The Biliirrgan Project

A regional conservation toolkit for the glossy black-cockatoo

Saving our Species

NSW GOVERNMENT

Artist and designer Nikita Ridgeway from Aboriginal design agency Boss Lady Creative Designs created the People and Community symbol.

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Acknowledgement of Country

We acknowledge the Traditional Custodians of this land where we work, play and live, the peoples of the Gumbaynggirr, Yaegl and Bundjalung nations. We acknowledge their spiritual and cultural belonging and recognise their continuing connection to land, waters and culture.

We pay our respects to Elders past, present and emerging.

This resource may contain images or names of deceased persons in photographs or historical content.

Summary

The Biliirrgan Project aims to secure the future of the Biliirrgan (Gumbaynggirr for glossy black-cockatoo) on Gumbaynggirr, Bundjalung and Yaegl Country in the Nambucca Valley, Bellingen, Coffs Harbour and Clarence Valley local government areas (LGAs) of northern New South Wales. The Black Summer bushfires of 2019–20 burnt approximately 45% of the glossy black-cockatoo habitat in these LGAs.

Glossy black-cockatoos are patchily distributed across most of the project area, but their very large home ranges and high mobility make it difficult to count or estimate the size of the local population. As an alternative to counts of individual birds, the Biliirrgan Project team calculated the carrying capacity of the project area based on habitat mapping and food availability measured in the field. However, the resulting population estimates appear to be unrealistically high, and the relationship between glossy black-cockatoos and food availability requires further investigation.

Aside from food availability, glossy black-cockatoo numbers might be depressed by factors affecting their breeding success, for example, inflated levels of nest predation which have been a problem in other parts of the species' range, or a shortage of suitable nest hollows. The first step in assessing breeding success is finding nests. The 'Glossy Squad' team of citizen scientists have so far located 7 active nest trees in the Biliirrgan project area, and we hope to discover more in coming years.

Better knowledge of population size, breeding success and the location of key habitat features such as nest trees will enable targeted local conservation efforts in the future. Ultimately, our intention is that the Biliirrgan Project will result in the delivery of one or more local area management programs in key parts of the project area. In the meantime, there are useful actions that we can take to help conserve glossy black-cockatoos. This regional conservation toolkit details the findings of the Biliirrgan Project to date, and elaborates conservation actions relating to 5 main themes:

1. locating nests
2. protecting important habitat (including nests) from bushfires, clearing and other threats
3. restoring and/or expanding habitat
4. involving citizen scientists and local communities in glossy black-cockatoo conservation
5. improving knowledge of the glossy black-cockatoo in the Biliirrgan project area.

Introduction

The Biliirrgan Project aims to secure the future of the Biliirrgan (Gumbaynggirr for glossy black-cockatoo) on Gumbaynggirr, Bundjalung and Yaegl Country in the Nambucca Valley, Bellingen, Coffs Harbour and Clarence Valley local government areas (LGAs) of northern New South Wales (NSW).

The purpose of this toolkit is to detail actions which will help achieve this aim. The work presented here was funded by the multiregional and strategic initiatives stream of the Australian Government's bushfire recovery program.

The document is in 3 sections:

1. Background information – general background information about the glossy black-cockatoo
2. Glossy black-cockatoos in the Biliirrgan project area – the results of studies carried out for the Biliirrgan Project, and a summary of what we know about glossy black-cockatoos in the project area
3. Recommended management actions.

1. Background information

1.1 The glossy black-cockatoo (south-eastern subspecies)

The glossy black-cockatoo, or Biliirrgan, has 3 subspecies, of which only the south-eastern form (*Calyptorhynchus lathami lathami*) occurs in New South Wales. The south-eastern glossy black-cockatoo (simply called the glossy black-cockatoo in this document) is listed as vulnerable to extinction under both NSW and Commonwealth legislation (*Biodiversity Conservation Act 2016*, *Environment Protection and Biodiversity Conservation Act 1999*, respectively). Large areas of glossy black-cockatoo habitat were burnt in the Black Summer bushfires of 2019–20 (Cth DCCEEW 2022).

1.2 Existing plans and conservation guidelines

Existing plans and conservation guidelines for the glossy black-cockatoo include:

- *Glossy black-cockatoo conservation guidelines for south-eastern Queensland and far north-eastern New South Wales* (Glossy Black Conservancy 2022)
- *Conservation advice for* Calyptorhynchus lathami lathami *(south-eastern glossy black cockatoo)* (Cth DCCEEW 2022)
- *South-eastern glossy black-cockatoo (*Calyptorhynchus lathami lathami*) Saving our Species strategy* (DCCEEW n.d.).

The Glossy Black Conservancy's conservation guidelines are particularly relevant as they relate to an area that is just north of, and ecologically similar to, the Biliirrgan project area. A draft national recovery plan for the glossy black-cockatoo under the Environment Protection and Biodiversity Conservation Act is also in preparation.

1.3 Identification

Glossy black-cockatoos are black cockatoos with red or orange panels in their tails. They are the only black cockatoo with a red tail in the Biliirrgan project area. (Another black cockatoo species with a red tail panel, the red-tailed black-cockatoo [*Calyptorhynchus banksii*], occurs further north and west of the project area).

Adult female glossy black-cockatoos have orange or red tail panels and brown-black heads with yellow markings. The pattern of yellow markings is unique to each female, allowing the identification of individual adult female birds (also known as 'flossies'). Adult male glossy black-cockatoos have plain brown-black heads and red tail panels. Juvenile and sub-adult males have black barring in their tail panels. Fledglings (young birds that have only recently left the nest) are similar to young males, but have pale yellow spots and flecks on their head, chest, shoulders and belly.

Birdlife Australia's *South-eastern glossy black-cockatoo field guide* (Birdlife Australia 2022) is an excellent resource for identifying the sex and age of glossy black-cockatoos.

1.4 Diet

The glossy black-cockatoo feeds only on the seeds of she-oaks (*Allocasuarina* and *Casuarina* species). Within the project area, the main food species are the forest she-oak (*Allocasuarina torulosa*) and black she-oak (*Allocasuarina littoralis*). The coast she-oak (*Casuarina equisetifolia*, also known as the horsetail she-oak), which has been widely planted on coastal sand dunes, is also eaten. Strictly speaking, glossy black-cockatoos do not consume the seeds of Allocasuarinas, but only the seed kernels. Depending on sex and breeding status, glossy black-cockatoos require between 130 and 268 forest she-oak cones per day, or between 208 and 429 black she-oak cones per day. Over the course of a year, a single glossy black-cockatoo is estimated to chew through between 47,450 and 95,630 she-oak cones (DCCEEW 2022).

Forest she-oak (*Allocasuarina torulosa*)

Forest she-oaks are widespread on deeper soils throughout the project area, sometimes growing into large trees over 20 m tall. They occur mostly in eucalypt forests, including wet sclerophyll forests transitioning into rainforest. For reasons unknown, only a small proportion of forest she-oak individuals produce cones, meaning that sites with high densities of forest she-oaks do not necessarily provide large amounts of glossy black-cockatoo food (Brian Hawkins, personal observation).

Black she-oak (*Allocasuarina littoralis*)

The black she-oak is found in drier locations and on shallower, rockier soils than the forest she-oak. It is widespread along the coast in the project area (for example, around Hungry Head and in much of Yuraygir National Park), but also occurs patchily in the hinterland (for example, around Dundurrabin, Stockyard Creek, Chambigne, Dilkoon, Gulmarrad and Sherwood). Black she-oaks produce many more cones per unit area than do forest she-oaks (see data below). Places where black she-oaks occur at high densities constitute the best glossy black-cockatoo habitat in the project area.

Coast she-oak (*Casuarina equisetifolia*)

The coast she-oak is not native to the project area, but was introduced from northern Australia to rehabilitate coastal dunes after sandmining. In some places, for example just north of the Bellinger River mouth near Mylestom, stands of large coast she-oaks provide high densities of cones and constitute high-quality glossy black-cockatoo habitat. Birds seem to feed on coast she-oak from late summer through to winter.

Feed trees

‘Feed trees’ are those individual trees that glossy black-cockatoos feed in. Not all she-oak individuals produce cones (for example, male she-oaks do not), and glossy black-cockatoos are fussy about which cone-producing she-oaks they will eat from; they tend to prefer those trees that are most nutritionally profitable. Glossy black-cockatoos are often faithful to the same feed trees over many years. For example, birds have been feeding on a particular forest she-oak in Kangaroo River State Forest in the Coffs Harbour hinterland since at least 2004 (Brian Hawkins, personal observation).

Conversely, glossy black-cockatoos may also change their selection of feed trees over time (Murdoch 2008), because cone production by individual she-oaks can vary widely from year to year (Cameron 2006a). Thus, the fact that there are no chewed cones beneath a tree now does not mean that the tree won't be used in the future.

When glossy black-cockatoos feed on she-oak seeds they leave behind fragments of chewed cones, known as 'chewings' or 'orts'. Chewings persist on the ground beneath feed trees for long periods, allowing us to identify feed trees up to several months after they have been used.

1.5 Breeding

Glossy black-cockatoos mate for life, and pairs stay together all year round. They nest in hollows in large old eucalypts (living or dead). Trees that develop suitable glossy black-cockatoo nest hollows are thought to be at least 100-years-old and possibly much older. Potential nest hollows have the following characteristics:

- located >8 m above the ground
- located in branches >30 cm in diameter
- located in a branch or stem angled no more than 45° from vertical
- a minimum entrance diameter of 15 cm (Cameron 2006b).

Glossy black-cockatoo nests tend to be loosely clustered, often occurring within 1 km of other nests (Garnett et al. 1999). Although birds have been known to fly up to 14 km between feeding and nesting areas, most glossy black-cockatoo nests are within 1 km of feeding habitat and 200 m of permanent water (Mooney and Pedler 2005).

The nesting season in eastern Australia is thought to last from around March to September (Glossy Black Conservancy 2022). There is some evidence that glossy black-cockatoo pairs in coastal eastern Australia do not breed the year after they have successfully fledged a chick (Russell Jago and Mike Barth, personal communication; see also Section 2 below). The female lays a single egg, which she incubates for around 30 days. While the female is incubating the egg or brooding the young chick, the male feeds her near the nest each day in the late afternoon and sometimes in the morning. The nestling fledges (leaves the nest) approximately 90 days after hatching and is then fed by both parents until at least the onset of the following breeding season (Glossy Black Conservancy 2022). During this period of dependency, the juvenile accompanies its parents at all times.

1.6 Social organisation

Glossy black-cockatoos are social birds, generally occurring in pairs, trios (a pair plus a dependent young) or small groups of pairs. Larger flocks of up to 90 birds are sometimes seen post-breeding, or when food is apparently limited, or at watering holes (Garry Germon, personal communication). There are more male than female glossy black-cockatoos (Lee et al. 2015), and unattached young males sometimes form small flocks.

1.7 Movement patterns

Daily

Glossy black-cockatoos spend much of their time foraging (66% in south-east Queensland and 88% in south-east New South Wales) (Clout 1989; Murdoch 2008), resting during the hottest hours of the day. Towards sunset they generally fly from their foraging areas to drink from a creek, pond, dam or puddle, then head off to roost; and they sometimes also drink in the morning.

Yearly

The ranging behaviour of the glossy black-cockatoo is poorly known, even for the Kangaroo Island population which is the most intensively studied in Australia. The population on Kangaroo Island is segregated into 6 'flocks', where each flock is a group of birds that restricts its movements to a well-defined area, with only some movement between flocks. Most individuals remain within their natal flocks. Twenty-seven percent (27%) of birds on Kangaroo Island were never observed away from the general area where they had fledged, and of those that moved, most remained in the 'flock region', with only 23% observed moving into a different flock region (Glossy Black Conservancy 2022). Movement patterns may be related to the availability of resources around roosting and nesting sites. During breeding, some birds may make daily round-trip flights of up to 30 km to forage (Pepper 1996). Glossy black-cockatoos are considered seasonal visitors to several locations in south-east Queensland, and seasonal movements may be more prevalent on mainland Australia, where resources are more dispersed, than on Kangaroo Island (Glossy Black Conservancy 2022).

1.8 Cultural significance

Biliirrgan is the Gumbaynggirr word for glossy black-cockatoo. The Yaegl word for black cockatoos in general is Aangin, and the Bundjalung word for black cockatoo is Gahr (Lower Richmond dialect). Investigations into the local cultural significance of glossy black-cockatoos are ongoing. The birds are connected with both fire and rain (Uncle Gary Williams, personal communication).

1.9 Threats

Table 1 lists the threats and supporting evidence identified in the Australian Government's *Conservation advice for south-eastern glossy black-cockatoo* (Cth DCCEEW 2022), together with a comment on each threat with regards to the Biliirrgan project area.

Table 1 Threats to the glossy black-cockatoo and supporting evidence, together with comments relating to the Biliirrgan project area

Threat	Evidence	Comment on threat in Biliirrgan project area
Inappropriate fire regimes	**Increase in frequent, large-extent, high-intensity wildfires.** Wildfire is a major ongoing threat for south-eastern glossy black-cockatoos (*Calyptorhynchus lathami lathami*), which could affect both their habitats and the birds directly. The 2019–20 bushfires impacted many Australian fauna and flora species. Around 25% of the overall distribution of the south-eastern glossy black-cockatoo was burnt, and 34% of the species' area of occupancy. Additionally, the species was identified as a priority bird after the fires, requiring urgent management action. On Kangaroo Island, repeated severe fire in the 1990s effectively excluded the drooping she-oak (*Allocasuarina verticillata*) from areas within Flinders Chase National Park, which resulted in the local extinction of a flock of the Kangaroo Island subspecies (*Calyptorhynchus lathami halmaturinus*). Recent post-fire surveys in south-east Queensland confirmed the presence of glossy black-cockatoos only in areas that were unburnt or affected by low-moderate fire. The birds were absent from areas of high or severe fire impact. The risk of more-frequent wildfires under climate change is a serious threat for the subspecies. **Inappropriate fire management** (for example, prescribed fires are too intense or too frequent) may significantly impact the subspecies' feeding and breeding habitats. Burning of fire-sensitive tree species, such as black she-	A significant threat. Forty-five percent (45%) of the glossy black-cockatoo habitat in the project area (as mapped as part of the project) burnt in the Black Summer bushfires, resulting in a reduction in food availability of about 27% (see Section 2.3).

Threat	Evidence	Comment on threat in Biliirrgan project area
	oak and drooping she-oak, may render feeding habitat unsuitable for a long time. Conversely, habitats that have been unburnt for too long may also decrease in quality. Studies found that on Kangaroo Island, old, long unburnt habitat (60+ years post-fire) offers poor food quality and is rarely used by glossy black-cockatoos. The impacts of fire management activities will vary across the subspecies' range. Ensuring a diversity of age classes within foraging habitat is likely to be important. As such, fire management, including the frequency and timing of planned burning, should consider and incorporate each specific region's ecological requirements.	
Clearing of native vegetation/timber harvesting	Historical and current land clearance (for example, for agriculture, urban development and timber harvesting) has been the main threat causing the decline of the subspecies. The loss of feeding habitat and trees likely contributed to the fragmented distribution of the subspecies (also see 'Habitat fragmentation' threat). The loss of large, hollow-bearing trees is another consequence of vegetation clearance, which reduces nest site availability even in areas not extensively cleared. Further removal of habitat without consideration of the impacts on the south-eastern glossy black-cockatoo could result in significant habitat loss, fragmentation and degradation, causing further decline of the subspecies.	A significant threat. Between 2015 and 2020, woody vegetation loss in the project area averaged 2,957 ha per year, comprising 438 ha for agriculture, 2,254 ha for forestry and 265 ha for infrastructure (DPE 2022a).
Habitat fragmentation	As a result of land clearance, habitat fragmentation has become a threat and is potentially a major threat in the future if subpopulations become isolated, leading to the loss of genetic diversity and increased risk of extinction.	Glossy black-cockatoo habitat in the project area is relatively well connected, and the isolation of subpopulations appears unlikely.

Threat	Evidence	Comment on threat in Biliirrgan project area
	Wildfire may also accelerate and increase the extent and degree of fragmentation. With the increasing frequency and intensity of wildfires, more habitat may become unsuitable for both foraging and breeding, leading to further fragmentation of habitats and populations. Fragmented habitat may encourage competitors from more open habitat, for example, common brushtail possum (*Trichosurus vulpecula*), which is one of the main threats impacting the Kangaroo Island subspecies' breeding success.	
Grazing	Grazing by rabbits (*Oryctolagus cuniculus*), other feral herbivores and stock not only causes a decline in extent and productivity of foraging habitat of the subspecies, but it also impedes the regeneration ability of native vegetation after fires, including feed tree species for the subspecies. Interactions with other threats such as fire and habitat clearance and fragmentation may exacerbate these effects.	Good regeneration by Allocasuarinas was observed in both burnt and unburnt sites during surveys conducted for the project, and grazing is unlikely to be a major threat in the project area. However, feral deer are an emerging issue on the Mid North Coast and may be problematic in the future.
Invasive weeds	Invasive weeds have the ability to change the floristic and structural characteristics of habitat, thereby changing resource availability. Furthermore, some weeds may increase the flammability of the habitat, amplifying wildfire risks. More research is required to assess the weed species which may impact south-eastern glossy black-cockatoo feeding and breeding habitats, and the extent of this threat.	Good regeneration by Allocasuarinas was observed in both burnt and unburnt sites during surveys conducted for the project, suggesting that weeds are not having a major impact on glossy black-cockatoo habitat in the project area. However, exotic pine (*Pinus* spp.) wildlings adjacent to plantations in areas such as Yuraygir National Park are potentially competing with black she-oak and may reduce feeding habitat for glossy black-cockatoos in the medium and long term.

Threat	Evidence	Comment on threat in Biliirrgan project area
Increased likelihood of extreme events (that is, heatwave and drought)	Average temperatures in Australia have increased by around 1.4°C in the past century, and global temperatures are likely to exceed 1.5°C in the next 20 years if global greenhouse gas emissions are not reduced immediately. More frequent and extreme heatwaves are projected across Australia. Rainfall may also vary regionally under the changing climate, with low rainfall predictions in parts of south-eastern Australia. Climate change has increased, and will continue to increase, so the likelihood of extreme events such as wildfire, drought and heatwaves, which may have detrimental impacts on south-eastern glossy black-cockatoos and their habitat, will also continue.	Heatwaves are likely to become more frequent on the NSW North Coast, which includes the project area. Annual rainfall in the area is likely to increase due to climate change (AdaptNSW n.d.).
Temporal or spatial shift of resource availability as a result of climate change	As they have a specialised diet and their distribution appears to be associated with resource availability, changes in resource availability caused by climate change may impact the subspecies' distribution, breeding success and survival. Cone production in central New South Wales appears to be linked to climate factors such as rainfall. Monitoring of she-oak habitats in the Lockyer Valley, west of Brisbane, also showed significant increase in tree mortality associated with drought conditions. The die-off rate for the black sheoak (the main food source for the subspecies in that region) increased by 5.4% for every millimetre reduction in rainfall (6-monthly moving average) prior to the observations. In central New South Wales, there is a correlation between breeding success and seasonal rainfall. Changing rainfall patterns and increasing likelihood of heatwaves and	The effects of climate change on temporal or spatial shifts in glossy black-cockatoo food availability in the project area are difficult to predict.

Threat	Evidence	Comment on threat in Biliirrgan project area
	droughts in Australia means that future resource availability for the subspecies is of particular concern.	
Competition for nest hollows	A large proportion of Australian bird species use tree hollows as nesting sites, and almost all arboreal marsupials use tree hollows. As a result, inter-specific competition may be common. Some potential hollow competitors include the common brushtail possum, galah (*Eolophus roseicapillus*), little corella (*Cacatua sanguinea*), and sulphur-crested cockatoo (*Cacatua galerita*). The loss of large hollow-bearing trees due to land clearance and deforestation is problematic as large hollows take centuries to form in eucalypts. Larger, older trees have a higher chance of bearing larger hollows, which is an important characteristic for glossy-black cockatoo nest sites. South-eastern glossy black-cockatoos are especially vulnerable to hollow loss as they often nest in loose aggregations, and nest areas have relatively high densities of hollows. It is absolutely crucial to implement actions to prevent the loss of, and encourage the recruitment of, large hollow-bearing trees in order to minimise the lag effect and long-term risk of extinction of hollow-dependent species such as the south-eastern glossy black-cockatoo. Nest boxes and artificial hollows are becoming an increasingly common management intervention to minimise the impacts of loss of nest sites for hollow-nesters. Birds such as the south-eastern glossy black-cockatoo require specific hollow dimensions. Although nest boxes have not been used successfully for glossy black-	Finding and monitoring nest sites will shed light on the magnitude of this threat in the project area. The lace monitor (*Varanus varius*) is also a potential competitor for hollows in the project area.

Threat	Evidence	Comment on threat in Biliirrgan project area
	cockatoos on the mainland, extensive studies have been conducted on the Kangaroo Island subspecies and a successful nest box program has been implemented. It is important for nest box programs to be tailored to the targeted threatened species as studies have shown that simply setting up generic nest boxes mostly attracts pest species rather than the intended threatened species. Furthermore, artificial nest sites cannot completely replicate resources that large, hollow-bearing trees provide. In general, nest boxes should only be considered where there is evidence that a shortage of natural hollows exists or is suspected.	
Psittacine beak and feather disease (PBFD)	PBFD is a potentially fatal disease caused by psittacine circovirus, typically transferring between adults, nestlings and contaminated nest hollows. Although south-eastern glossy black-cockatoos are susceptible to PBFD, the threat level is relatively low compared to other threats. With decreasing nesting hollows and intensified competition (see 'Competition for nest hollows' threat), it is possible that the likelihood of disease transmission could be greater in the future.	There is no information on this threat in the project area.
Predation	Based on studies of the Kangaroo Island subspecies, nest predation by common brushtail possums may be a threat. Predation by introduced predators such as feral cats (*Felis catus*) and red fox (*Vulpes vulpes*) does not appear to be a major threat. Further research is required to fully understand the extent of the threat of predation on south-eastern glossy black-cockatoos, including both native and introduced predators.	Finding and monitoring nest sites will shed light on the magnitude of this threat in the project area.

Threat	Evidence	Comment on threat in Biliirrgan project area
Bird and egg collection	Like many other threatened parrots in Australia, the illegal collection of adult birds and eggs is a potential threat. The extent of this threat is unknown, but if active it may have detrimental impact on the subspecies' reproductive success.	There is no information on this threat in the project area, but it's important that locations of nest sites are not made public.

Source: Threat and evidence text is sourced from Cth DCCEEW (2022).

Table 2 lists additional threats from the Saving Our Species 'action toolbox' for the glossy black-cockatoo.

Table 2 Additional threats listed in the Saving Our Species action toolbox for the glossy black-cockatoo

Threat	Comment on threat in Biliirrgan project area
Firewood collection resulting in loss of hollow-bearing trees, reduced recruitment of hollow-bearing trees, and disturbance of breeding attempts	This could be a problem in parts of the project area where residents cut their own firewood.
Reduced access to surface water in close proximity to foraging and nesting habitat	This threat is more of a problem in drier parts of the glossy black-cockatoo's range. Creeks, rivers, dams, ponds and puddles are common in the project area, and few locations would be more than a few hundred metres from surface water, except during intense droughts.
Limited information on the location of nesting aggregations and the distribution of high-quality breeding habitat	This is the major knowledge gap in the project area. Prior to the Biliirrgan Project, there were no active nest sites recorded on the department's BioNet Atlas or Birdlife Australia's Birdata (website and app). Nest-finding workshops and surveys undertaken as part of the Biliirrgan Project have since resulted in the discovery of 7 active nests, at Sawtell/Toormina, Kalang, Brierfield, Darkwood and Dundurrabin 3 nests).
Disturbance from coal-seam gas and open-cut coalmining causing loss of foraging and breeding habitat as well as disturbing reproductive attempts	This threat is more of a problem in other parts of the glossy black-cockatoo's NSW range.

Note: 'The department' refers to NSW Department of Climate Change, Energy, the Environment and Water.

2. Glossy black-cockatoos in the Biliirrgan project area

This section of the toolkit reports the results of studies carried out for the Biliirrgan Project and summarises what we know about glossy black-cockatoos in the project area. The studies presented here include:

- desktop habitat mapping
- field surveys of glossy black-cockatoo habitat, including assessments of food and nest hollow availability
- a summary of the impacts of the Black Summer bushfires on glossy black-cockatoos and their habitat
- an attempt to calculate the carrying capacity of glossy black-cockatoo feeding habitat in the project area by combining habitat mapping and field survey results
- searches for glossy black-cockatoo nests.

2.1 Desktop mapping of glossy black-cockatoo habitat

We used 2 existing vegetation community mapping products to produce a map of potential habitat:

- *Fine-scale vegetation mapping for the Coffs Harbour LGA* (OEH 2012) for the Coffs area
- NSW State Vegetation Type Map (DPE 2022b) for the other LGAs.

The potential habitat map is referred to as *Biliirrgan Webmap_habitat_planting* (arcgis.com) (see link in 'More information' section to access the map online where it can be viewed at various scales).

We classed a vegetation community as glossy black-cockatoo habitat if **both** of the following criteria were met:

- either forest she-oak or black she-oak had a mean cover-abundance score of at least 2 (equating to at least 5 plants, and at least 5% cover, in a 20 × 20 m plot), **and**
- the frequency (that is, the proportion of flora survey plots in which a species was recorded) of forest she-oak and black she-oak in that community summed to at least 10%.

We subdivided glossy black-cockatoo habitat into classes, based on the frequency and cover-abundance of the most frequent Allocasuarina species, as shown in Table 3 and Appendix A.

Table 3 Habitat classes used in mapping

Habitat class	Dominant (most frequent) Allocasuarina species	Summed Allocasuarina frequency	Mean cover-abundance of dominant Allocasuarina species
torulosa_Mod	Forest she-oak (*Allocasuarina torulosa*)	10–55%	2 or greater (equating to at least 5 plants, and at least 5% cover)
torulosa_High	Forest she-oak (*Allocasuarina torulosa*)	>55%	2 or greater (equating to at least 5 plants, and at least 5% cover)
littoralis_Mod	Black she-oak (*Allocasuarina littoralis*)	10–55%	2 or greater (equating to at least 5 plants, and at least 5% cover)
littoralis_High	Black she-oak (*Allocasuarina littoralis*)	>55%	2 or 3 (equating to at least 5 plants, and 5–50% cover)
littoralis_VeryHigh	Black she-oak (*Allocasuarina littoralis*)	>55%	4 or greater (equating to at least 5 plants, and >50% cover)

These classes were developed after preliminary field investigations of the relationship between Allocasuarina cone density (a proxy for glossy black-cockatoo habitat quality) and mapped Allocasuarina frequency and cover-abundance. There is no 'very high' category for forest she-oak because field surveys found that communities with forest she-oak cover-abundance of 4 or 5 did not have higher cone densities than communities with forest she-oak cover-abundance of 2 or 3.

There are approximately 908,155 ha (or 9,082 km^2) of glossy black-cockatoo habitat in the Biliirrgan project area (see accompanying online map), which equates to about 67% of the total land area. The area of the various habitat classes is shown in Table 4 and Figure 1. Forty-five percent (45%) of the glossy black-cockatoo habitat in the project area burnt in the Black Summer bushfires of 2019–20 (see map in Appendix A).

Table 4 Areas of mapped glossy black-cockatoo habitat classes

Habitat class	Area UNBURNT in Black Summer fires (ha)	Area BURNT in Black Summer fires (ha)	Total area (ha)
torulosa_Mod	128,088	79,870	207,958
torulosa_High	321,120	309,160	630,280
littoralis_Mod	29,427	8,296	37,723
littoralis_High	19,703	12,429	32,132
littoralis_VeryHigh	62	0	62
TOTAL	**498,400 (55%)**	**409,755 (45%)**	**908,155**

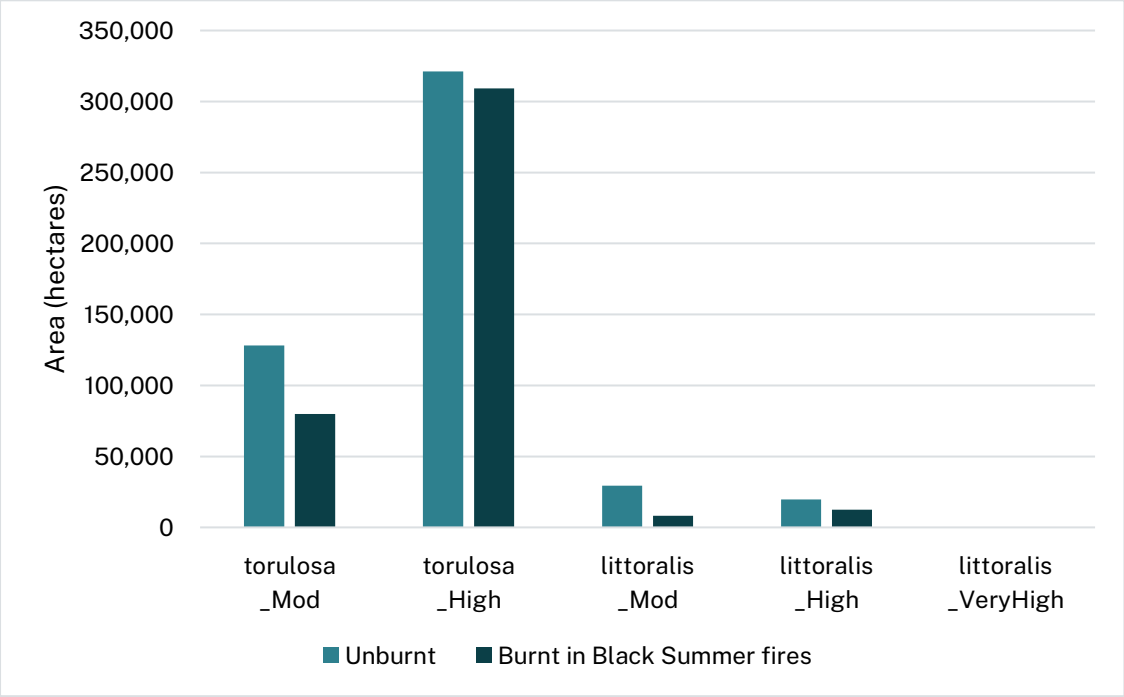

Figure 1 **Area of habitat classes burnt and unburnt in project area during Black Summer fires**

Forty-seven percent (47%) of glossy black-cockatoo habitat in the project area is in state forest, 24% in national park, 2% on Crown land and 27% in other tenures including private ownership (Table 5 and Figure 2).

Table 5 **Mapped glossy black-cockatoo habitat by tenure**

	Crown land	State forest	NPWS estate	Other	Total
Glossy black-cockatoo habitat (ha)	21,968	424,586	218,519	243,081	908,155
Percent of total glossy black-cockatoo habitat	2%	47%	24%	27%	100%

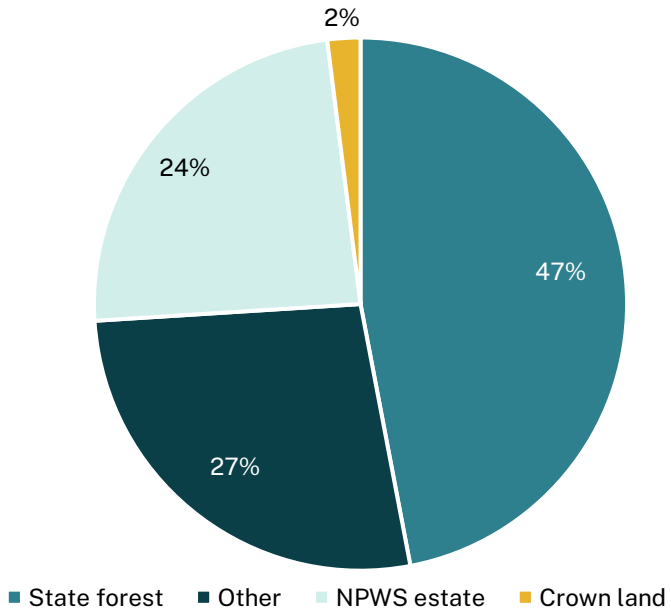

Figure 2 **Glossy black-cockatoo habitat in project area by tenure**

Limitations of mapping

The habitat map was derived from the best existing vegetation mapping for each LGA. However, the existing mapping was not designed specifically for recording Allocasuarina densities and was done at a scale which means that there are often discrepancies between mapped vegetation communities and the vegetation on the ground. The State Vegetation Type Map aims for (but does not necessarily achieve) an on-ground accuracy of 70%. Also, Allocasuarinas are not evenly distributed across a community, but tend to be clumped as a result of factors such as fire history. Therefore, even where the vegetation mapping is accurate, Allocasuarina densities may differ substantially from the average for a given vegetation community.

Our field investigations found that the glossy black-cockatoo habitat mapping is reliable at larger scales. For instance, landscapes where there are large areas of mapped high-quality glossy black-cockatoo habitat tend to have large areas of high-quality habitat on-ground. However, because of the limitations outlined above, at finer scales the mapping is less reliable. For example, Allocasuarinas may be completely absent from a site mapped as high or very high quality habitat, or may occur in high densities at sites not mapped as habitat at all. At finer scales, the map should not be assumed to be a true representation of habitat on-ground.

2.2 Field surveys

We carried out field surveys in mapped glossy black-cockatoo habitat. The aims of the field survey program were as follows (and are discussed in more detail below):

- to assess food availability for glossy black-cockatoos ('cone counting')
- to map additional locations of glossy black-cockatoo feed trees

- to assess drought impacts on glossy black-cockatoo habitat
- to assess Allocasuarina regeneration in burnt and unburnt areas
- to assess the availability of potential nesting hollows in the project area.

We surveyed 150 sites (see accompanying online map), stratified by fire history (burnt or unburnt in the Black Summer fires) and habitat class (Table 6).

Table 6 Number of field survey sites in each habitat class

Mapped habitat class	Number of sites surveyed		Total
	Unburnt	Burnt	
torulosa_Mod	6	12	18
torulosa_High	55	39	94
littoralis_Mod	12	6	18
littoralis_High	8	10	18
littoralis_VeryHigh	2	0	2
Total	**83**	**67**	**150**

The sites were randomly located in state forest or national park estate, between 60 and 200 m off a road or track. Four sites (not shown on the online maps) were located on private land. The sites were mostly in the Coffs coast and hinterland, which was initially the focus of the project. The project area was subsequently expanded due to community interest and because the habitat mapping was done at the scale of LGAs.

Each site was a 56-m radius circle, which equates to an area of 1 ha. At each site we recorded data on canopy species and vegetation structure, fire and drought impacts, Allocasuarina regeneration, and glossy black-cockatoo habitat (including estimating the number of cones on trees – we didn't count cones on the ground). We used the proforma shown in Figure 3 to record our findings. The surveys were conducted between July 2022 and August 2023. Site data are provided on the department's website (see link in 'More information' section).

Biliirrgan project habitat survey pro forma			
Site Code:		Date:	
Easting/X:		Northing/Y:	
Datum:		Personnel:	
Location:			
Site moved? Reason if moved:			
Canopy cover %:		Canopy sp. 1:	
Canopy sp. 2:		Canopy sp. 3:	
% burnt (2019–20):		Severity (2019-20)[1]:	
Drought impact on Allocasuarina class:[2]		Allocasuarina regeneration class[3]:	
No. trees with chewed cones:		No. feeding events:	
No. potential nest trees:[4]		No. potential nest hollows:	
No. stags:[5]		No. large old trees (dbh > 60 cm)	
Photo numbers:			

Food tree species	% cover	Cone abundance value[6]	Total number of cones (% cover * abundance value)
Allocasuarina torulosa			
Allocasuarina littoralis			
Casuarina equisetifolia			

Comments:

1. Scorch marks on trunks below 3 m (low); scorch marks reach canopy (moderate); some dead canopy branches (high); lots of dead canopy branches (extreme)
2. No drought impacts evident in Allocasuarinas (none); up to 20% of canopy impacted by drought (low); 20–50% of canopy impacted by drought (mod); >50% of canopy impacted by drought (high)
3. No evidence (none); up to 20 plants per ha (sparse); 20 - 100 plants per ha (moderate); 100–500 plants per ha (common); >500 plants per ha (abundant)

4. Trees with hollows >8 m above ground AND situated in branches or stems >30 cm in diameter AND angle of branch or stem no more than 45 degrees from vertical AND entrance diameter > 15 cm
5. Dead trees with DBH > 30 cm at 8 m height
6. Mean cones (on trees) per 10 m by 10 m area of Allocasuarina cover (i.e. 1% of site)

Figure 3 Glossy black-cockatoo habitat survey proforma

Food availability ('cone counting')

A key goal of the field surveys was to estimate the number of Allocasuarina cones at each 1-ha site. We did this by estimating the percentage cover of each Allocasuarina species, and by estimating the number of Allocasuarina cones in a typical 10 m x 10 m patch of Allocasuarina cover (i.e. 1% of the site). Multiplying the values for cone abundance and percentage cover (Figure 3) allowed us to estimate the number of Allocasuarina cones at each 1-ha site. Table 7 and Figure 4 show the mean number of Allocasuarina cones per hectare for each habitat class.

Table 7 **Average number of Allocasuarina cones per hectare for each habitat class**

Mapped habitat class	Average number of Allocasuarina cones per hectare (number of sites in brackets)	
	Unburnt	Burnt
torulosa_Mod	3,455 (n = 6)	2,354 (n = 12)
torulosa_High	3,811 (n = 55)	1,384 (n = 39)
littoralis_Mod	2,629 (n = 12)	0 (n = 6)
littoralis_High	13,505 (n = 8)	2,525 (n = 10)
littoralis_VeryHigh	55,700 (n = 2)	NA (n = 0)

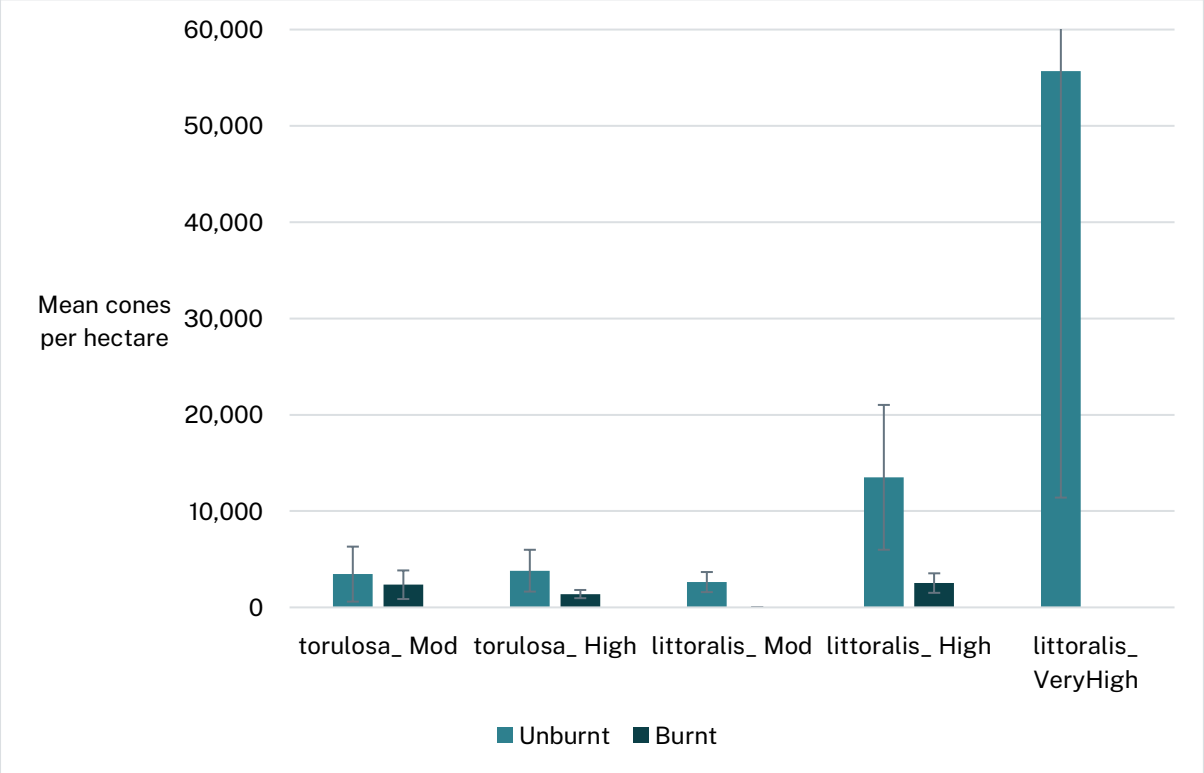

Figure 4 **Allocasuarina cone densities (cones/ha) by habitat class in areas burnt and unburnt by Black Summer fires**

A few things about these results are worth noting:

- The best black she-oak (*A. littoralis*) habitat (high and very high) had much higher cone densities than the best forest she-oak (*A. torulosa*) habitat (Photos 1 and 2). This was even more notable when we compared on-ground habitat classes (that is, where sites were categorised as either 'torulosa' or 'littoralis' based on which species was actually dominant on the ground) rather than mapped habitat classes (that is, where we categorised sites based on the mapping). We found that on-ground littoralis_High sites had 12.5 times the cone densities compared to on-ground torulosa_High sites (19,756 c.f. 1,580).
- Cones were still present at burnt sites, but at lower densities than at unburnt sites.
- The cone densities are very low compared to some other areas that have been studied. For example, cone densities on Kangaroo Island, where the drooping she-oak (*A. verticillata*) is the main food species, have been reported as between 334,000 and 835,000 cones per hectare (Chapman and Paton 2002). The best site visited in the Biliirrgan project area had a cone density of 120,000 cones per hectare.

By multiplying the figures for cones per hectare in Table 7 by the hectare figures in Table 4, we were able to calculate the estimated total number of Allocasuarina cones in the project area: 378,292,330 black she-oak cones and 2,282,137,711 forest she-oak cones for a total of 2,660,430,041 cones. In reality, not all of these cones would be available as food. Cones might be unavailable because birds cannot find them, or because cone densities are too low to make searching and foraging worthwhile, or because the risks of exploitation (for example, exposure to predators) are too great. The proportion of cones available to glossy black-cockatoos in the project area is unknown, but has been estimated at 83% in other areas (DCCEEW 2022).

Photo 1 **Thicket of black she-oak (*Allocasuarina littoralis*) in Yuraygir National Park. High-quality black she-oak habitat like that pictured here tends to have much higher cone densities than habitat where the dominant Allocasuarina is forest she-oak (*Allocasuarina torulosa*), which does not form thickets. Photo: Brian Hawkins/DCCEEW**

Photo 2 **High-quality forest she-oak (*Allocasuarina torulosa*) habitat on the Eastern Dorrigo Plateau near Lowanna. Unlike black she-oak (*Allocasuarina littoralis*), this species does not form thickets, and forest she-oak habitat tends to have much lower cone densities than habitat dominated by black she-oak. Photo: Brian Hawkins/DCCEEW**

Glossy black-cockatoo feed trees

Of the 150 sites surveyed, only 13 (or 8.7%) had feed trees (that is, trees with signs of feeding by glossy black-cockatoos). We found 45 feed trees in total, including 20 black she-oak feed trees at a single site on private property near Dundurrabin (Photo 3). The locations of all feed trees have been entered into the NSW BioNet Atlas. Only 2 feed trees were within the area that burnt in 2019–20. Table 8 shows the number of feed trees in each habitat class (as assessed on-ground).

Photo 3 **This site in a black she-oak (*Allocasuarina littoralis*) thicket near Dundurrabin contained 20 feed trees (that is, trees with chewed cones beneath them indicating glossy black-cockatoo feeding). Photo: Brian Hawkins/DCCEEW**

Table 8 **Number of feed trees in each habitat class (as assessed on the ground), burnt and unburnt**

Habitat class (dominant Allocasuarina assessed on-ground)	Total number of feed trees (number of sites in brackets)	
	Unburnt	Burnt
torulosa_Mod	8 (n = 8)	0 (n = 8)
torulosa_High	8 (n = 51)	2 (n = 42)
littoralis_Mod	0 (n = 9)	0 (n = 6)
littoralis_High	22 (n = 12)	0 (n = 3)
littoralis_VeryHigh	5 (n = 2)	NA (n = 0)
TOTAL	**43 (n=83)**	**2 (n=59)**

There were more feed trees per hectare in habitat dominated by black she-oak (as assessed on-ground; see Table 9 and Figure 5) than in forest she-oak habitat, although this trend was exaggerated by the site near Dundurrabin that had 20 black she-oak feed trees.

Table 9 **Average number of feed trees per hectare for habitat dominated by black she-oak (*Allocasuarina littoralis*) and forest she-oak (*Allocasuarina torulosa*) (as assessed on the ground)**

Dominant Allocasuarina (assessed on-ground)	Average number of feed trees per hectare (number of sites in brackets)	
	Unburnt	Burnt
Black she-oak (*Allocasuarina littoralis*)	1.17 (n = 23)	0 (n = 9)
Forest she-oak (*Allocasuarina torulosa*)	0.27 (n = 59)	0.04 (n = 50)

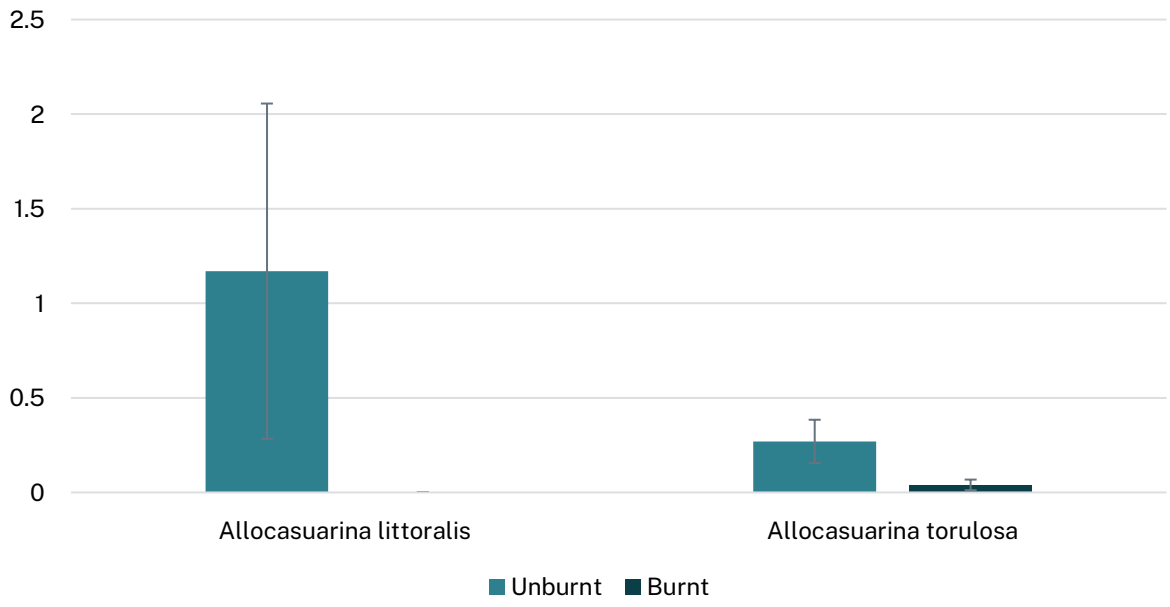

Figure 5 **Feed trees per hectare in black she-oak (*Allocasuarina littoralis*) and forest she-oak (*Allocasuarina torulosa*) habitat (as assessed on-ground) in burnt and unburnt sites**

Impacts of drought on glossy black-cockatoo habitat

Few unburnt sites showed much impact of the drought that preceded the Black Summer fires. For obvious reasons, drought impacts were impossible to assess in burnt sites. The only area where we observed widespread moderate to high drought impacts on Allocasuarinas was the coastal heathland around Wooli in Yuraygir National Park (Photo 4).

Photo 4 **Stand of black she-oak (*Allocasuarina littoralis*) killed by drought in Yuraygir National Park near Wooli. Photo: Brian Hawkins/DCCEEW**

Allocasuarina regeneration in burnt and unburnt glossy black-cockatoo habitat

Allocasuarina regeneration was observed at 83% (49/59) of burnt sites and 88% (72/82) of unburnt sites. These figures exclude sites where no Allocasuarinas were present (for unburnt sites) or where there was no sign of Allocasuarinas in the general vicinity of the site (for burnt sites).

On the whole, we found that Allocasuarinas at burnt sites were recovering well, via the dual mechanisms of basal sprouting and seeding. Basal sprouting appeared to be the dominant recovery mechanism for forest she-oak (Photo 5), while black she-oak was recovering primarily from seed (Photo 6).

Photo 5 **Regenerating forest she-oaks (*Allocasuarina torulosa*) in high severity fire site near Clouds Creek, 2½ years after the Black Summer fires. Most of the forest she-oak shoots are regenerating from basal sprouts. Photo: Brian Hawkins/DCCEEW**

Photo 6 **Regenerating black she-oaks (*Allocasuarina littoralis*) near Nymboida River near Platypus Flat, 2½ years after the Black Summer fires. Black she-oak mostly regenerates from seed. Photo: Brian Hawkins/DCCEEW**

Availability of potential nest hollows in the project area

There was an average density of 2.8 potential nest hollows per hectare at the survey sites, with little difference between burnt and unburnt sites (Figure 6). This finding is surprising, given anecdotal observations that many hollow-bearing trees were destroyed in the Black Summer bushfires. Possible explanations are that hollows are easier to see in burnt sites, where there is less obscuring foliage than in unburnt sites, and/or that bushfires have the potential to create hollows (at least in the short term) by turning living trees into stags. There was an average of 2.4 stags per hectare in burnt sites, compared with 1.4 in unburnt sites.

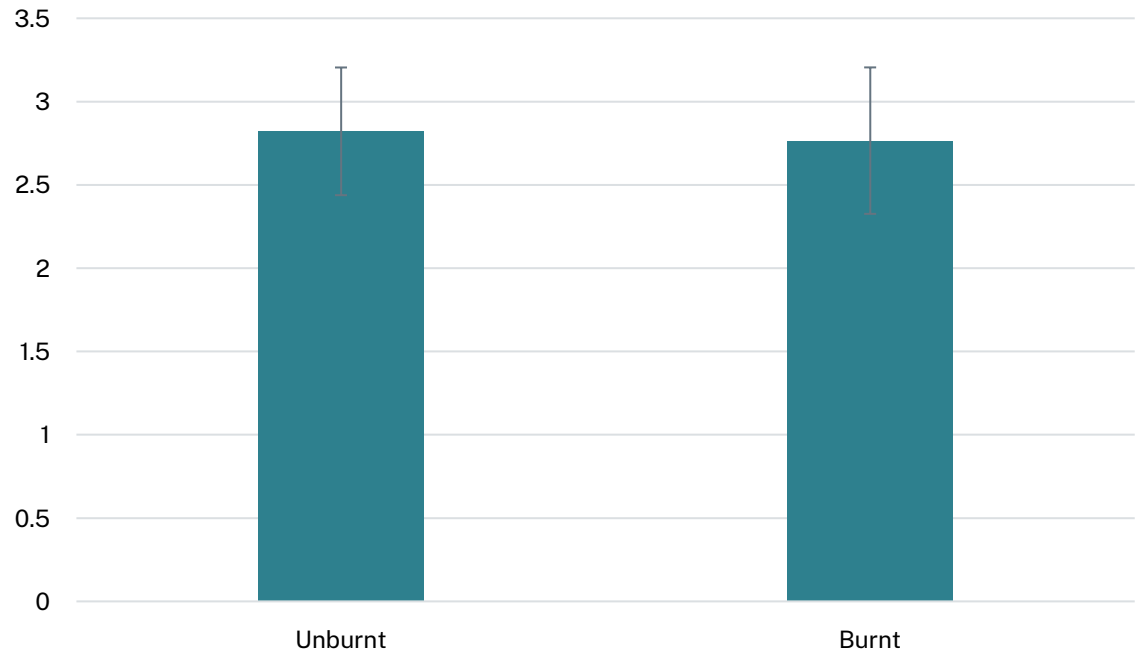

Figure 6 **Number of potential nest hollows per hectare in burnt and unburnt sites**

Given that there is 908,155 ha of mapped glossy black-cockatoo habitat in the project area, a figure of 2.8 potential nest hollows per hectare might suggest that nest sites are plentiful across the landscape. However, it should be noted that:

- hollow abundance as observed from the ground does not necessarily reflect the actual abundance of nesting hollows as perceived by a glossy black-cockatoo
- we don't have a good understanding of what constitutes glossy black-cockatoo nesting habitat in the project area – it's possible that the landscape position or other characteristics of many of the potential nest hollows we observed might rule them out as glossy-black cockatoo nest sites
- competition with other hollow-dwelling fauna, for example, brush-tailed possums, lace monitors and carpet pythons (*Morelia spilota*), could mean that many suitable hollows are unavailable for glossy-black cockatoos.

Photo 7 **Example of a stag that was assessed as a potential nest tree from the ground. Photo: Brian Hawkins/DCCEEW**

2.3 Summary of impacts of Black Summer bushfires on glossy black-cockatoos

This section draws on the results of the field surveys detailed above and also conversations with local citizen scientists to summarise the impacts of the Black Summer bushfires on glossy black-cockatoos. The Black Summer bushfires of 2019–20 burnt 45% of the glossy black-cockatoo habitat in the Biliirrgan project area. The breakdown of habitat class by fire severity is shown in Table 10. Fire severity classes follow the fire extent and severity map classes (see 'More information' section).

Table 10 **Percentage breakdown of habitat class by fire severity. Values are the percentage of each habitat class in each fire severity category.**

Habitat class	Fire severity					Total
	Unburnt	Low severity	Moderate severity	High severity	Extreme severity	
torulosa_Mod	62%	10%	14%	9%	6%	100%
torulosa_High	51%	9%	17%	13%	10%	100%
littoralis_High	61%	6%	13%	14%	5%	100%
littoralis_Mod	78%	6%	7%	6%	4%	100%
littoralis_VeryHigh	100%	0%	0%	0%	0%	100%
All habitat classes combined	**55%**	**9%**	**16%**	**11%**	**9%**	**100%**

Note: Severity classes: Low = burnt understorey, unburnt canopy. Moderate = partial canopy scorch. High = full canopy scorch +/– partial canopy consumption. Extreme = full canopy consumption.

Not all Allocasuarina stems within the burnt area were killed; many survived, especially where fire severity was lower, and have continued to produce cones post-fire. We estimate that the Black Summer fires reduced glossy black-cockatoo food availability in the Biliirrgan project area by about 27%. This calculation is based on the figures in Table 4 and Table 7.

Our data suggest that the Black Summer fires did not reduce the availability of potential nest hollows, at least in the short term, possibly because the fires created new hollows in dead trees (stags). However, the 'life expectancy' of a dead tree is shorter than the life expectancy of a living tree, meaning that burnt areas may have lower hollow availability in the long term.

Although Allocasuarinas are regenerating well in burnt areas, as of 2022 none of the regenerating stems were old enough to produce cones. Regenerating black she-oaks may begin producing cones within 3 to 5 years of fire, and forest she-oaks within 7 years. The length of time before cone densities in burnt areas recover to pre-fire levels is unknown but is likely to be at least 15 years post-fire.

During and after the Black Summer fires, much larger than usual numbers of glossy black-cockatoos were reported from unburnt parts of the project area. For example, there were groups of up to 40 birds at Fernmount, Bellingen, the Promised Land and Hungry Head (data from Bellingen Birders), and groups of around 10 birds at Sawtell. These large numbers were temporary. The largest group of glossy black-cockatoos observed in the project area since 2020 was 19 birds at Hungry Head.

The fate of the 'bushfire refugee' birds is unknown. Some may have returned to the fire footprint – we recorded chewed Allocasuarina cones in 2 burnt sites during fieldwork for this toolkit. Observers at Dundurrabin, near the fire footprint boundary, report that glossy black-cockatoos disappeared from the area after the Black Summer fires, returning in December 2022 (Deb and Ken Thornhill, personal communication).

2.4 Carrying capacity of glossy black-cockatoo feeding habitat in the project area

Using an unpublished department methodology (DCCEEW 2022) for calculating carrying capacity based on cone numbers and cone consumption rates (that is, 130 to 413 Allocasuarina cones eaten per bird per day, depending on Allocasuarina species and the sex and breeding status of birds), we calculated that the Biliirrgan project area contains enough food to support an estimated 12,853 birds. This is well in excess of the minimum number required to maintain a robust population, which is estimated to be 250 breeding pairs, equating to 675 to 800 birds (DCCEEW 2022).

We suspect that the actual size of the local population is far less than the figure above. At a workshop for local birders and conservationists held in May 2023, audience 'guesstimates' of the number of glossy black-cockatoos in the project area ranged from less than 50 to around 2,000 birds. Moreover, prior to the Black Summer bushfires the national population of the glossy black-cockatoo was estimated at only 7,500 birds (Cameron et al. 2021).

There are 2 plausible explanations for the discrepancy between the calculated carrying capacity of the project area and the likely much lower actual number of birds. One possibility is that the assumptions detailed in the methodology (DCCEEW 2022) are not met in the project area. Although trials in other parts of the glossy black-cockatoo's range found that known population sizes aligned fairly well with the carrying capacity predicted by the methodology, none of these trials involved landscapes where forest she-oak is the dominant feed tree species. It is possible that in forest she-oak habitats, where cones tend to be widely but thinly spread, a much lower percentage of the total food resource is available to glossy black-cockatoos than in landscapes dominated by thicket-forming Allocasuarinas, such as are common in other parts of the species' range. The methodology assumes that 17% of the total food resource is unavailable to birds, however, this percentage may be much higher in the Biliirrgan project area. We re-ran the carrying capacity calculations under the assumption that 50% of the total food resource was unavailable to birds. The calculated carrying capacity of the Biliirrgan project area under this assumption was 7,711 birds, still far in excess of the highest expert guesstimates. A second possibility is that food availability may not be the

primary factor limiting glossy black-cockatoo numbers in the project area, or at least not at the time of our study. It may be that factors that affect breeding success are more influential.

2.5 Nesting in the Biliirrgan project area

Locating nests

In May 2023, a week-long workshop was held in Toormina to train conservationists to find glossy black-cockatoo nests. The workshop led to the development of a local 'Glossy Squad', a loose network of citizen scientists dedicated to glossy black-cockatoo conservation. The Glossy Squad name and logo (Figure 7) are courtesy of Glossies Northern Rivers.

Figure 7 **The 'Glossy Squad' logo. Reproduced courtesy of Wales Design and Glossies Northern Rivers (wildbnb.com.au)**

After the workshop, Glossy Squad members spent over a thousand person-hours searching for glossy black-cockatoo nests from May to August 2023 in several different locations, including Urunga, Gulmarrad, Kalang, Braunstone, Valla, Sawtell/Toormina and Dundurrabin. Eventually, this work culminated in the discovery of 3 active nests in the project area, at Sawtell/Toormina, Kalang and Dundurrabin. A fourth nest was found at Red Range, close to but outside the Biliirrgan project boundary. In the winter of 2024, an additional 4 active nests were found, at Dundurrabin (2 new nests), Darkwood and Brierfield. Of the 8 nests found so far (including the Red Range nest), 3 are in New England blackbutts (*Eucalyptus campanulata*), 2 are in stags, one is in a tallowwood (*Eucalyptus microcorys*), one is in a Sydney blue gum (*Eucalyptus saligna*) and one is in a coastal blackbutt (*Eucalyptus pilularis*).

Nest success

Monitoring by acoustic recorders in 2023 found that the Kalang, Dundurrabin and Red Range nests successfully fledged chicks, but the Sawtell/Toormina nest failed (Table 11). The reason for the failure of the Sawtell/Toormina nest is unknown. Nest success for 2024 has not yet been assessed.

The expected nest success rate for glossy black-cockatoos is around 50% (Garnett et al. 1999; Matt Cameron, personal communication). We don't yet have enough information to make a meaningful assessment of the nest success rate in the Biliirrgan project area, because nests that fail typically do so within the first 2 months after laying (Matt Cameron, personal communication), and at least 2 of the 4 nests discovered in 2023 had already passed this stage when they were found.

Table 11 Fate of glossy black-cockatoo nests detected in 2023

Nest location	Date of nest discovery	Fate of nest	Date of fledging/nest failure	Comments
Dundurrabin	17/6/2023	Successful	21/7/2023 to 2/8/2023	Chick approaching fledging on 21/7/2023. Gap in monitoring between 21/7/2023 and 2/8/2023. No calling at nest site from 2/8/2023 onwards. Pair with fledgling observed nearby in Dundurrabin on 10/8/2023.
Kalang	5/6/2023	Successful	31/7/2023	–
Sawtell/Toormina	9/6/2023	Failed	27/6/2023	Last calls at nest recorded on 26/6/2023.
Red Range	Before 24/5/2023	Successful	23/8/2023	–

Probable dates of egg laying and hatching

Extrapolating backwards from the dates of fledging in Table 11, egg-laying in the Dundurrabin, Kalang and Red Range nests appears to have occurred between 23 March and 23 April 2023 and hatching between 22 April and 23 May 2023.

Possible bi-annual breeding

Two lines of evidence support the hypothesis that, unlike birds on Kangaroo Island, glossy black-cockatoo pairs in the Biliirrgan project area do not nest the year after a successful breeding event. Firstly, in the autumn and winter of 2023, Glossy Squad members saw several pairs of glossy black-cockatoos in company with juveniles born in 2022, suggesting that these pairs would not attempt to breed again until 2024. Secondly, a nest camera installed on the Dundurrabin nest tree in the summer of 2023–24 did not record any return visits by the pair that successfully nested there in 2023 (although a different female visited the nest on several occasions in December 2023 and January 2024, laying an egg in early March 2024).

Low proportion of pairs attempting to nest

In 2 areas where birds were monitored intensively in 2023 – Urunga and Gulmarrad – Glossy Squad volunteers did not find any evidence of pairs attempting to nest. At Gulmarrad there were 4 pairs of birds, and at Urunga there were up to 19 birds in total, including at least 3 pairs that showed signs of breeding (that is, inspecting potential nest hollows, males soliciting copulation, females begging/being fed by males). Despite

frequent monitoring, none of the Gulmarrad or Urunga birds were found to be nesting. The absence of successful nesting in these areas was confirmed in the spring and summer of 2023 by the Glossy Squad's failure to detect any fledglings among the Gulmarrad or Urunga birds (although a fledgling did appear at Urunga in early 2024, presumably from a nest in a different location).

A study in central New South Wales found that more glossy black-cockatoo pairs attempted to breed when there had been good rainfall in the previous year, resulting in high food availability (Cameron 2009). We do not know whether food availability in the Biliirrgan project area was high or low in 2023 compared to other years. However, a search of the Bureau of Meteorology's *Climate data online* map for rainfall in the project area indicated rainfall was well above average in 2022 (168% of the annual mean at Ulmarra, and 188% of the annual mean in Coramba), suggesting that food availability should have been relatively high. This raises the possibility that the low proportion of pairs attempting to nest may have been influenced by factors other than food availability.

Gulmarrad and Urunga are both peri-urban areas where there are large tracts of cleared/developed land without suitable nesting trees for glossy black-cockatoos. Although some hollow-bearing trees are present in these landscapes, the lack of nesting attempts by the local glossy black-cockatoos suggests that suitable hollows may be in short supply. Where present, they might be occupied by other species such as brush-tailed possums and lace monitors. A study in south-western New South Wales found that glossy black-cockatoo nests were more likely to be located in areas with higher densities of potential nest hollows (Cameron 2006b), and the 3 glossy black-cockatoo nest trees located in the Biliirrgan project area in 2023 were all at sites where there were multiple other potential nest hollows nearby. It may be that Gulmarrad and Urunga – and possibly many other parts of the project area – possess insufficient densities of potential nest hollows to allow nesting by more than a fraction of the glossy black-cockatoo pairs present. The installation of artificial nest hollows in these areas could benefit the birds.

2.6 Summary of current knowledge

Although the studies documented here have made a useful beginning, many aspects of glossy black-cockatoo ecology in the Biliirrgan project area remain poorly understood. However, there are several important things we do know:

- Glossy black-cockatoos are widely distributed across most of the project area, which contains approximately 9,000 km^2 of potential habitat (including habitat that burnt in the Black Summer fires). See accompanying online *Biliirrgan Webmap_habitat_planting* (see link in 'More information' section).
- Although glossy black-cockatoos are widely distributed, they are rare at most places and times. For example, out of 150 sites visited in mapped glossy black-cockatoo habitat, feed trees (Allocasuarinas with chewed cones) were found at only 13 sites and birds were observed at only a single site.

- Some areas appear to be glossy black-cockatoo ‘hotspots’, where birds are frequently sighted in all or most months of the year, sometimes in relatively large numbers (>8 birds). Examples of glossy black-cockatoo hotspots include the Urunga, Dundurrabin, Promised Land and Braunstone areas.
- The main local food trees are black she-oak and forest she-oak. Areas of black she-oak habitat generally have more glossy black-cockatoo food per unit area than forest she-oak habitat. Hotspots seem to be located where there are good patches of black she-oak habitat.
- 45% of glossy black-cockatoo habitat in the project area burnt in the Black Summer bushfires of 2019–20 (see accompanying online maps).
- During and after the Black Summer fires, numbers of glossy black-cockatoos in unburnt areas temporarily rose, presumably due to an influx of ‘bushfire refugees’. The ultimate fate of these refugee birds is not known.
- Active glossy black-cockatoo nests are known from 5 locations in the project area: Kalang, Sawtell/Toormina, Dundurrabin, Darkwood and Brierfield. The appearance of fledgling birds in spring indicates that they also nest in other areas.

3. Recommended management actions

Table 12 Recommended management actions for glossy black-cockatoos in the Biliirrgan project area

Themes and actions	Priority	Comments
Finding nests		
Hold workshop(s) for the conservation community on finding glossy black-cockatoo nest trees	High	Nest finding workshop held in May 2023.
Search for nest trees	Very high	Nest searches by the Glossy Squad found 4 active nests in 2023 and a further 4 in 2024; further searches are planned for future years.
Protecting habitat		
Protect nest trees from burning	Very high	This could be achieved through a combination of fire planning and on-ground works (for example, raking around / wetting down nest trees and planning low-intensity burns outside the nesting season to reduce fuel loads around nest trees).
Protect nest trees from clearing	Very high	The first step to protecting nest trees from clearing is ensuring that their locations are entered into BioNet. Depending on the tenure and zoning of the land on which a nest tree occurs, statutory protections may apply. For example, there is a mandatory 50-m radius buffer around any glossy black-cockatoo nest trees on state forest estate. Educating the community about the value of hollow-bearing trees is also important. Well-meaning landholders have in some cases targeted dead trees for firewood collection in the belief that they are of low value to fauna.

Themes and actions	Priority	Comments
Ensure nest locations are not revealed to the general public	Very high	The intention is to protect the birds from possible nest poaching. Glossy black-cockatoo records in BioNet and Birdata are 'denatured' for non-licensed users.
If monitoring shows nest predation to be an important threat, protect nests from predation	Very high (if necessary)	Iron trunk collars have been effective at reducing nest predation by brush-tailed possums on Kangaroo Island.
Incorporate glossy black-cockatoo habitat (feeding and nesting) into fire planning	High	Mechanisms include landscape fire management plans, the *Bushfire environmental assessment code* (RFS 2021) and other fire planning instruments.
Plan strategic low-intensity burns to protect important glossy black-cockatoo habitat	High	A low-intensity planned burn was conducted in glossy black-cockatoo habitat in Guy Fawkes National Park prior to the Black Summer bushfires. The planned burn had little effect on Allocasuarinas and appears to have mitigated the impacts of the Black Summer bushfires. At this stage, there appear to be few other landscape-scale options for protecting glossy black-cockatoo habitat from bushfires.
Where Allocasuarina senescence is reducing food availability, consider low-intensity burning to stimulate recruitment of juveniles	Medium	Senescence is more likely to be a problem for black she-oak than for the longer-lived forest she-oak, and has been reported from some sites near Urunga.
Explore options for protecting glossy black-cockatoo habitat (feeding, nesting and drinking) within the planning system	Medium	Options include: • adding glossy black-cockatoo habitat to the NSW Biodiversity Values Map • working with local councils on development control plans that include glossy black-cockatoo habitat • advocating for greater protection of glossy black-cockatoo habitat in forestry operations • establishing conservation agreements with landholders (for example, through the Biodiversity Conservation Trust).

Themes and actions	Priority	Comments
Protect glossy black-cockatoo habitat from the impacts of feral species such as deer	Low (but may be a high priority in the future)	Deer of several species are an emerging threat in the project area and could have impacts on recruitment of Allocasuarinas.
Restoring/expanding habitat		
Restore and expand feeding habitat in strategic areas	Medium	The highest priority areas are lands/areas that are: • managed for conservation • near glossy black-cockatoo habitat and records • within mapped corridors • close to potential drinking and nesting sites. See accompanying online map at *Biliirrgan Webmap_habitat_planting* (arcgis.com). Plantings/restoration work should be consistent with bushfire considerations. Although our surveys and mapping suggest that feeding habitat may not be limiting to glossy black-cockatoos in the project area, there is a real possibility that, in light of likely climate and bushfire scenarios, this may not be the case in the future. Habitat around human settlements is more likely to survive future bushfires than habitat in remote areas, given that the focus of firefighting efforts is likely to be around houses, so there is a benefit in restoring/expanding glossy black-cockatoo habitat in areas with houses. Planting can also be an alternative to low-intensity burning where Allocasuarina senescence is a problem (for example, at some sites near Urunga).

Themes and actions	Priority	Comments
Install nest boxes designed specifically for glossy black-cockatoos in strategic areas (that is, land managed for conservation, close to permanent water and substantial food sources but with few hollow-bearing trees)	Medium	Although the data presented here suggest that potential nest hollows are generally widespread across the landscape, that doesn't necessarily mean that there are sufficient suitable hollows for glossy black-cockatoos. There may be areas close to good feeding habitat and drinking sites where lack of suitable hollows is preventing nesting by glossy black-cockatoos. Urunga–Hungry Head, Gulmarrad and Dundurrabin are areas that might benefit from nest box installation.
Collect seed from known feed trees, propagate and plant in strategic areas	Medium	The highest priority areas are lands/areas that are: • managed for conservation • near glossy black-cockatoo habitat and records • within mapped corridors • close to potential drinking and nesting sites. See accompanying online map at *Biliirrgan Webmap_habitat_planting* (arcgis.com). Plantings/restoration work should be consistent with bushfire considerations. Although our surveys and mapping suggest that feeding habitat may not be limiting to glossy black-cockatoos in the project area, there is a real possibility that, in light of likely climate and bushfire scenarios, this may not be the case in the future. Habitat around human settlements is more likely to survive future bushfires than habitat in remote areas, given that the focus of firefighting efforts is likely to be around houses, so there is a benefit in restoring/expanding glossy black-cockatoo habitat in areas with houses.

Themes and actions	Priority	Comments
Explore opportunities to include Allocasuarinas in other plantings (for example, for koala conservation)	Medium	Allocasuarinas are also koala (*Phascolarctos cinereus*) food trees.
Provide nest trees for the future	Medium	Plantings and restoration areas should include eucalypt species likely to develop hollows suitable for glossy black-cockatoos (for example, coastal blackbutt and New England blackbutt).
Ensure water is available close to feeding/roosting/nesting habitat during dry periods	Medium	
Involving the community		
Recruit and train citizen scientists in: • finding feed trees • identifying the age and sex of birds • photographing birds • entering data into BioNet or Birdata	High	
Develop one or more smaller-scale local area management programs with the aim of maintaining robust glossy black-cockatoo populations of 250 breeding pairs (equating to 675–800 birds in total) in each area	Medium	Possible candidate areas include Urunga–Nambucca, Dundurrabin, the Eastern Dorrigo Plateau, the Lower Clarence (Maclean–Yamba), and Coutts Crossing–Braunstone.
Hold events promoting community involvement in glossy black-cockatoo conservation (for example, talks, walks and workshops), including events targeted at the Aboriginal community	Medium	
Support Birdlife Australia's 'Great Glossy Count' event	Medium	The Great Glossy Count is a citizen science event that collects data across the distribution of the south-eastern glossy black-cockatoo.

Themes and actions	Priority	Comments
Improving knowledge		
Monitor nests with cameras and/or acoustic monitors	High	The call recogniser developed by Daniella Teixeira (Queensland University of Technology) could be used in acoustic monitoring
Continue surveys for birds and feed trees	High	
Explore options for statistically robust population monitoring	High	Options include: • coordinated counts (for example, Birdlife Australia's Great Glossy Count) • landscape-scale acoustic monitoring (possibly incorporating broad-scale acoustic monitoring undertaken by the Department of Primary Industries) • a mark-recapture design using photographs of individually recognisable female birds.
Report on survey and monitoring results and project learnings	High	Reporting should be available to the public (apart from sensitive locational data such as nest sites).
Ensure as many glossy black-cockatoo records as possible (including feed-tree records) are entered into BioNet and/or Birdata	High	Birdata is a more user friendly interface, at least for now, but BioNet is the point of truth for NSW planning decisions. The current intention is to upload glossy black-cockatoo records from Birdata to BioNet 3 times per year. Entering records into BioNet is preferable if time is critical (for example, if glossy black-cockatoo habitat is likely to be subject to development in the near future).
Accompany glossy black-cockatoo records with photographs of birds wherever possible. Ideally, the photos should show key identification features (tail feathers, yellow spots in the case of fledglings, and left and right head profiles for adult females)	Medium	It is straightforward to add photos via Birdata.

Themes and actions	Priority	Comments
Produce fine-scale, field-based mapping of glossy black-cockatoo habitat in areas of high-value habitat under development pressure	Medium	The mapping won't be useful unless there is a specific planned use, for example, if a local council has agreed to incorporate the mapping into a development control plan or similar.
Use satellite imagery and habitat mapping to regularly monitor the extent of glossy black-cockatoo habitat in the Biliirrgan project area	Medium	
Explore the relationship between mapped glossy black-cockatoo habitat (particularly forest she-oak habitat) and glossy black-cockatoo presence/abundance, with the aim of testing/fine-tuning the assumptions involved in producing the estimates of carrying capacity detailed in this document	Medium	Although trials in other parts of the glossy black-cockatoo's range found that known population sizes aligned fairly well with the carrying capacity predicted by the methodology detailed in this document, none of these trials involved landscapes where forest she-oak is the dominant feed tree species. It is possible that in forest she-oak habitats, where cones tend to be widely but thinly spread, a much lower percentage of the total food resource is available to glossy black-cockatoos than in landscapes dominated by thicket-forming Allocasuarinas, such as are common in other parts of the species' range. The department's methodology assumes that 20% of the total food resource is unavailable to birds, however, in forest she-oak habitats, this percentage may be much higher.
Monitor the recovery of glossy black-cockatoo habitat from the Black Summer bushfires	Medium	
Monitor the impact of feral species (for example pigs and deer) on glossy black-cockatoo habitat	Medium	
Automate regular data uploads into BioNet from Birdata, iNaturalist, eBird, NatureMapr etc.	High	
Investigate the movement ecology of glossy black-cockatoos in the Biliirrgan project area	Medium	Methods could include radio tracking and analysis of photographs of individually recognisable adult female birds.

Themes and actions	Priority	Comments
Collaborate and share knowledge with relevant conservation/land management organisations	Medium	Relevant organisations include the Glossy Black Conservancy, Landcare, Land for Wildlife, the Biodiversity Conservation Trust and local Aboriginal land councils.
Create a website to communicate important information about the project to the public	Medium	
Other		
Other relevant actions listed in the Glossy Black Conservancy's *Glossy black-cockatoo conservation guidelines* (2022), the Australian Government's *Conservation advice for the south-eastern glossy black-cockatoo* (Cth DCCEEW 2022), the Saving Our Species action toolbox for the glossy black-cockatoo and other conservation plans for the species	Medium	

Appendix A: Screenshots of Biliirrgan Project online mapping

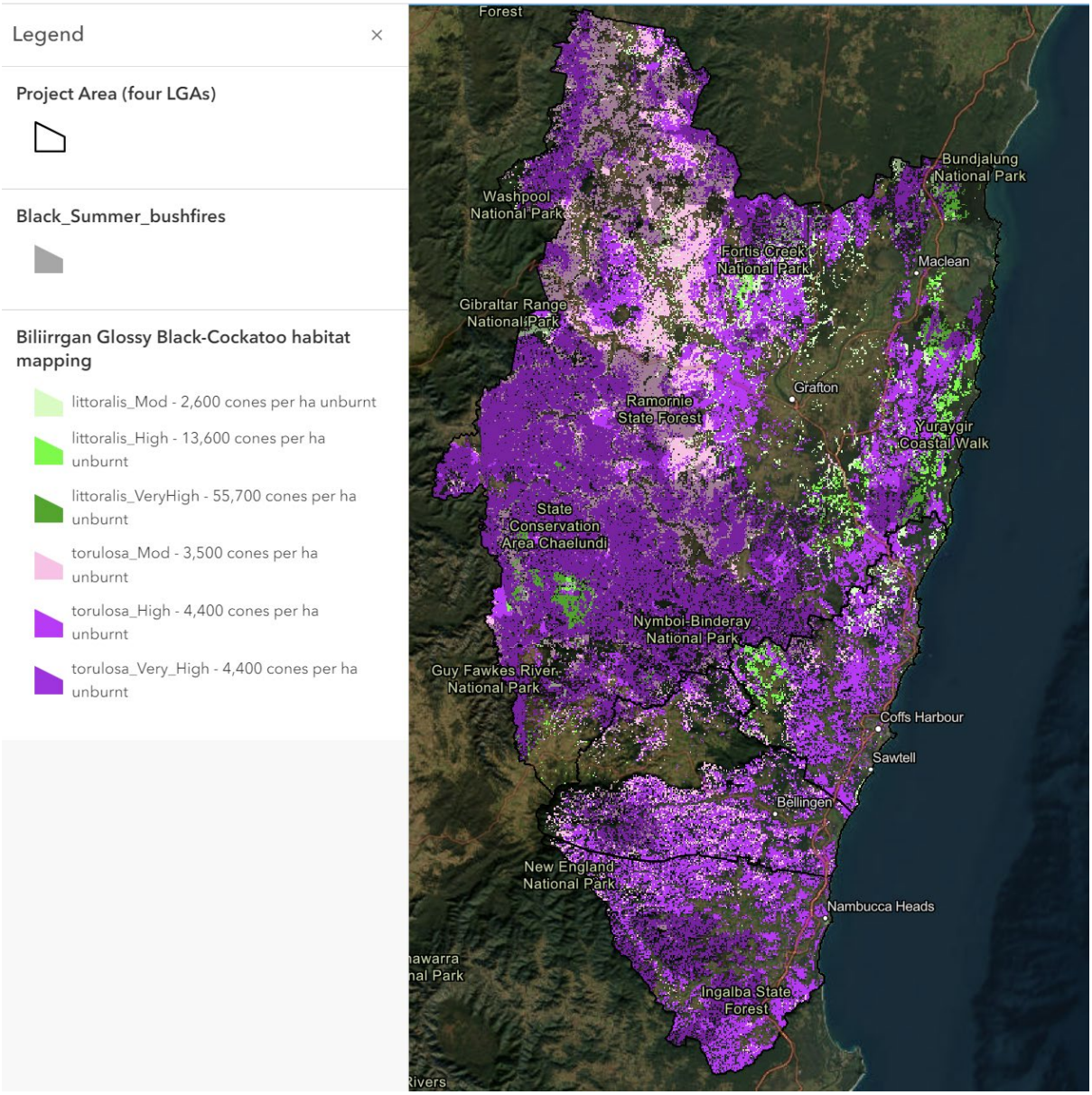

Figure 8 **Screenshot of *Biliirrgan Webmap_habitat_planting* (arcgis.com) online map showing habitat classes (refer to Table 3)**

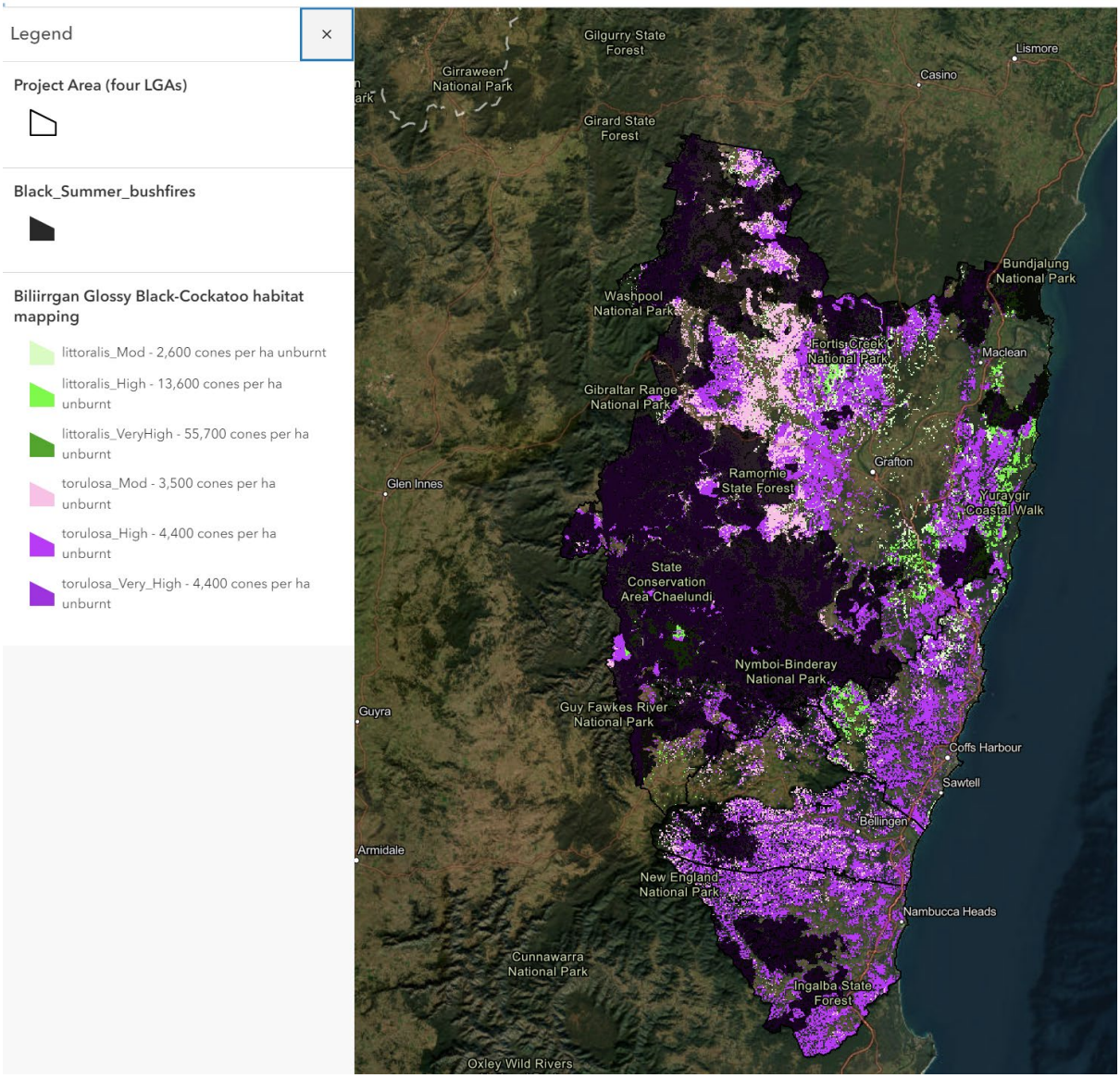

Figure 9 **Screenshot of *Biliirrgan Webmap_habitat_planting* (arcgis.com) online map showing extent of Black Summer bushfires**

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More information

- Biliirrgan Webmap_habitat_planting (arcgis.com)
- Biodiversity Values Map
- Birdata
- Bushfire recovery for wildlife and their habitat – Australian Government webpage
- Climate Data Online – Map search (bom.gov.au)
- Fire extent and severity maps
- NSW BioNet
- Survey site data (public land)