

Notice of and reasons for the Final Determination

The NSW Threatened Species Scientific Committee, established under the *Biodiversity Conservation Act 2016* (the Act), has made a Final Determination to list the Giant Barred Frog, *Mixophyes iteratus* Straughan, 1968 as a VULNERABLE SPECIES in Part 3 of Schedule 1 of the Act and, as a consequence, to omit reference to the Giant Barred Frog, *Mixophyes iteratus* Straughan, 1968 from Part 2 of Schedule 1 (Endangered species) of the Act. Listing of Vulnerable species is provided for by Part 4 of the Act.

The NSW Threatened Species Scientific Committee is satisfied that the Giant Barred Frog, *Mixophyes iteratus* Straughan, 1968 has been duly assessed by the Commonwealth Threatened Species Scientific Committee under the Common Assessment Method as provided for by Part 4.14 of the Act. After due consideration of TSSC (2021), the NSW Threatened Species Scientific Committee has made a decision to list the species as Vulnerable.

Summary of Conservation Assessment

The Giant Barred Frog, *Mixophyes iteratus* Straughan, 1968 was found to be Vulnerable in accordance with the following provisions in the *Biodiversity Conservation Regulation 2017*: Clause 4.3 (c)(d)(e i,ii,iii,iv) because: i) the species has a moderately restricted area of occurrence of 1,908 km²; ii) it is known from three threat-defined locations; and iii) continuing decline is inferred in the species' extent of occurrence, area of occupancy, extent and quality of habitat, number of subpopulations and number of mature individuals.

The NSW Threatened Species Scientific Committee has found that:

1. The Giant Barred Frog, *Mixophyes iteratus* Straughan, 1968 belongs to the family Myobatrachidae. It is the largest of the barred frogs and Australia's second largest frog. Females are larger than males, having a snout-to-vent length (SVL) to 120 mm and weighing around 190 g. Males reach 88 mm (SVL) and weigh up to 80 g. The skin is finely granular above and smooth below. The dorsal surface is beige to dark brown with darker blotches. Typical of barred frogs, an irregular, dark, vertebral stripe is present. The stripe commences between the eyes and extends to the vent, sometimes breaking up into a series of blotches along the midline. The flanks are pale yellow with irregular dark spots or mottling. The ventral surface is yellow to white. The head is large and broad with a prominent projecting snout, giving the species a more triangular shape than other *Mixophyes* species. A black stripe commences at the snout and continues through the nostril and eye, extending over a distinct tympanum, before terminating at a point above the shoulder. The ventral surface of the chin is typically yellow with fine brown mottling. The upper lip has irregular darker markings. The eyes are prominent with a vertical black pupil. The iris is pale silvery-white to pale gold and often brighter in the top half. The limbs are long and muscular and have a series of dark and pale crossbars of similar width along their length. The hind limbs are proportionately larger than in

NSW Threatened Species Scientific Committee

other *Mixophyes* species, with the back of the thigh ranging from black, with a few large yellow spots, to being marbled black and yellow. There is often a rust colouration along the outer toes and fingers. The fingers lack webbing, while the toes are fully webbed, with only the last two joints of the fourth toe free (as opposed to three joints of the toe being free of webbing in the other *Mixophyes* species). The outer metacarpal is poorly developed. The inner metatarsal tubercle is well developed but only half as long as the first toe (versus being nearly of equal length in the other *Mixophyes* species). Discs are absent on the toes and fingers (Meyer *et al.* 2001; Hines 2012; Cogger 2014; Anstis 2017).

2. Tadpoles are large (maximum total length is over 100 mm), deep-bodied, and ovoid. The tail is twice as long as the body. From above, the colouring is gold or dull copper-gold, with dark spots/splotches and a dark patch at the base of tail. As the tadpole grows, gold pigments may gradually become duller. The underside is transparent in early stages before gradually turning silver-white in later stages. The snout of the tadpole is rounded. The eyes are positioned dorsolaterally and are prominent with a vertical pupil noticeable by the later stages of development (about stage 37). The iris is golden, and a bright gold ring surrounds the pupil. The nares are equidistant between snout and eyes and open laterally. The oral disc is surrounded by papillae. The spiracle is short and opens in a dorsoposterior fashion below the body axis and near the midpoint of the body. The vent tube is dextral. The tail is thick and muscular with fins that are moderately arched to near the midpoint before tapering to a rounded tip. The fins are opaque with dark flecking except the anterior half of the ventral fin (Meyer *et al.* 2001; Hines 2012; Anstis 2017).
3. The Giant Barred Frog is sparsely distributed from near Hervey Bay, south-east Queensland (Hines 2012) to Warrimoo in the Blue Mountains, New South Wales (NSW) (OEH 2017). Much of the occupied habitat in Queensland falls on private land (Hines 2012) and over 75 percent of the species' NSW distribution occurs outside of National Parks and Wildlife Service estates (OEH 2017).
4. In NSW, strongholds are in the north-east, particularly the Coffs Harbour-Dorrigo catchment and Washpool National Park (NP). Elsewhere in NSW, very small disjunct subpopulations occur south to Warrimoo in the Blue Mountains (OEH 2017). Known locations include, but are not limited to Mebbin NP, the upper Tweed River, Whian Whian State Conservation Area, the Bungawalbyn area, the Manning River catchment (NSW Scientific Committee 1999), the Macleay, Hastings and Hawkesbury River catchments (C. Slade pers. comm. November 2023), and the Watagans area (Anstis 2017).
5. The Giant Barred Frog population can be broadly divided into three distribution zones separated by intervening dry areas. The northern distribution: north and west of Brisbane, Queensland (including the Sunshine Coast hinterland), within the Mary River and Stanley River catchments; the central distribution: from areas west and south-west of the Gold Coast, Queensland to the ranges north-west of Newcastle, NSW; and the southern distribution: from the Hunter Valley, through

NSW Threatened Species Scientific Committee

the Hawksbury River catchment, to the Blue Mountains, NSW (DOE 2020). Despite the isolation of these zones from each other, examination of the nuclear genome (allozymes) of subpopulations across the entire range shows no geographical differences that would indicate sub-species or species delineation (Mahony *et al.* 2006).

6. The Giant Barred Frog has a moderately restricted geographic distribution. The Area of Occupancy (AOO) of the Giant Barred Frog was estimated to be 1908 km² using 2 x 2 km grid cells, the scale recommended by IUCN (2022). The Extent of Occurrence (EEO) was estimated to be 132,654 km² and is based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2022).
7. The number of mature individuals of this species is not known with certainty (Hines 2012; Quick *et al.* 2015), but it is considered likely to be greater than 10,000 individuals (M. Mahony pers. comm. April 2020 in TSSC 2021; H. Hines pers. comm. April 2020 in TSSC 2021).
8. The Giant Barred Frog is a large, ground-dwelling frog found near permanent flowing drainages (from shallow, rocky rainforest streams to slow-moving rivers) in lowland open wet-forests (rainforest and wet sclerophyll forest) and (to a lesser degree) on cleared land (NSW Scientific Committee 1999; Lewis and Rohweder 2005; Anstis 2017). The species is mostly associated with pools in larger streams. It is a noted habitat specialist and stays in the riparian zone all year round, generally confined to a narrow strip of vegetation either side of a stream or river (Lemckert 1999; Lemckert and Brassil 2000; Meyer *et al.* 2001; Hines 2012). Short term studies of movement patterns show that individuals move up to 100 m in a night but not more than 20 m from the stream, with the majority staying within 10 m (Lemckert and Brassil 2000; Koch and Hero 2007; OEH 2017). Juvenile frogs appear to have similar movement patterns to adults (Lemckert and Brassil 2000). During rainfall, the Giant Barred Frog has been observed to move away from waterways, possibly as flood avoidance behaviour (Koch and Hero 2007).
9. In the breeding season (spring to autumn), males call from the ground beside streams, with peak periods in November and February (Hines 2012; Anstis 2017). The call of the male appears to precede rainfall (Goldingay *et al.* 1999) and has been described as a deep, guttural grunt 'ork' (OEH 2017). Calling does not occur on a nightly basis, being more sporadic in nature, and this allows males to move freely without the requirement of defending a site (Lemckert and Brassil 2000).
10. Once eggs are laid and fertilised, the female kicks them out of the water, sticking them onto overhanging or steeply sloped banks or rocks. Once hatched, the tadpoles then drop into the stream below (Knowles *et al.* 2015; Anstis 2017). The average clutch size is 2000 eggs (Anstis 2017). Tadpoles can grow to over

NSW Threatened Species Scientific Committee

100 mm, and it may take up to 14 months between egg laying to completion of metamorphosis (Lemckert and Brassil 2000; OEH 2017). Consequently, tadpoles may overwinter (Meyer *et al.* 2001). Tadpoles are bottom-dwellers, grazing over rocks and the substrate in still or slowly flowing pools or at the sides of streams. They are powerful swimmers and the sectorial disk enables quite firm adherence in flowing water (Anstis 2017).

11. The Giant Barred Frog does not burrow into the soil like other barred frogs (Lemckert and Brassil 2000) but instead hides within the leaf litter by day, well camouflaged by dorsal pigment patterns (Anstis 2017). Behavioural surveys indicate that temperature is the most important climatic variable influencing this behaviour. During cold conditions (<18 °C), males (in particular) bury under the leaf litter but usually remain in a position with their head clearly exposed (Lemckert and Brassil 2000; Koch and Hero 2007).
12. The Giant Barred Frog is believed to be a generalist feeder, likely to eat any potential prey items encountered when foraging, with large insects, snails, spiders, and frogs included in its diet (Lemckert and Shoulder 2007; OEH 2017).
13. The main threats to the Giant Barred Frog are adverse fire regimes, increased temperatures and changes in rainfall resulting from climate change, the clearing of vegetation resulting in habitat fragmentation and chytrid fungus infection. Given the extent of the 2019-20 bushfires, which are believed to have impacted 37 percent of the distribution range of the Giant Barred Frog (with 13 percent burnt in high to very high severity fire), the three distribution zones can be identified as three separate threat-defined locations, each of which could be rapidly affected in a single bushfire season (which can involve multiple fire events).
14. As a non-burrowing species, the Giant Barred Frog faces a great threat from fire, through both direct contact as well as a reduction in leaf-litter for foraging and shelter. Wildfires can also adversely affect stream breeding habitat by increasing water temperature, altering water chemistry (Lyon and O'Connor 2008), and creating sediment/ash runoff 'slugs' that can form in waterways following rainfall (Lyon and O'Connor 2008; Alexandra and Finlayson 2020). These slugs can fill in crevices in stream substrates, reducing the availability of refugia for tadpoles (Welsh and Ollivier 1998), and promote toxic algal blooms (Alexandra and Finlayson 2020) that can deoxygenate the water and cause egg and tadpole death. Sediment slugs are known to impact aquatic ecosystems up to 80 km downstream of burnt areas (Lyon and O'Connor 2008), greatly increasing the impact to stream dependent species outside of the immediate burnt area.
15. In 2019-20, following years of drought, catastrophic wildfire conditions culminated in fires that covered an unusually large area of eastern and southern Australia. An analysis showed that 37 % of the distribution of the Giant Barred Frog was affected

NSW Threatened Species Scientific Committee

by these fires (with 13 % burnt in high to very high severity fire), and the estimated proportional population change for this species from pre-fire levels to 1 year after the fire was an overall decline of 10 % from pre-fire levels, but that the decline could be as large as 37 % (bound of 80 % confidence limits; Legge *et al.* 2021). 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' is listed as a Key Threatening Process under the Act.

16. Climate projections for eastern Australia include reduced rainfall, increased average temperatures, and more frequent droughts. These conditions will increase the scale, frequency and intensity of wildfires (CSIRO 2007; CSIRO and Bureau of Meteorology 2015) and could negatively impact the duration and seasonality of stream breeding sites (Lemckert and Penman 2012). Climate change impacts are compounded by the Giant Barred Frog's restricted area of occupancy, low population density at sites (particularly within the south of the species' range), short generation length (4–5 years), and large body size. These variables are identified as increasing the risk of local extinction (Oza *et al.* 2012; Hagger *et al.* 2013; Pearson *et al.* 2014) and are amongst the strongest predictors of species' vulnerability to climate change (Pearson *et al.* 2014). Therefore, it is considered that the Giant Barred Frog is highly vulnerable to climate change, having the physiological and ecological traits that confer both low resistance and low resilience to climate change (Hagger *et al.* 2013; Tanner-McAllister *et al.* 2018). 'Anthropogenic climate change' is listed as a Key Threatening Process under the Act.
17. Large-scale clearing has resulted in the remaining subtropical rainforest of south-east Queensland and north-east NSW being reduced to a discontinuous arc along the Great Dividing Range (Hagger *et al.* 2013). Within this habitat, much of the Giant Barred Frog's distribution is on private land, outside of the protection of National Parks and Wildlife Service estates and riparian zone protection within State Forests, and in the lower reaches of streams that are the focus of agricultural and rural residential development (Hines 2012; OEH 2017). The Giant Barred Frog is impacted by disturbance (Hero and Morrison 2004). Lemckert (1999) observed that the species is found more frequently at sites surrounded by a high proportion of undisturbed vegetation. The Giant Barred Frog is absent in forests in early stage of regeneration but can inhabit regenerated forests, irrespective of how extensive the original disturbance may have been. The Giant Barred Frog is predominantly found in a limited range of wet forest types (Lemckert 1999; Lemckert and Brassil 2000; Meyer *et al.* 2001; Hines 2012). This specialisation, together with the noted fragmentation of the population (OEH 2017; DOE 2020), the low number of individuals at localities (particularly within the south of the species range; OEH 2017), its sensitivity to disturbance (Lemckert 1999; Hero and Morrison 2004), and its low dispersal ability (Lemckert and Brassil 2000; Koch and Hero 2007; OEH 2017), increases the Giant Barred Frog's susceptibility to local extinction due to

NSW Threatened Species Scientific Committee

land clearing (Lemckert 1999; Lemckert and Brassil 2000; OEH 2017). 'Clearing of native vegetation' is listed as a Key Threatening Process under the Act.

18. Disease appears to have already greatly impacted the population of the Giant Barred Frog, with a decline in the 1970s to 1990s likely the result of Chytridiomycosis, an infectious disease caused by the amphibian chytrid fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*) (Ingram and McDonald 1993; Laurance *et al.* 1996; NSW Scientific Committee 1999; Goldingay *et al.* 1999; Hero and Morrison 2004; Hines 2012; Berger *et al.* 2016). The Giant Barred Frog is known to carry chronic infections of *Bd*, with Ingram and McDonald (1993) suggested that species abundance dropped by up to 90 % across its geographic range, largely as a result of disease (later identified as chytridiomycosis). While it is unclear whether Barred Frogs are continuing to decline from *Bd* infection (Hunter and Gillespie 2011; OEH 2017), there is no evidence that *Bd* has disappeared from any location in eastern Australia (Voyles *et al.* 2009; Newell *et al.* 2013), acquired immunity towards *Bd* in frogs has not been demonstrated, and frogs have been shown to become reinfected even after multiple exposures (Murray *et al.* 2009; Cashins *et al.* 2013; Berger *et al.* 2016). This means that the threat to the Giant Barred Frog from *Bd*, especially subpopulations at higher elevations in mesic environments appearing to be more susceptible to decline (Laurance *et al.* 1996; Hero and Morrison 2004; Skerratt *et al.* 2010; Hero *et al.* 2015), remains high. 'Infection of frogs by amphibian chytrid causing the disease chytridiomycosis' is listed as a Key Threatening Process under the Act.
19. Based on ongoing threats and the impacts from the 2019-20 bushfires, the Giant Barred Frog population is projected to continue to decline in EOO, AOO, extent and quality of habitat, number of locations or subpopulations, and number of mature individuals (Hero *et al.* 2006). In particular, the already isolated and scattered nature of the subpopulations (NSW Scientific Committee 1999; Hines and the South-east Queensland Threatened Frogs Recovery Team 2002), together with the low dispersal ability (and associated poor recolonisation potential) of the species (Lemckert and Brassil 2000), reduces the likelihood of recovery from future extreme events associated with land-clearing, climate change, or disease (Hagger *et al.* 2013).
20. The Giant Barred Frog, *Mixophyes iteratus* Straughan, 1968 is not eligible to be listed as an Endangered or Critically Endangered species.
21. The Giant Barred Frog, *Mixophyes iteratus* Straughan, 1968 is eligible to be listed as a Vulnerable species as, in the opinion of the NSW Threatened Species Scientific Committee, it is facing a high risk of extinction in Australia in the medium-term future as determined in accordance with the following criteria as prescribed by the *Biodiversity Conservation Regulation 2017*:

NSW Threatened Species Scientific Committee

Assessment against *Biodiversity Conservation Regulation 2017* criteria

The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome: Vulnerable under Clause 4.3 (c)(d)(e i,ii,iii,iv).

Clause 4.2 – Reduction in population size of species

(Equivalent to IUCN criterion A)

Assessment Outcome: Data deficient.

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| (1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon: | | | |
| | (a) | for critically endangered species | a very large reduction in population size, or |
| | (b) | for endangered species | a large reduction in population size, or |
| | (c) | for vulnerable species | a moderate reduction in population size. |
| (2) - The determination of that criteria is to be based on any of the following: | | | |
| | (a) | direct observation, | |
| | (b) | an index of abundance appropriate to the taxon, | |
| | (c) | a decline in the geographic distribution or habitat quality, | |
| | (d) | the actual or potential levels of exploitation of the species, | |
| | (e) | the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites. | |

Clause 4.3 - Restricted geographic distribution of species and other conditions (Equivalent to IUCN criterion B)

Assessment Outcome: Vulnerable under Clause 4.3 (c)(d)(e i,ii,iii,iv).

| | | | |
|--|-----|---|---|
| The geographic distribution of the species is: | | | |
| | (a) | for critically endangered species | very highly restricted, or |
| | (b) | for endangered species | highly restricted, or |
| | (c) | for vulnerable species | moderately restricted, |
| and at least 2 of the following 3 conditions apply: | | | |
| | (d) | the population or habitat of the species is severely fragmented or nearly all the mature individuals of the species occur within a small number of locations, | |
| | (e) | there is a projected or continuing decline in any of the following: | |
| | | (i) | an index of abundance appropriate to the taxon, |
| | | (ii) | the geographic distribution of the species, |
| | | (iii) | habitat area, extent or quality, |
| | | (iv) | the number of locations in which the species occurs or of populations of the species, |
| | (f) | extreme fluctuations occur in any of the following: | |

NSW Threatened Species Scientific Committee

| | | |
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| | (i) | an index of abundance appropriate to the taxon, |
| | (ii) | the geographic distribution of the species, |
| | (iii) | the number of locations in which the species occur or of populations of the species. |

Clause 4.4 - Low numbers of mature individuals of species and other conditions

(Equivalent to IUCN criterion C)

Assessment Outcome: Not met.

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| The estimated total number of mature individuals of the species is: | | |
| (a) | for critically endangered species | very low, or |
| (b) | for endangered species | low, or |
| (c) | for vulnerable species | moderately low, |
| and either of the following 2 conditions apply: | | |
| (d) | a continuing decline in the number of mature individuals that is (according to an index of abundance appropriate to the species): | |
| | (i) | for critically endangered species very large, or |
| | (ii) | for endangered species large, or |
| | (iii) | for vulnerable species moderate, |
| (e) | both of the following apply: | |
| | (i) | a continuing decline in the number of mature individuals (according to an index of abundance appropriate to the species), and |
| | (ii) | at least one of the following applies: |
| | (A) | the number of individuals in each population of the species is: |
| | (I) | for critically endangered species extremely low, or |
| | (II) | for endangered species very low, or |
| | (III) | for vulnerable species low, |
| | (B) | all or nearly all mature individuals of the species occur within one population, |
| | (C) | extreme fluctuations occur in an index of abundance appropriate to the species. |

Clause 4.5 - Low total numbers of mature individuals of species

(Equivalent to IUCN criterion D)

Assessment Outcome: Not met.

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| The total number of mature individuals of the species is: | | |
| (a) | for critically endangered species | extremely low, or |
| (b) | for endangered species | very low, or |
| (c) | for vulnerable species | low. |

**Clause 4.6 - Quantitative analysis of extinction probability
(Equivalent to IUCN criterion E)**

Assessment Outcome: Data deficient.

| The probability of extinction of the species is estimated to be: | | | |
|--|-----|-----------------------------------|--------------------|
| | (a) | for critically endangered species | extremely high, or |
| | (b) | for endangered species | very high, or |
| | (c) | for vulnerable species | high. |

Clause 4.7 - Very highly restricted geographic distribution of species–vulnerable species

(Equivalent to IUCN criterion D2)

Assessment Outcome: Not met.

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| For vulnerable species, | the geographic distribution of the species or the number of locations of the species is very highly restricted such that the species is prone to the effects of human activities or stochastic events within a very short time period. |
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Chairperson
NSW Threatened Species Scientific Committee

Supporting Documentation:

Threatened Species Scientific Committee (TSSC) (2021). Conservation Advice *Mixophyes iteratus* Giant Barred Frog. Department of Agriculture, Water, and the Environment, Canberra, Australia.

NSW Threatened Species Scientific Committee

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NSW Threatened Species Scientific Committee

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NSW Threatened Species Scientific Committee

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NSW Threatened Species Scientific Committee

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