Addressing specific considerations of the EIS findings and the impact on threatened species of native frogs

Hunter Transmission Project (HTP)

Proponent: NSW EnergyCo

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1. Landscape scale considerations

The cumulative impacts of the HTP proposal on biodiversity values are unacceptably high. It is ironic that to achieve the desirable environmental value of clean energy supply there is such a significant a trade-off against biodiversity values.

This trade-off is not necessary. There is an alternative. That is underground transmission, placed along the current 300 kV transmission route from Eraring to Broke, or another route that passes along already mostly cleared land. The upfront cost of underground cabling is recognised to be higher (AEMO 2022) but the total environmental cost should be considered against a time frame that is over many decades. Once a 70 m easement is constructed through native vegetation communities and managed as open space in perpetuity, there is an on-going impact on biodiversity. The cost is born by the native species that rely on closed forests, unimpeded movement for foraging and breeding and genetic interchange among populations. Underground cabling would not require the costs of clearing and on-going management of a new corridor, it could be placed in the current 300 KV corridor. There would be minimal visual impacts to communities and landowners, and minimal biodiversity impacts post construction. In total, underground cabling would be needed for about 50 km, and various reports indicate that high voltage AC (HVAC) is most affordable at this distance, mostly because it avoids the cost of substations that make direct current more expensive (i.e., converting from AC to DC and back again). There is no doubt that the construction of underground cabling for a 500 KV transmission line is a significant engineering task. Nonetheless the EIS should transparently compare costed alternatives so that the public is informed of the alternatives to such high levels of biodiversity impact.

> *"The Hunter Transmission Project design has prioritised the use of previously disturbed land, with the selection of a corridor within the State forests being a key*

strategy to avoid and minimise impacts on private properties and residential communities". (page 18 HTP Executive Summary).

- Clear statement that impacts on biodiversity values are traded-off against impact on private properties and residential communities. Presumably these impacts are mostly visual amenity and the cost of compensation.
- This is despite the facts that the extent of biodiversity impacts was not available until EIS studies were completed. A decision had already been made on the chosen route.
- There is another solution to visual impact and biodiversity impact → underground cabling. Yes, probably more expensive (but that has not been tested against the cost of constructing a completely new transmission corridor compared to working within an existing corridor). Furthermore, the cost should be considered as a decadal/century costing against the loss and ongoing impact on biodiversity.

"There would be some temporary and permanent impacts during construction. The environmental assessment addresses the potential impacts associated with the construction, operation, decommissioning and rehabilitation of the project, as well as the mitigation measures to avoid and minimise potential impacts." (page 18, HTP Executive Summary).

- This is a considerable understatement when 66 threatened species and 11 Endangered Ecological Communities are impacted to varying degrees.

"Around 207 hectares of native vegetation associated with 7 endangered ecological communities listed as endangered under the NSW Biodiversity Conservation Act 2016 would be cleared. Three threatened ecological communities (158 hectares) are critically endangered under the Environment Protection and Biodiversity Conservation Act 1999.

Two of the directly impacted threatened ecological communities are also identified as potential serious and irreversible impact entities, including 4.22 hectares of poor condition Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions and 12.37 hectares of Warkworth Sands Woodland in the Sydney Basin Bioregion.

Of the directly impacted threatened ecological communities, the largest portion of impact is to the Central Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions threatened ecological community, with around 141.38 hectares of thinned, poor or planted native vegetation to be cleared."

Construction of the project would also have potential direct impacts on:

38 threatened flora species, comprising 22 species listed under the both the NSW *Biodiversity Conservation Act 2016* and *Environment Protection and Biodiversity Conservation Act 1999,* 14 species listed under the NSW *Biodiversity Conservation Act 2016* only, and 2 species listed under the *Environment Protection and Biodiversity Conservation Act 1999* only.

Of these 38 threatened flora species, 8 are potential serious and irreversible impact entities.

28 threatened fauna species, comprising 15 species listed under the both the NSW *Biodiversity Conservation Act 2016* and *Environment Protection and Biodiversity Conservation Act 1999,* 13 species listed under the *Biodiversity Conservation Act 2016.* Of these 28 threatened fauna species, 6 are potential serious and irreversible impact entities" (pg 19. HTP Executive Summary).

Construction of the project also has the potential to result in indirect impacts to native vegetation and threatened species habitat beyond the area of direct impact as well as prescribed impacts associated with regional habitat connectivity where the transmission line intersects native vegetation, including:

inadvertent impacts on adjacent habitat or vegetation including: impact to habitat surrounding caves that are known or potential breeding habitat for threatened microbat species and Sooty Owl, impact to habitat surrounding known locations of Brush-tailed Rock Wallaby populations

- reduced viability of adjacent habitat due to edge effects
- reduced viability of adjacent habitat due to noise, dust or light spill
- transport of weeds, pests and pathogens from the site to adjacent vegetation
- increased risk of starvation, exposure and loss of shade or shelter
- loss of breeding habitats
- trampling of threatened flora species
- increased risk of fire
- increased risk of collision with lines and electric and magnetic field impacts from new infrastructure.

Surface water
"The surface water study area is partially located within the major surface water catchments of the Hunter River, Lake Macquarie and Tuggerah Lakes. The majority of the project impact area ultimately drains to the Hunter River via several major (and minor) watercourses including Wollombi Brook and Congewai Creek."

This is not a full description of the surface water impacts. There is a lack of appreciation of the importance of the headwaters of the Wyong River which is situated where the Olney Substation is proposed to be located. The drainage divide of the Wyong River and Dora Creek form a small, dissected plateau at the northern end of the Central Coast Range. This small plateau and its first order streams and small soaks provide critical breeding habitat for three threatened frog species *(Rawlinsonia (= Litoria) littlejohni, Mixophyes australis* and *Heleioporus australiacus australiacus*) Two of these species have their only regional populations on this plateau.

I have two major concerns regarding the EIS and its outcomes. The first addresses the issues at the larger landscape scale and the second some specific comments on threatened fauna for which I have specific scientific knowledge.

2. Cumulative Impacts on Biodiversity

The EIS lists the total extent of land to be modified directly for the life of the transmission line, indirectly during construction, and indirectly via edge effects associated with creation of a permanent easement. This information can be regarded as totalling the cumulative impacts on biodiversity, but on the other hand the EIS focuses on direct and indirect impacts of individual threatened species and endangered ecological communities (EEC). By taking an individual species and EEC approach the cumulative effect is not addressed, which is quite extraordinary. Impacts are detailed for threatened species and EECs. Creating individual biodiversity offsets, as occurs in the BAM process, fails to address cumulative impacts on ecosystem function, which is the basis of biodiversity resilience. A fundamental of ecology is that all living species form part of a food web, and interconnections are critical to survival, and together the interplay of abiotic and biotic components create ecosystems. Essentially, if this project is to proceed as planned whole communities are altered, and connectivity is broken for that community not just individual species. The predicted impact on so many species indicates a cascading effect on biodiversity (Burris et al 1997), something that is not addressed by the *BA Act*.

3. Specific comments

In this section I address the reported impacts on three threatened frog species *(Rawlinsonia [= Litoria] littlejohni, Mixophyes australis and Heleioporus australiacus australiacus*). Each species is listed as Endangered (EPBC Act).

The approach taken by the EIS is to assess the impact on these frogs by measuring the direct and indirect impacts on their habitats by the extent of measured habitat, and then to apply the BAM offset calculations. <u>This approach fails to consider the HTP impacts in the context of the total distribution or regional distribution of each of these frogs</u>. To be fair this is a failing of the offsetting approach applied in the Biodiversity Assessment Method (BAM, *NSW BA Act*).

Rawlinsonia littlejohni (Littlejohn's Tree Frog)

Mapping the distribution of *R. littlejohni* across its entire range shows that there are only three populations (definition of population follows that of the IUCN Conservation Risk Assessment which is also the definition used in *EPBC Act* assessment). One population is on the Woronora Plateau south of Sydney (extends from Heathcote to the Illawarra escarpment in the south and the Nepean River in the west), the second is on the Kings Tableland in the Blue Mountains World Heritage Area (BMWHA), and the third is in the northern portion of the Central Coast Ranges in Olney State Forest (SF) (Mahony et al 2020, Klop-Toker et al 2022). <u>The extent of the distribution in Olney SF coincides almost directly with the placement of the HTP Olney substation and HTP easement</u>.

It is my assessment that the placement of the HTP infrastructure threatens the ongoing persistence of *R. littlejohni* in the Central Coast Range. It threatens the extinction of one of only three remaining populations of this endangered species. The decline of this frog from its former range has been precipitous (see Mahony et al 2020, and *EPBC Act* Scientific Committee assessment). While the Atlas of Living Australia (ALA) and BioNet show that the species historically occurred at many other locations (e.g., in the south of the Central Coast Ranges at Ourimbah SF, on the Newnes Plateau and in the Blue Mountains region), intensive targeted surveys have failed to detect the species across large areas of its former range (Mahony et al 2020, Klop-Toker et al 2022, Beranek et al 2023) and there are no recordings of the species outside the limited distribution described above, or in the very large citizen science databases (*iNaturalist* and FrogID database of records accessed July 2025).

The only occurrence of *R. littlejohni* in the Central Coast Range is at the northern end of the range. The nearest population geographically is on the Kings Tableland in the BMWHA, and after that the Woronora Plateau. Molecular phylogenetic studies have shown that the populations are isolated and there is no evidence of migration of individuals among these populations (Mahony et. al. 2020, Stock et al 2022). However, the molecular genetic evidence does not indicate that the isolation has been for a sufficient time for speciation to occur and therefore provides evidence that the populations were connected in recent evolutionary times.

What has caused the isolation of these populations? The study by Mahony et al (2020) discusses the role of the amphibian disease chytridiomycosis in the decline and considers evidence that it is highly susceptible to the disease (see Skerratt et al 2007). The most parsimonious explanation for the disjunct distribution, in three widely separated populations, is that they were once interconnected and that interchange of individuals, and genes, occurred regularly. Otherwise, the gene pools would be greatly divergent. If this explanation is accepted the scenario is that an extensive decline in the geographic distribution of this formerly once widespread species has occurred in the past 20 to 30 years, most likely caused by the amphibian disease chytridiomycosis. Furthermore, the conservation risk assessment (*EPBC Act, and IUCN Conservation Risk Assessment Guidelines 2019*) indicates that the decline is ongoing if not halted or reversed the species is predicted to be extinct within 50 years.

The EIS maps the habitat of the frog which will be affected by the Substation and HTP easement (Figure 14.14) without any context of the total distribution of the frog in the area. <u>The context is that the area impacted is almost the total distribution of the frog in the Central Coast Range</u>. It is not as if there are hundreds of hectares of habitat and the impact, is say, 10 or 20% of that total, in this case the impact is above 80% of the known habitat in the Central Coast Range. The assessment should include an understanding of the scale of that impact on the regional distribution of the species. In reality the outcome is likely to be the extinction of this population and therefore one-third of the known populations of this species.

Rawlinsonia littlejohni is a habitat specialist, it breeds only in still waters, ephemeral and permanent ponds. In nature in the Central Coast Range these ponds occur only in the first order streams on the upper elevations of the small plateau that exists at the northern end of the range. That location is in Olney SF, and it is the very site where the substation and transmission corridor are proposed. The plateau is drained to the south and southwest by small streams at the headwaters of the Wyong River and to the north and northeast by headwaters of Dora Creek, and at the drainage divide are less than 100 m apart.

The frog is also recognised as being forest dependent. There are no known records of this frog from cleared land. It does occur in a range of forest types, including heaths and dry forests, but never from open land. It is most unlikely that the frog will persist where a transmission corridor which is cleared or reduced to a shrub layer occurs.

It is also known that this frog will breed in human constructed forest dams (fire dams) (Lemckert et al 2005; Stock et al 2022). This observation was fundamental to conservation actions to build resilience for this endangered frog by adding human made ponds at specific locations in the forest. This approach was commenced after the wildfires of 2019-2020 when evidence indicated that the frog was threatened with extinction from possible catastrophic environmental events such as severe wildfires (Legge et al 2022a, 2022b Ward et al 2020, Mahony et al 2022, 2023, Beranek et al 2023. Sopniewski et al 2025).

Major works proposed for the HTP (substation placement and construction, transmission corridor and associated road and access infrastructure) on the relatively small plateau in the north of the Central Coast Ragne (Olney SF) will disrupt the natural hydrology of the headwater streams and therefore directly impact the natural breeding sites used by Littlejohn’s frog. Construction of the transmission corridor will bisect known breeding sites, and it is unlikely that the frogs will cross open areas created by the corridor.

It is valuable to consider why this frog persists in one relatively small area of forest at the Central Coast Range. Why is it that the frog does not occur in forest habitats in Watagan NP, or in some old growth areas of Jilliby Conservation Area?

Various hypotheses have been considered (see Mahony et al 2020, Stock et al 2022, 2023, Scheel et al 2015; Duncan et al 2025), and it is most likely that the species persists where is does because the habitat and climate provide a refuge where the species can overcome the amphibian disease chytridiomycosis. This is because the fundamental niche of the disease and the frog do not overlap in some habitats. It is only in these habitats where the frog persists. The frog survives on a knifes edge. There are some abiotic and biotic features in the local environment of the northern end of the Central Coast Range (Olney SF) that provides the frog with habitat where it can resist infection. Laboratory studies show the frogs are highly susceptible to the disease (University Newcastle, K Klop-Toker unpublished data), so their persistence is not because they have some innate immunity.

In numerous other cases where frogs persist with the disease pathogen it is often a warmer climate or some feature of the water quality that enable persistence (see Duncan et al 2025). Persistence occurs where it does because of unique environmental attributes found only at that site. The exact mixture of those attributes remains poorly understood. What is evident is that a major environmental disturbance such as that proposed by placement of a substation and easement through the known distribution is unacceptable based on the principle of precaution. In this case it is not an application of the precautionary principle, as is often the case because of the unknown, but what is known. Direct evidence that this species has in the past and continues to exhibit rapid declines over a vast area of formerly occupied habitat. It follows that at sites where it persists every effort should be made not to disturb the natural system.

Using population genetic analysis to assess the conservation of *R. littlejohni*, Stock et al (2022, 2023) showed that the Olney population lacked genetic diversity (low heterozygosity values) and sub-populations were isolated. Low genetic diversity occurs when a population is reduced to such an extent that mating occurs between close relatives or at some stage in the recent past the population has been so reduced in size that only a few individuals contribute to the gene pool. This in turn leads to inbreeding depression. The evolutionary consequences of inbreeding are a reduction in individual fitness which often leads to the gradual decline of a population. The outcome of these population genetic investigations demonstrates that the Central Coast Range population of *R. littlejohni*, is facing what is referred to as the extinction vortex. It is this scientific information along with the detailed evidence of its decline in distribution and abundance that was used to nominate the species for listing at Endangered under the *EPBC* and *BA Acts*. What is the use of having threatened species legislation when it is is ignored in planning decisions. All the available information in this case indicates that a decision on the route of the HTP was made without adequate investigation of the biodiversity impacts. A decision made to avoid other unpalatable impacts.

Stochastic Environmental Events: Extinction is often related to one or a few major environmental catastrophes. The wildfires of 2019-20 which followed a prolonged drought and the highest maximum seasonal and annual temperatures in eastern Australian represent such a combination of events. Several studies demonstrated that for forest dependent species, such as this frog species, there was a high likelihood that they would be impacted by high severity wildfire (Abrams et al 2020, Ward et al 2020, Collins et al 2021, 2021, Legge et al 2022, Mahony et al 2022). With such widespread and severe fires this environmental catastrophe could lead to the extinction of populations from a region and thereby increase the conservation risk of extinction for the species (Ward et al 2020, Legge et al 2022). During the 2019-2020 megafires the only large portions of the Sydney Basin (apart from urban areas) that did not burn to some extents were the Central Coast Range and the

Woronora Plateau (GBAMM Fire severity mapping _ NPWS_SEED). Much of the Blue Mountain WHA that is directly to the west of the Central Coast Range burnt in what is known as the Gosper's Mountain fire (NSW NPWS World Heritage Report 2021). This fire approached the northern end of the Central Coast Range from Corrabare SF, and in the southwest from the Hawkesbury Valley immediately to west of Mangrove Mountain (south of Kulnura and Mangrove Mountain). The fire did not move into the Central Coast Range due to a fortunate change in weather and the work of fire crews. It was only a matter of good fortunate that the fire did not extend to two of the remaining refuges of *R. littlejohni*. As a habitat specialist that relies on forests this species was predicted to be highly susceptible to severe and intense wildfires (Mahony et al 2023, Rumpff et al 2023). Extensive monitoring of the impact of the wildfires on *R. littlejohni* in the BMWHA and of its close sibling species *R. watsoni* in the Illawarra region found significant impacts on both species where they coincided with severe wildfire (Beranek et al 2023, Mahony et al 2023, Daly et al 2024).

Populations of any species that occur in small and isolated distributions face a heightened risk of threat from stochastic environmental events, be that fire or any other event (e.g. drought). <u>There is no consideration in the EIS of the increased risk that the threatened frog populations face because of fragmentation and isolation of habitats that will occur because of the proposal</u>.

Conservation actions post the 2019-2020 wildfires: Leveraging on the observation that Littlejohn's frogs will breed in human constructed fire water dams, the University of Newcastle in collaboration with Forest Corporation NSW embarked on a "breeding habitat enhancement project" to increase the number of breeding sites, and to bridge the distance between two known breeding areas (about 3 km apart) in Olney SF. The overall aim was to add demographic and genetic resilience to the population by increasing abundance, local distribution, and connectivity. Prior to the habitat enhancement, population genetics investigations had indicated that there was little or no movement between these two breeding sites (Stock et al 2022, 2023, Nolan et al 2025). Ponds of suitable size and hydrological characteristics were constructed at selected sites and to bridge the gap between the two separate sites. Individuals were translocated between the populations to increase population genetic diversity. These actions were conducted in an experimental process to be able to assess the effectiveness of the conservation actions. The project involved collaboration with Forest Corporation NSW ecologists and NSW NPWS Saving Our Species officers. Funding for on-ground works came from NSW Environmental Trust Grant (Callen and Klop-Toker, UoN) and a multi-partnered DAWE post fire restoration grant (Mahony, Beranek, Callen, Klop-Toker – UoN; Rowley - Aust Mus; Donnellan -SAM, Slade -Forest Corp). Funding from DAWE and NSW Enviro Trust covered the costs of on-ground actions (pond construction and environmental and aboriginal cultural archaeological assessments) the research component and much of the planning by Forest Corp NSW was provided as in-kind by academics and students (UoN).

Summary: Unfortunately, the on-ground works of the conservation program coincide with or are bisected by the proposed HTP. It is not likely that the population of *R. littlejohni* can persist with such a high level of habitat disturbance.

Heleioporus australiacus australicus (Giant Burrowing Frog)

Much of what has been said above about the potential impact of the proposed HTP on Littlejohn's frog could be repeated here for the Giant Burrowing Frog. The focus will be on specifics of its ecology, distribution and evidence of decline. This frog is also a habitat specialist.

The population of *H. a. australiacus* in the Central Coast Range is restricted to the northern end of the range, with the species being recorded only in the headwater's catchment of the Wyong River and Dora Creek, in much the same area of the drainage divide as described above for Littlejohn's frog. This population represents the most northern and eastern population of the species, and it is isolated from the nearest known population to the south at Ourimbah SF by about 22 km. This isolated population meets the definition of a population using the IUCN Conservation Risk Assessment procedure.

Reproduction: Giant Burrowing Frogs breeds in ephemeral waterbodies at the headwaters of streams. They occasionally will breed in isolated ponds and in some circumstances will breed in gutters along the edge of roads, although such sites may represent environmental traps that reduce population resilience. It eggs are laid into a hollow or under debris at the edge of the water body, and when the tadpoles hatch, they enter the nearby pool and will get washed down stream with flow after rainfall. While the frog makes use of ephemeral pools for breeding, the tadpoles grow to a large size (mean 80 mm body length, Anstis 2017) and rely on ponds holding water for at least six months to enable growth and development. In most cases the breeding sites are associated with natural geological features that involve the discharge of groundwater to the pools in which tadpole occur (Penman et al 2005, 2008, Stauber 2006). These hydrological systems are associated with eroded sandstone plateaus and ridges and are easily disturbed by structures such as roads and artificial drainage lines. Also associated with these systems are a requirement for a soil profile that enables the frogs to burrow up to about 0.3 m during periods of inactivity (aestivation coincides with periods of low rainfall and low environmental temperatures) (Penman et al 2008).

Adults are territorial and two studies using marked animals (radio-tracking) report that they move up to at least 500 to 600 m away from the breeding site (Penman et al 2005, Stauber 2006). During the day and over long periods of dry the adults and juveniles burrow in sandy soils with a low clay content and in the Sydney Basin Bioregion, to which the sub-species is restricted, this is related to the local geology which determines the soil profile. In the context of the population at the northern end of the Central Coast Range there is a distinctive sandy loam soil on the plateau (Lambert Land System, Murphy et al 2004, Soil classification and Maps) that supports a heath vegetation community. Adult and juveniles forage over a large area of the forest floor and are territorial (Penman et al 2004, 2005, 2008, 2015; Stauber 2006) which reduces the density of adults in an area. There are no records of this frog from cleared and open areas.

Disturbance of the natural hydrology and soils where this species occurs are likely to result in the modification of natural breeding habitats, foraging and burrowing areas and lead to the decline of this frog. Because it relies on such a large natural home range the density of adults in an area is low. Restriction of the habitat area by placement of the infrastructure associated with the HTP on the small plateau at Olney is likely to result in the local extinction of this frog.

Breeding habitats of this frog are limited and for the population at the northern end of the Central Coast Range only a handful of sites have been identified (Lemckert et al 2005). This is quite different to the recording of observations of frogs in wildlife databases (e.g., ALA or BioNet), which are usually based on single individuals observed by methods such as spotlighting, and it is therefore very difficult to measure or predict impact without a firm understanding of the local ecology of the frog.

It is also likely that changes to the natural ecosystem that increases the severity and/or frequency of wildfire will have a negative impact on this frog. The impact of wildfire on this frog has been investigated (Penman et al 2015, Beranek et al 2023). Penman (2006) examined the impact on burrowed adults of a “cool control burn” in the Eden forestry area and developed a biophysical model to investigate the extent of the range of the species. He found a negative impact of high severity fires and a relationship between rainfall and distribution. Following the wildfires of 2019-20 targeted surveys were conducted for the occurrence of this frog in several areas where burns were intense (Beranek et al 2023). The outcomes were mixed with the frog disappearing in some locations but being observed in others twelve months after the fires. Infrastructure associated with the HTP is likely to result in an increase frequency of fires, in part associated with asset protection near the substation and corridor. Changes in the natural fire regime have an impact on the natural vegetation community occupied by these frogs and may have a direct impact on survival.

Intensive field investigations of the detection and distribution of this frog in parts of the Blue Mountains region have recently been reported (Kelly et al 2025, in press). Detection probability was found to be amongst the lowest reported for any amphibian, and occupancy models indicated that density in the landscape was low. Whether this represents a natural situation or the result of on-going declines in abundance remains unknown. Whatever the case this species of frog faces local extinction where human activities alter hydrology on local streams.

Summary: As with Littlejohn’s tree frog the impact of the HTP on the Giant Burrowing Frog needs to be considered in the regional context. Once again, the placement of the substation and corridor on the small plateau which forms the drainage divide of the Wyong River and Dora Creek in the norther Central Coast

Range coincides with the only known habitat of the frog in the region. Alteration to this habitat will most likely lead to the extinction of the local population.

Mixophyes australis (formerly referred to *M. balbus*) Southern Stuttering Frog.

Distribution*:* *Mixophyes australis* is distributed from the Carrai Plateau on the southern side of the Macleay River in New South Wales south to the Cann River catchment in East Gippsland Victoria. All records occur in wet forest habitats in drainages that flow to the east of the Great Dividing Range. Its distribution includes three bioregions (Thackway & Cresswell 1997), the southern quarter of the North East Coast, the Sydney Basin and Southeast Corner bioregions. Across its distribution, records occur from low to almost the highest possible elevations in these bioregions. There are two geographically isolated subpopulations based on molecular genetic analysis (Mahony et al 2023). The population in the Central Coast Range (Olney SF) is part to the southern sub-population. This subpopulation was assessed as 'Endangered' using the IUCN Conservation Risk Assessment criteria (Mahony et al 2023)
Habitat and Ecology: The ecological requirements of adults and larvae of *M. australis* are reasonably well known. This species is found in association with first and second order permanent and ephemeral streams in temperate and sub-tropical rainforest, wet sclerophyll forest, and also in moist gullies in dry forest (Gillespie & Hines 1999). Statistical modelling using presence and absence data and 24 environmental predictors from the northern portion of the range of *M. australis* (Barrington and Hastings Ranges) showed a preference for the interiors of large forest tracts in areas with relatively cool mean annual temperatures, at sites that were typically free from any disturbance with a thick canopy and relatively simple understorey (NSW NEFBS 1994).

Adult males spend most of their lives in the riparian zone where they shelter under leaf litter or burrow into the topsoil or under debris such as logs when inactive during all seasons. Males will leave these protected sites during active periods from spring through to autumn, at which times they move to nearby streams to call from the bank or among rocks next to the riffle zone where oviposition occurs (Knowles *et al.* 2015). Females move away from the riparian zone, and like males, shelter under leaf litter and burrow into the topsoil during periods of inactivity. Larvae are nektonic and occupy pools between riffle zones in small streams (Daly 1998).

Embryonic development and larval morphology were described by Knowles *et al.* (2015). *Mixophyes australis* deposit eggs among small pebbles or debris in gently flowing shallow water.

Summary: Together the ecology and life history show that *M. australis* is a habitat specialist. The history of recent declines and disappearances from over thousands of square kilometres (Mahony et al 2023) demonstrate that remaining populations require the highest level of protection. It is my assessment based on these biological observations that the placement of the HTP across the upland plateau and associated landscapes of the Central Coast Range will have an unacceptable negative impact on the survival of this frog. The critical habitat for this frog is the first order streams and riparian habitats, and continuous forested habitats connecting them. Major threats from the HTP are direct impacts on hydrology and integrity of the first order streams and habitats of the riparian zones. Indirect impacts would include fragmentation and isolation of breeding from foraging and aestivation sites caused by corridor/easement clearing and road construction. The link between continuous forested habitat and persistence in the face of chytrid fungus remains unknown.

Consideration of threats: There are several potential threats to these species, with previous conservation assessments considering the role of human activities and introduced predators (Hero *et al.* 2006, Gillespie *et al.* 2014, Gillespie *et al.* 2020). Factors such as forestry practices, land clearing, and introduction of non-native sport fish (salmonids) were considered, but the authors could not find any convincing evidence that alone, or in combination, that these factors could explain the extensive population declines observed, especially from native forests and in National Parks. The authors concluded that *"disease, such as chytridiomycosis, might also be a factor in its decline"*. My position is stronger, and I consider there is convincing correlative and direct evidence (Mahony 2013) that infection with chytrid (*Batrachochytrium dendrobatidis*) causing the disease chytridiomycosis is the cause of population declines and disappearances (See also Duncan et al 2025).

A notable feature of the current distribution is the disappearance of populations from higher altitude but with persistence at lower and mid altitudes in locations such as the Barrington Range and the Blue Mountains, a pattern reported in several other frogs susceptible to chytridiomycosis (Berger *et al.* 2004, Skerratt *et al.* 2007). Testing for the occurrence of chytrid infection revealed relatively high prevalence of infection in three widely separated populations (Mahony 2007). However, there have been no studies that link infection status and mortality thresholds, and apart from the occasional observation of dead frogs in streams, which occurs in the Central Coast Range, we are unable to quantify the impact of chytridiomycosis on population demography.

While habitat loss, degradation and fragmentation may have played a role in some declines, they do not appear to be responsible for declines over large geographic areas. *Mixophyes* species are forest dependent, obligate stream breeders reliant on riparian zones with canopy cover over 50% (Hunter & Gillespie 2011, Geyle *et al.* 2021). They do not occur where forests have been cleared for agriculture unless riparian zones remain unaffected. Populations in the north of the distribution of *M. australis* (Central Coast Range, Myall Range and Hasting Range), occur in locations subjected to selective harvesting over many decades. That forestry is not the cause of the declines in large geographic areas is shown where disappearances have occurred in protected areas without forestry activities. For example, *M. australis* has disappeared from the Greater Blue Mountains World Heritage Area, a large area (1.03 million hectares of sandstone plateaux, escarpments and gorges dominated by temperate eucalypt forest) which has many upland streams that historically provided habitat for the frog.

Mahony et al (2023) postulated that the cause of extensive declines in the southern third of the distribution of *M. australis* is because of susceptibility of the frog to the amphibian disease chytridiomycosis, which arrived in the area prior to 1980. This begs the question as to why the impact of the disease is not uniform across the

frog's distribution. The current distribution and abundance of populations may be modulated by the relationship between the frog host, the amphibian pathogen, and possibly environmental factors in a complex interaction (Scheele *et al*. 2017, 2019a, Brannelly *et al*. 2018, 2021). There has been one landscape test for the occurrence of chytrid in the southern coastal forests of NSW, and that study examined sibling species of stream frog (*Litoria lesueuri* and *L. wilcoxi*) (Kriger & Hero 2007, Kriger *et al*. 2007). These frogs co-occur with *Mixophyes* species across most of their range. Thirty-one independent streams were surveyed which covered the latitudinal range of *M. balbus* and *M. australis* and in six sites in the south of the range chytrid prevalence was between 40% and 70%, which were among the highest values from 31 populations studied (Kriger & Hero 2007, Kriger *et al*. 2007).
Field evidence shows that *M. australis* declined markedly in the Central Coast Range in the mid 1980's to the point where they could not be located at higher altitude stream sites (Mahony 1993). Surprisingly, after 2010 populations have re-established in several locations, but it is not known whether they are derived from small remnants of the historic populations or are the result of migration from lower altitude or across headwaters. A similar situation has been reported in the closely related congener *M. fleayi* in the Main Range Queensland (Symonds *et al*. 2007) and Eastern Border Ranges areas of north-east NSW and south-eastern Queensland (Newell *et al.* 2013, Quick *et al.* 2015). Similarly, in northern Queensland several stream frogs disappeared at higher elevations but remain at lower elevations and during the warmer seasons some frogs disperse back to higher elevations (Sapsford *et al*. 2013). In these cases the cause of declines is directly linked to the susceptibility of the frogs to chytrid, and the capacity of the frogs to persist with, or recover from the disease, in warmer low altitude habitats (Rowley & Alford 2013, Rowley *et al*. 2007, Puschendorf *et al.* 2009). A similar situation may occur in *M. australis* in the Central Coast Ranges. Support for this postulate comes from surveys of chytrid prevalence in the adults and tadpoles across several seasons which show relatively high prevalence of the pathogen (Mahony 2007, 2013). In addition to the possibility of movement of frogs from lower elevations to reoccupy higher habitats it also possible that there has been a change in the dynamics of the disease in some populations, such that the frogs have adapted, or the disease is less virulent, or possibly the role of other frogs in the community that harbour the disease has changed (Scheele *et al.* 2017, Brannelly *et al.* 2018).

Chytrid was detected in the high elevation site where *M. australis* occurred at Mount Werong, the one known remaining location in the Blue Mountains region (White pers. comm.), but despite this, the species remained at this one location up until 2019. Superficially, this may seem a good reason to question the postulate that chytrid was responsible for the decline and disappearance of populations from the south and at higher elevations in this species, but there are other examples where isolated populations of species of frog that are susceptible to chytrid remain, such as *Taudactylus eungellensis* (Retallick *et al.* 2004), *Pseudophryne corroboree* (Hunter *et al*. 2010), and *Litoria booroolongensis* (Hunter & Smith 2013).

If chytrid is the cause of the disappearance of *M. australis* from about the southern half of its distribution, and the decline in the northern half of its distribution, then unlike most of the reported disappearances of frogs in upland rainforests in Queensland, where the affected species have narrow distributions, the disappearance in *M. australis* is from an extensive area at least 800 km north to south and of variable width up to 100 km east to west.

More recently in the summer of 2019-2020 catastrophic wildfires burnt greater than 40% of the eucalypt forest of eastern Australia and penetrated into rainforest vegetation that is not considered to be fire resilient. Impacts of these wildfires on fauna were assessed using expert a rapid quantitative assessment (van Eeden *et al*. 2020, Jolly et al 2022), expert elicitation (Legge *et al.* 2022, 2022) and a field based quantitative assessment of impact, that included *M. australis* has been conducted (Beranek et al 2023, Mahony et al 2023). The impact of fires on species of *Mixophyes* is considered to be moderate because of their reliance on moist riparian habitats, however the consequence for small and fragmented populations remains to be investigated (Mahony *et al.* 2022).

Summary: As with the other two threatened frogs considered above the impact of the HTP on the Southern Stuttering Frog needs to be considered in the regional context. Once again, the placement of the substation and corridor on the small plateau which forms the drainage divide of the Wyong River and Dora Creek in the northern Central Coast Range is a crucial component of the known habitat of the frog in the region. Alteration to this habitat will threaten the persistence of the local population. The Central Coast Range population is the only remaining population of this species in its former range from east Gippsland to the Hunter River. The species is now considered extinct in the vast Blue Mountains World Heritage Area and the southeastern forest of NSW.

ADDENDUM
IUCN Red List threat assessment for *Mixophyes australis*
In the following assessments only the suitable IUCN Criteria that are met are included.

Criterion A. 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.
Generation length is inferred to be at least 4 to 5 years based on demographic studies (Knowles *et al.* 2014). For the purpose of this analysis, we use 12 to 15 years for three generations.

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.

(a) direct observation, and (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat.
There has been a **>**30% inferred population size reduction.
Threshold score is “Vulnerable”

Criterion B. Geographic distribution

Sub-criterion B1. Extent of occurrence (EOO).

(IUCN Categories EOO. Critically Endangered <100 km^2, Locations =1; Endangered <5,000 km^2, location <5; Vulnerable < 20,000 km^2, Locations <10)

The EOO (alpha hull) for the taxon is 2,734 km^2 and there are < 10 locations (Table 1).

Threshold score is >100 km^2 <5000 km^2.

Threshold score is “Endangered”

AND/OR

Sub-criterion B2. **Area of Occupancy (AOO)**

(IUCN Categories AOO. Critically Endangered. <10 km^2, Endangered <500 km^2, Vulnerable <2,000 km^2)

The AOO of all subpopulations is 1128 km^2 post-2010. (Table S1).

Threshold score >500 km ^{2} <2000 km^2.

Threshold score is “Vulnerable”

AND at least two of the conditions (a to c).

(a) Severely fragmented or number of locations. (IUCN: Critically Endangered, number of locations = 1, Endangered, number of locations <5, Vulnerable <10).

Number of locations < 5, (Central Coast Range, Myall Range, Barrington Range, Blue Mountains).

Threshold score is “Endangered”.

(b) Continuing decline projected in EOO, and AOO.

Our assessment is based on the observations of long-term decline in the southern one third of the range and on-going disappearance of population in the Blue Mountains region (Table 1).

Threshold score is “Endangered”.

Summary. Across its entire distribution *M. australis* is assessed as “Endangered”, Criterion B1(a)(b).

The two subpopulations of *M. australis* meet the conservation status assessment criteria for “Endangered” 2B1a,b: 1) Subpopulations north of the Hunter River (i.e., Myall Range, Barrington Range and Hastings Range), and 2) subpopulation south of the Hunter River (Central Coast Range, Blue Mountains and Illawarra region to east Gippsland.

We consider that special consideration for conservation management should be made for the subpopulation in the Central Coast Ranges, since it represents the remaining persistence in the whole of the Sydney Basin. areas which are both in the southern subpopulation:

The Mt Werong area population (Blue Mountains) is separated by a distance of about 150 km from the nearest extant record in the Central Coast Ranges. The Mt Werong area comprises 3 records in the past decade (AOO 8 km^2, EOO <10 km^2, 1

location). The current position is that this population is presumed to have disappeared.
The Macquarie Pass (Illawarra region) population, which is about 50 km from the nearest record in the Blue Mountains region, and about 150 km from extant records the Central Coast Ranges. The Illawarra location comprises one extant record (AOO 4 km^2, EOO 1 km^2, 1 location). This site is currently involved in a reintroduction project (Daly & Craven 2011, Garry Daly pers. comm.), and successful captive husbandry of specimens collected from this site has been reported (Banks *et al.* 2014).

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