

The Distributions of Six Cryptic Reptile Species in the Perth Region, Western Australia: Appraising Their Persistence in a Transforming Landscape

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Abstract

Significant and ongoing land clearing within the Perth region has resulted in severe declines in its rich herpetofauna diversity over the last several decades, with many species experiencing widespread extirpations. Several species have since become extremely rare and are confined to a handful of locations; whether or not some species even continue to persist in the region is ambiguous, due to a lack of recent records. The aims of this study are to examine contemporary occurrences of *Brachyurops fasciolatus fasciolatus*, *Ctenopus gemmula*, *Delma concinna concinna*, *Diplodactylus polyophthalmus*, *Lerista christinae* and *Lucasium alboguttatum* in the Perth region. These records suggest that the distribution of the species have declined here in recent decades. Further survey-work is required to address knowledge gaps in their current distributions, in order to identify remaining populations and conserve locally significant species, which may continue to persist in localities bearing sufficient habitat. Targeted surveys are most suited for this task, with heavy focus on historical collection sites and under-surveyed expanses of habitat.

[Editor's note: Grey literature listed in the Appendix is denoted in the text by an asterisk]

INTRODUCTION

Despite its exceptional herpetological richness, the Perth region (Fig. 1) has been experiencing significant losses in herpetofauna for decades, because of rapid urban sprawl and land development, as well as its numerous associated threatening processes such as habitat degradation, fragmentation, and introduced species (Storr *et al.* 1978*; How *et al.* 2022). Land development continues to occur and has recently resulted in the destruction of faunally rich bushlands occupied by rare and locally significant species in the north of the Perth region. One species is officially considered lost from the Perth region, the Ringed Brown Snake *Pseudonaja modesta* (How & Dell 1994), while one of the world's most endangered reptiles, the Western Swamp Tortoise *Pseudemydura umbrina*, is now restricted to only two wetlands in the north of the Perth region (as well as a handful of translocated populations beyond the Perth region), despite a historically greater distribution (Kuchling & Burbidge 1996*; How & Dell 2000; Schmölz *et al.* 2021; Paget *et al.* 2023).

Estimates as far back as 1998 suggested less than 30% of native vegetation remains uncleared on the Swan Coastal Plain in the Perth region (Government of Western Australia 1998*; How & Dell 2000). There has been a further major decrease in the decades since then, particularly with rapid urban development (Western Australian Land Information Authority; <https://map-viewer-plus.app.landgate.wa.gov.au/>; 20 May 2024). As such, the widespread habitat destruction in recent decades has led to drastic declines in vertebrate species diversity (Storr *et al.* 1978; How & Dell 2000; Stenhouse 2004; Ramalho *et al.* 2014). In many small suburban bushland remnants, only the most resilient species may persist, while more sensitive species are quickly lost from such reserves, due to reduced habitat, fewer resources, greater exposure to feral predators, and amplified habitat degradation (How & Dell 2000). In time, even the most resilient species probably will not survive in these small suburban reserves, as resources become exhausted and genetic diversity becomes deleteriously limited. Although biological surveys are always conducted prior to land clearing, they are often too limited in their com-

prehensiveness and conducted under strict time constraints. This may lead to inaccurate under-representations of local biodiversity assemblages and the potential for threatened species to be undetected (M. Bamford, pers comm., 20 August 2023). Translocation programmes have been proposed as a viable method to mitigate faunal mortalities incurred by land clearing (Thompson & Thompson 2015), but these present several underlying issues pertaining to animal welfare (Menkhorst *et al.* 2016; Bradley *et al.* 2023). The deleterious impacts of rapid urban development are most evident in the rarest herpetofauna species, which are known from extremely few, if any, recent records, leading to concerns about their current and future status within the Perth region. This paper reviews six rare species (Fig. 2) characterised by a paucity of information on their current geographical extents within the Perth region, by documenting their historical records, where they may possibly occur undetected and the likelihood of their continued survival. These species have been selected because: (i) their current occurrence in Perth is minimal; (ii) their distributions are ambiguous or data deficient; and (iii) past records indicate a historically greater distribution or abundance in the region. Many such records represent the northernmost or southernmost limits of their distributions (Bush *et al.* 2010) and as such, populations in Perth are highly significant.

For the purposes of this paper, the Perth region is defined by the administrative boundaries of the local government areas – the City of Wanneroo in the north, the Shires of Mundaring and Serpentine-Jarrahdale, and Cities of Swan, Kalamunda and Armadale to the east, and the City of Mandurah to the south. This encompasses both the Swan Coastal Plain and the Darling Range, which respectively host differing but partially overlapping herpetofaunal assemblages (How & Dell 2000; Bush *et al.* 2010).

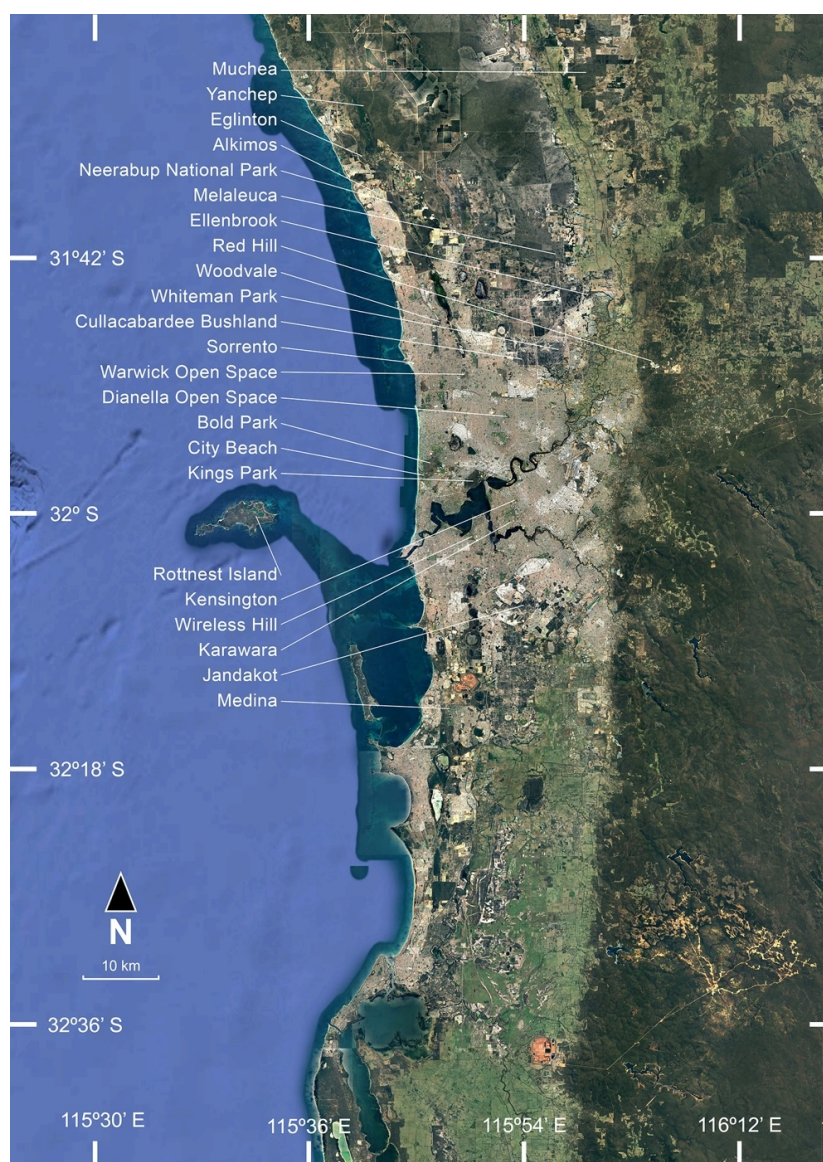


Figure 1. Map of Perth region (Google Earth image, December 2020). Localities mentioned in the text are shown.

SPECIES

Brachyuropis fasciolatus fasciolatus (Günther 1872)

The Narrow-banded Shovelnose Snake *Brachyuropis fasciolatus fasciolatus* (Fig. 2a) is a small fossorial elapid inhabiting a variety of arid habitats throughout southern Western Australia, such as spinifex deserts, sandy *Banksia* woodlands and coastal heathlands (Bush *et al.* 2010; Wilson & Swan 2013). It is known from several historical records throughout the north of the Perth region (OZCAM 2024a; Table 1; Fig. 3). However, recent records are extremely scarce and have only been made in undisturbed expanses of bushland in Yanchep, Ellenbrook and Melaleuca (S. Vinen, pers comm. 17 May 2024; B. Maryan, pers comm. 24 May 2024).

How *et al.* (2022) recorded only eighteen captures of *B. f. fasciolatus* in a 35-year herpetofauna monitoring programme at Bold Park, with none being captured after 1999 despite continued annual surveying until 2022. This suggests that the species has since been lost from this reserve (How 2024). Between 1987 and 1999, *B. f. fasciolatus* was the least frequently recorded fossorial elapid, a trend observed at other reserves throughout the Perth region (Arnold *et al.* 1991*; Maryan *et al.* 2002; B. Maryan, pers comm., 24 May 2024). This may reflect a

lesser tolerance to human disturbance than other fossorial elapids, although the factors influencing this lessened tolerance remain unclear. Another likely factor is the significant habitat degradation that has occurred at Bold Park, with apparent prolific weed infestations degrading the microhabitats that this fossorial species requires (How & Shine 1999), and few areas of high-quality native vegetation remaining. However, this would not explain the continued persistence of four other fossorial elapid species at Bold Park (How *et al.* 2022; How 2024).

A single individual was recorded at Maralla Road Nature Reserve in Ellenbrook by Maryan *et al.* (2002), but subsequent search efforts have failed to locate additional individuals (Irvine 2023). Populations likely persist in the expansive *Banksia* woodlands west of Tonkin Highway, which was historically continuous with the nature reserve prior to the construction of the highway. Since the initial survey, significant land clearing has occurred within the nature reserve, and the extension of Tonkin Highway has separated the reserve from the vast expanse of bushland towards the west (Western Australian Land Information Authority December 2023*). Other sections of the reserve have been severely degraded by human activities such as illegal dumping of rubbish (Coffey Environments 2016*), likely having a deleterious impact upon *B. f. fasciolatus* populations there. A deceased



Figure 2. Examples of the six rare species reviewed in this paper. a) *Brachyuophis fasciolatus fasciolatus*, from Yanchep (Fig. 1); species maximum length 390 mm (Wilson & Swan 2013). b) *Ctenotus gemmula*, from Stirling Ranges National Park, WA; species maximum snout-vent length (SVL) 58 mm (Wilson & Swan 2013); photo from B. van der Heide. c) *Delma concinna concinna*, from Zuytdorp, WA; species maximum length (SVL) 112 mm (Wilson & Swan 2013); photo from J. Eastwood. d) *Diplodactylus polyophthalmus*, from Dianella Open Space (Fig. 1); species maximum length (SVL) 54 mm (Wilson & Swan 2013). e) *Lerista christinae*, from Mooliabeene, WA; species maximum length (SVL) 39 mm (Wilson & Swan 2013). f) *Lucasium alboguttatum*, from Melaleuca (Fig. 1); species maximum length (SVL) 57 mm (Wilson & Swan 2013).

individual was found in 2016 in a nearby suburban backyard in Ellenbrook, suggesting the possibility of the species' persistence in the area (S. Vinen, pers. comm. 17 May 2024). Further surveying is required to investigate this.

The capture of a single individual in Melaleuca in 2010 represents what is likely an extant population (B. Maryan, pers. comm., 24 May 2024). The *Banksia* woodlands throughout Melaleuca are expansive and retain high vegetation quality, hence why the species has been able to persist there.

Arnold *et al.* (1991*) captured a single individual at Whiteman Park in 1986, along with other uncommon and locally significant species such as *Ctenotus gemmula* Storr, *Lucasium alboguttatum* (Werner) and *Neelaps calonotus* (Duméril, Bibron, Duméril). Within the area, expansive habitats remain intact and relatively undisturbed, apart from the recently extended Tonkin Highway separating Whiteman Park from the historically continuous Cullacabardee Bushland. Further surveying is required to ascertain the status of *B. f. fasciolatus* in this area, as it is possible the species persists to this day.

There have also been two recent observations of *B. f. fasciolatus* in Yanchep, both in 2022 (J. McGhie, pers. obs.) and in this study (Fig.

2a) confirming that the expansive *Banksia* woodlands throughout this area supports an extant population.

Snakes appear to have a strong reliance on larger expanses of habitats to survive than lizards, with a positive relationship existing between the richness of snake species and the area of a reserve (How & Dell 1994). This trait increases their susceptibility to habitat fragmentation and *B. f. fasciolatus* evidently exhibits this trait to a far greater degree than other species.

Ctenotus gemmula Storr 1974

The Jewelled Sandplain Ctenotus *Ctenotus gemmula* (Fig. 2b) is a semi-fossorial skink patchily distributed throughout southwestern Australia between Cooljarloo and Toolinna, inhabiting sandy *Banksia* and mallee woodlands, and heathlands (Bush *et al.* 2010; Kay & Keogh 2012; Wilson & Swan 2013; Bamford *et al.* 2015*). Populations on the Swan Coastal Plain are listed as Priority Three under State legislation (Department of Biodiversity, Conservation and Attractions 2024*). The Priority Three listing is granted for 'species that are known from several locations', where there exists 'significant remain-

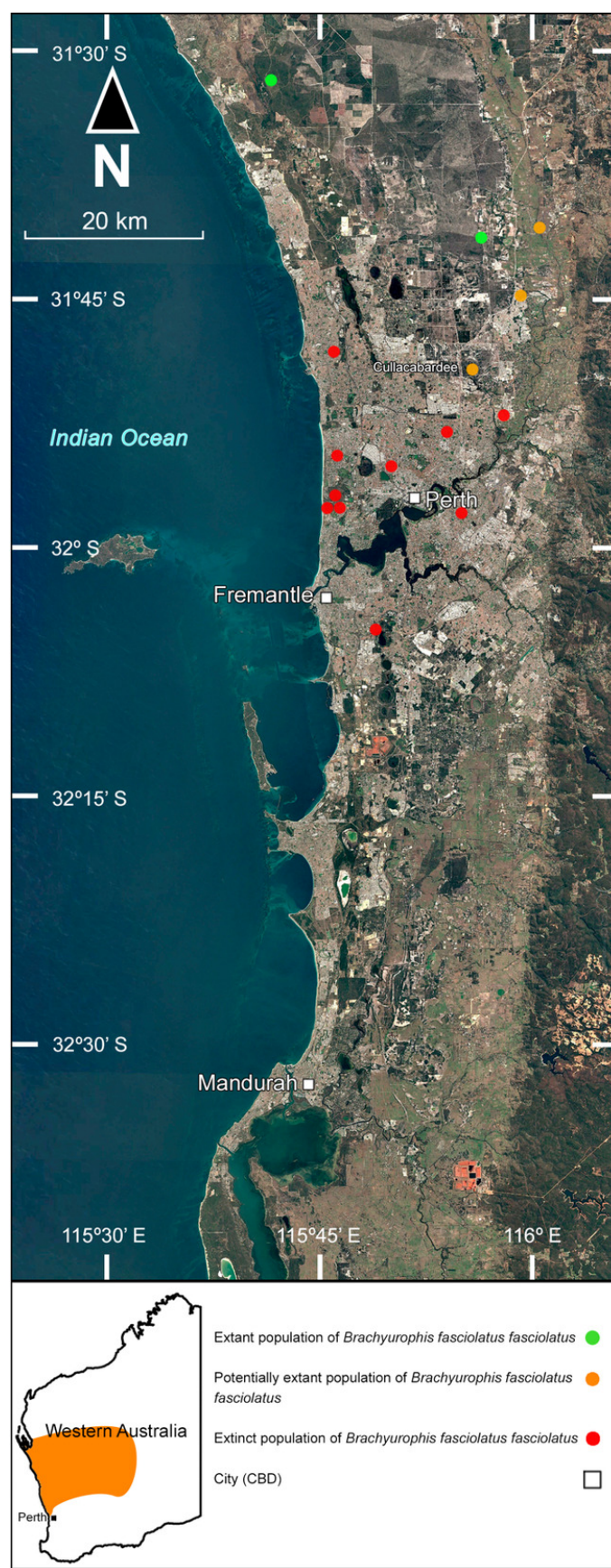


Figure 3. *Brachyurophis fasciolatus fasciolatus* populations within the Perth region. Green circles denote extant populations; orange circles denote possibly extant populations; and red circles indicate populations that are likely extirpated. The overall distribution of the species is shown in orange on the inset map. Sources for localities are summarised in [Table 1](#).

Table 1. *Brachyurophis fasciolatus fasciolatus* locations within the Perth region, the most recent records and the current population status at the locations.

Location	Last record	Status	Reference/source
Bold Park	1999	Extirpated	How 2024
Bullsbrook	<1968	Possible	Western Australian Museum (R4253)
Caversham	<1968	Extirpated	Western Australian Museum (R5939)
City Beach	1974	Extirpated	Western Australian Museum (45624)
Doubleview	1960	Extirpated	Western Australian Museum (R14244)
East Victoria Park	1953	Extirpated	Western Australian Museum (R10760)
Ellenbrook	2016	Possible	S. Vinen, pers comm. 17 May 2024; Appendix 1.2
Hillarys	1980	Extirpated	Western Australian Museum (R73168)
Melaleuca	2010	Extant	B. Maryan, pers comm., 24 May 2024
Morley	1960	Extirpated	Western Australian Museum (R13468)
Mount Claremont	1996	Extirpated	Western Australian Museum (R126504)
Mount Hawthorn	<1968	Extirpated	Western Australian Museum (R8389)
North Lake	<1968	Extirpated	Western Australian Museum (R1311)
North Perth	<1968	Extirpated	Western Australian Museum (R7056)
Swanbourne	1980	Extirpated	S. Wilson, pers comm. 3 July 2023
Whiteman Park	1986	Possible	Arnold <i>et al.</i> 1991*
Yanchep	2022	Extant	pers. obs.

Table 2. *Ctenotus gemmula*. List of locations within the Perth region, the most recent records, and the current population status at the locations.

Location	Last record	Status	Reference/source
Ellenbrook	1992	Possible	Maryan <i>et al.</i> 2002
Jandakot	1973	Possible	Western Australian Museum (R43994)
Karawara	1975	Extirpated	Western Australian Museum (R50127)
Melaleuca	1977	Possible	Western Australian Museum (R138116)
Medina	1979	Extirpated	Western Australian Museum (R68241)
Whiteman Park	1986	Possible	Arnold <i>et al.</i> 1991*

ing areas of apparently suitable habitat, much of it not under imminent threat' (Environmental Protection Authority 2023*, p. 4).

Numerous specimens were collected in the latter half of the twentieth century, indicating the species' historical abundance within the Perth region, albeit at relatively few locations (Storr 1974; OZCAM 2024b; Table 2; Fig. 4). Forty specimens were collected in Karawara by M. Peterson between 1967 and 1975 (Storr 1974; OZCAM 2024b). However, urban development has resulted in limited habitat remaining today, too little to permit the species' continued survival (Peterson 2005). Specimens have also been collected from Medina, Jandakot, Whiteman Park, Melaleuca, and Maralla Road Nature Reserve in Ellenbrook (Arnold *et al.* 1991*; Maryan *et al.* 2002; OZCAM 2024b). Although sufficient habitat remains at most of these sites, no records exist from the 21st century. Jandakot and Melaleuca have been surveyed intermittently in recent decades but have failed to capture further *C. gemmula* individuals, despite ample quality habitat remaining (Davidge 1979; Maryan 1993; Bamford Consulting Ecologists 2003*; ENV 2009*; B. Maryan, pers comm. 24 May 2024). Further surveying is required to ascertain the species' current status at each location but on the basis of recent survey-work, there is a strong likelihood that most populations of *C. gemmula* in the Perth region have been lost (Maryan *et al.* 2017).

Recent records of *C. gemmula* from the Swan Coastal Plain have entirely originated from the Cataby/Cooljarloo area, ca. 150 km north of Perth, where detailed long-term fauna monitoring has been conducted since 1986 and the species has been infrequently recorded (Bamford 1995; Bamford & Calver 2015; Bamford *et al.* 2015*;

Maryan *et al.* 2017; OZCAM 2024b). As such, it is possible that the population there represents the only remaining one on the Swan Coastal Plain, with all others having been extirpated in recent decades. This may be a matter of serious conservation concern and warrants review by the Department of Biodiversity, Conservation and Attractions (DBCA). An elevated conservation ranking above Priority Three may be necessary to recognise the severe decline incurred by Swan Coastal Plain populations of *C. gemmula*. The nearest extant population is ca. 470 km southeast of Cooljarloo, at the Stirling Range National Park (Kay & Keogh 2012; Fig. 2b), rendering the Cataby/Cooljarloo population an extremely disjunct outlier population.

Delma concinna concinna (Kluge 1974)

The West Coast Javelin *Delma Delma concinna concinna* (Fig. 2c) is an arboreal pygopodid lizard endemic to coastal regions of Western Australia between Neerabup National Park and Zuytdorp Nature Reserve (Wilson & Swan 2013; OZCAM, 2024c). The species inhabits dense heathlands with complex heath understories and is occasionally highly abundant (Bamford 1998 as *Adys concinna*; Bush *et al.* 2010; Wilson & Swan 2013). The holotype of *D. c. concinna* was collected in a Sorrento backyard in 1962 (Kluge 1974). Additional specimens have since been collected in primarily coastal localities throughout the northern Perth metropolitan area (Thompson & Thompson 2015; Moore *et al.* 2015a*; GHD Group Pty Ltd 2018*; OZCAM 2024c; Table 3; Fig. 5). However, many of these records likely represent now-extirpated populations.

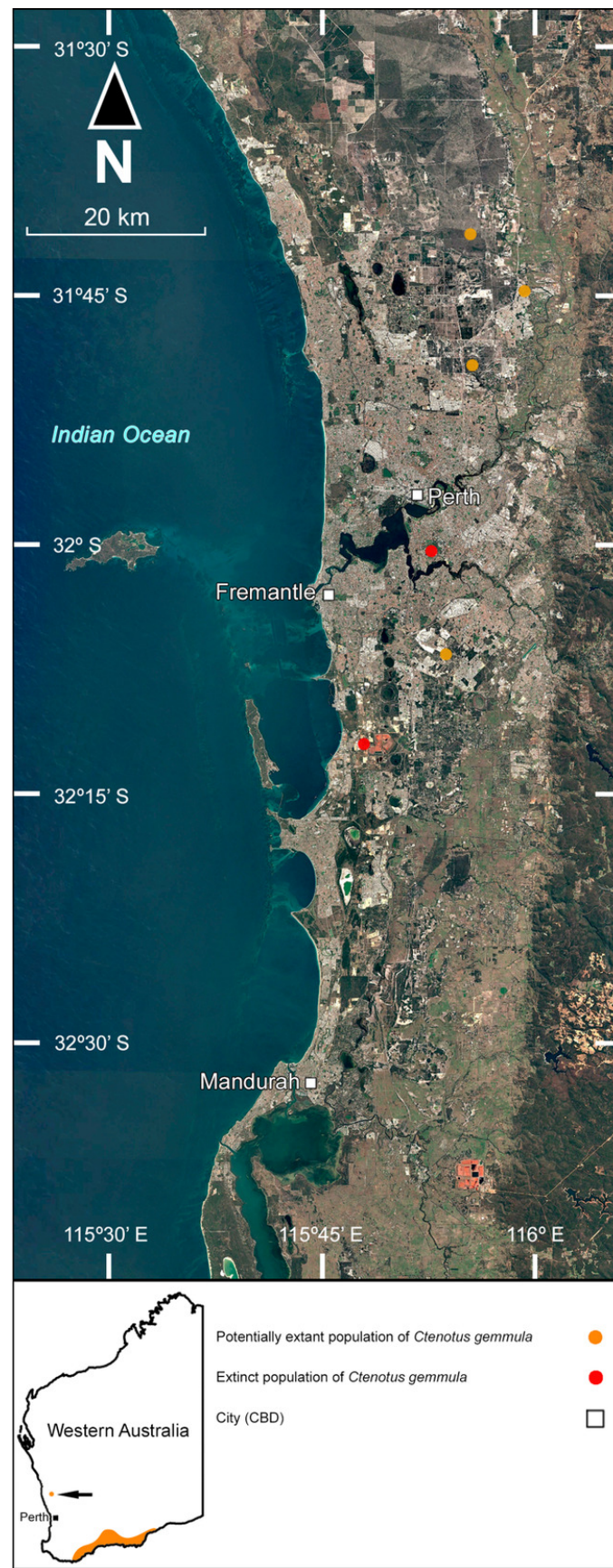


Figure 4. *Ctenotus gemmula* populations within the Perth region. Orange circles denote extant populations; and red circles indicate populations that are likely extirpated. The overall distribution of the species is shown in orange on the inset map. Sources for localities are summarised in [Table 2](#).

Table 3. *Delma concinna concinna*. List of locations within the Perth region, the most recent records, and the current population status at the locations.

Location	Last record	Status	Reference/source
Alkimos	2012	Possible	Thompson & Thompson 2015
Burns Beach	1998	Possible	R. Davis, pers comm. 7 December 2023
Eglinton	2001	Possible	Western Australian Museum (R146352)
Melaleuca	2011	Extant	Moore <i>et al.</i> 2015b*
Neerabup National Park	2018	Extant	GHD 2018*
Sorrento	1962	Extirpated	Kluge 1974
Yanchep	1977	Possible	Western Australian Museum (R59132)

The species was captured in a faunal translocation programme at a ca. 14 ha bushland remnant in Alkimos in 2012, which preceded the clearing of that bushland remnant (Thompson & Thompson 2015). All individuals trapped during the programme were subsequently translocated to an adjacent national park (Thompson & Thompson 2015). The presence of the species in such a small bushland remnant demonstrated its ability to persist in small bushland remnants, but how long it can persist before extirpation remains unclear. Therefore, a small number of individuals possibly persist in similarly small bushland fragments throughout the area, which continues to experience ongoing land clearing (Western Australian Land Information Authority; <https://map-viewer-plus.app.landgate.wa.gov.au/>; 20 May 2024). However, whatever remaining individuals persist would be unlikely to constitute a viable population. This is probably the case for Eglinton, where *D. c. concinna* was historically recorded, but which is similarly experiencing ongoing land clearing.

The persistence of the species within Neerabup National Park is unsurprising, given that it was historically continuous with Sorrento, where the holotype was collected (Kluge 1974). GHD Group Pty Ltd (2018*) captured a single individual in 2018, confirming that the expansive national park retains an extant population. However, it is unlikely that *D. c. concinna* continues to persist in the narrow corridor of coastal heath along the Sorrento foreshore, near where the holotype was collected (Kluge 1974).

The species was also recorded at a rehabilitated wetland in Melaleuca in 2011 (Moore *et al.* 2015a*). Given the size and habitat quality of the vegetation throughout the Melaleuca area, a population likely exists throughout the entire area. However, it is unusual that this was the first capture of *D. c. concinna* there, as previous surveys have failed to record this species (Huang 2009*; B. Maryan, pers comm. 24 May 2024).

Delma concinna concinna's scarcity throughout the Perth region is unusual when considering the abundance of the West Coast Keeled Legless Lizard *Pletolax gracilis* Cope, another pygopodid lizard with which *D. c. concinna* shares habitat requirements and behavioural similarities – namely an arboreal lifestyle characterised by extraordinarily swift locomotion (Bamford 1998; Bush *et al.* 2010). In contrast to *D. c. concinna*, *P. gracilis* can be relatively abundant even in small suburban bushland remnants, despite its extremely cryptic nature (How & Dell 2000; Bush *et al.* 2010; Irvine 2023). Despite their contrasting abundances, both species are dependent on high habitat quality and dense heath complexes to facilitate their arboreal lifestyles (Bamford 1998; Bush *et al.* 2010). While sharing many similarities in their habitat requirements and ecology, *P. gracilis* utilises both coastal and inland habitats (Kluge 1974; Shea & Peterson 1993; Bush *et al.* 2010, How *et al.* 2022), while *D. c. concinna* appears to be mostly confined to coastal and near-coastal habitats in the Perth region (Bush *et al.* 2010; GHD Group Pty Ltd 2018*). The factors causing the scarcity of *D. c. concinna* but not *P. gracilis* within the Perth region remain to be understood.

Diplodactylus polyophthalmus Günther 1867

The Spotted Sandplain Gecko *Diplodactylus polyophthalmus* (Fig. 2d) is a small diplodactylid gecko found between Perth and Arrowsmith West (Bush *et al.* 2010; Wilson & Swan 2013; OZCAM 2024d). The species primarily occupies sandy *Banksia* and *Eucalyptus* woodlands but has also been recorded on stony lateritic soils (Bamford 1986; Harris & Bamford 2007*; Doughty & Oliver 2013). It is listed as “Vulnerable” by the International Union for Conservation of Nature (IUCN) (Gaikhorst *et al.* 2017).

Historically merged with the more widespread *D. lateroides* Doughty and Oliver, *D. polyophthalmus* is primarily restricted to the Swan Coastal Plain and is one of the rarest geckos in the Perth region (Doughty & Oliver 2013). Throughout the 1980's and 1990's, How and Dell (2000) recorded the species in a handful of small suburban bushland remnants north of the Swan River, namely Woodvale, Warwick and Dianella Open Spaces, as well as Kings Park. Additional specimens have also been recorded at several other localities throughout the Perth region (OZCAM 2024d; S. Wilson, pers comm. 26 March 2023; Table 4; Fig. 6), though many of these populations are now likely extirpated (Doughty & Oliver 2013).

Due to the heightened vulnerability of reptiles in small suburban bushland remnants, the current distributions of *D. polyophthalmus* populations in Perth remains uncertain. The few records in the 21st century have almost entirely come from Dianella Open Space (Irvine 2023; OZCAM 2024d; R. Lloyd, pers comm. 28 April 2024). However, there are concerns for this population's viability, due to the size of the reserve's severely limited resources, probably affecting carrying capacity and genetic diversity. Additionally, suburban bushland remnants are extremely susceptible to pollution, feral predators, and habitat degradation (Stenhouse 2004, 2005; Ramalho *et al.* 2014). A recent site visit identified localised weed infestations that had arisen within a matter of months and no *D. polyophthalmus* observable in the area, despite extensive searching with one individual being found just three months prior. This reinforces concerns of this population's fragility and the habitat's susceptibility to rapid degradation.

The presence of a species within an isolated reserve does not necessarily indicate the persistence of a population, with remaining individuals possibly constituting a functionally extinct population (How & Dell 1994); this is often the case in long-lived species and may indeed be the case for the Dianella Open Space population of *D. polyophthalmus*. However, the only way to verify this is to undertake long-term monitoring of this population, investigate the population structure and identify the generation length, which is currently unknown.

Dianella Open Space is the smallest reserve where *D. polyophthalmus* was recorded by How and Dell (2000) and its continued presence at this reserve is anomalous, as it has not been recently detected in other larger bushland remnants in the Perth region. The factors permitting the continued survival of this population are unknown, but the persistence of this species at Dianella Open Space establishes the possibility of *D. polyophthalmus* persisting at other small suburban reserves throughout the Perth region that retain adequate habitat qual-

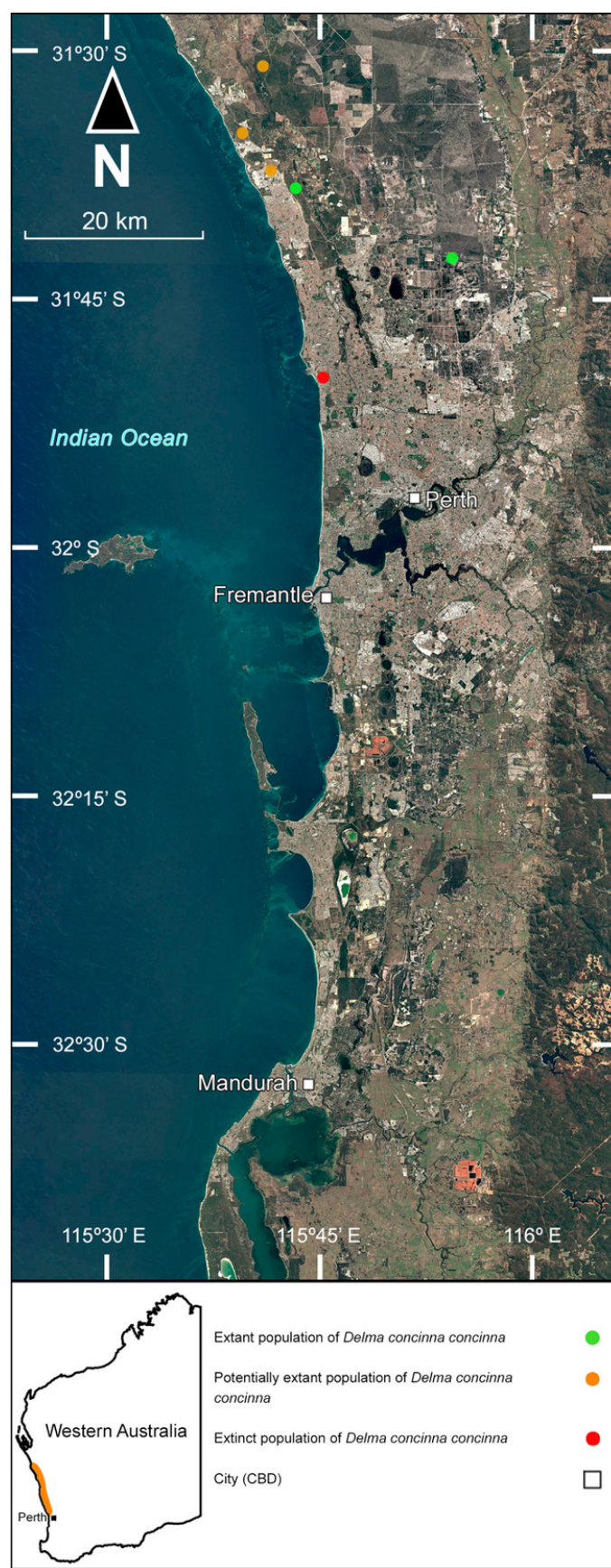


Figure 5. *Delma concinna concinna* populations within the Perth region. Green circles denote extant populations; orange circles denote possibly extant populations; and red circles indicate populations that are likely extirpated. The overall distribution of the species is shown in orange on the inset map. Sources for localities are summarised in [Table 3](#).

Table 4. *Diplodactylus polyophthalmus*. List of locations within the Perth region, the most recent records, and the current population status at the locations.

Location	Last record	Status	Reference/source
Balcatta	1962	Extirpated	Western Australian Museum (R14859)
Balga	1976	Extirpated	S. Wilson, pers comm., 26 March 2023,
Dianella Open Space	2023	Extant	pers. obs.
Duncraig	1984	Extirpated	Western Australian Museum (R87866)
East Victoria Park	<1979	Extirpated	Western Australian Museum (R11484)
Eglinton	1959	Possible	Western Australian Museum (R15244)
Forrestfield	1963	Extirpated	Western Australian Museum (R19368)
Kings Park	1993	Extirpated	How & Dell 2000
Maddington	<1979	Extirpated	Western Australian Museum (R388)
Neerabup National Park	1977	Possible	Western Australian Museum (R59390)
Red Hill	2006	Extant	Harris & Bamford 2007*
Thornlie	1986	Extirpated	Western Australian Museum (R96216)
Wanneroo	1966	Possible	Western Australian Museum (R26856); Western Australian Museum (R26857)
Warwick Open Space	1995	Possible	How & Dell 2000
Woodvale	1985	Possible	Western Australian Museum (R94695)

ity. Many such reserves have not been surveyed systematically, leaving room for further investigation of this matter.

Harris and Bamford (2007*) recorded two forms of *D. polyophthalmus* at Red Hill (prior to the description and splitting of *D. lateroides* from *D. polyophthalmus* in 2013). While a specimen from only one of these forms was collected by them and lodged with the Western Australian Museum (later verified as *D. lateroides*), it could be inferred that the other form represents *D. polyophthalmus*. This is the only population on the Darling Range, as well as the only recorded instance of sympatry with *D. lateroides*, which is restricted to the Darling Range within the Perth region (Doughty & Oliver 2013). Despite the primarily stony habitat being atypical for *D. polyophthalmus*, Harris and Bamford (2007*) also recorded other reptile species scarcely found on the Darling Range and preferring sandy coastal vegetation, such as *Demansia reticulata* (Gray) and *Pletholax gracilis*.

The absence of *D. polyophthalmus* at Kings Park is unusual, given the reserve's size and the species' persistence in the far smaller habitat at Dianella Open Space. Annual surveying has failed to capture the species in three decades (R. Davis, pers comm. 7 December 2023) – the species' absence may possibly be attributed to the heightened human disturbance and infestations of weeds at Kings Park.

Records from the Perth region, between Perth and Yanchep, have been regarded as one of two disjunct clusters of populations, the other comprising records from between Cataby and Eneabba (Doughty & Oliver 2013; Gaikhorst *et al.* 2017). However, a record has since been made at Arrowsmith West in 2017, representing the current northernmost limit of the species (OZCAM 2024d). No further specimens have been recorded from Champion Bay or the surrounding area (*ca.* 110 km north of Arrowsmith West), where the holotype was first collected in the nineteenth century (Günther 1867).

Additionally, the *ca.* 100 km gap between the northern and southern populations proposed by Doughty and Oliver (2013) neglects to mention specimens captured at Mooliabeene, located within said gap (Bamford 1986). A single individual was also captured at nearby Boonanning Nature Reserve in 2012 (Moore *et al.* 2015b*). However, it does indeed appear that these are the only records in this gap. It is possible that undetected populations occupy the intervening *Banksia* woodlands within this gap, such as Moore River National Park and Namming Nature Reserve, pending further survey-work in the area.

Another interesting knowledge gap is the habitat preference of *D. polyophthalmus*. Whilst typically documented as preferring sandy *Banksia* and *Eucalyptus* woodlands, the species has also been recorded utilising habitats atop lateritic soils and even appears to be confined

to these habitats instead of sandier habitats wherever available (Bamford 1986; Bamford *et al.* 2015*). As such, the minimal occurrence of *D. polyophthalmus* on the Darling Range (apart from the Red Hill population), which is characterised by predominantly lateritic soils, is most intriguing. It is possible that the species possesses poor interspecific competitive abilities, with the Darling Range possessing far more gecko species than the Swan Coastal Plain (Bush *et al.* 2010).

Recent records of *D. polyophthalmus* originate from only a handful of locations, suggesting that the species may be very patchily distributed and highly vulnerable to local stochastic stressors (Doughty & Oliver 2013; Gaikhorst *et al.* 2017). Some historical collection sites have not yielded further specimens in recent years, such as Eneabba and Mooliabeene, warranting additional survey-work in these areas to verify the continued persistence of the species. A review by the DBCA may be warranted, as the species' overall patchy distribution and drastic declines from the Perth region may be a serious conservation concern (Doughty & Oliver 2013).

Lerista christinae Storr 1979

The Bold-Striped Slider *Lerista christinae* (Fig. 2e) is a small fossorial skink inhabiting sandy *Banksia* woodlands and heathlands on the northern Swan Coastal Plain, between Muchea and Mount Adams (Bush *et al.* 2010; Bamford & Metcalf 2012*; R. Davis, pers comm. 7 December 2023). It is listed as “Vulnerable” by the IUCN (Cowan *et al.* 2017).

Within the Perth region, *Lerista christinae* was historically known only from two specimens collected on Rottne Island in 1970 and 1986 (Smith 1997), before the first mainland specimens were collected at Maralla Road Nature Reserve in Ellenbrook in 1992, representing a significant range extension on the mainland (Maryan *et al.* 2002; Table 5; Fig. 7). At the time, the species appeared to be relatively abundant at that nature reserve (Maryan *et al.* 2002). However, subsequent survey efforts failed to locate further individuals there (Irvine 2023), leading to concerns that the species has since been extirpated. Since the initial survey by Maryan *et al.* (2002), significant land clearing has occurred within the nature reserve, and the extension of Tonkin Highway has separated the reserve from the vast expanse of bushland towards the west (Western Australian Land Information Authority; <https://map-viewer-plus.app.landgate.wa.gov.au/>; 20 May 2024). Other sections of the reserve have also been severely degraded by human activities (Coffee Environments 2016*), although the effect on *L. christinae* populations has not been determined. As the species' range does not ex-

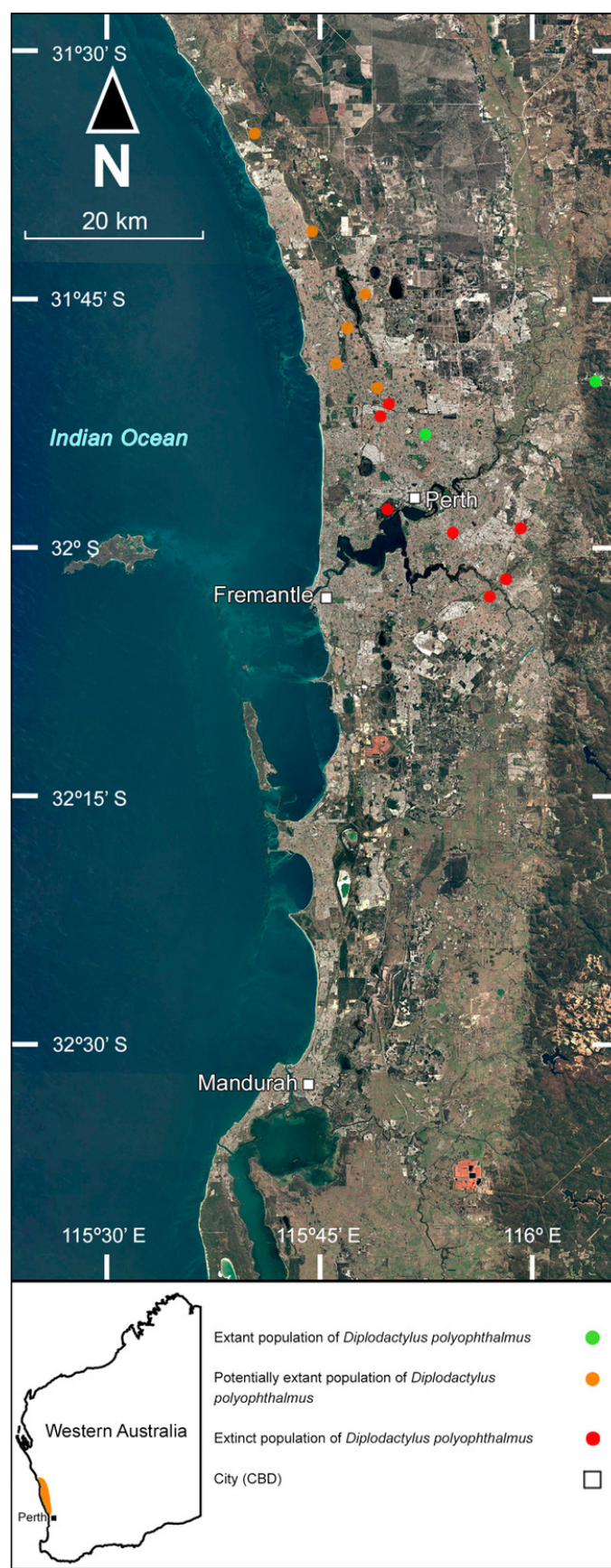


Figure 6. *Diplodactylus polyophthalmus* populations within the Perth region. Green circles denote extant populations; orange circles denote possibly extant populations; and red circles indicate populations that are likely extirpated. The overall distribution of the species is shown in orange on the inset map. Sources for localities are summarised in [Table 4](#).

Table 5. *Lerista christinae*. List of locations within the Perth region, the most recent records, and the current population status at the locations.

Location	Last record	Status	Reference/source
Ellenbrook	2000	Possible	Maryan <i>et al.</i> 2002
Rottnest Island	1986	Extirpated	Smith 1997

tend into inner metropolitan Perth, it is unknown if it can persist in small suburban reserves. While it would stand to reason that *L. christinae* can indeed survive in small suburban reserves, as can all other locally occurring *Lerista* spp. (How & Dell 2000; Bush *et al.* 2010), this would not explain its possible extirpation from Maralla Road Nature Reserve in recent decades. Perhaps *L. christinae* possesses a lessened tolerance to disturbance than other *Lerista* spp.

Populations may persist in the expansive *Banksia* woodlands west of Tonkin Highway and throughout Melaleuca, which was historically continuous with the nature reserve prior to the construction of the highway, however, despite several surveys in this area over the years, the species has not been detected (Huang 2009*; B. Maryan, pers comm. 24 May 2024).

Similarly, the Rottnest Island population has likely been extirpated as well, as no specimens have been recorded since 1986 (Smith 1997), despite extensive surveying on the island (Maryan *et al.* 2015). Significant human disturbance is a likely factor in the decline of this population, due to increased tourism, reinforcing the possibility that *L. christinae* possesses a far lower tolerance to human disturbance. However, four other *Lerista* spp. continue to persist on the island, including the threatened Perth Slider *L. lineata* Bell (Bush *et al.* 2010, Maryan *et al.*, 2015).

Based on the most recent records, the range of *L. christinae* does not appear to reach the Perth region, with none being recently recorded south of Ippolo Road Nature Reserve near Muchea, just outside of the Perth region (R. Davis, pers comm. 7 December 2023).

Beyond the Perth region, *L. christinae* occupies sandy kwongan heath and *Banksia* woodlands north to Mount Adams and is occasionally locally abundant (Bamford 1986; Bamford & Metcalf 2012*). However, recent records of *L. christinae* originate from only a handful of locations, suggesting that the species may be very patchily distributed and highly vulnerable to local stochastic stressors. A review by the DBCA may be warranted, as the species' overall patchy distribution and declines from the Perth region may be a serious conservation concern.

Lucasium alboguttatum (Werner 1910)

The White-spotted Ground Gecko *Lucasium alboguttatum* (Fig. 2f) is a small diplodactylid gecko abundant throughout sandy woodlands and coastal heathlands along the Western Australian coast between Melaleuca and Coral Bay (Bush *et al.* 2010; Wilson & Swan 2013). It is represented by only one extant population in the Perth region, at Melaleuca, with two specimens being recorded in 2009 and 2024 (OZ-CAM 2024; He & Kynadi 2024; Table 6; Fig. 8). The *Banksia* woodlands at Melaleuca are expansive, and retain high vegetation quality, perhaps allowing the species to persist there.

Throughout the latter half of the 20th century, specimens were recorded in Bold Park and City Beach, the last of which was captured in 1995 (How *et al.* 2022). The absence of further specimens captured during the remainder of their 35-year herpetofauna monitoring programme at Bold Park strongly suggests the species has now been lost from this reserve (How 2024). A possible factor is the significant habitat degradation that has occurred at Bold Park, with apparent prolific weed infestations, and few areas of high-quality native vegetation remaining.

Records of *L. alboguttatum* at Wireless Hill and Kensington in 1983 and 1990 respectively represent the southernmost records of this species, albeit represented by only a handful of individuals at each reserve (Smith 1985*; Turpin 1990, 1991). However, both populations are likely extirpated, due to the small sizes of the reserves, habitat degradation, and the species' natural scarcity in smaller reserves (Turpin 1990, 1991; How *et al.* 2022). Therefore, the losses of these two populations, as well as the Bold Park/City Beach population, represent a significant local range contraction and it is likely that these two populations were first detected when they had already become non-viable and undergoing a decline.

Eleven individuals were trapped in a survey at Whiteman Park in 1986 by Arnold *et al.* (1991*), indicating its abundance in larger reserves retaining ample habitat quality (though only one was captured there by Drew 1998). Thus, it is possible that the species continues to persist at this reserve, and the historically continuous Cullacabardee Bushland.

DISCUSSION

The contrast between historical and current distributions of these species seems to be a testament to the significant threat posed by land development on herpetofaunal diversity. The deleterious effects of land development probably remain the most pertinent threat towards biodiversity in the Perth region. Due to the rapid progression of land redevelopment in the Perth region (Newman 2014), it is imperative that sufficiently comprehensive studies of faunal diversity and ecology are conducted prior to and in the years after each development. This may aid urban planners in the synthesis of developments that are more conducive to maintaining faunal diversity.

Owing to their cryptic nature, these species are unfortunately denied the same recognition within the public consciousness as more charismatic species, primarily consisting of iconic mammals and birds. A significant impediment to the conservation of these species, among many others, is a paucity of survey effort. Survey-work in the last few decades has significantly extended the geographical limits (or otherwise recorded from unexpected regions) of many reptile species (Turpin 1990, 1991; Smith 1997; Maryan *et al.* 2002; Algaba 2005; Davis & Bamford 2005; Harris & Bamford 2007*; Davis & Wilcox 2008; Thompson *et al.* 2008), although some such records were likely made in the midst of the populations' extirpation, such as the Wireless Hill and Kensington populations of *L. alboguttatum*. Recently documented discoveries have indicated that populations of cryptic species can persist undetected in un-surveyed or under-surveyed reserves throughout the Perth region, provided they maintain adequate habitat quality. The lack of intensive survey efforts can be attributed to greater environmental impact assessment focus in resource-interest regions, such as the Pilbara and Kimberley (Davis & Wilcox 2008), and areas of heavy development, such as the north of the Perth region. However, some environmental impact assessments have been extremely lacking in comprehensiveness, undertaking basic fauna assessments that only entail a desktop study and a basic reconnaissance survey, referred to as a 'basic survey' by the DBCA (Environmental Protection Authority 2020*). In contrast, a 'basic survey' entails a comprehensive flora and fauna survey, employing pitfall, funnel and cage trapping to complement the methodologies of a 'basic survey' (Environmental Protection Authority 2020*). Employing these methods are more likely to detect

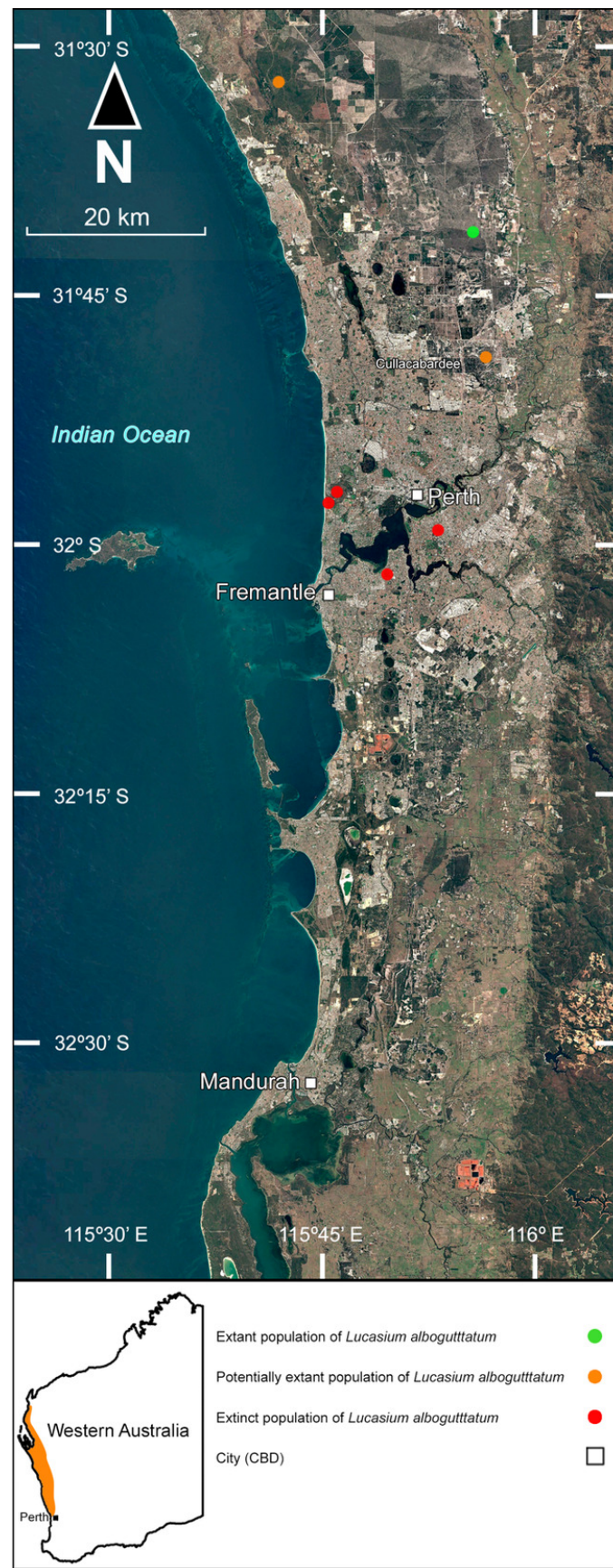


Figure 8. *Lucasium alboguttatum* populations within the Perth region. Green circles denote extant populations; orange circles denote possibly extant populations; and red circles indicate populations that are likely extirpated. The overall distribution of the species is shown in orange on the inset map. Sources for localities are summarised in [Table 6](#).

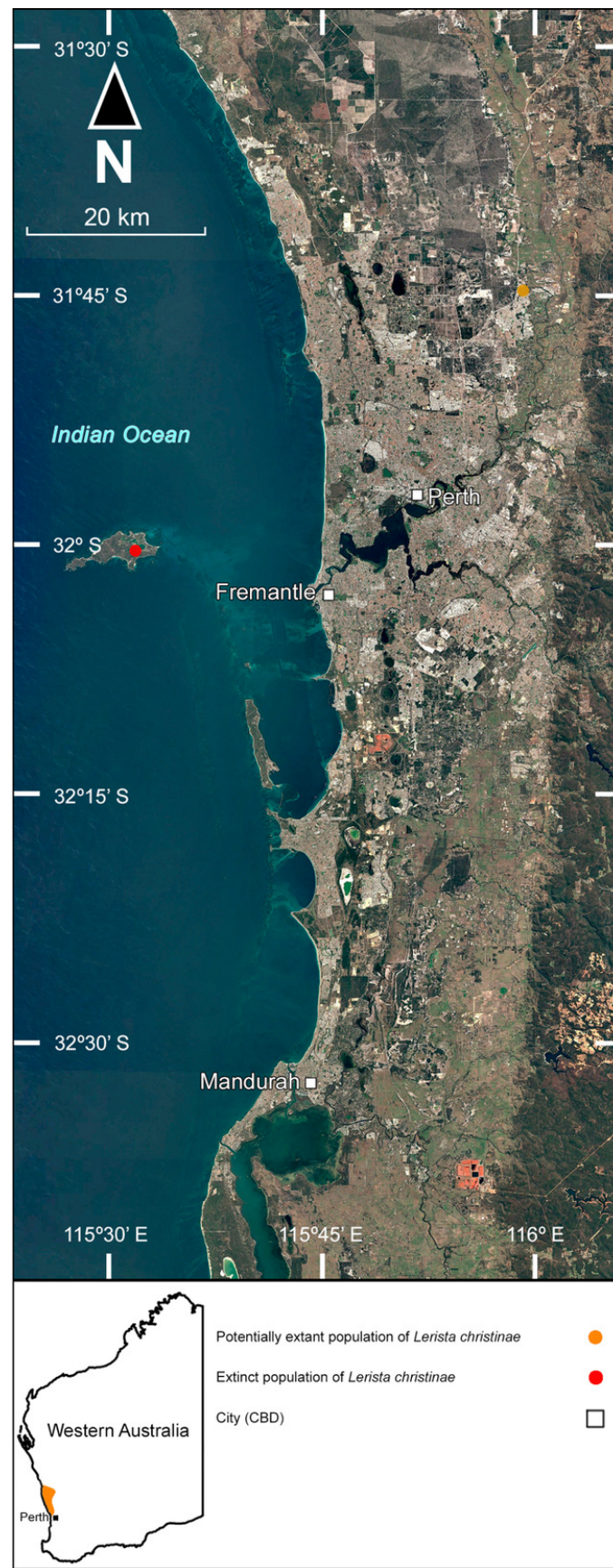


Figure 7. *Lerista christinae* populations within the Perth region. Orange circles denote extant populations; and red circles indicate populations that are likely extirpated. The overall distribution of the species is shown in orange on the inset map. Sources for localities are summarised in [Table 5](#).

Table 6. *Lucasium alboguttatum*. List of locations within the Perth region, the most recent records, and the current population status at the locations.

Location	Last record	Status	Reference/source
Bold Park	1995	Extirpated	How 2024
City Beach	1960	Extirpated	Western Australian Museum (R13429)
Kensington	1990	Extirpated	Turpin 1991
Melaleuca	2024	Extant	He & Kynadi 2024
Whiteman Park	1997	Possible	Drew 1998
Wireless Hill	1983	Extirpated	Smith 1985*

these oftentimes cryptic species, with the detection of conservation significant species theoretically (but not always) posing a major barrier to further development.

Furthermore, targeted surveys may be useful in surveying for these cryptic species, with certain methodologies and survey methods drastically favouring certain species. Fossorial species, such as *B. f. fasciolatus* and *L. christinae*, can be readily found by raking spoil heaps and leaf litter on warm winter days with a pronged cultivator (Maryan 2002; Bush *et al.* 2007, 2010; Maryan *et al.* 2023). Pitfall and funnel traps are industry standard in all biological surveys (Thompson & Thompson 2007) and are often the only reliable survey method to detect particularly cryptic species such as *C. gemmula* and *D. c. concinna*. Opportunistic night-time surveys are useful for detecting nocturnal species such as *D. polyophthalmus* and *L. alboguttatum*, which are inactive during the day but can be sighted at night as they forage in the open and their reflective eyeshine can be sighted by torchlight (Bush *et al.* 2007).

The survival of all native fauna in the Perth region seems to have been threatened by urban development, but further research is required to determine the extent of this. Further widespread declines seem inevitable, and this is most likely to affect the rarest species that have undergone severe verifiable declines over the last few decades. Other processes such as climate change and inappropriate prescribed

burning regimes may also act as synergistic stressors upon biodiversity (Valentine *et al.* 2012). The protection of remaining refugia is therefore imperative and contingent on first addressing the knowledge gaps pertaining to these species and their ambiguous presence within the Perth region, with comprehensive biological assessments and survey-work required to accomplish this before further populations are lost.

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APPENDIX

The grey literature in this Table bibliography is publicly available through the government approval websites: Department of Biodiversity, Conservation and Attractions library catalogue <https://library.dbca.wa.gov.au>, Jandakot Airport <https://www.jandakotairport.com.au>, Environmental Protection Authority <https://www.epa.wa.gov.au>, Main Roads Western Australia <https://www.mainroads.wa.gov.au> and Landgate <https://www.landgate.wa.gov.au>.

Appendix Table. List of “grey” literature cited in text (i.e., unpublished reports available through government agencies either on-line or through their libraries).

Authors	Title	Source
Arnold, G. W., Smith, G. T., & Brooker, M. G. (1991)	Whiteman Park Fauna Survey. CSIRO Division of Wildlife and Ecology	https://library.dbca.wa.gov.au/#record/151288
Bamford Consulting Ecologists. (2003)	<i>Fauna Survey of Jandakot Airport</i> . Unpublished Report to Jandakot Airport Holdings, Perth, Western Australia.	https://www.jandakotairport.com.au/images/files/EPBC/Doc-10-Attachment-1-Bamford-2002.pdf
Bamford, M., & Metcalf, B. (2012)	<i>Fauna Assessment of Tiwest's Dongara Project</i> . Report prepared for Tiwest Joint Venture, Western Australia.	https://www.epa.wa.gov.au/sites/default/files/PER_documentation2/2011%20-%20Bamford%20-%20Fauna%20Assessment.pdf
Bamford, M., Bancroft, W., & Turpin, J. (2015)	<i>Cooljarloo West Development Envelope Fauna Assessment</i> . Prepared for Tronox Management	https://www.epa.wa.gov.au/sites/default/files/PER_documentation/Bamford%202015%20terrestrial%20fauna.pdf
Coffey Environments (2016)	<i>Perth Darwin National Highway (Swan Valley Section) - February 2016 Part B: Response to Submissions</i> . Environmental Protection Authority	https://www.epa.wa.gov.au/sites/default/files/Proponent_response_to_submissions/NLWA-03-EN-RP-0037_Rev6_PDNH_RTS.pdf (Accessed: 20 May 2024)
Department of Biodiversity Conservation and Attractions (2024)	<i>Threatened and Priority Fauna List</i>	https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatenedspecies/Listings/Threatened and Priority Fauna List.xlsx
ENV (2009)	<i>Jandakot Airport Fauna Survey</i> . Report prepared for Jandakot Airport Holdings Pty Ltd.	https://www.jandakotairport.com.au/images/files/EPBC/Doc-11-Attachment-2-ENV-2009.pdf
Environmental Protection Authority (2020)	<i>Technical Guidance – Terrestrial vertebrate fauna surveys for environmental impact assessment</i> . Environmental Protection Authority, Western Australia.	https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/EPA-Technical-Guidance-Vertebrate-Fauna-Surveys.pdf
Environmental Protection Authority (2023)	<i>Conservation Codes For Western Australian Flora and Fauna</i>	https://www.epa.wa.gov.au/sites/default/files/Referral_Documentation/DWERDT480152%20%20App%206%20-%202020%20Western%20Australian%20and%20Commonwealth%20of%20Australia%20Conservation%20Codes%282%29.pdf
GHD Group Pty Ltd (2018)	<i>Mitchell Freeway Extension Hester Avenue to Romeo Road Biological Survey. Report to Main Roads, WA.</i>	https://www.mainroads.wa.gov.au/contentassets/88b62d14ff8d444b8f77e8d4b2d441ad/mitchell-freeway-extension-final-appendix-a-biological-survey-report-part8.pdf?v=49eca0
Government of Western Australia (1998)	<i>Perth's Bushplan</i>	Western Australian Planning Commission, Perth
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Huang, N. (2009)	<i>Reptile Fauna of the Gnanagara Sustainability Strategy Study Area: A Literature Review</i> . Western Australia, Department of Environment and Conservation	https://library.dbca.wa.gov.au/#record/115817
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