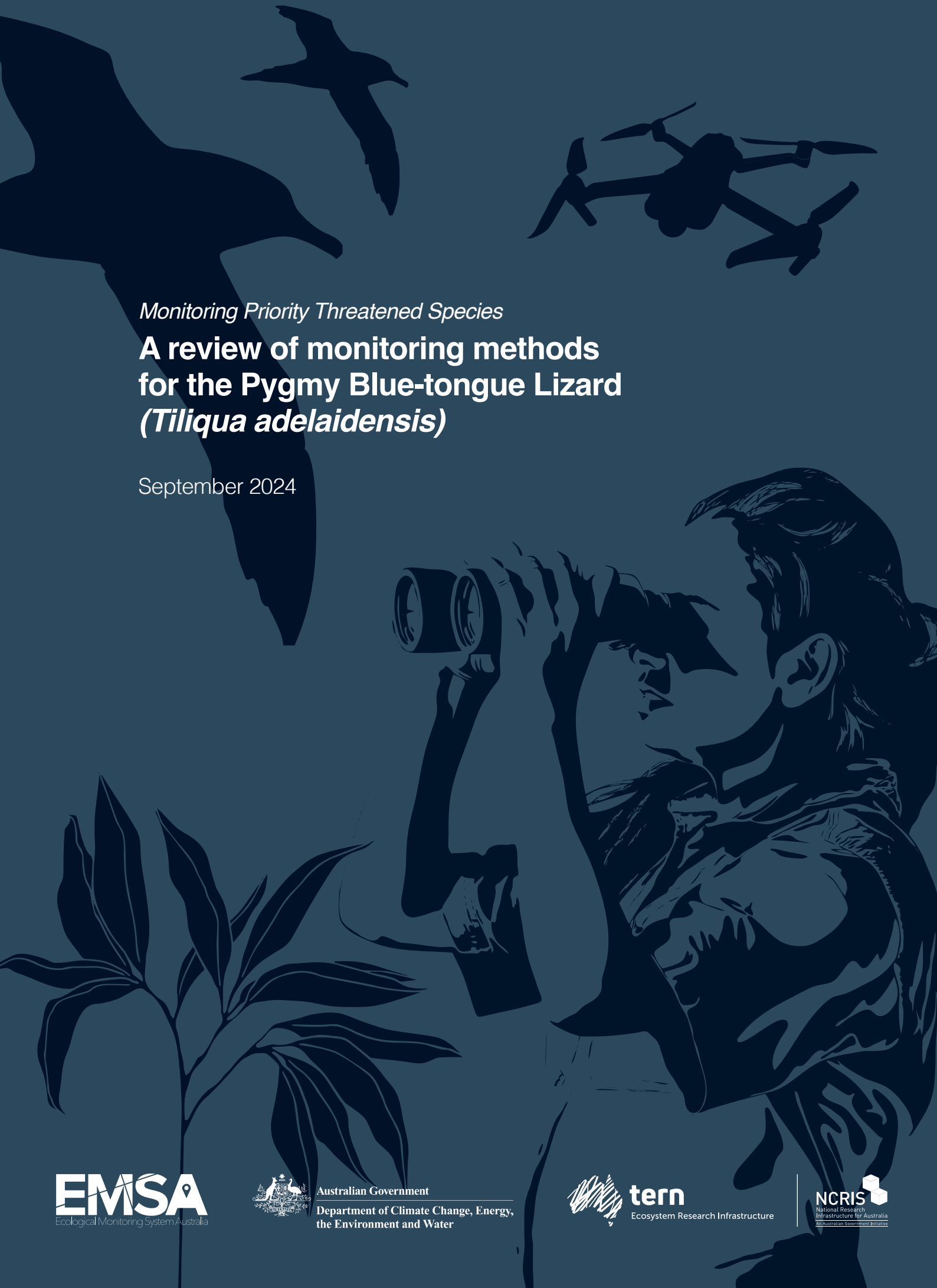

Monitoring Priority Threatened Species

A review of monitoring methods for the Pygmy Blue-tongue Lizard *(Tiliqua adelaidensis)*

September 2024

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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.

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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.

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1 Background

1.1 Species name

The Pygmy Blue-tongue Lizard (*Tiliqua adelaidensis*, Peters, 1863) is also colloquially referred to as the Adelaide Blue-tongue Lizard.

1.2 Conservation status

The Pygmy Blue-tongue Lizard (PBLT) is listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth)and in South Australia under Schedule 7 of the *National Parks and Wildlife Act 1972* (SA). The conservation status of the species is outlined in Table 1.

The species is also listed as Endangered under the International Union for the Conservation of Nature (IUCN) Red List of Endangered Species because its area of occupancy (AOO) is less than 500 km^2, it occurs as a severely fragmented population, and there is ongoing destruction of its habitat due to intensification of agriculture which is further reducing its AOO and resulting in the loss of both mature individuals from populations and entire subpopulations. Furthermore, the species depends on continued land management, including active conservation and the maintenance of traditional low-intensity grazing practices, to prevent its extinction (Fenner et al. 2018).

The PBTL had been considered extinct before it was rediscovered near Burra, in the Mid North region of South Australia, in 1992 (33 years after the previous record; Armstrong & Reid 1993; Armstrong et al. 1993). Prior to its rediscovery, the limited information on the species was known from only 20 museum specimens, mostly collected in the nineteenth century (Ehmann 1982; Shea 1992). Since its rediscovery, the PBTL has been subject to a recovery program, focussing primarily on research to determine its distribution, habitat, ecology and management requirements (Duffy et al. 2012).

Table 1. National, international and state conservation status for the Pygmy Blue-tongue Lizard

Jurisdiction	Conservation status	Legislation orlisting
Commonwealth	Endangered	*Environment Protection and Biodiversity Conservation Act 1999*
South Australia	Endangered	*National Parks and Wildlife Act 1972*
IUCN	Endangered	IUCN Red List of Threatened Species

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.Therefore the TSX does not currently hold data on the Pygmy Blue-tongue Lizard. 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

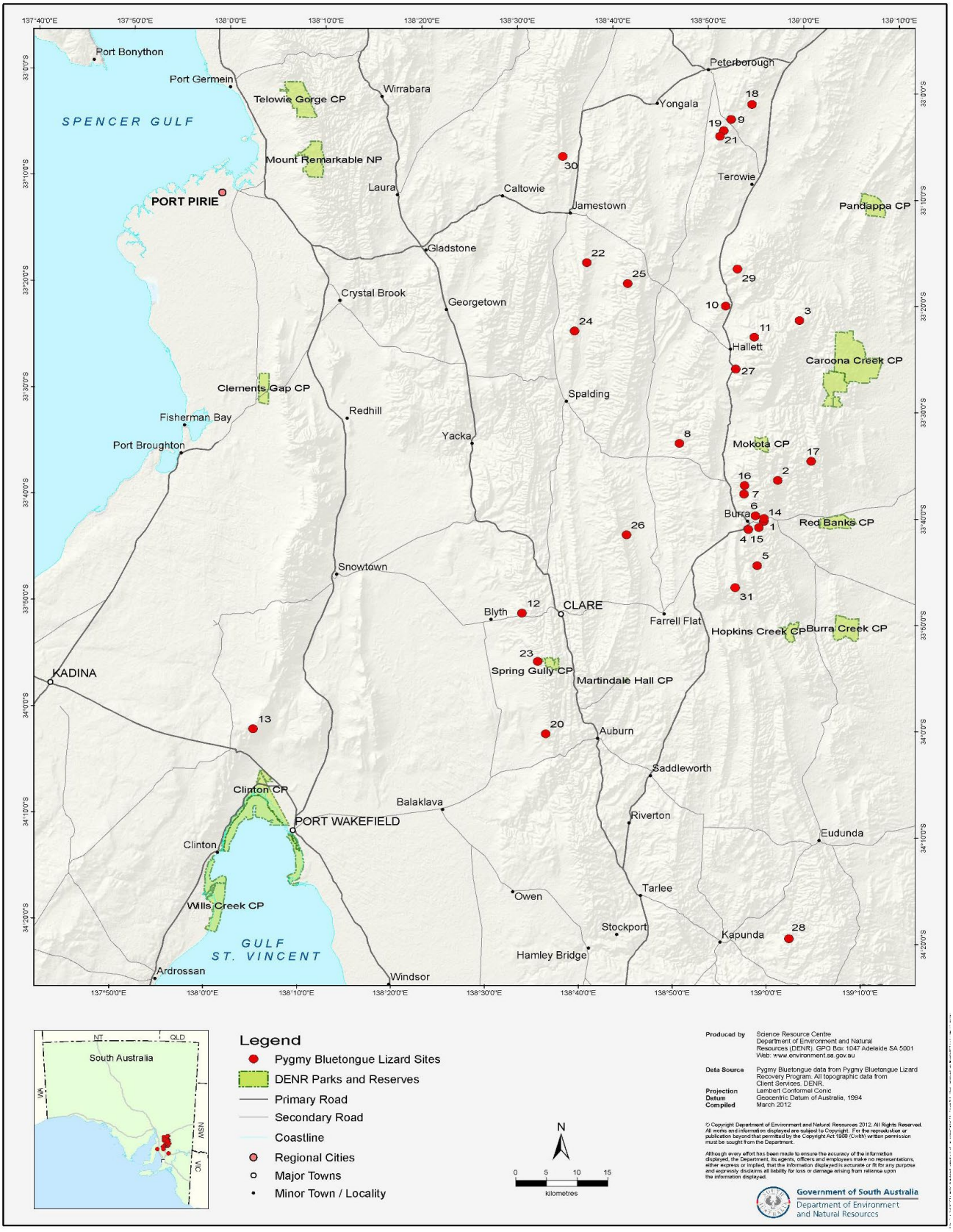
The PBLT is endemic to South Australia, where its population is severely fragmented and occupies less than 500 km^2. The species is known from 37 sites (DCCEEW 2023) in the Mid North region of the state

(Figure 1), ranging from Kapunda in the south to Peterborough in the north, and west to the South Hummocks (north of Port Wakefield). Most of these sites are on privately owned agricultural land that is primarily used for sheep grazing and not protected under formal agreements, and surrounded by cultivated land or other unsuitable habitat (Duffy et al. 2012). One site has been placed under a Heritage Agreement (DCCEEW 2023) and another has been purchased by the Nature foundation and is being solely managed for the species (Nature Foundation 2021). The full extent of most of the population is yet to be determined. Therefore, some isolated populations may occur within larger, more contiguous populations (Schofield 2007).

Very little is known of the historical distribution of the species. However, the relative abundance of PBTL specimens in European collections in the 19th century indicates that the species was previously more common and has undergone a marked decrease in its distribution (Shea 1992).

The total PBTL population size remains unknown. In 2000, a population estimate of approximately 5000 lizards was suggested based on ten sites. However, a further 22 populations have now been recorded, and one is believed to be extinct. Population density is highly variable at the sites, ranging from 15–200 individuals per hectare (Clarke 1999; Duffy et al. 2012).

Figure 1. The locations of known populations of Pygmy Blue-tongue Lizards



Source: Duffy et al. (2012)

1.5 Habitat requirements

The PBTL occurs in natural grassland habitats, ranging from grasslands with high native biodiversity to highly degraded grasslands dominated by exotic grasses (Milne 1999). The species has been recorded at sites dominated by grass species, including *Austrostipa* spp. (spear-grasses), *Rytidosperma* spp. (wallaby grasses), *Aristida behriana* (brush wire-grass) and *Lomandra* spp. (iron-grasses; Hutchinson et al. 1994; Souter et al. 2007).

The PBTL occupies empty burrows of wolf spiders (Lycosidae) or trap door spiders (Mygalomorphae). The species uses narrow (approximately 1–2 cm), vertical spider burrows for shelter during the day, refuge from predators, ambush points for hunting passing prey, basking sites for thermoregulation, and birthing sites (Milne 1999; Milne et al. 2003). The species is reliant on an adequate supply of deep (at least >20 cm, but preferably >30 cm when available) spider burrows for survival (Fellows et al. 2009; Milne 1999; Milne & Bull 2000; Souter et al. 2007). A variety of burrow widths are also required to support a population of different aged individuals, as individuals often choose burrows that suit the width of their head to help avoid predation (Duffy et al. 2012; Milne & Bull 2000; Milne et al. 2002; Souter et al. 2007). Aside from a slight beveling of the burrow edges, caused by their movement in and out of the burrows, PBTLs make no obvious external modifications to the burrows (Duffy et al. 2012).

The Mid North region of South Australia where the PBTL occurs, has hot, dry summers and cool, moist winters. The species is found in various soil types but is known to be more abundant in areas of free-draining grey-brown or red calcareous soils and lithosol soils. The PBTL is found in higher abundance on the lower slopes of hillsides (Duffy et al. 2012). The species occurs in the Iron-grass Natural Temperate Grassland of South Australia ecological community, which is listed as Critically Endangered under the EPBC Act (Turner 2012).

1.6 Biology and ecology

The PBTL is a skink that is grey, grey-brown or orange-brown above, with paler flanks. Its body, limbs and tail are scattered with darker spots and blotches mixed with paler scales, and its belly is white or cream with scales with pale brown margins. It grows to a total length of less than 20 cm and has short limbs (Cogger 2018). Adult males typically have wider heads but are shorter than females (Hutchinson et al. 1994). The PBTL is the smallest member of the genus *Tiliqua* and unlike the other members, it has a pink tongue (Duffy et al. 2012).

The PBTL has a spring mating season (October–November; Hutchinson et al. 1994; Milne & Bull 2000). Males can reproduce from one year of age, while females are sexually mature from approximately 1–2 years of age (Duffy et al. 2012). The species exhibits predominantly a promiscuous mating system with partners chosen at random with respect to the level of relatedness among neighbouring lizards (Schofield et al. 2014). In spring, females move around burrows seemingly to attract male mates (Ebrahimi et al. 2015a), while males typically leave their burrows for a day or longer (Milne 1999). Like the other *Tiliqua* species, the PBTL bears live young, with individual females bearing up to four young. Young are born between January and March and disperse from the mother's burrow within weeks of their birth to find their own burrows (Clarke 1999; Duffy et al. 2012; Milne & Bull 2000).

Aside from basking at the entrance to their burrow in warmer months, PBTLs rarely venture beyond the immediate vicinity of their burrow at any time. The species is believed to be a sit-and-wait forager for at least late summer and autumn, moving only short distances from their burrow to capture prey (Hutchinson et al. 1994). From September to October, most of the day is spent basking, while from November to December, with warmer temperatures, basking activity is greater in the early morning (Milne 1999).

PBTLs are omnivorous, predominantly feeding on medium-sized arthropods that they ambush from their burrows. Scat and stomach content examinations have recorded the remains of grasshoppers, ants, small spiders, beetles, snails, cockroaches and plant material (including Dianella seed, chenopod material and Medicago leaves and flowers; Fenner et al. 2007; Milne 1999). The species has been found to change prey items opportunistically over spring and summer, with a greater extent of plant material found in the diet as summer progresses (Fenner et al. 2007).

1.7 Threats

The key threats to the PBTL include habitat fragmentation (Ebrahimi & Bull 2015; Smith et al. 2009), loss of habitat (Clarke 1999), inappropriate grazing regimes (Clayton & Bull 2015; Clayton & Bull 2017; Ebrahimi & Bull 2015), and weeds (Souter 2003).

The remaining PBTL populations are geographically isolated by cultivated land, with most natural grassland habitat remaining on hill slopes and the vast majority of the flatter areas being ploughed (Smith et al. 2009). Cultivation destroys spider and PBTL burrows and any spiders or lizards occupying them and permanently alters the vegetation and soil characteristics (Clarke 1999). Therefore, any further land use changes (e.g. cultivation, wind farm developments), which would fragment and permanently alter PBTL habitat, are a major threat to the species (Duffy et al. 2012).

The grazing regime of sheep can impact PTBLs in many ways. Heavy grazing may negatively impact PBTLs and spiders by reducing available burrows and burrow-digging behaviour (Clayton & Bull 2015). Sheep grazing can destroy shallow burrows, in particular, through trampling and the production of burrow-filling debris (Clayton & Bull 2017). Furthermore, simulated grazing pressure was found to reduce PBTL body mass increases and reduce the tendency of PBTLs to move around their burrow or to another burrow (Ebrahimi & Bull 2015). In contrast, reduced grazing intensity increased PTBL body condition and the abundance of grasshoppers (primary source of food; Nielsen & Bull 2020).

High and dense growth of Wild Oats (*Avena barbata*) and other weed species may reduce opportunities for PBTLs to bask, ambush insect prey, and find mates. Furthermore, weeds may also make habitat unsuitable for burrowing spiders (Souter 2003). Weed control may also threaten the species if high-disturbance techniques are used, or native plant species are affected (Duffy et al. 2012).

Other potential threats include insecticides, herbicides and fertilisers (Duffy et al. 2012), fire (Fenner & Bull 2007), and predation (predators include brown snakes, birds of prey and foxes; Clarke 1999; Nielsen & Bull 2016).

2 Existing monitoring

2.1 Overview of monitoring methods

The most effective means of surveying the PBTL is to use a fibre-optic burrowscope (e.g. videoscope, endoscope, borescope) to inspect spider burrows for the presence of PBTLs (DSEWPC 2011). Any areas of natural grassland within and closely beyond the known distribution of the PBTL, which have not been previously cultivated and contain wolf and trapdoor spider burrows, may be capable of supporting the species, particularly in areas with free-draining grey-brown or red calcareous soils or lithosol soils on the lower slopes of hillsides (Duffy et al. 2012). Arthropod prey and particular plant species, which form part of their diet, are also required for the presence of PBTLs (Fenner et al. 2007).

The key population monitoring index is the number of individual PBTLs per hectare, measured annually in 100 x 100 m monitoring plots. Monitoring should be conducted in late February to March to record the number of adults and juveniles in the population (Duffy et al. 2012). Given the highly fragmented habitat of the species, the number of populations and area of occupancy are also important indices.

2.2 Monitoring resources

Key resources with information for monitoring the PBTL include:

- Recovery Plan for the Pygmy Bluetongue Lizard *Tiliqua adelaidensis* (Duffy et al. 2012) – Outlines a long-term monitoring methodology that was undertaken between 2005 and 2011 by the South Australian Department of the Environment and Natural Resources. The methodology provides detailed information of the aim, method, location, timing, and observers of the long-term monitoring program.
- EPBC survey guidelines (DSEWPC 2011) – does not cover long-term monitoring of the PBTL, instead focusing on survey and collection techniques similar to those outlined in the recovery plan.
- Hornsdale Wind Farm SEB: Native Vegetation and Pygmy Blue-tongue Lizard Management Plan (EBS Ecology 2015) – Outlines a monitoring methodology, based on the methodology in the recovery plan, for a 10 year monitoring program within a Significant Environmental Benefit (SEB)/PBTL offset area for the development and operation of a wind farm.

2.3 Survey methods

2.3.1 Direct observation using a burrowscope

All suitable spider burrows are examined using a fibre-optic burrowscope (e.g. videoscope, endoscope, borescope) to determine the presence of PBTLs in a permanently marked one-hectare square plot (100 x 100 m; see Table 2). Suitable spider burrows are defined as circular in cross section and 10–20 mm in diameter, and greater than 10 cm deep. To observe the inside of the spider burrows, the tip of the burrowscope is gently pushed down the burrow until a PBTL or the bottom of the burrow is observed (Duffy et al. 2012).

The entire plot is searched for all suitable spider burrows, which are marked temporarily with survey pins. Once the surveyors are confident that all suitable spider burrows have been located, the survey for PBTL presence is undertaken. All marked spider burrows are checked for PBTL occupancy by one surveyor. At the same time, another records the location of the burrow using a GPS, as well as the contents of the burrow (e.g. PBTL, spider, empty, debris), number and age class (i.e. juvenile, sub-adult, adult) of PBTLs if present, and the estimated depth of the burrow. The temporary survey pins

are removed after a burrow is checked to ensure no burrow is checked more than once (EBS Ecology 2015). Monitoring should be conducted by two experienced surveyors or an experienced surveyor with assistance from a volunteer. To increase the number of experienced surveyors, volunteers can be trained over several surveys (or until competent) by an experienced surveyor (Duffy et al. 2012). Monitoring should take between 1.5–3 hours per one-hectare plot, depending on the number and detectability of spiders burrows present.

Monitoring is conducted annually in February–March to coincide with the time of year with minimal ground cover, making spider burrows easier to detect (Duffy et al. 2012). This timing also coincides with the time of year when young are born (Milne 1999; Milne et al. 2002), which allows important demographic information to be collected.

The burrow-dwelling behaviour of the PBTL is a crucial factor facilitating this monitoring methodology. The use of a burrowscope permits direct observation of PBTLs in their burrows, and their sedentary nature enables long-term monitoring of all individuals within the survey plot (Duffy et al. 2012). This methodology has formed the basis for long-term monitoring programs associated with wind farm developments in the Mid North region of South Australia (e.g. EBS Ecology 2015).

Table 2. Methods overview of key studies using direct observation surveys with burrowscope.

Study design	Survey effort	Area surveyed	Location	Reference
All suitable spider burrows were examined using a burrowscope to determine the presence of PBTLs in permanently marked one-hectare square plots (100 x 100 m). Monitoring conducted during a single survey in February–March.	Six-year annual monitoring program (2005–2009, 2011).	1 ha plot at nine sites (i.e. sub-populations).	Burra (Sites 1, 2, 4 and 6) Clare (Site 12) Hallet (Sites 3 and 11) Jamestown (Site 22) Peterborough (Site 9)	(Duffy et al. 2012)
	10-year annual monitoring program (proposed to begin after 2015).	Ten 1 ha plots within 75 ha SEB/PBTL offset area.	Hornsdale Wind Farm SEB/PBTL offset area	(EBS Ecology 2015)

2.3.2 Other methods

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

- Pitfall trapping – This method is not effective for long-term monitoring of this species, as individuals rarely move far from their burrow. Capture rates at a locality with high population density were only 1.3 lizards per 100 trap days during the peak active season (November to December) and nil during February (Milne 1999). Furthermore, digging in pitfall traps is potentially damaging to the limiting resources of spider burrows.
- Camera trapping – This method is not effective for long-term monitoring of this species, as individuals rarely move far from their burrow. However, camera traps focused on PBTL burrows have been used to observe PBTL behaviour, including basking, general movements, mating movements, predation and burrow residency (Bull et al. 2015; Ebrahimi & Bull 2015; Ebrahimi et al. 2015a, 2015b), which may be complimentary to population monitoring data.
- Hand capture – PBTLs can be captured from burrows using an insect (e.g. mealworm, grasshopper) tied to fine fishing line suspended from the end of a long fishing rod and dangled just beyond the burrow (Milne 1999; Smith et al. 2009). This method has been used to take body measurements of PBTLs, collect blood and tissue samples for genetics analysis, and capture individuals for laboratory research (Milne & Bull 2000; Nielsen & Bull 2020; Schofield et al. 2014; Shamiminoori et al. 2014). Body measurements and genetics analysis may be complementary to population monitoring data. Burrows should not be excavated unless absolutely necessary to collect individual PBTLs, as the PBTLs do not construct them and are a limiting resource (DSEWPC 2011).

Additional methods that may have potential future applications include:

- Detector dogs – To locate occupied PBTL burrows.

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

Key agencies, organisations or individuals identified as having been previously or currently actively involved in monitoring the PBTL include:

- South Australian Department for Environment and Water
- Northern and Yorke Landscape Board
- Flinders University
- South Australia Museum.

4 Survey guideline recommendations gathered from the literature

This literature review of the monitoring methods relating to the PBTL has identified the following key points to be considered when developing species-specific survey guidelines:

- Examining all suitable spider burrows using a fibre-optic burrowscope (e.g. videoscope, endoscope, borescope) to determine the presence of PBTLs in a permanently marked one-hectare square plot (100 x 100 m) is the most effective means of surveying the PBTL, and therefore the only monitoring method relevant to progress to a protocol.
- The key population monitoring index is the number of individual PBTLs per hectare, measured annually in 100 x 100 m monitoring plots. Monitoring should be conducted in late February to March to record the number of adults and juveniles in the population (Duffy et al. 2012).
- A fibre-optic burrowscope is an item of specialist equipment that is required. However, once a burrowscope is acquired, the method is practical, easily implemented and requires little expertise.
- Videoscopes are preferred over burrowscopes with an eyepiece and external light source. Videoscopes have an internal light source, and their screens provide a much clearer view of the burrow and enable images and video to be captured. Furthermore, the joystick controller of videoscopes is much more user-friendly than the two rotational dials on burrowscopes with an eyepiece and external light source.
- A large number (e.g. 100+) of survey pins are required to temporarily mark burrows until they are inspected. At this point, they are removed to ensure no burrow is checked more than once. If there are not enough survey pins, inspect marked burrows up to a certain point within the extent of marked burrows, then mark burrows beyond this with the previously removed survey pins and repeat if necessary.
- Two surveyors should walk transects up and down the plot, each starting at opposite ends and scanning the area 1–2 m on either side of each transect to find and mark burrows.
- Examining suitable spider burrows using a fibre-optic burrowscope can be undertaken in areas of suitable habitat as part of a baseline survey to determine the extent of occurrence of the species and suitable locations to establish monitoring plots.
- The following Ecological Monitoring System Australia (EMSA) modules developed by TERN for the Australian Government should be considered for surveying the PBTL:
  - Targeted Surveys – Can be used to record the search area (i.e. one-hectare square plot or baseline survey search area) and location of occupied and unoccupied burrows within the search area.
  - Camera trapping – Camera traps focused on PBTL burrows can be used to observe PBTL behaviour, which may be complementary to population monitoring data.
  - In addition, the Plot Description, Floristics, Cover, Soils, Condition and Vegetation Mapping modules may be beneficial for assessing the suitability of a location against PBTL habitat preferences.
- Pitfall and camera trapping are ineffective for long-term monitoring of PBTLs as individuals rarely move far from their burrow.
- PBTLs can be captured via fishing from burrows to take body measurements of PBTLs and collect blood and tissue samples for genetics analysis, which may be complementary to population monitoring data.

- Burrows should not be excavated unless absolutely necessary to collect individual PBTLs, as the PBTLs do not construct them and are a limiting resource.

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