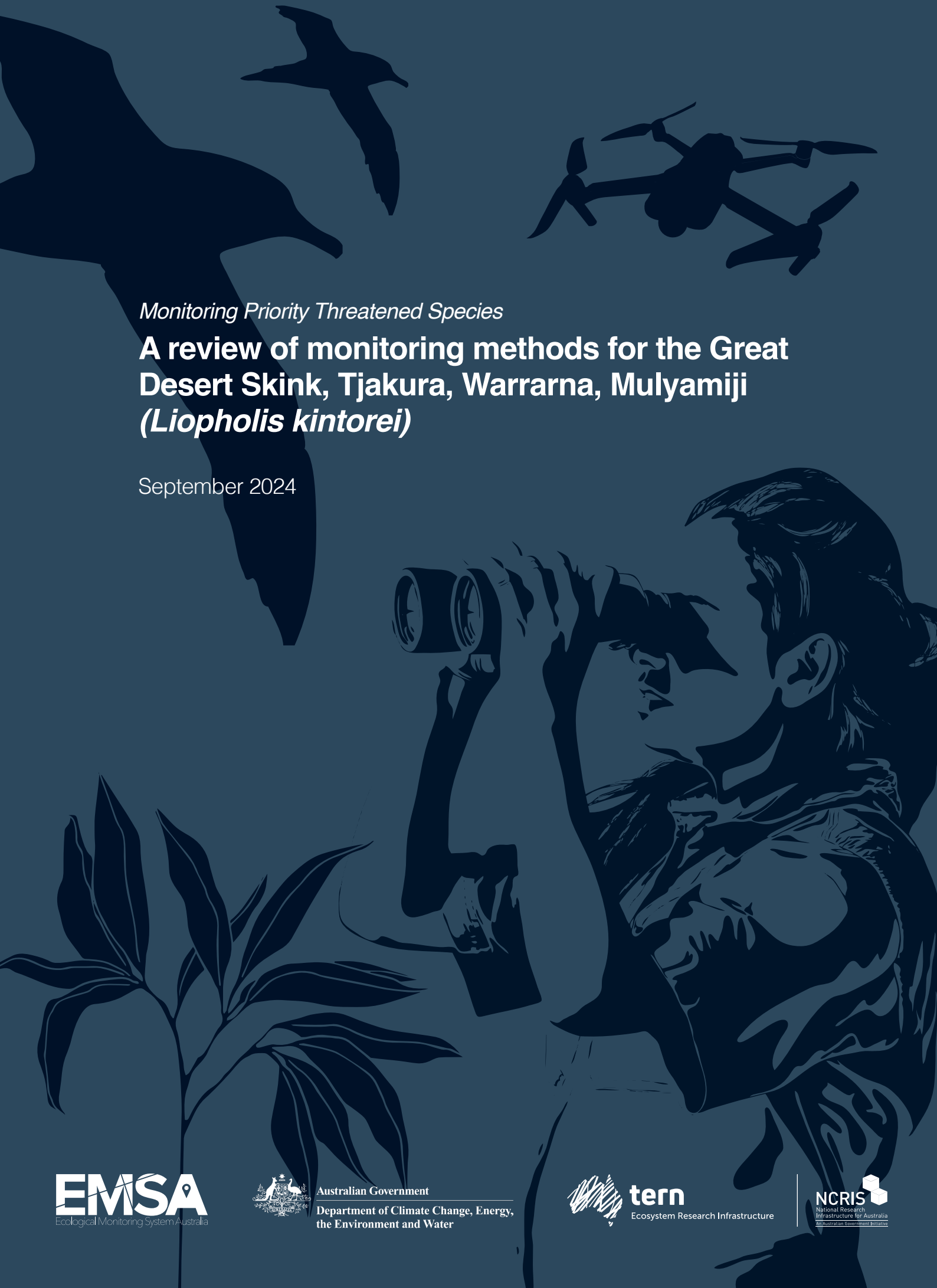


Monitoring Priority Threatened Species

A review of monitoring methods for the Great Desert Skink, Tjakura, Warrarna, Mulyamiji *(Liopholis kintorei)*

September 2024

EMSA
Ecological Monitoring System Australia

Australian Government
Department of Climate Change, Energy, the Environment and Water

tern
Ecosystem Research Infrastructure

NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

Citation

TERN Australia (2024) Monitoring Priority Threatened Species: A review of monitoring methods for the Great Desert Skink (*Liopholis kintorei*) Version 1 Report to the Department of Climate Change, Energy the Environment and Water. TERN, Adelaide.

Version

Version 1.

Last updated: 2 September 2024

Acknowledgements and contributions

This work was funded by the Australian Government Department of Climate Change, Energy, the Environment and Water.

Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

Copyright

Disclaimer

About

This literature review collates information on one of the 110 priority threatened species identified in the *Threatened Species Action Plan 2022-2032* and has been reviewed by invited practitioners experienced in monitoring the species.

The *Survey Guidelines for Monitoring Threatened Species* project, a collaboration of the Department of Climate Change, Energy, the Environment, and Water (DCCEEW) and the Terrestrial Ecosystem Research Network (TERN), aims to improve our knowledge of threatened species by enhancing accessibility and sharing of quality scientific threatened species data. By developing best practice field survey guidelines and recommendations, practitioners will be better equipped to conduct standardised, repeatable surveys.

By identifying the monitoring methods typically implemented by practitioners, documenting and assessing the techniques known to work, and identifying opportunities to standardise the methods, we can move towards ensuring all monitoring is species-appropriate, comparable between practitioners and populations, and repeatable over time. Further, together with consistent terminology, guidelines, instructions, and data collection, we can refine efforts and resources to measure and share information. Data collected using robust, standardised methods will improve our knowledge of threatened species and underpin threatened species recovery at scale. This project is essential to establishing monitoring protocols and data repositories to enhance the accessibility and sharing of threatened species data.

TERN has prepared the literature reviews for the Department of Climate Change, Energy, the Environment, and Water. For further information, please visit the EMSA Threatened Species Survey Guidelines website. Additional information, particularly monitoring methods and techniques not included that should be considered, can be brought to the author's attention by emailing tern@adelaide.edu.au for consideration for future updates.

Contents

Figures

Tables

Appendices

1 Background

1.1 Species name

Previously within the *Egernia* genera and known as *Egernia kintorei* (McAlpin 2001), the Great Desert Skink is now scientifically known as *Liopholis kintorei* (Stirling and Zietz, 1893). Aboriginal groups know the species as Tjakura, Tjalapa, Warrana or Mulyamiji.

1.2 Conservation status

The Great Desert Skink is currently listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) and identified as a priority threatened species under the *Threatened Species Action Plan 2022-2032* (DCCEEW 2022). The species is listed as Vulnerable by the International Union for Conservation of Nature (IUCN) Red List, and is considered threatened in all three jurisdictions of its range. The conservation status of status of the Great Desert Skink is summarised in Table 1.

Table 1. National, international and state and territory conservation status for the Great Desert Skink

Jurisdiction	Conservation status	Legislation or listing
IUCN	Endangered	IUCN Red List for threatened species
Commonwealth	Vulnerable	*Environmental Protection Act 1999*
South Australia	Endangered	*National Parks and Wildlife Act 1972*
Western Australia	Vulnerable	*Biodiversity Conservation Act 2016*
Northern Territory	Vulnerable	*Territory Parks and Wildlife Conservation Act 1976*

1.3 Summary of data held in the Threatened Species Index

The Threatened Species Index (TSX) provides reliable and robust measures of change in the relative abundance of Australia's threatened and near-threatened species at national, state and regional levels. Understanding these changes in species populations is crucial for monitoring Australia's conservation progress and allows users to measure and report on the benefits of conservation investments and to justify and design targeted management responses. Currently, the index is restricted to birds, plants and mammals, with new groups to be added in the near future.

The TSX does not hold data on the Great Desert Skink. More information on the TSX, including how to contribute threatened species monitoring data to the index, can be found on the TSX website.

1.4 Distribution and abundance

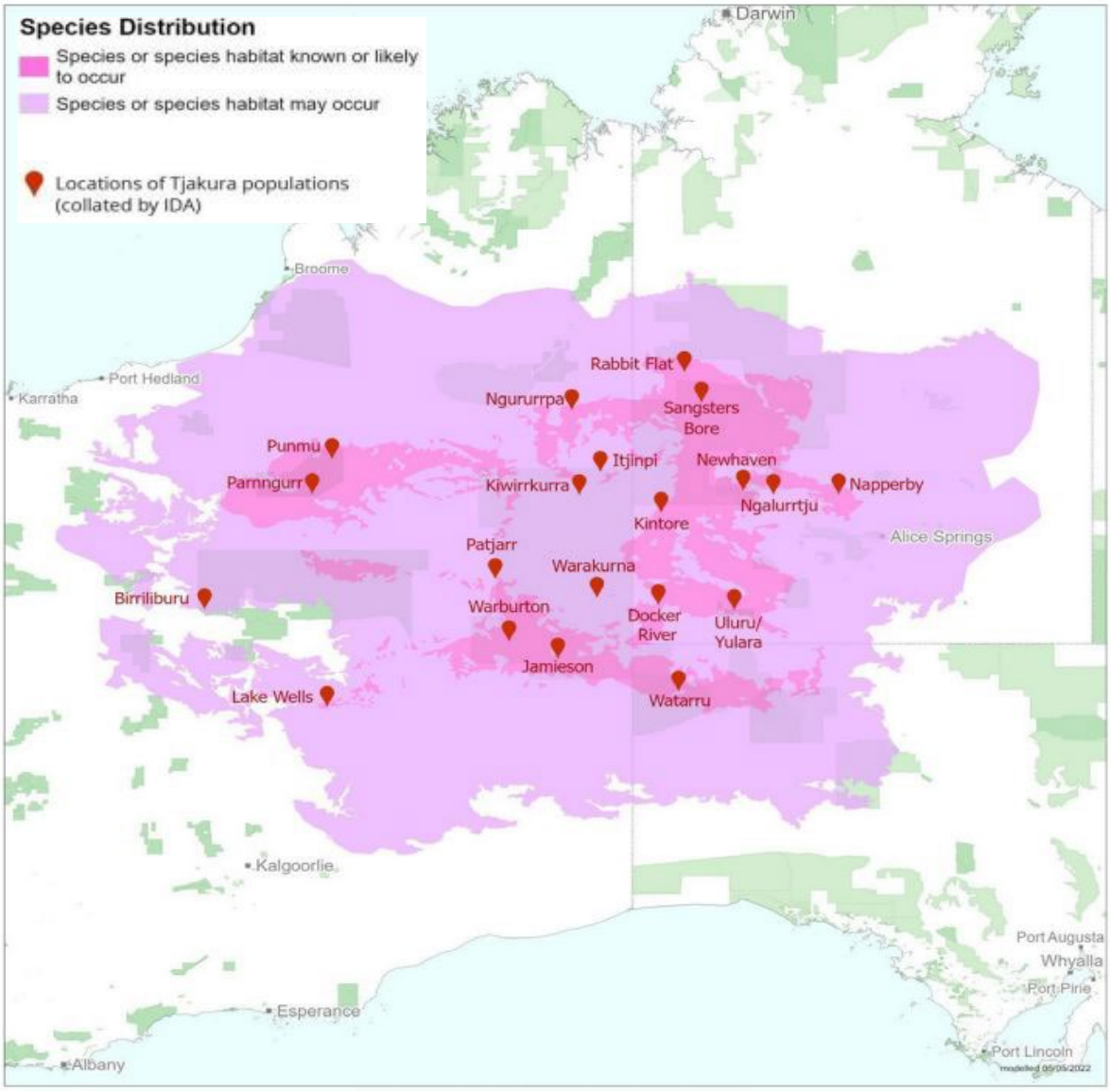
The Great Desert Skink is a species endemic to Australia's arid zone (Chapple et al. 2008; Dennison et al. 2015; DEPWS 2021; Moore et al. 2018a). Historically the Great Desert Skink was distributed across the arid and semi-arid areas of Western Australia, South Australia and the Northern Territory, where populations were dispersed but connected by the deserts of western central Australia (Moore et al. 2015). Occupied deserts historically included the Great Sandy, Gibson, Great Victoria and the Tanami Deserts (McAlpin 2001). Despite this, the historical range has been constricted (Moore et al. 2018a), in part due to the species' specialised habitat requirements (Dennison 2015).

The Great Desert Skinks' current known distribution is scattered but concentrated in patches across an expansive area (Figure 1). In 2018 the IUCN described an overall extent of occurrence for the

species of about 500,000 km^2 (Paltridge et al. 2018). However, recent survey work has extended the known range in the south west and increased the extent of occurrence to 770,000 km^2.

Despite the species' expansive range, actual presence has been recorded at fewer than 100 localities (McAlpin et al. 2011). A number of these records occur within declared conservation areas such as the metapopulation within the Australian Wildlife Conservancy's 262,000 ha Newhaven Wildlife Sanctuary (Cadenhead et al. 2016), Uluru-Kata-Tjuta National Park and the Watarri Indigenous Protected Area within the Anangu Pitjantjatjara Yankunytjatjara Lands (APY Lands) (Dennison et al. 2015; McAlpin 2001). Across the species range there are three distinct genetic populations (Dennison et al. 2015). The Tanami Desert and the population within Uluru-Kata Tjuta National Park and the Newhaven Wildlife Sanctuary remain the 'strongholds for the species' (DEPWS 2021; Indigenous Desert Alliance 2023; McAlpin 2001). There is no definitive total population number. However, it is estimated that the population in Western Australia is around 2,700, with an additional 4,500 in the Northern Territory and 50-100 in South Australia (Indigenous Desert Alliance 2023).

Figure 1. Distribution of the Great Desert Skink



Source: Department of Agriculture, Water and the Environment (DAWE) data sourced from (Indigenous Desert Alliance 2023)

1.5 Habitat requirements

As a burrowing desert species, the main habitat of the Great Desert Skink is sandplain (Cogger et al. 1993; Dennison 2015; DEPWS 2021) dominated by species of spinifex (*Triodia)* that form a mosaic of burnt and unburnt patches (Cadenhead et al. 2016; McAlpin 2001; Ridley et al. 2020). A mix of burnt and unburnt patches is ideal, as unburnt patches provide cover while burnt patches offer food resources (DOE 2022).

Modelling suggests that Great Desert Skinks are typically found in areas of elevation greater than 350 m where average daily temperatures greater than 20 °C are maintained and where their habitat is interspersed with a minimum of 50 % bare ground (McAlpin 1998; NESP Threatened Species Recovery Hub 2021). Soils of the occupied areas are sandy, nutrient-poor and are derived from sandstone and quartzite (Partridge 2008). Where the habitat is not sandy, the species occurs where the substrate is light gravel (Moore et al. 2018b).

The vegetation associations and habitat preferences differ according to locality (Dennison et al. 2015). However, a dominant spinifex cover with scattered shrubs of *Acacia, Eremophila, Grevillea. Hakea* and *Eucalyptus* are the most common. Within Uluru Kata-Tjuta National Park the Great Desert Skink exclusively occupies the spinifex sandplain between Uluru and Kata-Tjuta (Ridley 2015). However, the South Australian populations are found to occur in open Mulga (*Acacia aneura*) and Minyura *(Acacia minyura*) woodland over Woollybutt Grass (*Eragrostis eriopoda*) and spinifex (McAlpin 2001). In Western Australia, the Great Desert Skink predominantly occupies areas dominated by *Triodia* and *Eremophila* (Pearson et al. 2001). Populations within the Gibson Desert are associated with *Triodia basedowii* hummock grassland (McAlpin 2001), while those within Newhaven Wildlife Sanctuary are associated with spinifex alongside *Hakea, Melaleuca* and *Pluchea* (Moore et al. 2018a). The species is found in old drainage lines in the Great Sandy Desert and the Tanami Desert (DEPWS 2021; McAlpin 2001; Ridley et al. 2020). Soils within these drainage lines are lateritic (DEPWS 2021) and support spinifex, Woollybutt Grass, and Mulga (Ridley et al. 2020).

1.6 Biology and ecology

The Great Desert Skink is a burrowing species endemic to the Australian arid region (Moore et al. 2018a). The Great Desert Skink is a large skink weighing, on average, 350 grams. The species has an average snout-to-vent length of 200 mm (DEPWS 2021; Moore et al. 2018b), and total snout-to-tail length of up to 450 mm (Partridge 2008). Colouration typically mirrors the soil's colour, varying from orange to grey (Dennison 2015; DEPWS 2021). In some instances, males have blue-grey flanks, while females and juveniles are primarily brown or barred with orange and cream (DEPWS 2021). Females are often larger than males (Partridge 2008).

The species is primarily diurnal and is most active at dusk and dawn during summer, reflecting the active period of its invertebrate prey (Moore et al. 2018b; Partridge 2008). However, the species occasionally forages at night, so is not strictly diurnal (Pearson et al. 2001). In winter, the species has been observed hibernating within burrows (Moore et al. 2018b). The social burrowing behaviour of the Great Desert Skink is unlike other related *Egernia* species (Cadenhead et al. 2016; Dennison 2015). The burrows it constructs are complex (Moore et al. 2015), with various entrances and a web of tunnels spanning around 10 m in diameter and 80 cm to 1 m in depth (DEPWS 2021; Moore et al. 2018a; Partridge 2008). Construction and modification of burrows qualify the species as an 'ecosystem engineer', altering their environment's biotic and abiotic components (Ridley et al. 2020). The species does not defecate within the burrow, instead using a 1 to 3 m^2 area near burrow entrances, denoted as communal 'latrines' (DEPWS 2021; Partridge 2008).

Burrows offer shelter, protection from weather extremes and climatic events, and effective protection from predation (Cadenhead et al. 2016; McAlpin et al. 2011). Burrows are constructed considering available cover (Ridley et al. 2020) and proximity to terminate mounds , to ensure sufficient availability of resources (Dennison 2015; McAlpin et al. 2011). Great Desert Skinks prefer to forage near their burrow system (Moore et al. 2018a; Ridley et al. 2020) but have been observed travelling 150 m to obtain food (McAlpin et al. 2011). When resources become scarce, burrows are abandoned (McAlpin 1997; McAlpin et al. 2011; Partridge 2008). Termites are their primary food source, but as an omnivorous species, the Great Desert Skink will consume most invertebrates, small vertebrates and plant matter, including leaves, fruit and flowers (DEPWS 2021; McAlpin 2001; Partridge 2008). Ambush predation from the burrow is one method the species uses to capture invertebrates (McAlpin et al. 2011).

As a social species, burrows are usually occupied by aggregations that comprise related individuals (McAlpin et al. 2011; Moore et al. 2018a; NESP Threatened Species Recovery Hub 2021). Usually, burrows are occupied by parents and offspring (Dennison et al. 2015; McAlpin et al. 2011), which can be up to 10 individuals (DEPWS 2021; McAlpin 2001). These related groups are known to occupy a burrow system for up to seven years consistently (Dennison et al. 2015; McAlpin et al. 2011), with offspring generally dispersing after two years (Chapple 2003; Ridley et al. 2020) once they have reached sexual maturity (McAlpin 2001). Individuals disperse less than four kilometres on average but have been known to disperse up to nine kilometres away (Dennison et al. 2015; McAlpin 2000). Males disperse further than females, and may have more than one female mate, utilising multiple unique burrow systems (Dennison 2015). Breeding in the species is annual, with mating between September and October. A viviparous reptile (Partridge 2008), there is no external egg stage with mating followed by the live birth of one to seven offspring between November and January (McAlpin 2001; McAlpin et al. 2011; Moore et al. 2015; Pearson et al. 2001), after 10 to 11 weeks of gestation (Ridley 2015). The species is capable of living for 20 years (DOE 2022; McAlpin 2001).

1.7 Threats

Main threats to the Great Desert Skink include predation from introduced species, namely the Feral Cat (*Felis catus*) and Red Fox (*Vulpes vulpes*), and competition from introduced rabbits (*Oryctolagus cuniculus*). Fire regimes that transformed since European arrival, resulting in the loss of heterogeneous habitats, is an additional threat to the species (Dennison et al. 2015; DEPWS 2021; Moore et al. 2018b; NESP Threatened Species Recovery Hub 2021; Partridge 2008; Ridley et al. 2020). Modern fire regimes have created more fires of greater frequency and size that reduce available resources, reduce breeding success and increase the risk of predation (Cadenhead et al. 2016; Moore et al. 2015, 2018a). Other threats include infrastructure development, water harvest and spinifex harvest (McAlpin 2001). These threats have compounded (Cadenhead et al. 2016; DEPWS 2021), reducing the population size overall and removing dispersal opportunities, creating fragmented populations prone to inbreeding (Dennison 2015). These threats are further exacerbated by climate change (Moore et al. 2018b).

2 Existing monitoring

2.1 Overview of monitoring methods

The presence of the Great Desert Skink can be determined according to direct observation or observation of several characteristic signs. First and foremost, the species produces burrows with identifiable entrance points (McAlpin 2001). A communal latrine can also discern Great Desert Skink burrows from other lizard species (Partridge 2008).

Key population monitoring indices of the Great Desert Skink include (Moore et al. 2015):

- distribution mapping across the species' known range
- habitat mapping to identify occupied habitats amongst available habitats
- burrow occupancy to detect the extant presence
- abundance and population estimates
- population demographics, breeding success and survivorship

2.2 Monitoring resources

Monitoring the Great Desert Skink is challenging because it is distributed across areas that are difficult to access, individuals are difficult to observe unless outside the burrow, and the species is elusive and trap-avoidant (Dennison 2015). Much of the species' population monitoring to date has been conducted within conservation areas (Dennison et al. 2015) such as Newhaven Wildlife Sanctuary (Moore et al. 2018a) and Uluru-Kata Tjuta National Park (Ridley 2015). The species has been captured both in broad surveys within these areas and during targeted surveys.

Key resources with information for monitoring the Great Desert Skink are listed below.

- Looking after the Tjakura, Tjalapa, Mulyamiji, Warrarna, Nampu: National Recovery Plan for the Great Desert Skink (*Liopholis kintorei)* (Indigenous Desert Alliance 2023)
  - Aims to detect population change over 10 years.
  - Indigenous teams and ranges will conduct the surveys.
  - Burrow surveys will be the primary method because burrows are conspicuous, data is easy to interpret, and they are relatively cheap to conduct.
  - Burrow surveys consist of five people who walk in a line across a 500 x 200 m area. People remain 20 m apart during the survey.
  - Surveys should be conducted during March, at the end of the breeding season.
  - Other fields that should be recorded include fire history, habitat condition, predator signs and information about the vegetation present.
  - Burrow locations are mapped.
  - Difficulty arises because of the remote areas the species is present within.
- Arid Zone Monitoring Protocol (NESP Threatened Species Recovery Hub 2021)
  - Describes active search method where all signs of fauna present within a 2 ha area observed by two people for a set period of time.
  - The method has a standard collection template, workflow and established metadata.
  - The methods outline the optimal conditions for undertaking a 2 ha survey.
- Action Plan for Australian Lizards and Skinks 2017 (Chapple et al. 2019)

  - Provides a snapshot of the current conservation status of lizard and snake species in Australia.
  - Does not outline monitoring methods.
- Lizards cooperatively tunnel to construct a long-term home for family members (McAlpin et al. 2011)
  - Scientific paper outlines monitoring method focusing on detecting new burrow systems.
  - Does not include information on how the method was developed or trialled.
- Survey guidelines for Australia's threatened reptiles (DSEWPC 2011)
  - Active searching for burrow systems is highlighted as the optimal method of monitoring the species as it enables indirect and observation of activity (signs of presence and emergence from the burrow respectively).
  - Specific details of how to conduct surveys is not provided.
- Looking after Tjakura in the Anangu Pitjantjatjara Yankunytjatjara Lands, a Recovery Plan (Partridge 2008)
  - Provides minimum data recording standards for monitoring of Great Desert Skink colonies.
  - Highlights the importance of monitoring introduced predators and herbivores.
  - Lists a number of projects that have monitored the species each with a brief description.
- Recovery Plan for the Great Desert Skink (*Egernia kintorei*) (McAlpin 2001)
  - Discusses the importance of annual monitoring and provides a performance criterion against which monitoring and all other conservation activities should be measured against.
  - Identifies the importance of monitoring:
    - the impact of fire management and regime on the burrow occupancy rate
    - predator abundance and impact
  - Highlights the compilation of opportunistic observations by the recovery team

2.3 Survey methods

The Great Desert Skink is monitored primarily through burrow observation, followed by trapping and active searches (Dennison 2015; Ridley 2015; Ridley et al. 2020), with abundance estimates most commonly derived from active burrow occupation surveys (Indigenous Desert Alliance 2023). Monitoring should be conducted during warmer months (November to March) because this is when the Great Desert Skink is most active (McAlpin 2001; Moore et al. 2018a; Partridge 2008; Ridley 2015). It is assumed that the species hibernates during winter (DSEWPC 2011). Trapping, methods of direct observation and indirect observation are discussed in further detail below. The efficacy of these methods has not been determined or compared to date (DSEWPC 2011). Partridge (2008) identifies that monitoring known populations should be undertaken for a fortnight at minimum.

2.3.1 Indirect observation

Indirect methods of monitoring the Great Desert Skink involve observation of characteristic signs of the species' presence in an area, such as burrows, tracks and scats. The species produce distinctive burrows with multiple identifiable entrance points (McAlpin 2001). Great Desert Skink burrows can also be discerned from other lizard species by the presence of a communal latrine (Partridge 2008). To find burrows within an area, transects, active searches, targeted searches and random walks can

be used (Ridley 2015). More specifically, traditional tracking involves ten surveyors traversing an area in a line and then logging when the Great Desert Skink or its burrows are encountered. Finding and identifying Great Desert Skink burrows can be difficult because they are not obvious from a distance and do not occur systematically in the landscape (Ridley 2015). It is usually assumed that the presence of a burrow indicates that Great Desert Skinks have been present in an area within ten years prior (Partridge 2008). Images of burrow entrances, scats and tracks are available in Appendix 1. Table 2 provides a summary of Great Desert Skink studies using indirect observation.

Table 2. Methods overview of key studies using indirect observation surveys.

Survey type	Study design	Survey effort	Location	Reference
Burrow	▪ Search methodology varied between sites ▪ At Newhaven: 11 x500 m transects (10 m wide) searched within 50 ha sites ▪ At Yulara 11 x 6 ha 1 hr meandering search by 1 person ▪ At Kiwirrkurra IPA 3 x 30 ha (300 x 1000 m) sites searched by line of 8 people for 2 hrs ▪ Uluṟu – Kata Tjuṯa National 9 x 100 ha surveyed by meandering search ▪ Great Sandy Desert 3 x 10 ha (500 x 200 m sites searched by line of 4 people for 1 hr	▪ Compiled from records of 20 years of (mostly) annual monitoring ▪ 31 sites	Yulara, Newhaven Wildlife Sanctuary, Kiwirrkurra IPA and Uluru-katk Tjuta National park	(Indigenous Desert Alliance 2023; Southwell et al. 2023)
Burrow	▪ Single observer actively searched for burrows across 15 areas with three different fire histories. ▪ Behaviour observation also done at 59 active burrows with time lapse photography	▪ 65 hours (1 - 1.5 hours per search) ▪ 90 km surveyed	Uluru Kata-Tjuta National Park, NT	(Ridley 2015)
Burrows, tracks and scats	▪ Searches for new burrow systems and all known burrow systems were conducted ▪ Track activity and presence of scats was recorded ▪ Burrows were observed from a raised hide 8 m from a burrow system ▪ Activity, location and interaction was recorded ▪ Trapping was also done during this study to retrieve tissue for DNA analysis	▪ From 1999 to 2009 annual monitoring between September and April ▪ 30 observation hours ▪ 120 tissue samples ▪ 26 burrow systems ▪ 45 km^2 surveyed	Uluru-Kata Tjuta National Park, NT	(McAlpin et al. 2011)
Tracks	▪ Burrows were located within the survey area by walking transects 10 m apart ▪ Occupied burrows were chosen for experimental burns ▪ A 1.5 m area around each burrow was cleared ▪ The cleared area after the burn was used as a tracking ring and was swept to clear tracks ▪ Tracking began the morning after each burn and for unburnt sites tracking began after burns were complete ▪ Tracking rings were inspected daily between 7 and 8 am where the number of tracks and direction of travel was recorded ▪ Latrines were also inspected for fresh scats	▪ Burrows were monitored daily for 1 month then monthly for 3 months for up to 4 months post-fire ▪ 30 burrow systems ▪ 24 consecutive tracking mornings ▪ 75 ha surveyed	Newhaven Sanctuary	(Moore et al. 2015)

2.3.2 Trapping

Trapping enables individuals to be marked (i.e. microchips/personal implant transponders), health assessed, and genetic samples collected. Subsequently, where capture-mark-recapture is employed, the demographics, distribution and abundance can be determined. To physically trap Great Desert Skinks, box traps (i.e. treadle plate foldable traps, Elliott brand or similar) or pitfall traps have been used (DSEWPC 2011). Elliott traps have been set at burrow entrances (Dennison 2015; Moore et al. 2018b) or arranged within a monitoring plot. Pitfall traps used in research at Uluru National Park, were 29 cm deep buckets, arranged in a cross formation, with a drift fence. Table 3 provides a summary of Great Desert Skink trapping studies.

Table 3. Methods overview of key studies using trapping surveys.

Survey type	Study design	Survey effort	Location	Reference
Box trap trapping	▪ Individuals were trapped at their burrow system using Elliott traps ▪ The skinks were attached with temperature data-loggers and VHF transmitters	▪ Detail of trapping effort not provided ▪ 20 adult skinks trapped ▪ 75 ha surveyed	Newhaven Sanctuary, NT	(Moore et al. 2018b)
Pitfall and box trap trapping	▪ Great Desert Skink not the target species. ▪ Elliot traps were baited with oats and peanut butter.	▪ 6 pitfall traps ▪ 14 trapping sites ▪ 25 Elliot traps	Kiwirrkurra Indigenous Protected Area, NT	(Cowan et al. 2015)
Box trap trapping	▪ Trapping at all active tunnel entrances of burrow systems ▪ Elliott traps baited with tinned peas and corn set before dusk each night and checked early each morning ▪ Remote PIT-tag readers also used which are placed at burrows and record presence of tagged lizards passing through mark-recapture	▪ Intensive trapping during the breeding season of the species over 3 years ▪ 3064 trap nights per season ▪ 31 active burrow systems ▪ 330 PIT-read nights ▪ 20 ha surveyed	Newhaven Sanctuary, NT	(Dennison 2015)
Pitfall trapping	▪ Pitfall traps were set on each plot for 3 consecutive nights ▪ Traps were set in two cross formations placed 40 m apart, each cross had 2 pits on each arm and 1 in the centre ▪ Pits were cylindrical buckets 29 cm in diameter and 38 cm deep 7 m apart	▪ 6 plots ▪ 12 sampling occasions ▪ 18 pit traps	Uluru National Park, NT	(Masters 1996)

2.3.3 Other methods

Other monitoring methods that have been used but have not been widely implemented include:

- predator monitoring – predator tracks at burrows, presence of skink remains in predator scats (Moore et al. 2018a) and burrows that have been dug up (Rachel Paltridge, personal communication, 2 March 2023)
- tracking by Indigenous rangers or groups (Partridge 2008; Rachel Paltridge, personal communication, 2 March 2023)
- burrow cameras to confirm Great Desert Skink occupancy at burrows
- DNA sampling from latrines and subsequent DNA analysis
- GPS tracking (Dennison 2015)
- Personal implant transponder (PIT) tag readers at identified burrow entrances to monitor tagged individuals (Dennison 2015)
- direct observation (McAlpin et al. 2011).

Additional methods that may have future potential applications include:

- detector dogs – to sniff out occupied burrows
- eDNA within soil – to confirm the presence in a suspected area
- camera trapping to confirm the species presence and potential to detect age-classes present, and therefore confirm if a habitat is supporting a breeding population.

3 Key agencies and organisations involved in the species research and recovery

Key agencies, organisations or individuals identified as having been previous, or currently actively involved in monitoring the Great Desert Skink:

- Rachael Paltridge
- Indigenous Desert Alliance
- Siobhan Dennison.

4 Survey guideline recommendations gathered from the literature

This literature review of the monitoring methods relating to the Great Desert Skink has identified some key points that must be addressed when developing species-specific survey guidelines. These points include:

- Despite the species' expansive range, less than 100 sub-populations are known to exist. Survey methods that have detected the species' presence with their known range to date need further development to be effective across the species extensive potential range to allow confident detection or confirmation of absence in previously unsurveyed areas. Innovative techniques, such as the collection of environmental samples from burrow entrances thought to be occupied by Great Desert Skinks (meeting the criteria) and subsequent analysis, is one option that might prove beneficial over trapping and other sampling methods.
- Great Desert Skinks are not readily caught in pitfall or box traps. Therefore, lack of captures from trapping surveys cannot be interpreted as an absence.
- Trapping methods, including box traps and pitfalls, are required to enable individual marking and population estimates through mark-recapture studies. Individual Great Desert Skinks do not have unique markings. Therefore, individual identification from camera trapping is not suitable to estimate population abundance.
- Great Desert Skinks appear to have specific habitat requirements, including the need for a mosaic landscape of different aged vegetation relating to fire regimes and 50 % bare ground. Modelling also suggests that they are typically detected in habitat in areas of elevation greater than 350 m and where daily temperatures above 20 °C are maintained.

5 References

Cadenhead, NCR, Michael, RK, Danae, M, Steve, M & Brendan, AW 2016, 'Climate and Fire Scenario Uncertainty Dominate the Evaluation of Options for Conserving the Great Desert Skink', *Conservation Letters*, vol. 9, no. 3, pp. 181-190.

Chapple, DG 2003, 'Ecology, life-history, and behavior in the Australian scincid genus *Egernia*, with comments on the evolution of complex sociality in lizards', *Herpetological Monographs*, vol. 17, no. 1, pp. 145-180.

Chapple, DG, Hutchinson, MN, Maryan, B, Plivelich, M, Moore, JA & Keogh, JS 2008, 'Evolution and maintenance of colour pattern polymorphism in *Liopholis* (Squamata : Scincidae)', *Australian Journal of Zoology*, vol. 56, no. 2, pp. 103-115.

Chapple, DG, Tingley, R, Mitchell, NJ, Macdonald, SL, Keogh, JS, Shea, GM, Bowles, P, Cox, NA & Woinarski, JCZ 2019, *The Action plan for Australian lizards and snakes 2017*, CSIRO Publishing, Melbourne, Vic.

Cogger, HG, Cameron, EE, Sadlier, RA & Eggler, P 1993, *The Action plan for Australian reptiles. endangered species project number 124*, Australian Nature Conservation Agency, Canberra.

Cowan, M, Bray, R & Paltridge, R 2015, *Kiwirrkurra Indigenous protected area bushblitz survey: ,* Survey of Mammals and reptiles, Kiwirrkurra IPA.

DCCEEW 2022, *Threatened species action plan 2022–2032*, Department of Climate Change, Energy, the Environment and Water, Commonwealth Government of Australia,, Canberra, ACT.

Dennison, S 2015, 'Social organisation and population genetics of the threatened great desert skink, *Liopholis kintorei*', Department of Biological Sciences, PHD thesis, Macquarie University, Sydney, Australia.

Dennison, S, McAlpin, S, Chapple, DG & Stow, AJ 2015, 'Genetic divergence among regions containing the vulnerable great desert skink (*Liopholis kintorei*) in the Australian arid zone', *PloS ONE*, vol. 10, no. 6, pp. e0128874-e0128874.

DEPWS 2021, *Threatened species of the Nothern Territory: great desert skink Liopholis kintorei*, Department of Environment, Parks and Water Security, Darwin, NT.

DOE 2022, *Liopholis kintorei in species profile and threats database*, Department of the Environment, Canberra, ACT, viewed 9 June 2022.

DSEWPC 2011, *Survey guidelines for Australia's threatened reptiles. EPBC act survey guidelines 6.6*, Department of Sustainability, Environment, Water, Population and Communities, Canberra, ACT.

Indigenous Desert Alliance 2023, *Looking after Tjakura, Tjalapa, Mulyamiji, Warrarna, Nampu: a national recovery plan for the great desert skink (Liopholis kintorei)*. Commonwealth of Australia, Canberra.

Masters, P 1996, 'The effects of fire-driven succession on reptiles in spinifex grasslnads at Uluru national park, Northern Territory', *Wildlife Research*, vol. 23, no. 1, pp. 39-47.

McAlpin, S 1997, *Conservation of the great desert skink, Egernia kintorei, at Uluru-Kata Tjuta national park, NT*, Department of Biological Sciences, Northern Territory University.

McAlpin, S 1998, *Establishing a surveillance and monitoring program for Tjakura, Egernia kintorei, at Uluru-Kata Tjuta national park*, Consultancy Report to Environment Australia, , Canberra, ACT.

McAlpin, S 2000, *Monitoring Tjakura at Uluru - Kata Tjuta national park*, Parks Australia, Canberra, ACT.

McAlpin, S 2001, *A recovery plan for the great desert skink (Egernia kintorei)*, Arid Lands Environment Centre.

McAlpin, S, Duckett, P & Stow, A 2011, 'Lizards cooperatively tunnel to construct a long-term home for family members', *PloS ONE*, vol. 6, no. 5, p. e19041.

Moore, D, Kearney, MR, Paltridge, R, McAlpin, S & Stow, A 2015, 'Is fire a threatening process for *Liopholis kintorei*, a nationally listed threatened skink?', *Wildlife Research*, vol. 42, no. 3, pp. 207-216.

Moore, D, Kearney, MR, Paltridge, R, McAlpin, S & Stow, A 2018a, 'Feeling the pressure at home: predator activity at the burrow entrance of an endangered arid-zone skink', *Austral Ecology*, vol. 43, no. 1, pp. 102-109.

Moore, D, Stow, A, Kearney, MR & Pol, M 2018b, 'Under the weather?—the direct effects of climate warming on a threatened desert lizard are mediated by their activity phase and burrow system', *The Journal of animal ecology*, vol. 87, no. 3, pp. 660-671.

NESP Threatened Species Recovery Hub 2021, *Arid zone monitoring species profile: Tjakura (great desert skink)*.

Paltridge, R, Catt, G, Cowan, M, Gaikhorst, G, How, R, Zichy-Woinarski, J, Cogger, H & Teale, R 2018, *Liopholis kintorei*, The IUCN Red List of Threatened Species 2018.

Partridge, T 2008, *Looking after Tjakura in the Anangu Pitjantjatjara Yankunytjatjara Lands, a recovery plan.*, Anangu Pitjantjatjara Yankunytjatjara Lands, Umuwa SA.

Pearson, D, Davies, P, Carnegie, N & Ward, J 2001, 'The great desert skink (*Egernia kintorei*) in Western Australia: distribution, reproduction and ethno-zoological observations', *Herpetofauna*, vol. 31, no. 1, pp. 64-68.

Ridley, J 2015, 'Distribution, habitat associations and activity of great desert skinks (tjakura; *Liopholis kintorei*) in relation to fire and vegetation cover', School of Biological Sciences, Honours thesis, Charles Darwin University, Alice Springs, NT.

Ridley, JCH, Schlesinger, CA & Bull, CM 2020, 'Location of long-term communal burrows of a threatened arid-zone lizard in relation to soil and vegetation', *Austral Ecology*, vol. 45, no. 4, pp. 444-453.

Southwell, D, Moore, D, Merson, S & Paltridge, R 2023, *A power analysis to inform design of a monitoring program to detect trends in Tjakura*, report to the Resilient Landscapes Hub of the Australian Government's National

Environmental Science Program, University of Newcastle, Newcastle, NSW.

6 Appendices

Appendix 1. Photo examples of Great Desert Skink signs.

Great Desert Skink tracks in sand

Source: (NESP Threatened Species Recovery Hub 2021)

Great Desert Skink burrow

Source: T Potter 2018

Active Great Desert Skink burrow entrance with basking mound

Source: T Potter 2018

EMSA
Ecological Monitoring System Australia

emsa.tern.org.au