

THREATENED SPECIES SCIENTIFIC COMMITTEE

Established under the *Environment Protection and Biodiversity Conservation Act 1999*

The Minister approved this conservation advice and included this species in the Endangered category, effective from 13/11/2021

Conservation Advice

Phyllorhina kundagungan

Mountain Frog

Taxonomy

Conventionally accepted as *Phyllorhina kundagungan* Ingram & Corben, 1975.

Summary of assessment

Conservation status

Endangered: Criterion B2(a)(b)(i,ii,iii,iv,v) and Criterion C1.

The highest category for which *Phyllorhina kundagungan* is eligible to be listed is Endangered.

Phyllorhina kundagungan has been found to be eligible for listing under the following categories:

Criterion 1: A4(c)(e): Vulnerable

Criterion 2: B2(a)(b)(i,ii,iii,iv,v): Endangered

Criterion 3: C1: Endangered

Species can be listed as threatened under state and territory legislation. For information on the listing status of this species under relevant state or territory legislation, see

<http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>

Reason for conservation assessment by the Threatened Species Scientific Committee

This advice follows assessment of new information provided to the Committee to list the Mountain Frog.

Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 33 business days between 10 June 2020 and 24 July 2020. Any comments received that were relevant to the survival of the species were considered by the Committee as part of the assessment process.

Species/sub-species information

Description

The Mountain Frog is a small, squat, pear-shaped frog with a snout-to-vent length (SVL) to 28 mm. The skin is smooth with the occasional low ridge or tubercle present in some specimens, with the frequency of individuals with tubercles increasing to the south of the distribution range. Like other *Phyllorhina* species, individuals are variable in colour and pattern. The dorsal surface can be a base colour of yellow, orange, bright red, or black with patches of alternative colours. Two black V-shaped markings may be present on the back above the groin. In about half of the specimens, a pair of raised ridges is present, starting behind the eye and continuing posteriorly about a third of the way along the dorsum. The ventral surface is usually yellow or red with smaller patches of either colour, including a red patch on the throat and/or sides of the belly. Brown patches and white dots are also sometimes present. The under surfaces of the limbs range from yellow to yellow with a red or brown wash. Small, irregular-shaped, white marks are visible when the limbs are a darker colour. A black patch is present covering the cloaca and sometimes the adjacent upper thighs or entire upper thighs. The head is wider than it is long, and the snout is bluntly rounded. The tympanum is indistinct. A

dark facial stripe is present in about half the specimens, running from near the tip of snout, crossing the eye, and through to the base of the shoulder. The eyes are brown and prominent. The hind-limbs are short and stocky, and the arms are more robust in males than females. The fingers and toes are unwebbed. Breeding males have a poorly developed nuptial pad on the first finger, and females have spatula-shaped first and second fingers. The description of the adult is drawn from Knowles et al. 2004; Cogger 2014; Anstis 2017; and OEH 2019.

Tadpoles are small, growing to 22 mm in total length. The body is very small (5.5 mm) and oval, with the abdomen wider than it is deep. At later stages, the body turns darker with increased grey pigmentation, but the intestinal mass remains visible. The snout is rounded. The eyes are lateral in earlier stages, dorso-lateral later. The oral disc edges are slightly keratinised. The fins are clear with numerous blood vessels. The dorsal fin begins from just onto the body. Both the dorsal and ventral fins are shallow along the length of the tail with the tail-tip broadly rounded (Anstis 2017).

Distribution

The Mountain Frog has a restricted geographical range. It is known from a few mid-high elevation (above 700 m) breeding sites, within a small area of the Gondwana rainforests, either side of the Queensland-New South Wales (NSW) border. The Mountain Frog is known to be distributed from the Mistake Mountains in the Main Range National Park (NP), south-east Queensland to Beaury State Forest (SF), north-east NSW (Knowles et al. 2004; Parris 2004; Cogger 2014; Anstis 2017; Bolitho 2018). The Main Range NP contains the majority of the population (L Bolitho pers comm, cited in Newell 2018). However, a PhD thesis by L. Bolitho (unpublished) is expected to increase both the number of localities and records of the species. Specific details of the localities of Mountain Frog breeding sites are not disclosed in this document to minimise the risk of disturbance. Within the Main Range NP, peaks are not particularly high, with the highest peak measuring 1375 m. This effectively limits the available habitat the Mountain Frog can shift to in response to increased temperatures associated with climate change.

Relevant biology/ecology

The biology and ecology of the Mountain Frog are not fully understood. Further studies are required to provide information on population (size, structure, and dynamics), habitat requirements, and breeding biology. However, the habitat and reproductive biology of all *Phyllorhina* species are recognised as being similar and can be described in general (Hollis 2004; Knowles et al. 2004).

Habitat

The Mountain Frog is restricted to mid-high elevations (above 700 m) throughout its range. At these elevations, the habitat is characterised by cooler temperatures and greater moisture content due to high rainfall and cloud interception (Laidlaw et al. 2011; Hero et al. 2015). The Mountain Frog is found in highly localised distributions, usually in close association with rainforest streams (Knowles et al. 2004). Most records are from individuals found under rocks or leaf litter in the boggy margins of first and second order streams in upland rainforests (Knowles et al. 2004; Cogger 2014; Anstis 2017). Although, in a few instances, the species is also known from seepages in adjacent wet sclerophyll forest (H Hines 2020. pers comm 14 May). There are no records of the Mountain Frog from cleared or highly modified habitats.

Breeding

The Mountain Frog is a terrestrial breeding species and does not use water bodies for tadpole development (instead it lays its eggs in water-filled cavities). Breeding is known to occur in late August to early December (Anstis 2017; M Mahony 2020. pers comm 15 April). Males call from nest sites with a low-pitched, resonant, deep, guttural 'ork' (Lemckert & Mahony 2008; Hoskin et al. 2009; Anstis 2017). Breeding congregations are small. Surveys have recorded maximum group sizes from eight to eleven males at any one site (Knowles et al. 2004; Hines unpublished data; Schulz et al. (unpublished data from Queensland Government's WildNet database); H Hines 2020. pers comms 14 May).

Willacy et al. (2015) observed calling for *P. richmondensis* (Richmond Mountain Frog) to be primarily influenced by spring and early summer rainfall events, with the highest frequency of calling overlapping with temperatures between 15–16 °C. It is thought that rainfall cues *Phyloria* species to commence calling in response to increased nest moisture, which provides a suitable environment for egg and tadpole survival (Knowles et al. 2004; Lopez 2016; Newell 2018).

Females lay a small clutch of eggs (under 50) in the nest (Knowles & Mahony 2004). At the time of egg-laying, the female excretes a jelly like mucous and beats air bubbles into it, and the contained eggs, with her flanged fingers. Over time, the resulting foam loses its bubbles to become a still jelly but, whilst present, the foam provides adequate oxygen for the early embryo stage (Seymour et al. 1995; Knowles et al. 2004; Anstis 2017).

Tadpoles (and at least one parent) remain in the nest throughout their entire development until they emerge post-metamorphosis. While in the nest, tadpoles develop in a mixture of jelly and the very shallow water that drains through the nest (Hollis 2004; Knowles et al. 2004; Anstis 2017). Tadpoles are non-feeding and rely upon a residual yolk reserve for nutrition (Hollis 2004; Knowles et al. 2004; Hero et al. 2015).

Behaviour

There are no detailed studies on movement patterns of the Mountain Frog. However, Newell (2018) observed that *Phyloria* species rarely move far from nest sites. Tracking of the related *P. frosti* (Baw Baw Frog) showed the range of movement to be relatively small (0–11 m² in breeding periods and approximately 3–1000 m² post-breeding season). This conforms to studies on other amphibians that show most species do not move further than several hundred metres from their breeding sites (Hollis 2004).

The diet of adult Mountain Frogs is not known. Other *Phyloria* species feed on Hymenoptera species (sawflies, wasps, bees, and ants), Collembola species (wingless arthropods), Arachnia species (spiders), Amphipoda species (crustaceans), Orthoptera species (crickets), Diptera species (true flies), Coleoptera species (beetles), Hemiptera species (true bugs), and insect larvae (Lima et al. 2000).

Threats

Table 1: Threats impacting the Mountain Frog in approximate order of severity of risk, based on available evidence.

Threat factor	Threat type and status	Evidence base
Climate Change		
Increased temperature intensity/frequency and change to precipitation patterns	Known current	Climate change is expected to cause a pronounced increase in extinction risk for frog species over the coming century, with terrestrial breeding frogs identified as some of the most vulnerable taxa (Hero et al. 2005; Lemckert & Penman 2012; Hagger et al. 2013; Pearson et al. 2014; Lopez 2016). 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 & Bureau of Meteorology 2015) and could negatively impact the breeding success of the Mountain Frog. Rainfall and temperature have been observed to influence

		<p>the duration and frequency of male choruses (Hollis 2004; Willacy et al. 2015; Lopez 2016) and a change in pattern could shorten the breeding season. In addition, any reduction in nest moisture may impact egg and larval development (Lemckert & Penman 2012).</p> <p>Studies have suggested a continuing contraction of climate suitable envelopes for subtropical rainforest by 2050, isolating remnant vegetation and dependent animals to small pockets along ranges (Mellick et al. 2013; Lopez 2016). In addition, shifts in distribution to higher altitudes by endemic montane communities (mirroring any increase in temperature) may cause further geographical range contraction and increase the risk of extinction (Hagger et al. 2013; Lopez 2016).</p> <p><i>Philoria</i> species may be buffered from climate change due to inhabiting closed canopy rainforests (which are a thermally stable environment) (Lopez 2016) and through their burrows, where a barrier of soil and water further reduces temperature extremes (Willacy et al. 2015; Lopez 2016). Despite this buffering, impacts from climate change have been observed. Patch occupancy surveys failed to detect frogs at formerly known lower elevation sites during the 2017-19 breeding seasons, with prolonged drought conditions thought to be responsible for frog absence (D Newell 2020. pers comm 15 April).</p>
<p>Increased intensity/frequency of bushfire</p>	<p>Known current</p>	<p>Climate projections for eastern Australia of higher temperatures and change to rainfall patterns will increase the scale, frequency, and intensity of wildfires in the region (CSIRO 2007; CSIRO & Bureau of Meteorology 2015). Localised extinction of frogs has been observed through wildfire events. However, as a burrowing species, the Mountain Frog may face a reduced threat.</p> <p>In 2019-20, following years of drought (DPI 2020), catastrophic wildfire conditions culminated in fires that covered an unusually large area of eastern and southern Australia. An analysis by a team from the National Environmental Science Program (NESP) Threatened Species Recovery (TSR) Hub showed that 47 % of the distribution of the Mountain Frog was affected by these fires (with 8 % 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 19 % from pre-fire levels, but that the decline could be as large as 34 % (bound of 80 % confidence limits) (Legge et al. 2021). This sort of event is increasingly likely to reoccur as a result of climate change.</p>

Habitat loss and fragmentation		
Vegetation clearance/habitat fragmentation	Known current	<p>Due to large-scale clearing, much of the remaining subtropical rainforest of south-east Queensland and north-east NSW occurs in a discontinuous arc along the Great Dividing Range (Hagger et al. 2013). This clearing is likely to have substantially reduced the distribution range of the Mountain Frog (Knowles et al. 2004).</p> <p>Much of the remaining Mountain Frog habitat is protected within the National Park network (over 70 %) with the core distribution located in the Main Range NP. However, despite this protection, disturbance still poses a threat to Mountain Frog habitat. Historical disturbance (grazing, logging and wildfire) has opened the canopy in some areas of Main Range NP and encouraged weeds to establish in the understorey. These weeds have expanded into undisturbed areas and reduced habitat quality (DNPRSR 2013). In addition, logging has occurred in the immediate vicinity of known Mountain Frog sites (Knowles et al. 2004), large areas of plateau rainforest have been converted to plantation forestry, and a commercial ecotourism venture is being developed in Main Range NP (DES 2020). Compounding habitat loss through disturbance, an anticipated decline in the amount of montane rainforest habitat is predicted under moderate (RCP6.0) and extreme (RCP8.5) climate change scenarios (Lopez 2016).</p> <p>The Mountain Frog population is severely fragmented, encompassing several habitat fragments that are geographically isolated from each other. In the Main Range NP, the population is naturally fragmented (given the species strong association with drainage lines) with sites located over its length (Knowles et al. 2004). This fragmentation continues south into NSW, where isolated sites are identified in three separate National Parks (OEH 2019). This fragmentation, together with the probable low dispersal ability of the species (and associated poor recolonisation potential) (Newell 2018), reduces the likelihood of recovery from future extreme events (Hollis 2004; Hagger et al. 2013) and is recognised as a major threat to the persistence of the Mountain Frog (OEH 2019).</p>
Disease		
Chytridiomycosis caused by chytrid fungus	Known current	Chytridiomycosis is an infectious disease caused by the amphibian chytrid fungal pathogen <i>Batrachochytrium dendrobatidis</i> (<i>Bd</i>). Infected subpopulations exhibit diverse susceptibility to <i>Bd</i> . Some species do not exhibit any apparent symptoms whilst others are extremely vulnerable,

		<p>resulting in mass die-off and extinction (DOEE 2016).</p> <p>The Mountain Frog has been identified as having the greatest susceptibility to <i>Bd</i>-infection of all the <i>Philoria</i> species (Murray & Skerratt 2012). Sampling across its geographical range showed infection prevalence at 48 %, with 11 of 19 sampled headwater streams containing infected individuals (Bolitho et al. unpublished). In addition, the Mountain Frog is found at mid-high elevations and in close association with rainforest streams (Knowles et al. 2004), where environmental conditions are suitable for <i>Bd</i>, raising the chance of infection (Hero & Morrison 2004; Skerratt et al. 2010; Hero et al. 2015; Lopez 2016). However, there is no evidence of <i>Bd</i> related declines for the species and its disappearance from historical sites is thought to be related to climate change (drought) rather than disease.</p> <p>Eradicating <i>Bd</i> is difficult. Some amphibian species are reasonably tolerant, acting as a natural reservoir, spreading the pathogen, which persists even at low host densities. There is no evidence that <i>Bd</i> has disappeared from any known location in eastern Australia (Voyles et al. 2009; Newell et al. 2013).</p>
Invasive species		
Invasive weeds	Potential current	<p>In the distribution range of the Mountain Frog, significant areas of Lantana (<i>Lantana camara</i>), Crofton Weed (<i>Ageratina adenophora</i>) and Mistflower (<i>A. riparia</i>) infestations occur. Other encroaching noxious weeds include Madeira Vine (<i>Anredera cordifolia</i>), Moth Vine (<i>Araujia sericifera</i>), Blackberry (<i>Rubus fruticosus</i>), Annual Ragweed (<i>Ambrosia artemisiifolia</i>), and exotic grasses (DNPRSR 2013).</p> <p>The effect of these weeds is not known, but they may have negative impacts on the thermal buffering provided by the rainforest canopy (Lopez 2016); the suitability of areas for egg laying; and the composition of invertebrate assemblages, which are an important component of the diet of <i>Philoria</i> species (Lima et al. 2000). In addition, many of the exotic grasses were introduced to Australia for cattle grazing because of their high biomass. They compete with native species and can produce very high fuel loads, leading to higher intensity wildfires that can damage native vegetation and impact wildlife (DNPRSR 2013).</p>
Invasive fauna	Potential current	Feral Pigs (<i>Sus scrofa</i>) and domestic cattle are known in the Main Range NP where their grazing

		<p>on native vegetation, trampling, and use of breeding habitat as wallows is a potential threat (DNPRSR 2013; DOEE 2017). Strategic fencing has removed this impact from known habitat along some breeding sites (H Hines 2020. pers comm 14 May).</p> <p>The extent of predation by the feral cat on the Mountain Frog is unknown. However, a study by Woinarski et al. (2020) indicated that nearly 100 million frogs are killed annually in Australia by the feral cat. Compounding this predation rate, in the aftermath of a fire, survivors may be isolated in an environment without shelter and thereby become far easier to catch (Leahy et al. 2015; McGregor et al. 2015). In addition, the number of predators attracted to the area (Hradsky et al. 2017) and predator activity (Leahy et al. 2015) increase where habitat has been modified through frequent or intense burning.</p>
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How judged by the Committee in relation to the EPBC Act criteria and regulations

Criterion 1. Population size reduction (reduction in total numbers)			
Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4			
	Critically Endangered Very severe reduction	Endangered Severe reduction	Vulnerable Substantial reduction
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3, A4	≥ 80%	≥ 50%	≥ 30%
<p>A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.</p> <p>A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.</p> <p>A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(a) cannot be used for A3]</p> <p>A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.</p>	<p><i>based on any of the following:</i></p> <ul style="list-style-type: none"> (a) direct observation [except A3] (b) an index of abundance appropriate to the taxon (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat (d) actual or potential levels of exploitation (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites 		

Evidence:

Eligible under Criterion 1 A4(c)(e) for listing as Vulnerable.

The generation length of the Mountain Frog is unknown. However, the related Baw Baw Frog (at montane elevations) is believed to have a generation length of 4.5 years (males) and 8.2 years (females) (Hollis 2004). The Mountain Frog is likely to have a shorter generation length than the Baw Baw Frog, as the colder climate in the distribution range of the Baw Baw Frog (endemic to the Central Highlands of Victoria) likely increases the maximum age of individuals. Therefore,

the generation length for the Mountain Frog is tentatively set at four–eight years (with the relevant timescale for this criterion is considered to be 12–24 years) but should be adjusted as ecological knowledge of the species improves.

Threats, in particular climate change, are likely to have resulted in a population decline in the Mountain Frog. Climate change has the greatest impact at higher elevations, which are home to the largest concentration of threatened anuran species (41 percent), with terrestrial breeding frogs identified as some of the most vulnerable taxa (Hero & Morrison 2004; Hero et al. 2005; Lemckert & Penman 2012; Hagger et al. 2013; Pearson et al. 2014; Lopez 2016). The species' small and fragmented range, habitat specialisation of bogs and soaks, together with small clutch sizes and slow growth rates, increase its susceptibility to perturbations under climate change. Small range size and low fecundity are key correlates of extinction risk for Australian frogs (Hero et al. 2005; Murray et al. 2011). The general trend in endemic montane species is to move to higher altitudes, mirroring the increase in temperature. These shifts in distribution may cause geographical range contractions, resulting in a significant reduction of suitable habitat and increased risk of extinction (Hagger et al. 2013; Lopez 2016).

Philoria species are particularly sensitive to drought. The duration and frequency of male mating choruses is influenced by rainfall and temperature (Hollis 2004; Willacy et al. 2015; Lopez 2016), with a change in pattern potentially shortening the breeding season and a reduction in nest moisture possibly impacting egg and larval development (Lemckert & Penman 2012). Severe rainfall deficits can lead to the desiccation of microhabitats and could lead to mortality of juveniles and adults, either through effects on hydration or reductions in their invertebrate prey (Heard et al. 2021). Impacts from climate change have already been observed in the Mountain Frog population. Patch occupancy surveys failed to detect frogs at formerly known lower elevation sites during the 2017-19 breeding seasons, with prolonged drought conditions thought to be responsible for frog absence (D Newell 2020. pers comm 15 April).

The 2019-20 bushfires may have accelerated any population decline, through direct mortality, and the unfavourable post-fire conditions (loss of shelter, increased susceptibility to predators, and loss of prey), as well as a reduction in future recruitment (egg and tadpole death and breeding site degradation). Field studies during the 2020-21 breeding season found evidence of the impact of the 2019-20 bushfires, as well as drought conditions prevailing before the fires. Occupancy analysis showed frogs were significantly less likely to be found at burnt than unburnt sites and calling activity was lower post-fire when compared to before the fire in the 2016-17 breeding season. Two of 14 burnt sites (14 percent) were occupied (compared with 23 of 34 unburnt sites (68 percent), but relatively high counts were recorded (maximum 10), showing the species can survive fire and will attempt to breed in burnt habitat (Heard et al. 2021).

The Mountain Frog's small range size exacerbates its susceptibility to bushfires, for which the probability of impact to the entire range increases significantly as range size narrows. An analysis by a team from the NESP TSR Hub shows that a significant proportion of the range of the Mountain Frog was affected by 2019-20 bushfires: eight percent was burnt in high to very high severity fire, and a further 38 percent was burnt in low to moderate severity fire. A structured expert elicitation process was used to estimate the proportional population change for this species from pre-fire levels to immediately after the fire and then out to three generations after the fire, when exposed to fires of varying severity. These results, combined with the spatial analyses of fire overlap, suggest that one year after the fire, the species has experienced an overall decline of 19 percent from pre-fire levels, but that the decline could be as large as 34 percent (bound of 80 percent confidence limits). After three generations, the estimate for the overall population decline relative to the pre-fire population is predicted to be 31 percent, but potentially as much as 50 percent (bound of 80 percent confidence limit). For comparison, experts also estimated the population change over time in the absence of fire; by three generations, the overall population of the Mountain Frog after the fire was estimated to be 13 percent lower than it would have been had the 2019-20 fires not occurred (Legge et al. 2021).

The impact of *Bd* on the Mountain Frog is uncertain. However, the species has been identified as having the greatest probability of *Bd* infection of all *Phyllorhina* species (Murray & Skerratt 2012), being found at mid-high elevations, and in close association with rainforest streams (Knowles et al. 2004), where environmental conditions are suitable for *Bd* (Hero & Morrison 2004; Skerratt et al. 2010; Hero et al. 2015; Lopez 2016). Sampling across the geographical range has shown infection prevalence at 48 percent, with 11 of 19 headwater streams sampled containing infected individuals. Despite this high rate of infection, no signs of clinical chytridiomycosis has been observed, and there is no evidence of *Bd* related population declines. However, given the typically short duration of clinical chytridiomycosis, and the cryptic nature of the species, this is not unexpected (Bolitho et al. unpublished).

Given the extent of the habitat burnt by the 2019-20 bushfires and the sensitivity of *Phyllorhina* species to drought and fire intensity under climate change (Newell 2018), the Committee considers that the Mountain Frog will undergo a substantial reduction in numbers over three generation lengths (with the time period including both the past and future), equivalent to at least 30 percent, and the reduction and cause have not ceased. Therefore, the species has met the relevant elements of Criterion 1 to make it eligible for listing as Vulnerable.

Criterion 2. Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy			
	Critically Endangered Very restricted	Endangered Restricted	Vulnerable Limited
B1. Extent of occurrence (EOO)	< 100 km ²	< 5,000 km ²	< 20,000 km ²
B2. Area of occupancy (AOO)	< 10 km ²	< 500 km ²	< 2,000 km ²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented OR Number of locations	= 1	≤ 5	≤ 10
(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			
(c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			

Evidence:

Eligible under Criterion 2 B1,B2(a)(b)(i,ii,iii,iv,v) for listing as Endangered.

The Mountain Frog has a restricted geographical range within a small area of montane subtropical rainforest, distributed from the Mistake Mountains in the Main Range NP, south-east Queensland to Beaury State Forest, north-east NSW (Knowles et al. 2004; Parris 2004; Cogger 2014; Anstis 2017). The Mountain Frog has an extent of occurrence (EOO) estimated at 3800 km², and an area of occupancy (AOO) estimated at 48 km². These figures are based on the mapping of point records from a 20 year period (1999-2019), obtained from state governments, museums and CSIRO. The EOO was calculated using a minimum convex hull, and the AOO calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines 2014. The EOO meets the threshold for listing as Endangered under sub-criterion B1 and the AOO meets the threshold for listing as Endangered under sub-criterion B2.

The Mountain Frog population is considered severely fragmented (meeting sub-criterion (a)) with a projected greater than 50 percent of AOO in habitat patches that are not viable and with habitat patches separated by large distance (IUCN 2019). The Mountain Frog population spans several habitat patches that are geographically isolated from one another. The majority of the population is in Main Range NP and is naturally fragmented (given the species strong association with drainage lines and the species limited dispersal ability) with habitat patches separated from each other over its length (Knowles et al. 2004). This fragmentation continues

into NSW where isolated habitat patches are identified in three separate National Parks. This fragmentation is recognised as a major threat to the persistence of the Mountain Frog (OEH 2019), with the NSW Scientific Committee identifying that the species is likely to become extinct unless the circumstances and factors threatening its survival or evolutionary development cease to operate (NSW Scientific Committee 2005).

Based on ongoing threats, the Mountain 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, thereby meeting sub-criterion (b)(i,ii,iii,iv,v). In particular, the small population size, already high degree of isolation of subpopulations (Knowles et al. 2004; OEH 2019), and the low dispersal ability (and associated poor recolonisation potential) of the species (Newell 2018) reduces the likelihood of recovery from extreme events associated with climate change and disease (Hagger et al. 2013) (as identified in Criterion 1).

Climate change has already impacted the population. Prolonged drought is believed to be responsible for absence of frogs at formerly known lower elevation sites during the 2017-19 breeding seasons (D Newell 2020. pers comm 15 April) and the impact of the 2019-20 bushfires is significant, with 47 percent of the distribution range burnt (see Criterion 1).

The Committee considers that the species' extent of occurrence and area of occupancy are restricted, and the geographic distribution is precarious for the survival of the species because its occurrence is severely fragmented, and continuing decline in extent of occurrence, area of occupancy, habitat, number of locations and number of individuals may be inferred or projected. Therefore, the species has met the relevant elements of Criterion 2 to make it eligible for listing as Endangered.

Criterion 3. Population size and decline			
	Critically Endangered Very low	Endangered Low	Vulnerable Limited
Estimated number of mature individuals	< 250	< 2,500	< 10,000
AND either (C1) or (C2) is true			
C1 An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future)	Very high rate 25% in 3 years or 1 generation (whichever is longer)	High rate 20% in 5 years or 2 generation (whichever is longer)	Substantial rate 10% in 10 years or 3 generations (whichever is longer)
C2 An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:			
(a) (i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(a) (ii) % of mature individuals in one subpopulation =	90 – 100%	95 – 100%	100%
(b) Extreme fluctuations in the number of mature individuals			

Evidence:

Eligible under Criterion 3 C1 for listing as Endangered.

The population size of the Mountain Frog is not known with certainty. However, it is considered likely to be under 2500 individuals. Knowles et al. (2004) identified *Philoria* species as among the rarest vertebrates in eastern Australia. The majority of the Mountain Frog population is within Main Range NP with the species considered rare outside of this area (L Bolitho pers comm, cited in Newell 2018). All observations are restricted to a small number of calling males. The

largest number of calling males found at any one site is 11 (Schulz et al. unpublished data; H Hines 2020. pers comm 14 May), and a total of 306 records of the Mountain Frog (across all known sites) are recorded in the Atlas of Living Australia (as of 6 February 2020) (ALA 2020).

A high rate of population reduction of at least 20 percent is projected to occur over the next two generations. The direct and indirect impacts of the bushfires are the primary factors in this decline (See Criterion 1). In addition, the surviving population is further fragmented and less likely to recover from extreme events, such as climate change and disease (Hagger et al. 2013). This level of decline meets the threshold for listing as Endangered under sub-criterion C1.

The Committee considers that the estimated total number of mature individuals of this species is low with a projected continuing decline of at least 20 percent over the next two generations (8-16 years for this assessment). Therefore, the species has met the relevant elements of Criterion 3 to make it eligible for listing as Endangered.

Criterion 4. Number of mature individuals			
	Critically Endangered Extremely low	Endangered Very Low	Vulnerable Low (Medium-term future)¹
Number of mature individuals	< 50	< 250	< 1,000
D2 ¹ Only applies to the Vulnerable category Restricted area of occupancy or number of locations with a plausible future threat that could drive the species to critically endangered or Extinct in a very short time	-	-	D2. Typically: area of occupancy < 20 km ² or number of locations ≤ 5

¹ The IUCN Red List Criterion D allows for species to be listed as Vulnerable under Criterion D2. The corresponding Criterion 4 in the EPBC Regulations does not currently include the provision for listing a species under D2. As such, a species cannot currently be listed under the EPBC Act under Criterion D2 only. However, assessments that demonstrate eligibility for listing under other criteria may include information relevant to D2. This information will not be considered by the Committee in making its assessment of the species' eligibility for listing under the EPBC Act, but may assist other jurisdictions to adopt the assessment outcome under the [common assessment method](#).

Evidence:

Not eligible for listing.

The total number of mature individuals is likely above 1000 (see Criterion 3), which is not considered low. Therefore, the species has not met this required element of this criterion.

Criterion 5. Quantitative Analysis			
	Critically Endangered Immediate future	Endangered Near future	Vulnerable Medium-term future
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

Evidence:

Insufficient data to determine eligibility.

Population viability analysis has not been undertaken.

Conservation actions

Recovery plan

The Committee recommends that a national recovery plan for *Philoria kundagungan* is not required as the species' distribution range is largely contained within Main Range NP, where it is protected as a species of conservation significance. For sites in NSW, a targeted management strategy is being developed under the Saving Our Species program. A national recovery plan would not have a significant conservation benefit above the existing mechanisms, and an approved conservation advice provides sufficient direction to implement priority actions and mitigate against key threats.

Primary conservation actions

2019-20 bushfire response

- As per the guidance developed by Southwell (2020), conduct on-ground surveys to establish the extent of the population response to the 2019-20 bushfires and to provide a baseline for ongoing monitoring. Note: population monitoring should only be conducted during the breeding season, particularly during peak calling activity from late August to early December.
- Protect unburnt areas within or adjacent to recently burnt areas from further fire, in order to provide refuge sites, as well as protecting (from fire) unburnt areas that are not adjacent to burnt areas.
- Control introduced species to support recovery of populations affected by fires or populations near areas that have been affected by fire.
- Control introduced herbivores in burnt areas to support habitat recovery post fire.
- Control weeds and conduct habitat restoration works to support the regeneration of forest and streambank habitat at some localised sites. Note: cutting and pasting/painting methods should be used to control weeds as herbicide formulations can be toxic to frogs and tadpoles, particularly if they contain glyphosate and surfactants (Mann et al. 2003).
- Establish the impact of fire retardants used to fight bushfires on frog populations.

Conservation and management priorities

Habitat loss, disturbance and modifications

- Protect unburnt habitat (as per primary conservation actions).
- Protect breeding sites during the planning and implementation of controlled burns in the region.
- At all sites, minimise human disturbance to the Mountain Frog and its habitat.
- Investigate options for enhancing the resilience of the species' current habitat to climate change and options for providing new habitat that would be suitable for the species under climate change scenarios.
- Identify and conserve landscape characteristics that facilitate movement. Where feasible, connect isolated rainforest patches with corridors of wet forest, particularly along drainage lines in stream headwaters.

- Maintain tracks, particularly board-walks, and relocate recreational activities and roads away from sensitive habitat and breeding sites.

Invasive species (including threats from grazing, trampling, predation)

- In areas burnt by the 2019-20 bushfires, control introduced species (predators, herbivores, and weeds) in localised areas to support species recovery and habitat regeneration.
- Develop and implement longer-term strategies to control introduced predators by implementing eradication programs, where feasible.
- Monitor and control damage to riparian areas by feral pigs. Control numbers and fence key sites, where feasible. This may require a collaborative strategy with surrounding land holders and local government authorities to limit feral pigs from crossing into National Parks.
- Use fencing, or other measures, to reduce the access of domestic stock to stream banks.

Disease

- Investigate measures for minimising the impact of *Bd*-infection on Mountain Frog subpopulations. In particular:
 - Establish the susceptibility of the Mountain Frog to *Bd*, and whether the species has developed an immune response or if the strain is reduced in virulence.
 - Conduct research into mechanisms of frogs' resistance to *Bd* with any identified mechanisms considered in selective breeding methods to produce resistant frogs if reintroductions become necessary.
- Minimise the spread of *Bd*.
 - Implement suitable hygiene protocols (Murray et al. 2011) to protect priority populations as described in the threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis (DOEE 2016).
 - Provide disease identification and prevention protocols (methods of handling, diagnostic keys, etc.) to researchers and land managers for use in the field.
- Investigate options for *Bd* refuge sites, either within or outside of the natural known range of the species that may be used if required.

Stakeholder Engagement

- Provide input into the various impact assessment and planning processes on measures to protect the Mountain Frog and its habitat. These include water resource plans, park management plans and environmental impact assessments.

Survey and Monitoring priorities

- Conduct on-ground surveys to establish the extent of the population response to the 2019-20 bushfires and to provide a baseline for ongoing monitoring. Note: population monitoring should only be conducted during breeding season, particularly during peak calling activity, from late August to early December.
- Undertake regular monitoring for a small number of subpopulations during the breeding season. This survey work should build on patch survey work conducted prior to the

2019-20 bushfires. Note: frogs should not be disturbed at breeding sites under any circumstances.

- Undertake regular broad scale monitoring over the species' known range. Sites should span the altitudinal and latitudinal range and a range of other habitat characteristics. These data will be used to assess the species' status and assess further declines or re-establishment/recovery of subpopulations.

Information and research priorities

- Understand the potential influence of climate change on the long-term survival prospects of the species, due to altered temperatures, rainfall patterns, bushfires, environmental stressors and diseases.
- Model microhabitat usage of this species beyond burrows, by gathering more detailed geo-climatic (e.g. soil moisture) and physiological data (e.g. operative temperatures and water loss).
- Measure the critical thermal limits and preferred temperatures of the species to ascertain its physiological limits, sensitivity and vulnerability. Include potential impacts of temperature on all life stages.
- Investigate options for linking, enhancing or establishing additional populations.
- Improve understanding of the extent and impact of *Bd*-infection on the Mountain Frog to better inform how to apply existing or new management actions relevant to the recovery.
- Investigate population genetics to provide a baseline on effective population size, heterozygosity, and structure among the various populations.
- Assess the effects of fire on Mountain Frog survival and reproduction, including the species' long-term response to major fire events or altered fire regimes, through identifying those parts of its range that are most vulnerable, or conversely, where there are opportunities for enhancing refuges from fire.

Captive breeding/re-establish populations

- Improve understanding of husbandry methods for the species.
- Investigate options for reintroductions if subpopulations continue to become fragmented and isolated, especially if declines continue within isolated subpopulations. Any assisted translocation program should be done via captive reared and released animals. Where not deemed a threat to survival, monitor the movements of individuals via mark-recapture methods, radio tracking, or genetic methods.

Recommendations

- (i) The Committee recommends that the list referred to in section 178 of the EPBC Act be amended by **including** in the list in the Endangered category: *Philoria kundagungan*
- (ii) The Committee recommends that there not be a recovery plan for this species.

Threatened Species Scientific Committee

03/09/2020

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