Wild Training Zone (WTZ) lies to the west of the two exclosures and is bounded on two sides by the Dog Fence, which runs along the New South Wales–South Australia and New South Wales–Queensland borders. Inside this area, cat, fox and kangaroo populations are managed at low densities with the long-term aim of creating *in-situ* predator-avoidance training for reintroduced locally extinct mammal species (Pedler *et al*. 2018; West *et al*. 2018).

During the 16-month study period (May 2021 to August 2022), Wild Deserts employed three full-time ecological staff (TJH, RDP & RSW) along with other short-term staff, postgraduate research students and volunteers involved in mammal translocations and research fieldwork at the site. This field team was thus able to make opportunistic observations of birds during day-to-day fieldwork within the core study area and beyond, as well as targeted searches in new areas specifically for Eyrean Grasswrens in August 2021 and August 2022.

In addition, Eyrean Grasswrens were recorded during annual bird-monitoring surveys on several of the 70 replicate 1 km/10 hectare transects, which are part of long-term ecological monitoring established at the site in 2018. This monitoring is undertaken annually in August, with transects arranged in a structured before-after-control-impact (BACI) design across five treatments including the two feral-free Thipa and Minkgu Exclosures, the WTZ, in South Australia west of the border on Lindon and Bollards Lagoon pastoral leases, and in a control ('Park') treatment in Sturt National Park to the east of these areas (Figure 1).

Feral predator and kangaroo densities were monitored through multiple methods as part of ongoing ecological monitoring at the site, including a camera-trap grid of 45 cameras and 30 replicate 1-km-track transects inside and outside the WTZ and Park treatments. Daily rainfall records were taken at the Fort Grey Bureau of Meteorology recording site 46006. Fractional vegetation cover data using Landsat™ satellite imagery were queried and analysed through the VegMachine® online analysis interface (CSIRO 2022).

Grasswren observation techniques

In May 2021, camera traps opportunistically photographed Eyrean Grasswrens in the Mingku Exclosure, and calls were subsequently heard at the same site. These records alerted onsite staff, students, and volunteers to the species' presence in the local area, after which Eyrean Grasswrens were opportunistically recorded at additional sites.

Targeted searches for the species in areas of similar sand dune habitat were undertaken in August 2021 and August 2022. Revisits to previously occupied sites were undertaken to determine the continued presence of the species at those sites through the study period. During targeted searching, sand dunes were traversed slowly on foot by one to three observers. In instances where Eyrean Grasswrens were not observed passively, short bursts of call-playback were played through a mobile phone using recordings from either the *Pizzey & Knight Birds of Australia Digital Edition* (Pizzey & Knight 2020) or *The Michael Morcombe & David Stewart eGuide to Australian Birds* applications (Morcombe & Stewart 2021). At the location of each sighting, details of the dominant perennial (tree and shrub) and annual (ephemeral understorey) plant species and topographic characteristics were recorded, and photographs of the habitat were taken.

All grasswren species that have been studied occupy discrete, year-round territories up to 15 ha, depending on the taxon (Rowley & Russell 1997; Black & Gower 2017), though dispersal beyond these areas is thought to be possible (e.g. Black *et al*. 2015). Although no detailed studies have been made of Eyrean Grasswren home ranges, Schodde (1982) contended that they are less than a hectare when breeding. In this study, locations where Eyrean Grasswrens were seen <200 m apart were considered a single occupied site, based on our observations of pairs in the field with adjacent territories.

Observations

Eyrean Grasswrens were found at 39 sites beyond their previously known range between May 2021 and August 2022 (Figure 1, Table 1). This includes the most easterly record now known for this species, in Sturt National Park 11.5 km east of the New South Wales–South Australia border (Site 30). Two records from Omicron Station in Queensland up to 350 m north of the New South Wales border (Sites 6 and 36) represent the most southerly observations in Queensland by over 380 km.

Eyrean Grasswrens were recorded across all the Wild Deserts treatments (Figure 1), including inside the Thipa Exclosure (5 sites), the Mingku Exclosure (4 sites), and both the WTZ (11 sites) and Park treatments (15 sites), as well as outside on neighbouring pastoral properties in New South Wales (1 site), South Australia (1 site) and Queensland (2 sites). Opportunistic search effort reflected the areas where most time was spent in the field by the observers engaged at the Wild Deserts project site. Fieldwork included on-ground tracking of satellite-collared feral cats, indicating that Eyrean Grasswrens were persisting at sites occupied by these introduced predators. Indeed, the pair of Eyrean Grasswrens at Site 13 was observed <100 m from where a tracked cat was sheltering.

Evidence of recent breeding was recorded twice, at Site 1 and Site 7, where juvenile birds (short tails, indistinct striations, fleshy yellow gapes: see Higgins *et al*. 2001) were seen on 5 June 2021 and 10 October 2021, respectively (Table 1). In one instance, feeding by an adult male was observed and photographed (Figure 2).

Repeat visits to some sites demonstrated residency throughout the entire study period (Table 2). Of the nine sites that were known for ≥9 months (Sites 1–9), Eyrean Grasswrens were relocated at least once at eight of them.

Most of the Grasswrens were observed on dune crests, and the habitat at each site shared consistent floristic features: trees were mostly absent, low-to-medium understorey vegetation cover was scattered but dense, mid-storey shrub cover was sparse, branching and fallen

Table 1. Summary of Eyrean Grasswren records from this study. Initial search type: C = camera trap, O = opportunistic, T = targeted. Other abbreviations: NP = National Park, NSW = New South Wales, Qld = Queensland, SA = South Australia, Stn = Station, WTZ = Wild Training Zone. Dates are given as day/month/year. Full record details are in Appendix 1.

Site no.	*Location description*	*Initial search type*	*First recorded*	*Last recorded*	*Times detected*	*Max. count*
1	Minkgu Exclosure, Sturt NP, NSW	C	24/5/21	10/8/22	12	3
2	Park (control) area, Sturt NP, NSW	O	23/7/21	22/7/22	4	2
3	WTZ, Sturt NP, NSW	O	9/7/21	9/8/22	8	2
4	WTZ, Sturt NP, NSW	O	24/8/21	18/7/22	6	3
5	Minkgu Exclosure, Sturt NP, NSW	T	25/8/21	16/6/22	2	2
6	Omicron Stn, Qld	T	1/10/21	–	1	1
7	WTZ, Sturt NP, NSW	O	1/10/21	6/6/22	4	3
8	WTZ, Sturt NP, NSW	O	1/10/21	12/7/22	2	1
9	Park (control) area, Sturt NP, NSW	O	1/10/21	19/7/22	2	2
10	WTZ, Sturt NP, NSW	O	7/12/21	–	1	1
11	Winnathee Stn, NSW	O	4/12/21	–	1	1
12	WTZ, Sturt NP, NSW	T	8/2/22	12/7/22	3	2
13	WTZ, Sturt NP, NSW	O	28/2/22	–	1	2
14	WTZ, Sturt NP, NSW	O	24/3/22	8/4/22	2	2
15	Thipa Exclosure, Sturt NP, NSW	O	7/4/22	25/7/22	5	1
16	WTZ, Sturt NP, NSW	O	11/4/22	19/7/22	3	2
17	Minkgu Exclosure, Sturt NP, NSW	O	23/5/22	–	1	2
18	Thipa Exclosure, Sturt NP, NSW	O	2/6/22	15/6/22	2	2
19	Thipa Exclosure, Sturt NP, NSW	O	9/6/22	–	1	2
20	Thipa Exclosure, Sturt NP, NSW	O	14/6/22	17/8/22	3	3
21	WTZ, Sturt NP, NSW	O	12/7/22	–	1	1
22	Park (control) area, Sturt NP, NSW	O	19/7/22	–	1	1
23	Park (control) area, Sturt NP, NSW	O	22/7/22	–	1	3
24	Thipa Exclosure, Sturt NP, NSW	O	10/8/22	–	1	1
25	Park (control) area, Sturt NP, NSW	T	11/8/22	–	1	1
26	Park (control) area, Sturt NP, NSW	T	11/8/22	–	1	2
27	Park (control) area, Sturt NP, NSW	T	11/8/22	–	1	1
28	Park (control) area, Sturt NP, NSW	T	11/8/22	–	1	1
29	Park (control) area, Sturt NP, NSW	T	11/8/22	–	1	2
30	Park (control) area, Sturt NP, NSW	T	11/8/22	–	1	1
31	Park (control) area, Sturt NP, NSW	O	15/8/22	–	1	2
32	WTZ, Sturt NP, NSW	O	15/8/22	–	1	2
33	Park (control) area, Sturt NP, NSW	O	15/8/22	–	1	1
34	Minkgu Exclosure, Sturt NP, NSW	O	15/8/22	–	1	1
35	Lindon Stn, SA	O	17/8/22	–	1	2
36	Omicron Stn, Qld	T	17/8/22	–	1	1
37	Park (control) area, Sturt NP, NSW	T	18/8/22	–	1	1
38	Park (control) area, Sturt NP, NSW	T	21/8/22	–	1	2
39	Park (control) area, Sturt NP, NSW	T	21/8/22	–	1	1

dead shrubs were plentiful, and there were bare patches of sand without litter between this vegetation (Figure 3).

Lower-storey plant species commonly found at Eyrean Grasswren sites included long-lived perennials like Spiny Saltbush *Rhagodia spinescens,* and annual species that had germinated and proliferated after significant rainfall since 2020 such as Tangled Mulla Mulla *Ptilotus latifolius*, Longtails *Ptilotus polystachyus*, Buckbush *Salsola australis*, Bluebush Pea *Crotalaria eremaea* and Tall Kerosene Grass *Aristida holathera* (Appendix 1). Sandhill Canegrass was absent from all 39 sites.

No Eyrean Grasswrens were recorded in other widespread vegetation communities where the observers also spent significant field time, including open mulga *Acacia* sp. aff. *aneura* woodlands, dense shrublands of Silver Cassia *Senna artemisioides*, Silver Needlewood *Hakea leucoptera,* Sandhill Wattle *Acacia ligulata* or Narrow-leaved Hopbush *Dodonaea viscosa* subsp.

Figure 2. Eyrean Grasswrens seen in Sturt National Park: (a) a female (perched) and male (on ground) at Site 1; (b) a juvenile (on left: note the yellow gape, indistinct streaking in plumage, and shorter tail) being fed by the male (right) at Site 1; (c) a male at Site 7; and (d) a female at Site 3, identifiable from the chestnut flank feathers under the wing (Higgins *et al*. 2001). Photos: Thomas J. Hunt

angustissima, in ephemeral swamps, clay or gibber flats, or on swales away from the bases of dunes.

These Eyrean Grasswren records were made during a time of extensive vegetation growth following the above-average rainfall in 2020–2022, historically low kangaroo densities from drought-induced mortalities in 2017–2019, and low but increasing cat and fox densities (Figure 4). Although observers were present on-site from 2016, and standardised annual bird surveys across all treatments had been conducted since 2018, Eyrean Grasswrens were encountered only after rainfall broke the extreme drought conditions.

Discussion

The Eyrean Grasswren records presented here represent the first in New South Wales beyond the state border, noting that those previously recorded in 2016 were near the New South Wales–South Australia border fence (McAllan *et al*. 2017; and see Figure 1). Moreover, they suggest sustained persistence in the landscape, with evidence of breeding in habitats atypical from those usually recorded for this species.

McAllan *et al*. (2017) highlighted many of the landscape processes operating in New South Wales that may make the area less suitable for Eyrean Grasswren occupation when compared with South Australia, including high grazing pressure from kangaroos, sheep and goats, resulting in reduced vegetation cover, and higher numbers of feral cats and foxes from the exclusion of Dingoes. McAllan *et al*. (2017) suggested that reducing grazing pressure from kangaroos and sheep, and reducing pressure from feral predators, might allow Eyrean Grasswrens to occupy much of the sand dune habitat in far north-western New South Wales.

We hypothesise that the records presented here have been facilitated by the high rainfall and sustained ephemeral vegetation growth throughout the study area during 2020–2022, combined with low densities of predators, kangaroos and ungulate grazers, following 36 months of record-breaking drought between 2017 and 2019 (Bureau of Meteorology 2022). Eyrean Grasswrens have been reliably recorded in the Strzelecki Desert Dunefields just 25 km to the west of the New South Wales–South Australia border in perennial Sandhill Canegrass habitats, even during very dry conditions (Parker 1980; Schodde 1982; Higgins *et al*. 2001; Black & Gower 2017; Atlas of Living Australia 2022), which would present a large source population for a range expansion once favourable conditions return. Though grasswrens are thought to be weak fliers and poor long-distance dispersers (Schodde 1982; Higgins *et al*. 2001), some species appear to show mobility or nomadism in response to changing environmental conditions (e.g. Grey Grasswren *Amytornis barbatus*: see Hardy 2010; Black *et al*. 2015). It may therefore be reasonable to assume that Eyrean Grasswrens could disperse beyond their

Table 2. Months of the first and subsequent sightings of Eyrean Grasswrens, between May 2021 and August 2022, at each study site, indicated with grey shading and the symbol ✓. Instances where Eyrean Grasswrens were searched for at a site but not found are indicated with the symbol ×. Given the species' low detectability and territoriality (Black & Gower 2017), continued occupation at a site is possible between the first and last observations, even when instances of non-detection occurred between those dates.

Site no.	*May 21*	*Jun. 21*	*Jul. 21*	*Aug. 21*	*Sep. 21*	*Oct. 21*	*Nov. 21*	*Dec. 21*	*Jan. 22*	*Feb. 22*	*Mar. 22*	*Apr. 22*	*May 22*	*Jun. 22*	*Jul. 22*	*Aug. 22*
1	✓	✓	✓	✓		×						✓	✓			✓
2			✓	✓								✓		×	✓	
3			✓	✓			×				✓	✓	✓	✓		✓
4				✓								✓			✓	
5				✓								×		✓		
6						✓						×		×		×
7						✓					×	✓	×	✓		
8						✓					×		×	×	✓	
9						✓								×	✓	
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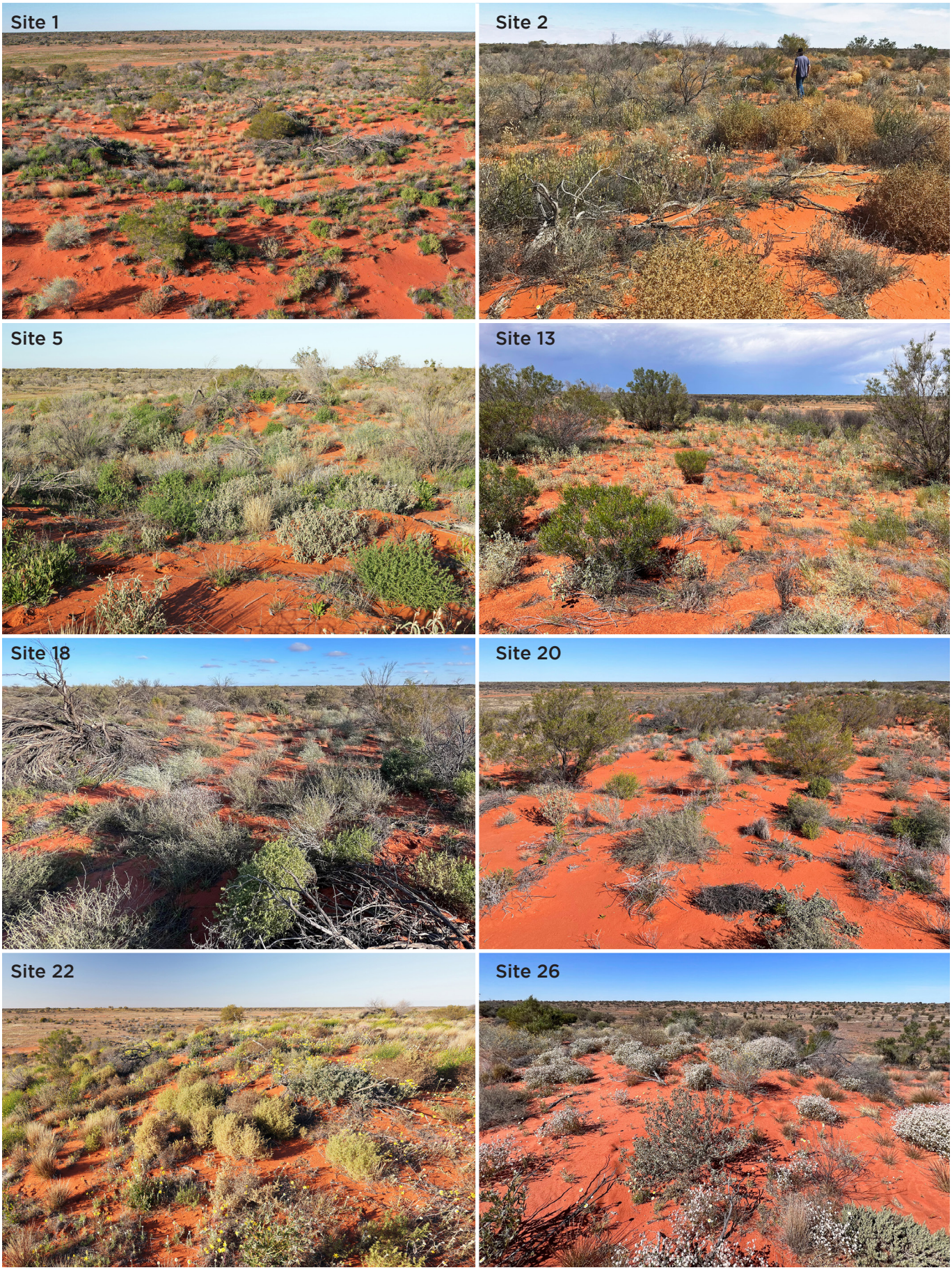

Figure 3. Examples of habitat at eight sites where Eyrean Grasswrens were observed, showing bare sand patches between the extensive growth of low ephemeral grasses and herbage including Buckbush, Spiny Saltbush, mulla mullas, scattered Sandhill Wattle and Narrow-leaved Hopbush, and the absence of Sandhill Canegrass. Photos: Reece D. Pedler (Site 2), Thomas J. Hunt (Sites 1, 5, 13, 18, 20, 22 and 26).

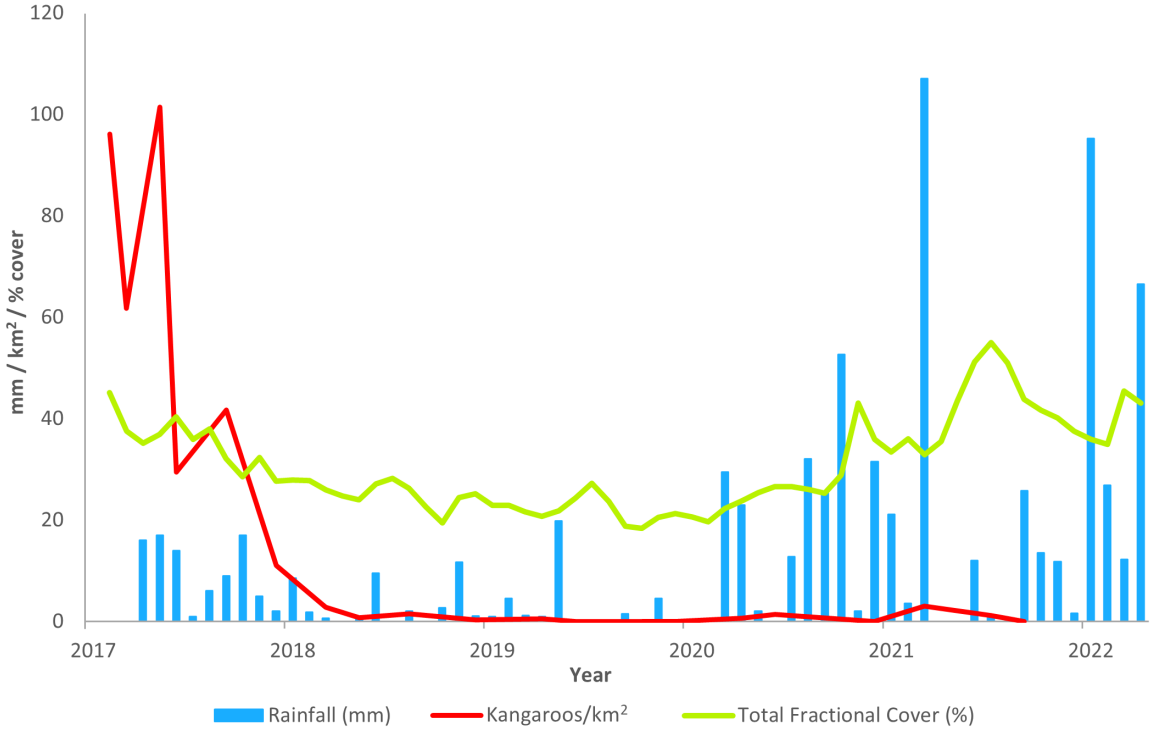

Figure 4. Monthly rainfall, kangaroo density and total fractional ground cover in the study area in Sturt National Park from January 2017 to April 2022.

drought refugia to take advantage of favourable seasonal conditions and widespread food and habitat resources.

It is unclear whether these records represent the first expansion of Eyrean Grasswrens into the eastern Strzelecki Desert in New South Wales, or whether this is simply the result of an improved search effort as McAllan *et al*. (2017) speculated. The Wild Deserts project has provided an opportunity for field ecologists to work permanently on-site in this area since 2016, thus increasing the search effort and chances of opportunistic observations of Eyrean Grasswrens. It therefore seems possible that similar expansions have occurred historically during periods of abundant vegetation growth after good rainfall but were not observed or documented.

Following the release of rabbit haemorrhagic disease virus (RHDV, or calicivirus), a range of threatened small mammals, including the Dusky Hopping Mouse *Notomys fuscus*, Plains Rat *Pseudomys australis* and Crest-tailed Mulgara *Dasycercus cristicauda*, have undergone startling population recoveries and re-occupation of historic ranges into the eastern Strzelecki Desert (Pedler *et al*. 2016). Thus, another plausible explanation is that this apparent Eyrean Grasswren expansion represents an additional example of this recent phenomenon, perhaps augmented by rainfall, vegetation growth and low densities of predators and herbivores.

North-western New South Wales represents notably different habitat for Eyrean Grasswrens compared with nearby areas in South Australia where this species is frequently recorded, such as Bollards Lagoon Station (Atlas of Living Australia 2022) – differences that may be driven by differential grazing, predation and habitat features (McAllan *et al*. 2017). At microscales, there is a much higher density of Sandhill Canegrass habitat in South Australia, the lack of which in New South Wales has been hypothesised as due to historic overgrazing by high numbers of sheep (McAllan *et al*. 2017). Sandhill Canegrass is extremely drought resistant and, even when dead, its dense and tangled structure remains for years (Cunningham *et al*. 2011). Schodde (1982) suggested that Sandhill Canegrass dunes provide reliable refugia for populations of Eyrean Grasswrens to retract to during extended dry conditions. The persistent structure of Sandhill Canegrass may provide the necessary habitat needed by Eyrean Grasswrens for shelter and breeding; indeed, their nests are most frequently constructed in the middle of Sandhill Canegrass tussocks, though there are records of nests in the spiny, dense growth of Australian Boxthorn *Lycium australe* (Morgan *et al*. 1961; Parker *et al*. 1978; Rowley & Russell 1997; Higgins *et al*. 2001). Despite the scarcity of both these plant species in Sturt National Park (TJH pers. obs.), Eyrean Grasswrens bred in the study area (Appendix 1), though no nests were found. Here, the most likely structural analogue for an Eyrean Grasswren nest site is the Spiny Saltbush. This intricately structured perennial shrub creates a dense shelter (Cunningham *et al*. 2011) and was recorded at 16 of the 39 study sites, including Sites 1 and 7 where juvenile birds were observed (Appendix 1).

Although some authors have listed Sandhill Canegrass as 'preferred habitat' of the Eyrean Grasswren (Black & Gower 2017), the species has been recorded in areas without Canegrass, such as in Lobed Spinifex *Triodia basedowii* on a flat near Purni Bore in the Simpson Desert (Parker *et al.* 1978), in mixed wattles *Acacia* spp. with emu bush *Eremophila* sp., hakeas *Hakea* sp. or Tangled Lignum *Duma florulenta* on the lower Kallakoopah and Warburton Creeks in the Simpson Desert in 2007 (Andrew Black pers. comm.), in Sandhill Wattle and Buckbush on

Quinyambie Station in 2015 (RDP pers. obs.), in Nitre Bush *Nitraria billardierei* and Spiny Saltbush shrubs on grey clay hummocks and samphire at Montecollina Bore on the Strzelecki Track, and in chenopods including Old Man Saltbush *Atriplex nummularia* in the Cobbler Sandhills region in the southern Strzelecki Desert (Black *et al*. 2011). These records suggest that vegetation association tolerances for this species can be more diverse than Sandhill Canegrass dunes alone. It remains to be seen whether Eyrean Grasswrens can persist long-term inside New South Wales where the more ephemeral nature of non-Sandhill Canegrass habitat may fail to provide adequate structure, cover and food resources over time, especially during periods of drought.

The eastern Strzelecki Desert dunefields extend into far north-eastern New South Wales and far south-western Queensland (Department of Climate Change, Energy, the Environment and Water 2020). Given this, we suspect that – with targeted searches – Eyrean Grasswrens could also be found further north, south and east of our study area where these dune systems and adequate ephemeral vegetation cover favour their continued expansion, for as long as advantageous environmental conditions persist. Indeed, our opportunistic record of Eyrean Grasswrens on Winnathee Station at Site 11 in December 2021, and the resighting of them near the McAllan *et al*. (2017) records by Rehberg (2021) in the same month (Figure 1), support this conjecture.

The Wild Deserts site in Sturt National Park is well placed to examine questions relating to long-term persistence in habitats without Sandhill Canegrass and with or without feral predators and herbivores, given the landscape-scale ecosystem manipulation and monitoring that has been established there (Pedler *et al*. 2018; Kingsford *et al*. 2021). Future monitoring of persistence of Eyrean Grasswrens at these sites over time will help to determine the extent to which land use, feral predators and herbivore densities influence their persistence.

These previously unrecorded range expansions and breeding events of Eyrean Grasswrens give hope that even species thought to have poor dispersal capabilities may be able to exploit unpredicted opportunities in a changing climate. A continued focus on documenting and understanding these events will provide important insights into conservation-relevant ecological knowledge.

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Appendix 1. Details of Eyrean Grasswren records from this study in 2021–2022. Observers: AR = Ashwin Rudder, BC = Brianna Coulter, BR = Bridget Roberts, CE = Cecile Espigole, DB = Donna Belder, DC = Dympna Cullen, JP = Janet Pedler, LP = Lynn Pedler, RP = Reece Pedler, RW = Rebecca West, SG = Simon Gorta, TH = Thomas Hunt, WP = Will Price. Dominant shrub, tree, or understorey sp. (species): *Ab. oto = Abutilon otocarpum; Ac. ane = Acacia sp. aff. aneura*; *Ac. lig = Acacia ligulate*; *Al. ole = Alectryon oleifolius*, *Ar. hol = Aristida holathera*; *At. hem = Atalaya hemiglauca*; *Ca. eri = Calotis erinacea*, *Cr. ere = Crotalaria eremaea*; *Do. vis = Dodonaea viscosa subsp. angustissima*; *En. tom = Enchylaena tomentosa*, *Er. lon = Eremophila longifolia*; *Ma. pyr = Maireana pyramidata*, *Po. stu = Polycalymma stuartii*; *Pt. lat = Ptilotus latifolius*; *Pt.* pol = *Ptilotus polystachyus*; *Rh. spi = Rhagodia spinescens*; *Sa. aus = Salsola australis*, *Se. art = Senna artemisioides*; *Si. amm = Sida ammophila*. Sighting date is given as day/month/year; Obs. = observer(s); *n* = no. of birds; Obs. method = observation method: C = camera trap, H = heard, S = seen; Search type: C = camera trap, O = opportunistic, P = passive, T = targeted; Playback:✓ = playback used in detection, × = no playback used in detection. Other abbreviations: NP = National Park, NSW = New South Wales, Qld = Queensland, SA = South Australia, Stn = Station, SW = south-western, WTZ = Wild Training Zone; F = female, J = juvenile, M = male.

Site no.	*Location*	*Date*	*Obs.*	*n*	*Obs. method*	*Search type*	*Play-back*	*Landform (& height)*	*Dominant shrub & tree sp.*	*Dominant under-storey sp.*	*Comments*
1	Minkgu Exclosure, Sturt NP, NSW	24/5/21	–	1	C	C	–	Dune crest (7 m)	Sparse *Ac. lig*, *Do. vis*, *Rh. spi*; patch of *At. hem* nearby	*Ar. hol*, *Pt. pol*, *Po. stu*, *Sa. aus*	Initially captured on camera traps. M, F & J seen; M observed feeding J on 5/6/21
		27/5/21	–	1	C	C	–				
		1/6/21	RW	2	H	O	×				
		5/6/21	TH	3	S	T	✓				
		6/6/21	–	1	C	C	–				
		11/6/21	–	1	C	C	–				
		Jul.–Aug. 2021	TH, RW, RP	3	S	T	✓				
		1/4/22	CE, WP	2	S	T	✓				
		17/5/22	–	2	C	C	–				
		10/8/22	TH	1	S	T	✓				
2	Park (control) area, Sturt NP, NSW	23/7/21	RP, JP	2	S	O	×	Dune crest (6 m)	*Do. vis*, *Rh. spi*, sparse *Ac. ane*	*Ar. hol*, *Pt. pol*, *Po. stu*, *Sa. aus*	Initially seen during standardised bird survey
		25/8/21	LP, RP	1	H	O	✓				
		1/4/22	CE, WP	1	S	O	✓				
		22/7/22	TH	1	S	T	✓				
3	Talpero Lookout, WTZ, Sturt NP, NSW	9/7/21	TH	2	H	O	×	Dune crest (10 m)	Very sparse *Ac. lig*, *Do. vis*, *Rh. spi*	*Cr. ere*, *Pt. lat*, *Pt. pol*, *Po. stu*, *Sa. aus*	Seen at this site during most visits. Site publicly accessible
		26/8/21	RP, LP	2	S	O	×				
		9/3/22	TH	2	S	T	✓				
		2/4/22	CE, WP	1	H	T	✓				
		11/4/22	TH	2	S	T	✓				
		14/5/22	TH	2	S	T	✓				
		7/6/22	TH	2	S	O	×				
		9/8/22	DB, AR	2	S	T	×				
4	WTZ, Sturt NP, NSW	24/8/21	RP	3	S	O	×	Dune crest (10 m)	Sparse *Ac. lig*, *Do. vis*	*Cr. ere*, *Pt. lat*, *Pt. pol*, *Po. stu*, *Sa. aus*	Initially seen during standardised bird survey
		25/8/21	RP, LP	2	S	T	✓				
		2/4/22	CE, WP	1	S	T	✓				
		6/4/22	CE, WP	2	S	T	✓				
		9/4/22	BR, SG	2	S	T	✓				
		18/7/22	TH	1	S	T	✓				

Appendix 1 continued

Site no.	*Location*	*Date*	*Obs.*	*n*	*Obs. method*	*Search type*	*Play-back*	*Landform (& height)*	*Dominant shrub & tree sp.*	*Dominant under-storey sp.*	*Comments*
5	Minkgu Exclosure, Sturt NP, NSW	25/8/21	TH	2	S	T	✓	Dune crest (7 m) & saddle	Sparse *Do. vis* (mostly dead), *Ac. lig*	*Ar. hol*, *Pt. lat*, *Pt. pol*, *Po. stu*, *Sa. aus*	M & F seen
		16/6/22	TH	2	S	T	✓				
6	Omicron Stn, Qld	1/10/21	TH	1	S	T	✓	Dune crest (8 m)	*Ac. lig*, *Do. vis*, *Rh. spi*; *At. hem* 100 m to north	*Ar. hol*, *Cr. ere*, *Pt. lat*, *Pt. pol*, *Si. amm*, *Sa. aus*	First record in far SW corner of Qld
7	WTZ, Sturt NP, NSW	1/10/21	TH	3	S	O	×	Dune crest (6 m)	Sparse *Ac. lig*, *Do. vis*, *Rh. spi*, many dead	*Cr. ere*, *Pt. lat*, *Pt. pol*, *Po. stu*, *Si. amm*, *Sa. aus*	Seen during feral cat monitoring. M, F & J seen 1/10/21
		6/4/22	TH	2	S	T	✓				
		9/4/22	TH	2	S	T	✓				
		6/6/22	TH	2	S	T	✓				
8	WTZ, Sturt NP, NSW	1/10/21	TH	1	H	O	✓	Dune crest (5 m)	*Ac. lig*, *Se. art*, dead *Ac. ane*	*Ar. hol*, *Ab. oto*, *Pt. pol*, *Sa. aus*	
		12/7/22	TH	1	H	T	✓				
9	Park (control) area, Sturt NP, NSW	1/10/21	TH	1	H	O	✓	Dune crest (10 m)	*Ac. lig*, *Do. vis*, many dead	*Po. stu*, *Sa. aus*	M & F
		19/7/22	TH	2	S	T	✓				
10	WTZ, Sturt NP, NSW	7/12/21	TH	1	S	O	✓	Dune crest (10 m)	*Do. vis*, *Rh. spi*	*Ar. hol*, *Cr. ere*, *Pt. lat*, *Sa. aus*	
11	Winnathee Stn, NSW	4/12/21	BC, DC	1	S	O	×	Dune crest (8 m)	Open *Ac. lig*, *Do. vis*	*Cr. ere*, *Pt. pol*, *Si. amm*, *Sa. aus*	Seen during Crest-tailed Mulgara surveys
12	WTZ, Sturt NP, NSW	8/2/22	TH	2	S	T	✓	Dune crest (15 m)	Scattered *At. hem*	*Ar. hol*, *Cr. ere*, *Pt. lat*, *Sa. aus*	M & F
		1/4/22	CE, WP	1	S	T	✓				
		12/7/22	TH	1	H	T	✓				
13	WTZ, Sturt NP, NSW	28/2/22	TH	2	S	O	×	Dune crest (10 m)	Scattered *Ac. lig* & *Do. vis*	*Ar. hol*, *Ab. oto*, *Si. amm*, *Sa. aus*	Seen during feral cat monitoring, 100 m from cat
14	WTZ, Sturt NP, NSW	24/3/22	TH	2	S	O	✓	Dune crest (12 m) & saddle	Sparse, large *Ac. lig*, *Do. vis*, *Rh. spi*	*Ar. hol*, *Ab. oto*, *Cr. ere*, *Pt. pol*, *Sa. aus*	M & F
		8/4/22	RP	1	S	O	×				
15	Thipa Exclosure, Sturt NP, NSW	7/4/22	TH	1	H	O	×	Dune base & dune crest (8 m)	*Ac. lig*, *Do. vis*, *Er. lon*, *Rh. spi*, some dead	*Ar. hol*, *Ab. oto*, *Cr. ere*, *Ca. eri*, *Sa. aus*	M & F; seen during pitfall trapping
		8/4/22	TH	2	S	T	✓				
		1/6/22	TH	1	S	T	✓				
		11/7/22	TH	2	S	O	✓				
		25/7/22	TH	1	H	O	×				
16	WTZ, Sturt NP, NSW	11/4/22	TH	2	S	O	×	Dune crest (7 m)	*Ac. lig*, *Do. vis*, some dead	*Ab. oto*, *Cr. ere*, *Pt. lat*, *Si. amm*, *Sa. aus*	M & F; seen during feral cat monitoring
		7/6/22	TH	2	S	O	✓				
		19/7/22	TH	1	S	T	✓				

Appendix 1 continued

Site no.	*Location*	*Date*	*Obs.*	*n*	*Obs. method*	*Search type*	*Play-back*	*Landform (& height)*	*Dominant shrub & tree sp.*	*Dominant under-storey sp.*	*Comments*
17	Minkgu Exclosure, Sturt NP, NSW	23/5/22	TH	2	S	O	✓	Dune crest (6 m)	*Ac. ane*, *Ac. lig*, *Rh. spi*	*Ar. hol*, *Ab. oto*, *Si. amm*, *Sa. aus*	Seen during bandicoot monitoring
18	Thipa Exclosure, Sturt NP, NSW	2/6/22	RP	2	S	O	×	Dune crest (10 m)	*Ac. ane*, *Do. vis*, *Ma. pyr*, *Rh. spi*	*Ar. hol*, *Ab. oto*, *Cr. ere*, *Pt. pol*, *Si. amm*, *Sa. aus*	Seen during bandicoot monitoring
		15/6/22	TH	2	S	O	✓				
19	Thipa Exclosure, Sturt NP, NSW	9/6/22	TH	2	S	O	×	Dune crest (10 m)	*Do. vis*, *Rh. spi*	*Ar. hol*, *Ab. oto*, *Cr. ere*, *Pt. lat*, *Si. amm*, *Sa. aus*	Seen during bandicoot monitoring
20	Thipa Exclosure, Sturt NP, NSW	14/6/22	TH	2	S	O	×	Dune crest (15 m)	*Ac. lig*, *Do. vis*	*Ar. hol*, *Ab. oto*, *Ca. eri*, *Cr. ere*, *Si. amm*	M & F; seen during bandicoot monitoring
		19/7/22	TH	1	S	T	✓				
		17/8/22	TH	3	S	O	×				
21	WTZ, Sturt NP, NSW	12/7/22	TH	1	H	O	✓	Dune crest (10 m)	*Ac. lig*, *Rh. spi*, *sparse Ac. ane*	*Ar. hol*, *Pt. pol*, *Sa. aus*	Seen during feral cat monitoring
22	Park (control) area, Sturt NP, NSW	19/7/22	TH	1	S	O	✓	Dune crest (10 m)	Scattered *Ac. lig*, *Do. vis*	*Ar. hol*, *Ca. eri*, *Po. stu*, *Sa. aus*	M; seen during fence check
23	Park (control) area, Sturt NP, NSW	22/7/22	TH	3	S	O	✓	Dune crest (10 m)	Sparse *Ac. lig*, *Do. vis*	*Ca. eri*, *Cr. ere*, *Pt. lat*, *Sa. aus*	M & F; seen during track surveys
24	Thipa Exclosure, Sturt NP, NSW	10/8/22	TH, DB, AR	1	H	O	✓	Dune crest (8 m)	*Do. vis*, *Rh. spi*, many dead	*Ca. eri*, *Cr. ere*, *Pt. lat*, *Sa. aus*	
25	Park (control) area, Sturt NP, NSW	11/8/22	AR	1	H	T	×	Dune crest (7 m)	*Ac. lig*, *Do. vis*	*Ar. hol*, *Cr. ere*, *Pt. lat*, *Sa. aus*	
26	Park (control) area, Sturt NP, NSW	11/8/22	AR	2	S	T	✓	Dune crest (10 m)	*Ac. lig*, *Do. vis*, *Rh. spi*	*Ar. hol*, *Cr. ere*, *Pt. lat*, *Sa. aus*	M & F
27	Park (control) area, Sturt NP, NSW	11/8/22	AR	1	H	T	✓	Dune crest (5 m)	*Ac. lig*, *Do. vis*	*Ar. hol*, *Cr. ere*, *Si. amm*, *Sa. aus*	
28	Park (control) area, Sturt NP, NSW	11/8/22	AR	1	S	T	✓	Dune crest (7 m)	*Ac. lig*, *Rh. spi*	*Cr. ere*, *Si. amm*, *Sa. aus*	
29	Park (control) area, Sturt NP, NSW	11/8/22	AR	2	S	T	✓	Dune crest (6 m)	*Ac. lig*, *Ma. pyr*, *Se. art*	*Ar. hol*, *Ab. oto*, *Cr. ere*, *Sa. aus*	M & unidentified bird
30	Park (control) area, Sturt NP, NSW	11/8/22	AR	1	S	T	✓	Dune crest (7 m)	*Ac. lig*, *Do. vis*, *Ma. pyr*	*Ar. hol*, *Cr. ere*, *Si. amm*, *Sa. aus*	M
31	Park (control) area, Sturt NP, NSW	15/8/22	TH	2	S	O	×	Dune crest (5 m)	*Al. ole*, *Do. vis*	*Ca. eri*, *Cr. ere*, *Pt. pol*, *Sa. aus*	M; seen during standardised bird survey
32	WTZ, Sturt NP, NSW	15/8/22	TH	2	S	O	×	Dune crest (10 m)	*Ac. lig*, *Rh. spi*, *Se. art*	*Ar. hol*, *Pt. lat*, *Po. stu*	M & F; seen during standardised bird survey

Appendix 1 continued

Site no.	*Location*	*Date*	*Obs.*	*n*	*Obs. method*	*Search type*	*Play-back*	*Landform (& height)*	*Dominant shrub & tree sp.*	*Dominant under-storey sp.*	*Comments*
33	Park (control) area, Sturt NP, NSW	15/8/22	RP	1	H	O	×	Dune crest (8 m)	*Ac. ane*, *Al. ole*, *Do. vis*	*Ar. hol*, *Ab. oto*, *Pt. pol*	Heard during standardised bird survey
34	Minkgu Exclosure, Sturt NP, NSW	15/8/22	LP	1	S	O	×	Dune crest (7 m)	*Ac. lig*, *Do. vis*	*Cr. ere*, *Pt. lat*, *Sa. aus*	Seen during standardised bird survey
35	Lindon Stn, SA	17/8/22	TH	2	S	O	×	Dune crest (10 m)	Scattered *Ac. lig*	*Ar. hol*, *Pt. pol*, *Po. stu*, *Sa. aus*	M & F; seen during standardised bird survey
36	Omicron Stn, Qld	17/8/22	TH	1	H	T	✓	Dune crest (10 m)	*Ac. lig*, *Do. vis*, *En. tom*	*Ar. hol*, *Cr. ere*, *Pt. lat*, *Sa. aus*	Second record in far SW corner of Qld
37	Park (control) area, Sturt NP, NSW	18/8/22	LP	1	S	T	✓	Dune crest (9 m)	*Ac. lig*, *Do. vis*	*Ar. hol*, *Cr. ere*, *Pt. lat*, *Sa. aus*	
38	Park (control) area, Sturt NP, NSW	21/8/22	RP, LP	2	S	T	✓	Dune crest (12 m)	*Ac. lig*, *Do. vis*	*Ca. eri*, *Pt. lat*, *Po. stu*, *Sa. aus*	No nest found but tracks to shrub suggestive
39	Park (control) area, Sturt NP, NSW	21/8/22	RP, LP	1	H	T	×	Dune crest (12 m)	*Ac. lig*, *Do. vis*	*Ca. eri*, *Pt. lat*, *Po. stu*, *Sa. aus*	