Australian Government
Department of Agriculture, Water and the Environment

Conservation Advice for *Callocephalon fimbriatum* (Gang-gang Cockatoo)

In effect under the *Environment Protection and Biodiversity Conservation Act 1999* from 2 March 2022.

This document combines the approved conservation advice and listing assessment for the species. It provides a foundation for conservation action and further planning.

Gang-gang Cockatoo (*Callocephalon fimbriatum*) © Copyright, Clayton Woods

Conservation status

Callocephalon fimbriatum (Gang-gang Cockatoo) is listed in the Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act) effective from 2 March 2022.

Callocephalon fimbriatum was assessed by the Threatened Species Scientific Committee to be eligible for listing under the EPBC Act under Criterion 1. The Committee's assessment is at Attachment A. The Committee's assessment of the species' eligibility against each of the listing criteria is:

- Criterion 1: A2bc: Endangered
- Criterion 2: Not eligible
- Criterion 3: Not eligible
- Criterion 4: Not eligible
- Criterion 5: Insufficient data

The main factor that makes the species eligible for listing in the Endangered category is that the population has declined by approximately 69% from 1999 – 2019 (i.e., before the 2019/2020 bushfires), based on the most reliable survey methods for the species (Cameron et al. 2021). In addition to this continuous and major decline in population numbers, the species also suffered mortality and habitat loss during the 2019/2020 bushfires. Estimates of the distribution impacted by fire range from 28 to 36% (Legge et al. 2020; Ward et al. 2020; Legge et al. 2021). The 2019/2020 bushfires may have reduced the carrying capacity of 40% of occupied grid cells by half and resulted in a 10% reduction in the overall population size (Cameron et al. 2021). An analysis based on expert elicitation estimated an overall population decline at one year post-fire of 21%, and that three generations post-fire the population would still be 29% lower than the pre-fire population size, and possibly as much as 52% lower (Legge et al. 2021), indicating a poor recovery rate. These predictions assume no further extreme drought or extensive fire events; however, such events are likely to reoccur over the assessment period, which would worsen the extent of population decline.

There are an estimated 25,300 (range 17,600 – 35,200) mature individuals in the wild with a declining trend (high reliability) (Cameron et al. 2021). The species' extent of occurrence (EOO) and area of occupancy (AOO) are estimated to be stable at 400,000 km^2 and 30,000 km^2, respectively (Cameron et al. 2021).

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

Species information

Taxonomy

Conventionally accepted as *Callocephalon fimbriatum* (Grant, 1803).

Description

Gang-gang Cockatoos are approximately 32–36 cm in length, 230–334 g in weight and have a wing length of 20–26 cm (Higgins 1999; Menkhorst et al. 2017). They are a small, stocky cockatoo, which are primarily slate-grey in colour. Adult males are distinguished by their scarlet-coloured head and wispy, filamentous crest that curls forward (Higgins 1999). The remainder of their plumage is usually mid-grey, with feathers narrowly edged dull-white. Occasionally, male Gang-gang Cockatoos have pale-yellow or dull-orange feathering on their breast or abdomen (Higgins 1999). Adult females have entirely mid-grey plumage, including on their head (Simpson & Day 1996). The feathers of adult females are broadly fringed with yellow-orange, giving a barred effect. This effect is particularly prominent on the underparts of the bird. The birds' secondaries, undertail-coverts, tail, and underwing-coverts are variably barred pale grey-yellow. Both sexes have broad wings and short tails (Higgins 1999). Juveniles are similar in appearance to females; however, their crest is rudimentary, and they appear washed green, particularly on their underparts and upper wing (Higgins 1999).

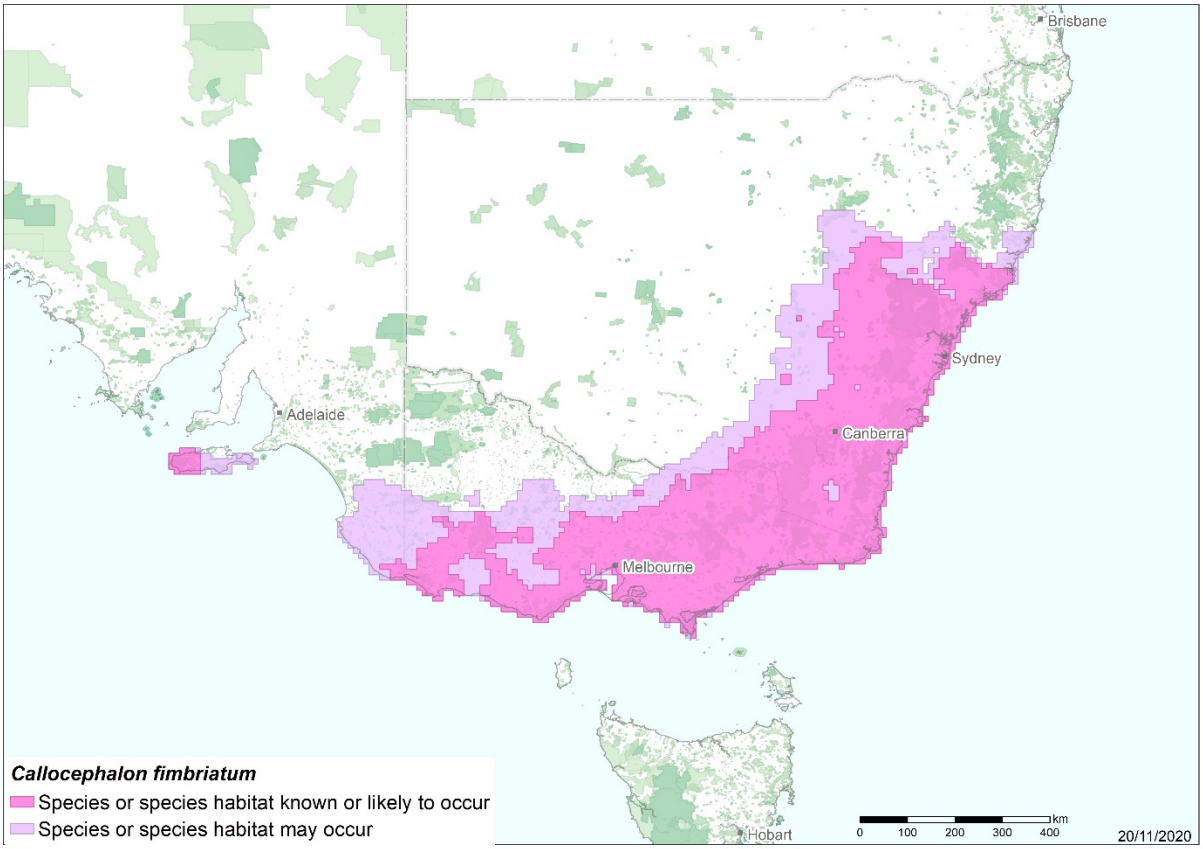
Distribution

Gang-gang Cockatoos are endemic to south-eastern Australia. The species is rare at the extremities of its range, with isolated records known from as far north as Coffs Harbour and as far west as Mudgee (Higgins 1999). It is adapted to cooler conditions and has always been more common at higher elevations and more southern latitudes.

It was thought that Gang-gang Cockatoos were widespread in eastern New South Wales, ranging from the central slopes and tablelands, east to the south coast and central-eastern New South Wales; however, reports on this are outdated (Shields & Crome 1992). The species was once widespread and numerous in Sydney and its surrounding areas, but its population has been greatly reduced in recent years. The last known breeding subpopulation within the Sydney metropolitan area now contains no more than 40 pairs (Smith & Smith 2019; NSW DPIE 2019), confined to the Hornsby and Ku-ring-gai Local Government Areas. This subpopulation is listed as an 'Endangered population' under the New South Wales Threatened Species Conservation Act, 1995. An estimated 54% of the species' distribution occurs within New South Wales National Parks and Wildlife Service estates (NSW OEH 2017). BirdLife Australia's Birdata (BirdLife Australia 2021) records indicate that Gang-gang Cockatoos are present in the Greater Blue Mountains World Heritage Area and Mid and Lower Central Coast. The species also occurs in the Australian Capital Territory. In Victoria, the Gang-gang Cockatoo is widespread through north-east and southern regions, with some records in east Melbourne, Mornington Peninsula, and south-western Gippsland (Higgins 1999; Menkhorst et al. 2017).

Gang-gang Cockatoos have been introduced to Kangaroo Island in South Australia, and on King Island in Tasmania (although the King Island subpopulation is now considered extinct) (Higgins 1999).

Map 1 Modelled distribution of Gang-gang Cockatoo



Source: Base map Geoscience Australia; species distribution data Species of National Environmental Significance database.

Cultural and community significance

Cockatoos are integral to songlines, dreaming stories, and Traditional Ecological Knowledge for Aboriginal communities. These stories relate to connectivity of country, to the movement of people, animals, plants, and celestial systems and are indicators of seasons and rain which informs management of country with fire and water. These stories and knowledge are held by people with responsibility for and kinship to these birds.

The species is known to occur on the lands of at least the following Indigenous peoples: Awabakal, Bidawal, Bunurong, Darkinjung, Dharawal, Dharug, Dhudhuroa, Dja Dja Wurrung, Eastern Maar, Gunaikurnai, Gunditjimara, Gundungurra, Jaithmathang, Jerrinja, Ngarigo, Ngunnawal, Nindi-Ngudjam Ngarigu Monero, Taungurun, Wadawurrung, Walgal, Warrabinga, Waveroo, Wiradjuri, Wodi Wodi, Wonnarua, Worimi, Wurundjeri, Yorta Yorta, and Yuin. Further research into the subject may benefit the conservation of the species by providing insights into traditional land management.

The Gang-gang Cockatoo has been the faunal emblem of the Australian Capital Territory since 1997. It is also the faunal emblem of Australian Capital Territory Parks and Conservation Service, and the Canberra Ornithologists Group.

Relevant biology and ecology

Habitat

Gang-gang Cockatoos primarily occur within the temperate eucalypt forests and woodlands of mainland south-east Australia (Menkhorst et al. 2017). The species is an altitudinal migrant.

During summer months, Gang-gang Cockatoos primarily inhabit mature, wet sclerophyll forests, typically dominated by eucalypts (Frith 1969; NSW Scientific Committee 2008). Eucalypt-dominated assemblages with dense, shrubby acacia, wattle and banksia understory support the highest density of birds (Higgins 1999). The species has also been reported in more open eucalypt assemblages, subalpine snow gum woodland, temperate rainforests, and occasionally regenerating forests (Forshaw 1989; Higgins 1999). Smith & Smith (1993) assessed the species as being frequent within blackbutt (*Eucalyptus pilularis*), Sydney red gum (*Angophora costata*), and turpentine (*Syncarpia glomulifera*) tall open forest and occasional in Sydney peppermint (*Eucalyptus piperita*) open-forest.

During winter months, Gang-gang Cockatoos tend to range beyond montane forests to inhabit woodland assemblages at lower, drier altitudes. Most birds occur in open eucalypt assemblages during this period (Shields & Crome 1992; Higgins 1999). The species is also observed in suburban areas of cities (i.e. Canberra, Sydney, and Melbourne), including within parks, gardens, and roadside tree plantations (Morcombe 1986; Higgins 1999). Occasionally, during winter months the species inhabits assemblages of river red gum (*Eucalyptus camaldulensis*), dense coastal thickets of *Leptospermum* or *Casuarina*, or heathland (Higgins 1999). Overlapping of winter and summer ranges is common, with some individuals choosing to winter at higher altitudes, and others remaining at lower altitudes during summer (Higgins 1999).

Diet and foraging

Gang-gang Cockatoos feed in small groups of up to 25 individuals (M Mulvaney 2021. pers comm 7 Sept). Foraging is mainly arboreal, occurring in the canopy of woodland assemblages (particularly within eucalypts) and less often within the understory (more often during *Acacia* seeding) (Higgins 1999). Feeding rarely occurs within shrubs and at ground-level (Higgins 1999). The species has a wide-ranging diet, feeding on 131 different plant taxa across 25 different plant families (M Mulvaney 2021. pers comm 7 Sept). The majority of these feeding records are from around Canberra, but when only sightings from native vegetation outside of Canberra are considered, only approximately 50 species are consumed (M Mulvaney 2021. pers comm 7 Sept).

The species regularly feeds on flower buds and seed pods, but also on blossoms, leaf buds, fruits, and seeds from both native and introduced ornamental species (M Mulvaney 2021. pers comm 7 Sept). Whilst feeding on native vegetation, Gang-gang Cockatoos rely heavily on eucalypts and acacia. Whilst feeding on introduced vegetation, the species primarily relies on species such as hawthorn (*Crataegus monogyna*), cotoneaster (*Cotoneaster glaucophyllus*) and *Pyracantha* berries. When occupying suburban areas, the species often feeds on seeds and berries found within gardens, particularly from ornamental trees, shrubs, and hedges (Higgins 1999). Gang-gangs also feed on insect larvae (Menkhorst et al. 2017) and are one of only a few bird species that feed on Sawfly larvae (COG N.D.).

Breeding and nesting requirements

Gang-gang Cockatoos are monogamous. Breeding usually occurs between October and January (Higgins 1999); however, records exist of breeding events in late August, early September, and March (Higgins 1999). Clutch sizes of two eggs are typical, but occasionally one or three are laid. Both sexes incubate the eggs over a period of 3-4 weeks (Davey & Mulvaney 2020). The fledging period lasts for 7–8 weeks, and the young continue to be fed by parents for 4–6 weeks after fledging (Endersby & Endersby 2001).

Gang-gang Cockatoos favour old growth forest and woodland assemblages for nesting, loafing, and roosting. The species nests in the hollows of tree trunks and limbs, or within the dead sprout of large, living eucalypts (Higgins 1999; Gibbons 1999; Gibbons & Lindenmayer 2000). Nesting and roosting sites are often near water (Beruldsen 1980), where larger hollow-bearing trees can be more common. Breeding aggregations are reliant on stands of suitable hollow-bearing trees (NSW OEH 2017; Davey & Mulvaney 2020). Multiple nests tend to be situated within a few hundred metres of each other.

Preferred hollows generally have an entrance height of 21.3 cm (minimum entrance height 12 cm) and an average entrance width of 13.1 cm (range 9–24 cm; Davey & Mulvaney 2020). The hollow chambers are generally around 20 cm in floor diameter, around 50.5 cm deep (range 22–90 cm) and occur around 7.5 m (range 5–9.4 m) above the ground (Davey & Mulvaney 2020). Both sexes work to enlarge the hollows by chewing at the sides, and then scraping debris out onto the ground, or using the debris to line the base of the hollow. Gang-gang pairs utilise multiple nest trees over different years, which may be a way of minimising nest parasitism or predation. Only about half of known nest trees are utilised each year (Davey & Mulvaney 2020), but individuals may use the same roosting and nesting site for multiple years (Higgins 1999). On three occasions, Gang-gang Cockatoos have been recorded utilising hollows that have developed in planted urban trees, the youngest being 58 years old (Davey & Mulvaney 2020).

Habitat critical to the survival

In summer months, Gang-gang Cockatoos generally occur in tall mountain forests and woodlands - particularly within mature, wet sclerophyll forests, dominated by eucalypts with dense, shrubby acacia and banksia understories, often in secluded valleys (Higgins 1999). They also occur in areas that include more open eucalypt assemblages such as subalpine snow gum (*Eucalyptus pauciflora*) woodland, temperate rainforests, and regenerating forests. Smith & Smith (1993) assessed the species as being frequent within blackbutt (*Eucalyptus pilularis*), Sydney red gum (*Angophora costata*), and turpentine tree (*Syncarpia glomulifera*) tall open-forest and occasional in Sydney peppermint (*Eucalyptus piperita*) and Sydney red gum (*Angophora costata*) open-forest.

During winter months, Gang-gang Cockatoos rely on drier more open eucalypt forests and woodland assemblages at lower altitudes. Open eucalypt assemblages such as box-ironbark make up their habitat during this period. The species also relies on assemblages of river red gum (*Eucalyptus camaldulensis*), dense coastal thickets of *Leptospermum* or *Casuarina*, or heathland and occurs in parks, gardens, and trees beside roads (Higgins 1999).

Habitat critical to the survival of the Gang-gang Cockatoo includes all foraging habitat during both the breeding and non-breeding season. For the purpose of this document, this does not include exotic feeding grounds such as ornamental trees, shrubs, and hedges within urban and suburban areas.

Gang-gang Cockatoos rely on stands of suitable hollow-bearing trees (NSW OEH 2017; Davey & Mulvaney 2020), which are a key component of their breeding habitat. Habitat critical to the survival includes hollow bearing trees with known or potential Gang-gang Cockatoo hollow chambers that are generally around 20 cm in floor diameter, around 50.5 cm deep (range 22–90 cm) and occur between around 7.5 m (range 5–9.4 m) above the ground (Davey & Mulvaney

2020; Davey et al 2021). Stands of trees within or adjacent to known breeding areas, that are likely to become hollow-bearing in future years, are also key components of this species' habitat.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat.

Key considerations in environmental impact assessments

Habitat critical to the survival of the Gang-gang Cockatoo occurs across a range of land tenures. Habitat critical to the survival of the species should not be destroyed or modified. Actions that have indirect impacts (e.g., noise and light pollution) on habitat critical to the survival should also be minimised. Actions that compromise adult and juvenile survival, such as the introduction of new diseases, weeds, or predators, should also be avoided.

When considering habitat loss, alteration, or degradation to habitat in any part of the Gang-gang Cockatoo's range, including in areas where the species 'may occur', surveys for occupancy at the appropriate times of the year, and identifying preferred foraging species remain an important tool in refining the understanding of an area's relative importance for Gang-gang Cockatoo. In addition, it is also important to note that Gang-gang Cockatoos opportunistically use areas depending on food availability. This means that birds may not utilise areas that constitute habitat critical to the survival in any one given year. This pattern of habitat use means that in order to assess the relative importance of a local area or region for Gang-gang Cockatoos, species occurrence data must span a number of seasons and years, so as to capture the seasonal and inter-annual movements of the species.

Actions that remove habitat critical to survival would interfere with the recovery of Gang-gang Cockatoos and reduce the area of occupancy of the species, and therefore must be avoided. It is important to retain both breeding and foraging habitats described above. It is also important to maintain both winter and summer habitats in reasonable proximity to each other, as Gang-gang Cockatoos are seasonal migrants, with altitudinal movements (Higgins 1999). If removal of habitat critical to the survival cannot be avoided or mitigated, then an offset must be provided. Actions must not be assessed in isolation and consideration must be given to existing and future activities that may impact the species to ensure conservation outcomes on a landscape scale are achieved.

Suitable offsets may include:

- Restoration of the quality and extent of feeding and breeding habitat.
- Restoration of native forest and woodlands adjacent to habitat critical to the survival to reduce edge effects.
- Management of threats (see *Threats*) in and adjacent to habitat critical to the survival.
- Other compensatory measures that will help address knowledge gaps to improve and maximise efficiency of the recovery of the species.

Threats

Gang-gang Cockatoos are adversely impacted by a range of threats including habitat loss, wildfire, climate change and competition for suitable nesting hollows.

The 2019/20 bushfires were unprecedented in their intensity and extent and are likely to have had a significant effect on Gang-gang Cockatoo population size. In total, 28–36% of known Gang-

gang Cockatoo habitat burnt during this event (Ward et al. 2020; Legge et al. 2021). The resulting loss of breeding, foraging, and roosting habitat has been exacerbated by pre-existing threats, including clearance of native vegetation within the species' range by forestry, agriculture, urban encroachment (Rose 1993; Nelson & Morris 1994; Cumming 1998; Whitford & Williams 2002) and planned burns that have reduced the availability of hollow-bearing trees and foraging resources.

Gang-gang Cockatoos breed mainly in mature forest and are less abundant in regenerating forest 10-15 years after logging (Higgins 1999). Old hollow-bearing trees are sometimes considered a hazard in planned burning activities, or unsightly or dangerous within urban areas. As such, they are often ringbarked, poisoned, or actively removed. Hollow-bearing trees suitable for nesting are now largely restricted to remnant patches of woodland and individual trees within otherwise cleared sites, whereas the species' typical nesting habitat is in tall mature forest with dense shrubby understorey (Higgins 1999).

Gang-gang Cockatoos are faced with increased intra/interspecies competition for remaining nesting sites. Species which compete with Gang-gang Cockatoos for nesting hollows include feral honeybees, Common Brushtail Possums (*Trichosurus vulpecula*), and other bird species such as Rainbow Lorikeets (*Trichoglossus moluccanus*), Eastern Rosellas (*Platycercus eximius*), Galahs (*Eolophus roseicapilla*), and Common Mynas (*Acridotheres tristis*; Davey & Mulvaney 2020). It is not yet known which of these species are the most significant competitors for hollows. Aggressive interactions have also been recorded between Gang-gang Cockatoos and Common Brushtail Possums, Australian Wood Ducks (*Chenonetta jubata*), Noisy Miners (*Manorina melanocephala*), and Sulphur-crested Cockatoos (*Cacatua galerita*).

Table 1 Threats impacting Gang-gang Cockatoo

Threat	Status and severity [a]	Evidence
Fire		
Inappropriate fire management	• Status: current/future • Confidence: known • Consequence: severe • Trend: stable • Extent: across the entire range	Inappropriate fire management regimes, including planned burning, may threaten Gang-gang Cockatoos if they are too frequent or infrequent, too hot, or too extensive. Inappropriate fire regimes can result in the direct mortality of individuals, remove Gang-gang Cockatoo nesting sites, reduce the availability of quality foraging sites, and increase individuals' vulnerability to other threatening processes (e.g., predators, or competitors). For example, the 2019/20 bushfires burnt approximately 28–36% (approximately 4,700,000 ha) of Gang-gang Cockatoo habitat (Ward et al. 2020; Legge et al. 2021), causing direct loss of habitat and individuals. One of the worst affected areas was the Greater Blue Mountains World Heritage Area, with 79% burnt, including 29% burnt at high to extreme severity (Smith 2021). The 2019/2020 fires may have resulted in direct 10% reduction in the overall population size (Cameron et al. 2021). An analysis based on expert elicitation estimated an overall population decline of 21% one year post fire, from the combination of direct mortality and indirect post-fire mortality (lack

Threat	Status and severity [a]	Evidence
		of feeding resources). The analysis predicted that three generations post-fire the population would be 29% lower than the pre-fire population size, with recovery constrained by impacts of other underlying threats, as well as the impact of high severity fire on hollow availability (Legge et al. 2021). Current and future climate change is expected to increase wildfire risk through more adverse fire weather, including an expected increase in the number of days of severe fire danger, and a potential lengthening of the fire season over much of the range of the Gang-gang Cockatoo (Clarke 2015). Projected climate change will also lead to changes in fuel dynamics via changes to vegetation composition and structure (Clarke 2015). Fire frequency and severity have strong implications for tree hollow abundance in montane and subalpine eucalypt forests, with stand-level hollow abundance decreasing with more frequent fires (Salmona et al. 2018), hence reducing nest-hollow availability for Gang-gang Cockatoo. In some parts of the species' range, hollow-bearing trees are also actively removed when considered a hazard to planned burning operations (e.g., in Victoria). The impacts of vegetation clearance and fire management activities will vary across the species' range and subpopulations. As such, fire management, including the frequency and timing of planned burning should consider and incorporate each specific subpopulations' ecological requirements.
Climate change		
Warming climate	• Status: current/future • Confidence: known • Consequence: severe • Trend: increasing • Extent: across the entire range	In recent decades a decline in Gang-gang Cockatoo reporting rates has been noted around lower elevations in northern Sydney, the Central Coast, and the Blue Mountains. These declines in reporting rates have not occurred to the same extent at higher elevations, suggesting a climate change effect. Throughout NSW and the ACT, the temperature is projected to increase by approximately 2.1 degrees Celsius by 2079 (Clarke 2015). The frequency of hot days is also projected to increase. Hotter temperatures will substantially increase water requirements of Gang-gang Cockatoos and may severely reduce survival rates for this temperature-sensitive altitudinal migrant (Higgins 1999). Gang-Gang Cockatoos are a cool temperate species and may be particularly vulnerable to increased temperatures. During the end of the 2019/2020 season, Canberra experienced record day temperatures and experienced high levels of smoke haze. During this period, unusual Gang-gang Cockatoo chick behaviours and mortality occurred that had not previously been observed. For example, death of chicks in

Threat	Status and severity [a]	Evidence
		nests from heat exhaustion during heat waves has been recorded. Additionally, chicks have been observed leaving or attempted to leave their hollows prematurely (Davey & Mulvaney 2020). Other effects of heatwaves could also include reduced reproductive success (McCreedy & van Riper 2015), potentially resulting in further population declines.
Altered rainfall patterns	• Status: current/future • Confidence: suspected • Consequence: unknown/moderate • Trend: increasing • Extent: across the entire range	It is predicted that across much of the Gang-gang Cockatoo's range summer rainfall will increase, and there will be an increase in the intensity and occurrence of summer storms due to climate change (Davey et al. 2019). Increased and heavier summer rainfall may result in increased flooding of nesting hollows. Of 16 hollows used in the ACT Region during the 2019/2020 season, three were flooded in the next season, though none of the three were utilised in the 2020/2021 season (Davey et al. 2019). Changes in rainfall patterns have the potential for widespread impacts. Seasonal shifts in rainfall can impact floral productivity i.e., for floral species that are reliant on winter rains for peak growth. Furthermore, changes in rainfall patterns may also affect the post-fire regeneration ability of important foraging and breeding habitat. Changes in foraging and feeding habitat will likely result in increased energy expenditure by the species, likely reducing the survival rate.
Predation, competition, and disease		
Competition for nest hollows with other species	• Status: current/future • Confidence: known • Consequence: severe • Trend: increasing • Extent: across part of its range	The ongoing loss and increasing shortage of nest hollows due to factors such as wildfire and land clearance can increase competition for nest hollows with other species, reducing the number of hollows available to Gang-gang Cockatoos. Competitors may include feral honeybees, possums, and other bird species such as Sulphur-crested Cockatoos, Rainbow Lorikeets, Little Corella, Long-billed Corella, and Common Mynas. Further research is required to better define the species which pose the greatest level of competition for nesting hollows. In the Blue Mountains region, Sulphur-crested Cockatoo and Rainbow Lorikeet populations have grown to dominate the forest bird community. Both species are capable of excluding Gang-gang Cockatoos from suitable nesting sites. Colonies of feral honeybees frequently occupy large hollows in trees. Such hollows are removed from the pool of hollows available to native species such as Gang-gang Cockatoos (NSW Government 2019). Due to the long time-periods required for hollow formation and the long residence times of bees, occupation by bees represents a long-term loss of a critical resource (NSW Government 2019). Feral honeybees also invade artificial

Threat	Status and severity [a]	Evidence
		nest-boxes and may result in nest failures (Trainor 1995). Over-abundant of Noisy Miners (*Manorina melanocephala*) and Bell Miners (*Manorina melanophrys*) can in some localities aggressively exclude Gang-gang Cockatoos from woodland habitat (NSW Government 2017).
Nest predation by Common Brushtail Possum	• Status: current/future • Confidence: known • Consequence: severe • Trend: unknown • Extent: across part of its range	Invasion of nesting hollows and predation of Gang-gang Cockatoo eggs and young by the Common Brushtail Possum (*Trichosurus vulpecula*) could lead to a decline in population numbers in some parts of their range (Garnett et al. 1999). Rates of predation by possums are likely elevated when habitat becomes fragmented following fires and land clearance (Hradsky et al. 2017). Without protection of eggs and young from possums, recruitment of Gang-gang Cockatoos to the adult population may be minimal (Garnett et al 1999; Garnett et al. 2011). Reproductive success of other cockatoo species (e.g., *Calyptorhynchus lathami*) has been improved by preventing possums from entering nest hollows (Garnett et al. 2011).
Psittacine beak and feather disease (PBFD)	• Status: current/future • Confidence: known • Consequence: severe • Trend: increasing • Extent: across part of its range	Gang-gang Cockatoos are susceptible to Psittacine beak and feather disease (Sarker et al. 2014). The subpopulation of Gang-gang Cockatoos from the Hornsby and Ku-ring-gai local government area has a high prevalence of the disease (DPIE 2019). Prevalence in other subpopulations is unknown. Beak and feather disease virus is highly prevalent in a range of abundant Australian psittacines (Martens et al. 2020). It is transmitted through feather dander, faeces, and saliva.
Habitat loss and degradation		
Land clearing	• Status: historic, current • Confidence: known • Consequence: severe • Trend: Declining • Extent: across part of its range	Clearing of native vegetation removes the tree and shrubs required by the Gang-gang Cockatoo for foraging and nesting (Nelson & Morris 1994; Cumming 1998). On cleared land now used for agricultural or urban development purposes, hollow-bearing trees suitable for nesting are largely restricted to remnant patches of woodland and individual trees within cleared sites (e.g., paddock trees). The replacement of lost hollow-bearing trees is virtually non-existent, given the long periods of time required for large hollows to form (del Hoyo et al. 1997).
Native forest timber harvesting	• Status: historic/current • Confidence: known • Consequence: low • Trend: decreasing • Extent: across part of its range	In historical clearfell forestry operations, large, old, hollow-bearing trees were often considered an impediment and unsuitable for timber production. For example, in the 1950s, large areas of old hollow-bearing trees were treated by ringbarking or by injecting poison (Florence et al. 1970). These dead trees had a standing life expectancy of about 50 years, but many fell due to the treatments. Those that

Threat	Status and severity [a]	Evidence
		remained had a limited lifetime (Ross 1998; Wormington et al. 2002). Gang-gang Cockatoos have been shown to be adversely affected by clearfell forestry operations, with the species being less abundant in regenerating forest for up to 10-15 years after timber harvesting (Higgins 1999). In Victoria, VicForests has been moving away from clearfell silviculture to a greater use of variable retention systems (VicForests 2021. pers comm 3 Sept). This method of timber harvesting retains forest structural elements for at least one harvesting rotation in order to preserve environmental values provided by structurally complex forests. There are also management strategies in place to mitigate impacts to hollow-dependent species such as the Gang-gang Cockatoo. Following harvesting, all forests harvested are allowed to regenerate (VicForests 2021. pers comm 3 Sept). Across south-east Australia, rates of native forest timber harvesting have reduced, and continue to reduce, substantially over time. In Victoria, native forest timber harvesting should completely cease by 2030 under the Victorian Forestry Plan (Victoria State Government 2021). In NSW, future rates of native forest timber harvesting are also expected to decline.

Status—identify the temporal nature of the threat;

Confidence—identify the extent to which we have confidence about the impact of the threat on the species;

Consequence—identify the severity of the threat;

Trend—identify the extent to which it will continue to operate on the species;

Extent—identify its spatial content in terms of the range of the species.

Each threat has been described in Table 1 in terms of the extent that it is operating on the species. The risk matrix (Table 3) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; and the efficacy of current management regimes, assuming that management will continue to be applied appropriately (Table 2). The risk matrix (Table 3) and ranking of threats has been developed in consultation with experts, community consultation and by using available literature.

Table 2 Risk prioritisation

Likelihood	Consequences				
	Not significant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Low risk	Moderate risk	Very high risk	Very high risk	Very high risk
Likely	Low risk	Moderate risk	High risk	Very high risk	Very high risk
Possible	Low risk	Moderate risk	High risk	Very high risk	Very high risk
Unlikely	Low risk	Low risk	Moderate risk	High risk	Very high risk
Unknown	Low risk	Low risk	Moderate risk	High risk	Very high risk

Categories for likelihood are defined as follows:
Almost certain – expected to occur every year
Likely – expected to occur at least once every five years
Possible – might occur at some time
Unlikely – such events are known to have occurred on a worldwide basis but only a few times
Rare or Unknown – may occur only in exceptional circumstances; OR it is currently unknown how often the incident will occur
Categories for consequences are defined as follows:
Not significant – no long-term effect on individuals or populations
Minor – individuals are adversely affected but no effect at population level
Moderate – population recovery stalls or reduces
Major – population decreases
Catastrophic – population extinction

Table 3 Gang-gang Cockatoo risk matrix

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain				• Warming climate • Inappropriate fire regimes • Land clearing	
Likely		• Nest predation by Common Brushtail Possum	• Competition for nest hollows with other species • Altered rainfall patterns • Native forest timber harvesting		
Possible		• Psittacine beak and feather disease (PBFD)			
Unlikely					
Unknown					

Priority actions have been developed to manage the threat particularly where the risk was deemed to be 'very high' or 'high'. For those threats with an unknown or low risk outcome it may be more appropriate to identify further research or maintain a watching brief.

Conservation and recovery actions

Primary conservation outcome

- To prevent further declines and support increases in the population size of the Gang-gang Cockatoo.

Conservation and management priorities

Inappropriate fire regimes

- Actively manage the landscape to minimise the risk of large wildfires, ensuring that this also meets the ecological requirements of the species.
- Ensure fire management (fire risk reduction, fire suppression and post-fire management activities) considers impacts on key breeding locations, foraging, roosting, and nesting habitat for Gang-gang Cockatoo.
- After fire, protect unburnt areas within or adjacent to recently burnt ground that may provide ongoing refuge.

Land clearing

- Cease all land clearing of habitat critical to the survival of Gang-gang Cockatoo.
- Retain hollow-bearing trees in all known Gang-gang Cockatoo nesting areas.
- Restore forests and woodlands within the known range of Gang-Gang Cockatoo.

Native forest timber harvesting

- Develop or improve forestry policies across the range of the species that promote the retention and recruitment of hollow-bearing trees suitable for Gang-gang Cockatoos.
- Protect and enhance the quality of potential habitat (both breeding and foraging) of the Gang-gang Cockatoo.

Competition for nest hollows with other species

- Develop, implement, and monitor a nest box program to increase the number of nesting sites available to Gang-gang Cockatoos, to sites where nesting hollows are a limiting resource.
- Monitor nest site competition (behavioural surveys) and monitor nesting outcomes.
- Implement control programs for native and invasive species identified as significant nest-hollow competitors, such as feral honeybees, possums, starlings, Noisy Miners, and Common Mynas.

Common Brushtail nest hollow competition and predation

- In peri-urban and urban areas with high possum densities, use nest site protection measures to safeguard roosting/nesting sites i.e., protect nests with iron tree collars to prevent possum access.

Stakeholder engagement/community engagement

- Develop and implement a broad strategy to raise awareness and educate the public about Gang-gang Cockatoo conservation, including the need for protection of large, old trees.
- Develop and implement a targeted strategy to promote the use of citizen science in relation to Gang-gang Cockatoo conservation.

Survey and monitoring priorities

- Fund research organisations to undertake further research into Gang-gang Cockatoo breeding, genetics, and population distribution, and encourage local citizen science groups to support these programs.
- Conduct long-term, regular, ongoing monitoring to assess population and subpopulation trends.
- Monitor bushfire-affected areas to assess the impact of wildfire on the species and its habitat, and the capacity of the species to recover from such events.
- Identify and map available habitat and assess habitat quality, including availability of key food species.
- Monitor Gang-gang Cockatoo populations for beak and feather disease.

Information and research priorities

- Undertake modelling to forecast further changes in abundance and distribution likely to be caused by climate change, and identify future climate-suitable areas.
- Conduct a genetics study to calculate recruitment rate, population size/trajectory, and genetic diversity/structure.
- Undertake further research/surveys to identify important foraging and breeding habitat and threats to these areas.
- Undertake further research/surveys to expand on current evidence of the species' ability to re-colonise fire-affected areas.
- Identify priority locations for nest tube deployment with consideration of habitat destruction from wildfires.
- Assess the impacts of wildfire and prescribed burning, especially on food resources.
- Assess the availability of suitable nest hollows and consider options to ameliorate limitations if nest site competition or hollow availability is a limiting factor for species' reproductive success.
- Determine the species' susceptibility to heat stress.
- Determine the prevalence of beak and feather disease virus and other pathogens across the species' range.

Recovery plan decision

A decision has been made to have a Recovery Plan. The Gang-gang Cockatoo has a large range throughout south-east Australia and requires a complex suite of recovery and threat abatement actions across multiple jurisdictions. Recovery actions will need to be coordinated across a large and diverse group of stakeholders and involve a wide variety of land managers and other stakeholders.

A Recovery Plan is considered likely to provide the additional conservation benefits required for this species.

Links to relevant implementation documents

- Commonwealth of Australia (2004) Beak and feather disease (psittacine circoviral disease). Department of Environment and Heritage, Canberra.
- Commonwealth of Australia (2005) Threat abatement plan for beak and feather disease affecting endangered psittacine species. Department of Environment and Heritage, Canberra.
- Commonwealth of Australia (2015) Threat abatement plan for predation by feral cats. Department of the Environment, Canberra.
- Commonwealth of Australia (2016) Threat Abatement Advice for the key threatening process 'Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species'. Department of the Environment and Energy, Canberra.

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The Threatened Species Scientific Committee finalised this assessment on 12 October 2021.

Attachment A: Listing Assessment for *Callocephalon fimbriatum*

Reason for assessment

This assessment follows prioritisation of a nomination from the TSSC.

Assessment of eligibility for listing

This assessment uses the criteria set out in the EPBC Regulations. The thresholds used correspond with those in the IUCN Red List criteria except where noted in criterion 4, sub-criterion D2. The IUCN criteria are used by Australian jurisdictions to achieve consistent listing assessments through the Common Assessment Method (CAM).

Key assessment parameters

Table 4 includes the key assessment parameters used in the assessment of eligibility for listing against the criteria.

Table 4 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	25,300	17,600	35,200	The population estimate of Gang-gang Cockatoos is based on several assumptions: the real AOO is twice that represented by records of presence (allowing for incomplete survey of distribution); the average density of birds 3.1 birds/km^2; the 2019/2020 fire season reduced the carrying capacity of 40% of grid cells by half; and the 2019/2020 fire season resulted in 10% reduction in the overall population size. In 2019/2020 at least 30% of all 1x1 km squares from which birds have been recorded since 1990 were burnt (Cameron et al. 2021). Legge et al. (2021) also estimated an overall population decline at one year post fire of 21% (80% confidence limits: 9-38%) but this is not incorporated in the current population estimate provided by Cameron et al. (2021).

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Trend	Decreasing			Reporting rates from 500 m radius area searches (recorded in 20,094/328,201 surveys), arguably the most reliable of the available survey methods for the species, declined by 69% from 1999–2019. This follows a significant decline of 22% between 1977–1981 and 1998–2001 (Barrett et al. 2002), including a decline of 44% in New South Wales (Barrett et al. 2007). However, the decline in 2 ha, 20 min surveys from 1999–2019 (recorded 8987/267 885 surveys) was only 15% with no clear trend (BirdLife Australia 2020; Cameron et al. 2021).
Generation time (years)	6.9	6.2	7.6	Bird et al. (2020)
Extent of occurrence	400,000 km^2	380,000 km^2	410,000 km^2	Gang-Gang Cockatoos occur along the Great Dividing Range from the Hunter Region of the central north coast of New South Wales in a broad arc around south-eastern Australia to the Otway Ranges and inland as far as Wagga Wagga, Albury, Rutherglen, Seymour and Ballarat with largely isolated subpopulations in the Otway Ranges, Grampians and southwestern Victoria to the South Australian border.
Trend	Stable			Cameron et al. (2021)
Area of Occupancy	30,000 km^2	22,700 km^2	40,000 km^2	The minimum AOO is the number of 2x2 km squares within which they have been recorded since 1990 but, given the remoteness of much of the distribution, the real AOO is assumed to be at least twice that and probably substantially greater (Cameron et al. 2021). In 2019/2020 at least half of the 30% of all 1x1 km squares from which birds have been recorded since 1990 were burnt (Cameron et al. 2021).
Trend	Stable			Cameron et al. (2021)
Number of subpopulations	1	1	4	Cameron et al. (2021)
Trend	Stable			Cameron et al. (2021)
Basis of assessment of subpopulation number	There could be three discrete subpopulations within south-western Victoria (Otway Ranges, Grampians and the far south-west), which may separate from those further east.			

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
No. locations	>10	>10	Not calculated	Cameron et al. (2021)
Basis of assessment of No. locations	An estimate of >10 locations was used in this assessment based on the most plausible serious threat – fire (Cameron et al. 2021). The number of locations was determined using the 2019/2020 fire extent across south-eastern Australia, which burnt 28 to 36% of the species' distribution (Legge et al. 2020; Ward et al. 2020; Legge et al. 2021); though unburnt habitat fragments remain within the fire-affected area. The risk of a fire extirpating all individuals of the species was considered. Given the extremely large range of the species, the lack of continuous vegetation cover, the nonuniform nature of fire severity, and the high access to fire-fighting resources, the risk of fire impacting this entire area is extremely unlikely. It is extremely unlikely that a single fire event would extirpate all individuals within one generation (6.9 years) (Cameron et al. 2021). The geographic position of unburnt locations will vary between fires, but there are always likely to be >10 locations (Cameron et al. 2021).			
Trend	Not calculated			Cameron et al. (2021)
Fragmentation	Not severely fragmented.			
Fluctuations	Not subject to extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals.			

Criterion 1 Population size reduction

Reduction in total numbers (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%

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

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.

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*]

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.

Based on any of the following

(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

Criterion 1 evidence

Eligible under Criterion 1 A2bc for listing as Endangered

Gang-gang Cockatoos are endemic to south-eastern Australia. The species' habitat was heavily impacted during the 2019/2020 bushfires. Estimates of the percentage of the distribution impacted by fire range from 28 to 36% (Legge et al. 2020; Ward et al. 2020; Legge et al. 2021). The 2019/2020 fires may have reduced the carrying capacity of 40% of occupied grid cells by half and resulted in a 10% reduction in the overall population size (Cameron et al. 2021). An analysis based on expert elicitation estimated an overall population decline of 21% one year post-fire (80% confidence limits: 9-38%), and that three generations post-fire the population would still be 29% lower, and possibly as much as 52% lower, than the pre-fire population size (Legge et al. 2021). These predictions assume no further extreme drought or extensive fire events; however, such events are likely to reoccur over the assessment period, which would worsen the extent of population decline.

The decline in Gang-gang Cockatoo populations had been occurring prior to the 2019/2020 wildfires. Data from the Atlas of Living Australia indicate that Gang-gang Cockatoos declined in NSW between the first atlas (1977-81) and the second atlas (1998-2001). The reporting rate for the species declined across its overall NSW range by 44%, and in the Sydney Basin bioregion by 57%. In addition, there is evidence of sudden and dramatic declines in the number of Gang-gang Cockatoos in the Hornsby and Ku-ring-gai Local Government Areas between the 2000s and 2010s (Smith & Smith 2018). The population of Gang-gang Cockatoos in these areas have been reduced to such a critical level, and its habitat has been so drastically reduced, that the species is considered to be in immediate danger of extinction (NSW DIPE 2019; P & J Smith 2021. pers comm 27 July).

Reporting rates from 500 m radius area searches (arguably the most reliable of the available survey methods for the species) declined by 69% from 1999–2019 (i.e., before the 2019-2020 fires). This follows a significant decline of 22% between 1977–1981 and 1998–2001 (Barrett et al. 2002). However, the decline in 2 ha, 20 min surveys from 1999–2019 was only 15% with no clear trend (BirdLife Australia 2020). Given the evidence of declines before the 2019, followed by substantial mortality caused by the 2019-2020 fires from which the species may struggle to recover, it is most likely that the overall decline in a three generation (21 year) period exceeds 50%.

The Committee considers that the species has undergone a severe reduction in numbers of 50–80% over the last three generations (approximately 20.7 years). The reduction has not ceased, the causes have not all ceased and are not fully understood. Therefore, the species has met the relevant elements of Criterion 1 to make it eligible for listing as **Endangered**.

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 km²**	**< 5,000 km²**	**< 20,000 km²**
B2.	Area of occupancy (AOO)	**< 10 km²**	**< 500 km²**	**< 2,000 km²**
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			

Criterion 2 evidence

Not eligible

The EOO is estimated at 400,000 km² (range 380,000–410,000 km²) and the AOO estimated at 30,000 km² (range 22,700–40,000 km²) (Cameron et al. 2021). The EOO is based on all records since 1990. The minimum AOO is the number of 2x2 km squares within which the species has been recorded since 1990 but, given the remoteness of much of the distribution, the real AOO is assumed to be at least twice that, and probably substantially greater (Cameron et al. 2021). The 2019/2020 fire burnt an estimated 30% of all 1x1 km squares from which birds have been recorded since 1990 (Legge et al. 2020). The number of locations has not been calculated, but the spatial nature of the threats, even though stochastic in space and time, is such that there are >10 geographically or ecologically distinct areas where a single threatening event could affect all individuals of the taxon present within a period of one generation. The total population is not severely fragmented, and the species is not subject to extreme fluctuations in EOO, AOO, number of subpopulations, locations, or mature individuals.

Following assessment of the data the Committee has determined that the species' geographic distribution is not precarious for its survival. Therefore, the species has not met this required element of this criterion.

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			

Criterion 3 evidence

Not eligible

The number of mature individuals is estimated to be 25,300 (range 17,600–35,200) (Cameron et al. 2021). The population is estimated to have declined by approximately 10% due to the 2019/2020 fires and was also likely experiencing ongoing, continuous decline of over 50% before the fires (Cameron et al. 2021). The species' geographic distribution is not precarious for its survival, and it is not subject to extreme fluctuations (Cameron et al. 2021).

The number of mature individuals of the species is not considered low, therefore the species does not meet the required elements to be listed as threatened under this criterion.

Criterion 4 Number of mature individuals

	Critically Endangered Extremely low	Endangered Very Low	Vulnerable Low
D. 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 km² 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 may include information relevant to D2. This information will not be considered by the Committee in making its recommendation 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*.

Criterion 4 evidence

Not eligible

The total number of mature individuals is estimated to be 25,300 (range 17,600–35,200). This estimate is based on the assumptions that the real AOO is twice that recorded; the birds occur at an average density of 3.1 birds/km²; and that the 2019/2020 fire season reduced the carrying capacity of 40% of grid cells by half and resulted in 10% mortality.

The total number of mature individuals 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

Criterion 5 evidence

Insufficient data

Population viability analysis has not been undertaken. Therefore, there is insufficient information to determine the eligibility of the species for listing in any category under this criterion.

Adequacy of survey

The survey effort has been considered adequate and there is sufficient scientific evidence to support the assessment.

Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 35 business days between 9 July and 27 August 2021.

Listing and Recovery Plan Recommendations

The Threatened Species Scientific Committee recommends:

(i) that the list referred to in section 178 of the EPBC Act be amended by **including** *Callocephalon fimbriatum* in the list in the Endangered category.

(ii) that there should be a recovery plan for this species.

Cataloguing data

This publication is available at the SPRAT profile for Callocephalon fimbriatum *(Gang-gang Cockatoo).*

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