

Conservation Assessment of *Uperoleia mahonyi*

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Uperoleia mahonyi Clulow, Anstis, Keogh & Catullo (Myobatrachidae)

Distribution: Endemic to NSW

Current EPBC Act Status: Not listed

Current NSW BC Act Status: Endangered

Proposed listing on NSW BC Act and EPBC Act: List as Endangered on the EPBC Act.

Conservation Advice: *Uperoleia mahonyi*

Summary of Conservation Assessment

Uperoleia mahonyi was found to be eligible for listing as Endangered Criterion B1ab(i, ii, iii, iv, v)+2ab(i, ii, iii, iv, v).

The main reasons for this are: (i) the distribution of *Uperoleia mahonyi* is highly restricted. The extent of occurrence (EOO) is 1,905 km² based on a minimum convex polygon enclosing all mapped occurrences of the species in NSW (Clulow *et al.* 2016), the method of assessment recommended by IUCN (2019). The area of occupancy (AOO) is estimated to be 36 km² based on nine 2 x 2 km grid cells, the scale recommended for assessing AOO by IUCN (2019). Both EOO and AOO fall below the thresholds for Endangered (<5,000 km² and <500 km² respectively); (ii) the species is considered to be severely fragmented, with populations separated by distances of up to 10 km and there are multiple barriers to dispersal between populations. Connectivity of amphibian populations is considered to be key to their viability and with a disruption to this connectivity, populations are prone to local extinctions with a low chance of recolonisation; (iii) there are continuing declines and the species faces numerous threats which have and will continue to impact potential habitat and extant populations across the species range.

Description and Taxonomy

The NSW Scientific Committee (2017) state that “Mahony’s Toadlet *Uperoleia mahonyi* Clulow, Anstis, Keogh & Catullo 2016 (family Myobatrachidae) is a small (males 30 mm, female 32 mm) but robustly built frog (Clulow *et al.* 2016). Like other members of the genus *Uperoleia*, this species has large parotoid glands covering the tympanum, unwebbed fingers, vomerine teeth vestigial or absent, inguinal colouration present and presence of inner and outer metatarsal tubercles (Clulow *et al.* 2016). This species is distinguished from all other *Uperoleia* species by a combination of ventral pigment (ventral surface completely covered with black and white marbling), presence of maxillary teeth, toes unwebbed, lack of colour patch below the knee and a “squelch” as a call (Clulow *et al.* 2016). The belly patterns of black and white patches appear marbled, more similar to the bellies of *Pseudophryne* spp., rather than simply stippled as commonly observed in *Uperoleia* spp. (Clulow *et al.* 2016). Inguinal (groin) and femoral (thigh) colour patches are orange with the femoral colour patch irregular in shape and large and always closer to knee than vent (Clulow *et al.* 2016). Tadpoles are indistinguishable from those of other *Uperoleia* species (see Anstis 2013) and are described in detail in Clulow *et al.* (2016).”

“*Uperoleia mahonyi* was first collected in 2007 and formally described in 2016 (Clulow *et al.* 2016). Prior to formal description this species was referred to as *Uperoleia* sp. Oyster Cove, *Uperoleia* sp. nov. (Oyster Cove, NSW) or *Uperoleia* sp. undescribed species (Lemckert 2010; OEH 2011, 2013; Anstis 2013; Parsons Brinkerhoff 2016). Letnic and Fox (1997a) referred to this species as *U. laevigata* (M. Letnic *in litt.* November 2016).”

Distribution and Abundance

The NSW Scientific Committee (2017) state that “*Uperoleia mahonyi* is endemic to the mid-north coast of New South Wales (NSW) and is found between Kangy Angy and Seal Rocks.”

“Clulow *et al.* (2016) and S. Clulow *in litt.* (November 2016) report this species occurring in eight locations on sand beds in the Port Stephens, Myall Lakes and northern Central Coast areas. Sites include Wyrabalong National Park, Tomago, Oyster Cove, Nelson Bay, Fingal Bay, Seal Rocks and Kangy Angy.” No further populations are known.

The distribution of *Uperoleia mahonyi* is highly restricted. The extent of occurrence (EOO) is estimated to be 1,905 km² based on a minimum convex polygon enclosing all mapped occurrences of the species in NSW (Clulow *et al.* 2016), the method of assessment recommended by IUCN (2019). The area of occupancy (AOO) is estimated to be 36 km² based on nine 2 x 2 km grid cells, the scale recommended for assessing AOO by IUCN (2019). The NSW Scientific Committee (2017) note that “Due to the recent discovery of this species, both the AOO and EOO may increase with further targeted surveys.”. However, the potential for some future increase in the known distribution, it is not expected that the geographic range will increase dramatically and so exceed the threshold for Endangered, as *U. mahonyi* is a habitat specialist and the required habitat is limited.

Uperoleia mahonyi is considered to be severely fragmented. Most known populations are separated by distances greater 10 km, further than the species is likely to disperse, in addition to being separated by physical barriers to dispersal such as roads, industrial areas, and heavily modified landscapes including golf courses and pasture. These kinds of barriers have been shown to considerably impair or prevent amphibian dispersal (Cushman 2006). In a review of the effects of habitat fragmentation on amphibians, Cushman (2006) highlighted that habitat connectivity was a key element of population persistence for amphibians which as a group are sensitive to disturbances and prone to frequent local extinctions and turnover (Edenham 1996; Hecnar and M'Closkey 1996; Alford and Richards 1999; Trenham *et al.*, 2003) requiring recolonization from adjacent habitat and populations to persist. On this basis and taking a precautionary approach to assessing this species, none of the populations can be considered viable in the absence of regular dispersal events between populations. It is likely that the impacts of habitat fragmentation and the numerous barriers to dispersal have eliminated or severely reduced population and habitat connectivity for the known populations and that the numerous threats (detailed below) in addition to the tendency for amphibians to experience stochastic local extinctions.

With regards to population size, the NSW Scientific Committee (2017) state that “Population size is unknown, however, at waterbodies where they are recorded, the estimated abundance is in the hundreds (S. Clulow *in litt.* November 2016).”

Further surveys are required to clarify population size in the species. Recent drought conditions have not been favourable for such surveys.

Ecology

The NSW Scientific Committee (2017) state that “Mahony’s Toadlet has been recorded almost exclusively on a substrate of leached (highly nutrient impoverished) white sand and is commonly associated with acid paperbark swamps (Clulow *et al.* 2016). *Uperoleia* species in general tend to be highly substrate specific and are limited to substrates (in this case sand) in which they are adapted to burrow (R. Catullo *in litt.* November 2016). Thom *et al.* (1992) and OEH (2012) describe the geomorphology and distribution of marine sediments in this area. Vegetation communities in which *U. mahonyi* has been found include wallum heath, swamp mahogany-paperbark swamp forest, heath shrubland and Sydney red gum woodland (Clulow *et al.* 2016). Aquatic vegetation at breeding sites includes sedges (*Schoenoplectus* spp., *Baumea* spp. and *Lepironia articulata*) and Broadleaf Cumbungi (*Typha orientalis*) (Clulow *et al.* 2016). Breeding habitat for Mahony’s Toadlet appears to be similar to that for Tylers Toadlet *U. tyleri*, which occupies permanent or semi-permanent swamps and ponds of

moderate size with no apparent flow of water (Clemann 2015; R. Catullo *in litt.* November 2016). Outside of the breeding period, adults of *U. mahonyi* are terrestrial. During non-breeding periods the species has been recorded up to 400 m from standing water within intact native vegetation, indicative of a need for large vegetation buffers around breeding sites to ensure persistence of this species (Westgate *et al.* 2012; Clemann 2015; Clulow *et al.* 2016). Females of other frog species move further away from waterbodies, so may be more sensitive to clearing than males (Penman *et al.* 2008; Clemann 2015). This species has also been recorded in disturbed environments, a golf course dam and a swale created by sand mining (Clulow *et al.* 2016), however Letnic and Fox (1997a) reported that it (as *U. laevis* M. Letnic *in litt.* November 2016) prefers later successional stages with established vegetation. Disturbed sites where this species has been reported all have intact native vegetation around breeding habitat (Clulow *et al.* 2016)."

"Several other threatened species of frog specialise in the oligotrophic and acidic conditions typical of wallum habitats which are wholly or largely restricted to lowland sand plains, dunes and sand islands of coastal south-eastern Australia (e.g. Olongburra Frog *Litoria olongburensis*, Cooloola Tree Frog *L. cooloolensis*, Freycinet's Frog *L. freycineti* and Wallum Froglet *Crinia tinnula*; see Meyer *et al.* 2006), so this specialisation is not unique. Mahony's Toadlet *U. mahonyi* has been recorded near the Dusky Toadlet *U. fusca* and at sites with a range of other frog species including Rocket Frog *Litoria nasuta*, Peron's Tree Frog *Litoria peronii*, Tyler's Tree Frog *L. tyleri*, Eastern Dwarf Tree Frog *L. fallax*, Jervis Bay Tree Frog *L. jervisiensis*, Striped Marsh Frog *Limnodynastes peronii*, Haswell's Froglet *Paracrinia haswelli*, Common Eastern Froglet *Crinia signifera* and Wallum Froglet *C. tinnula* (Clulow *et al.* 2016)."

"Breeding in *Uperoleia mahonyi* occurs in March (autumn) and October-November (spring) (Clulow *et al.* 2016). In the wild, the eggs are likely to be attached to thin strands of submerged vegetation and substrate such as leaf litter similar to the sites chosen by all other members of this genus (Anstis 2013; Clulow *et al.* 2016). The clutch size is unknown. Longevity is unknown but has been estimated at 5–14 years for *U. martini* (Clemann 2015). It is also estimated that it takes at least a year for individuals to reach maturity (R. Catullo *in litt.* 29 November 2016)."

"The diet of *Uperoleia mahonyi* is unstudied, however other *Uperoleia* species have been reported eating ants, pill bugs, springtails, beetles, termites and mites (Tyler 1999; Tyler and Knight 2011; R. Catullo *in litt.* November 2016). Tadpoles of similar species (e.g. *U. laevis*) are pond adapted, bottom dwellers which feed on sediment and algae (Anstis 2013). *Uperoleia* species are capable burrowers (in appropriate sediments) and have limited ability to move large distances across land or through urbanised areas so are likely to seek shelter near breeding sites during unfavourable conditions (Clemann 2015; R. Catullo *in litt.* November 2016). Rocks, logs and leaf litter may also be used for shelter and provide important refuges for invertebrate prey items (Lindenmayer *et al.* 2002)."

Research into habitat preferences, distribution, genetic exchange and movement of the species will be undertaken by Macquarie University over the next two years as part of the Saving Our Species program (L. Foster, pers. comm. Jun. 2018).

Threats

The NSW Scientific Committee (2017) state that "*Uperoleia mahonyi* faces a range of threats including habitat loss, habitat degradation and disease. Historical and ongoing urban and agricultural development, which is widespread in coastal NSW, results in the loss and fragmentation of habitat and also degrades adjoining uncleared areas through changes in water flow regimes and water quality. Historical clearing for housing (and other purposes) around the city of Newcastle, smaller satellite towns (e.g. Port Stephens, Hawks Nest, Tea Gardens) and the development of the foreshores of Tuggerah Lakes and Lake Macquarie have resulted in the loss of 31–44% of the potential habitat for this species in these areas (OEH 2012, 2016). Human populations in coastal areas are predicted to grow rapidly (ABS 2016). Human population growth is linked with extinction risk, habitat loss and

degradation (Harte 2007) and in NSW the human population is projected to increase by 48% in the period 2007–2056 (ABS 2016), which will increase the environmental impacts of land clearing, effluent disposal and water extraction. Population projections (percentage increase between 2011 and 2036) for the local government areas where this species is found are as follows: Port Stephens (37.9%), Central Coast (28.6%), Newcastle (27.5%), Lake Macquarie (15.2%) and Mid-Coast (8.4%) (Planning NSW 2016). The protected area system (e.g., National Parks and Nature Reserves) provides limits on the extent of clearing, however protected areas are still vulnerable to other threats and ongoing degradation from historical land uses (Brewer and Whelan 2003). Habitat suitable for *U. mahonyi*, consisting of trees or shrubs on suitable soils, is of naturally limited extent (OEH 2012, 2016). Remaining suitable habitat in the coastal areas between the Hawkesbury River and Port Macquarie is well reserved with 69% or 18,000ha of suitably vegetated podzols and 54% (19,280 ha) of suitably vegetated siliceous sands occurring in the reserve system (OEH 2012, 2016). This estimate is based on a larger area than the current known range and, within the known range of this species (the EOO with a 2km buffer applied) 62% (of a total of ~18,000 ha) of potentially suitable habitat is in reserves. Three of the eight known sites are in reserves. Non-reserved habitat is expected to be progressively cleared over time and clearing of other native vegetation will contribute further fragmentation.”

“Elevated nitrate loads (often present in urban or agricultural runoff), agricultural chemicals and pesticides (including mosquito control agents) are all potentially hazardous to frogs and tadpoles (Mann and Bidwell 1999; Meyer *et al.* 2006; DOE 2016). Eutrophic runoff can result in the establishment of exotic weeds (e.g. Boneseed and Bitou Bush, *Chrysanthemoides monilifera*) in low nutrient environments (Brewer and Whelan 2003; DOE 2016). Change of water permanence resulting from water extraction, sand mine rehabilitation, building of roads or clearing may be detrimental for a species that requires access to waterbodies for breeding and tadpole development (Brewer and Whelan 2003; DOE 2016).”

“One of the locations where this species has been recorded, the Tomago sand beds, has historically been harvested for water, potentially impacting breeding sites. Water harvesting has recently been suspended due to per- and poly-fluorinated alkyl substances (PFAS) contamination from the Williamstown Air Force Base. While PFAS are of low to moderate toxicity to frogs (OECD 2002, cited in Colville and McCarron 2003) it is unknown if these chemicals have had any detrimental impact on this species.”

“Sand mining, clearing, fire and industrial fallout, in the form of gaseous hydrogen fluoride and particulate fluorides, from Tomago Aluminium Smelter have also altered the patterns of vegetation at Tomago with changes in herpetofauna communities being reported (Fox *et al.* 1996; Letnic and Fox 1997ab; Taylor and Fox 2001). At sites with high fluoride levels, frogs, including *U. mahonyi* (which was formerly referred to as *Uperoleia laevigata* M. Letnic *in litt.* November 2016), were absent (Letnic and Fox 1997a). *Uperoleia mahonyi* was mainly found in late successional stages with established canopy cover, indicative of a need for native vegetation cover and suggesting that disturbance such as fire and clearing would negatively impact this species (at least in the short term) (Letnic and Fox 1997a). At Tomago in the late 1990s, at sites studied by Letnic and Fox (1997a), *U. mahonyi* was abundant and frogs were commonly caught in pitfall traps during wet weather in suitable habitat (M. Letnic *in litt.* November 2016).”

“Introduced red foxes and cats are potential predators of this species (Clemann 2015). The Plague Minnow *Gambusia holbrooki* is an introduced egg and tadpole predator. NPWS (2003) predicts that other *Uperoleia* are moderately impacted by Plague Minnow and by inference *U. mahonyi* is likely to be impacted by this species. Susceptibility to the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) is unconfirmed in *U. mahonyi*. The low elevation coastal locations in which this species is found are at risk of sea level rise (Meyer *et al.* 2006) and, due to coastal development, coastal sand deposits at many locations are likely to be negatively impacted by infrastructure protection, accelerating the adverse effects of sea level rise (Defeo *et al.* 2009).”

“Meyer *et al* (2006) reported that the presence of the Eastern Dwarf Tree frog *Litoria fallax* or the Rocket frog *Litoria nasuta* at wallum sites is indicative of disturbance (both have been reported to coexist with *U. mahonyi* by Clulow *et al.* 2016). There is potential for these more common species to displace Mahony’s Toadlet through competition or to act as reservoirs for the amphibian chytrid fungus (Meyer *et al.* 2006; Clenmann 2015). Once displaced, recolonisation is unlikely due to patchy habitat distribution and presumed limited mobility of this species. The introduced Cane Toad, *Rhinella marina* is a potential future threat (Shine 2010; Anstis 2013).”

“The recent discovery of *Uperoleia mahonyi* prevents any quantification of decline in this species. However, it is assumed that habitat loss and other threats would have negatively impacted *U. mahonyi* over the last 150 years, given the history of urban and agricultural development as well as habitat disturbance of coastal areas within the species known distribution.”

Assessment against IUCN Red List criteria

For this assessment it is considered that the survey of *Uperoleia mahonyi* has been adequate and there is sufficient scientific evidence to support the listing outcome.

Criterion A Population Size reduction

Assessment Outcome: Data Deficient

Justification: The recent discovery and lack of population data for *Uperoleia mahonyi* prevents the quantification of any reductions, however, given the species occurs in areas that have faced increasing pressure from urbanisation and agriculture it is considered highly likely that a population reduction has occurred.

Criterion B Geographic range

Assessment Outcome: Endangered under Criterion B1ab(i, ii, iii, iv, v)+2ab(i, ii, iii, iv, v)

Justification: The distribution of *Uperoleia mahonyi* is highly restricted. The extent of occurrence (EOO) is 1,905 km² based on a minimum convex polygon enclosing all mapped occurrences of the species in NSW (Clulow *et al.* 2016), the method of assessment recommended by IUCN (2019). The area of occupancy (AOO) is estimated to be 36 km² based on nine 2 x 2 km grid cells, the scale recommended for assessing AOO by IUCN (2019). Both EOO and AOO fall below the thresholds for Endangered (<5,000 km² and <500 km² respectively).

In addition to these thresholds, at least two of three other conditions must be met. These conditions are:

- a) The population or habitat is observed or inferred to be severely fragmented or there is 1 (CR), ≤5 (EN) or ≤10 (VU) locations.

Assessment Outcome: Sub criterion met for severe fragmentation.

Justification: *Uperoleia mahonyi* is considered to be severely fragmented as populations are isolated by distance (up to 10 km between most populations) and there are significant barriers to amphibian dispersal including roads, pastures, golf courses and urban areas. Populations are not considered to be viable unless there is some connectivity between populations as they have are prone to local extinctions and high turnover rates. Consequently populations that are lost are unlikely to be recolonised. The significant number of threats facing the species increases the likelihood of local extinctions occurring.

- b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals

Assessment Outcome: Sub criterion met for (i, ii, iii, iv, v)

Justification: The species is facing a range of threats including but not limited to habitat degradation, land clearing, sand mining, pollution of waterways, invasive predators, competition from other native species and chytrid fungus. In light of the significant development and industrial activity that has occurred across this species range it is considered likely that declines will continue in (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals.

- c) Extreme fluctuations.

Assessment Outcome: Data Deficient

Justification: There is insufficient data to assess whether the species experiences extreme fluctuations.

Criterion C Small population size and decline

Assessment Outcome: Data Deficient

Justification: There are currently no population estimates for the species, however, at water bodies where they are recorded the estimated abundance is in the hundreds.

At least one of two additional conditions must be met. These are:

- C1. An observed, estimated or projected continuing decline of at least: 25% in 3 years or 1 generations (whichever is longer) (CE); 20% in 5 years or 2 generations (whichever is longer) (EN); or 10% in 10 years or 3 generations (whichever is longer) (VU).

Assessment Outcome: Data Deficient

Justification: The recent discovery and lack of population data for *Uperoleia mahonyi* prevents the quantification of any declines.

- C2. An observed, estimated, projected or inferred continuing decline in number of mature individuals.

Assessment Outcome: Sub criterion met

Justification: The species is facing a range of threats including but not limited to habitat degradation, land clearing, sand mining, pollution of waterways, invasive predators, competition from other native species and chytrid fungus. In light of the significant development and industrial activity that has occurred across this species range it is considered likely that there are ongoing declines in the number of mature individuals.

In addition, at least 1 of the following 3 conditions:

- a (i). Number of mature individuals in each subpopulation ≤ 50 (CR); ≤ 250 (EN) or ≤ 1000 (VU).

Assessment Outcome: Sub criterion met at VU.

Justification: While the total number of mature individuals is unknown, at waterbodies where the species has been recorded the populations are estimated in the hundreds, therefore <1000.

- a (ii). % of mature individuals in one subpopulation is 90-100% (CR); 95-100% (EN) or 100% (VU)

Assessment Outcome: Sub criterion not met.

Justification: There are around eight known populations each of which is estimated to contain hundreds of individuals.

- b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Data Deficient

Justification: There is insufficient evidence at present to determine whether the species experiences extreme fluctuations.

Criterion D Very small or restricted population

Assessment Outcome: Vulnerable.

Justification: There are currently no population estimates for the species, however, at water bodies where they are recorded the estimated abundance is in the hundreds.

To be listed as Vulnerable under D, a species must meet at least one of the two following conditions:

- D1. Population size estimated to number fewer than 1,000 mature individuals

Assessment Outcome: Data deficient.

Justification: There are no population estimates for the species, however, where the species has been recorded numbers are estimated in the hundreds.

- D2. Restricted area of occupancy (typically <20 km²) or number of locations (typically <5) with a plausible future threat that could drive the taxon to CR or EX in a very short time.

Assessment Outcome: Vulnerable.

Justification: *Uperoleia mahonyi* has a restricted area of occupancy (36 km²) and is currently only known from eight locations. There are a number of plausible threats which could drive this species to CR or EX within a very short time including the Chytrid fungus, drainage or pollution of waterways, land clearing and habitat degradation.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient.

Justification: There is insufficient data to quantitatively assess the likelihood of extinction.

Conservation and Management Actions

There is no National Recovery Plan program for this species. The following is derived from the NSW Save our Species program and threat information.

Habitat loss, disturbance and modification

- Prevent further habitat loss due to development and industrial activities such as sand mining reserving known populations and increasing awareness of the species amongst ecological consultants conducting surveys for developments in the area.
- Implement increased riparian buffer zones around known populations, observations of the species in the field indicate that mature individuals spend a substantial amount of time in damp forest litter in wooded areas up to 400 m around water bodies and require such habitat for persistence.
- Ensure connectivity is maintained between suitable habitat patches and known populations, strategies may include:
 - The creation or maintenance of wildlife corridors.
 - The construction of tunnels and bridges over or under roads to reduce the risks of dispersing across roads.
- Control the use of chemicals in the area around known and potential habitats, including enforcing strict rules on the use and disposal of chemicals by industry in the area, as well as on residential and commercial uses of chemicals such as pesticides and fertilizers.

Invasive species

- Targeted baiting or trapping of foxes and cats around known populations.
- Monitoring for evidence of incursions by Cane Toads and acting quickly to prevent establishment by the species.

Ex situ conservation

- At present *ex situ* conservation is not believed to be necessary for the species survival, however, experiments to determine the species susceptibility to the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) should be undertaken.

Stakeholder Management

- Inform land owners and managers of sites where there are known populations and consult with these groups regarding options for conservation management and protection of the species.

Survey and Monitoring priorities

- Monitoring for increased habitat degradation.
- Targeted surveys to determine the population size of the species including demographic data on sex ratios and age groups, in particular the number of mature individuals.
- Monitoring for recruitment and declines over time.
- Monitoring for the arrival of new threats including Cane Toads and the Chytrid fungus.

Information and Research priorities

- Identifying the potential distribution of the species based on habitat and climatic modelling to inform targeted surveys for additional populations.
- Determine the susceptibility the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*).

References

- Alford RA, Richards SJ (1999) Global amphibian declines: a problem in applied ecology. *Annual Review of Ecology and Systematics* **30**, 133–165.
- Clulow S, Anstis M, Keogh JS, Catullo RA (2016) A new species of Australian frog (Myobatrachidae: *Uperoleia*) from the New South Wales mid-north coast sandplains. *Zootaxa*, **4184**, 285–315.
- Cushman SA (2006) Effects of habitat loss and fragmentation on amphibians: A review and prospectus. *Biological Conservation* **128**, 231–240.
- Edenhamn P (1996) Spatial dynamics of the European tree frog (*Hyla aborea* L.) in a heterogeneous landscape. Dissertation, Swedish University of Agricultural Sciences, Uppsala.
- Hecnar SJ, M'Closkey RT (1996) Regional dynamics and the status of amphibians. *Ecology* **77**, 2091–2097.
- IUCN Standards and Petitions Subcommittee (2019) Guidelines for Using the IUCN Red List Categories and Criteria, Version 14.
- NSW Scientific Committee (2017) Determination for provisional listing of an endangered species on an emergency basis, *Uperoleia mahonyi*. URL: <https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/nsw-threatened-species-scientific-committee/determinations/final-determinations/2017-2018/mahonys-toadlet-uperoleia-mahonyi-endangered-species-listing>
- Trenham PC, Shaffer HB, Koenig WD, Stromberg MR (2000) Life history and demographic variation in the California tiger salamander (*Ambystoma californiense*). *Copeia* **2000**, 365–377.
- Note:** for references mentioned in NSW Scientific Committee quotes see <https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/nsw-threatened-species-scientific-committee/determinations/final-determinations/2017-2018/mahonys-toadlet-uperoleia-mahonyi-endangered-species-listing>

Expert Communications

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