THE IMPACT OF THE 2019-2020 BUSHFIRES ON THE FEEDING HABITAT, NESTING HABITAT AND CARRYING CAPACITY OF ENDANGERED GLOSSY BLACK-COCKATOOS ON KANGAROO ISLAND

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Front cover: A glossy black-cockatoo nest box at Stokes Bay which was destroyed during the 2019-2020 bushfires.

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Above: Drooping sheoak cones that have shed their seed following the 2019-2020 bushfires.

Summary

The 2019-2020 bushfires on Kangaroo Island burnt around 210,000 hectares on western Kangaroo Island, and impacted many important feeding and nesting sites for the endangered Kangaroo Island glossy black-cockatoo (*Calyptorhynchus lathami halmaturinus*). The aim of this study was to investigate the impact of the recent bushfires on glossy black-cockatoo feeding and nesting habitat. Around 54 % of all mapped remnant drooping sheoak feeding habitat on Kangaroo Island was burnt in the fires, and will be unavailable as a food source to GBCs until it regenerates. Around 38.5 % of known nest trees were destroyed in the fire, and this included 29 % of nest boxes installed by the recovery program. It is estimated that the carrying capacity for GBCs on Kangaroo Island is approximately 333 individuals immediately post-fire, however this estimate has a high degree of uncertainty and is likely a minimum estimate, as it is based only on mapped habitat. Carrying capacity will also increase significantly as habitat regenerates post-fire and further revegetation project are carried out. We recommend the following management actions: 1) remaining unburnt feeding habitat is protected from fires or degradation; 2) regenerating woodlands burnt in the bushfires are protected from stock grazing; 3) revegetation of feeding habitat be carried out; and 4) management of nest sites continues to be a priority action.

Introduction

The South Australian subspecies of the glossy black-cockatoo (*Calyptorhynchus lathami halmaturinus*) (GBC) has a highly specialised diet and feeds almost exclusively on the seeds of the drooping sheoak (*Allocasuarina verticillata*) (Pepper *et al.* 2000). The GBC contracted in range following European settlement and the loss of dropping sheoak woodlands in mainland South Australia, and is now confined to Kangaroo Island (Mooney and Pedler, 2005; Berris e*t al.* 2018). As a result, GBCs are now classified as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999*.

A Recovery Program was initiated in 1995, and an active Recovery Team has worked since then to mitigate threats to the survival of this species (Berris e*t al.* 2018). Current on-ground activities are guided by the GBC *Strategic Plan 2015-2020* (Morgan *et al.* 2015) and the *Recovery Plan for the SA subspecies of the GBC 2005-2010* (Mooney and Pedler 2005). Since 1995, the population of GBCs on Kangaroo Island has increased from less than 200 to a minimum of 373 in 2016 as a result of the recovery actions undertaken (Berris et al. 2018).

In December 2019 and January 2020, bushfires burnt approximately 210,000 hectares of land on Kangaroo Island, close to half the area of the island. The fires occurred predominantly on the western half and north coast of the island, and initial spatial analysis using mapping provided by the

Country Fire Service revealed significant areas of GBC feeding and nesting habitat were within the burnt area and could have been impacted by fire. To determine the true impact of the bushfires on glossy black-cockatoo feeding and nesting habitat, we conducted on-ground surveys to determine the amount of feeding habitat and nests impacted by the 2019-2020 bushfires.

The aim of this survey was to 1) determine the amount, and the location of, intact GBC feeding habitat that remained on Kangaroo Island following the 2019-2020 bushfires, 2) determine the number of known nest trees that were destroyed in the 2019-2020 bushfires and; 3) estimate the number of GBCs the remaining feeding habitat can support until the burnt areas of feeding habitat regenerate and revegetation sites reach productive age.

Methods

Post-fire habitat mapping

Most drooping sheoak woodland on Kangaroo Island has previously been mapped by the GBC recovery program, and all known nests used by GBCs have been mapped. The 2019-2020 bushfire burnt area was overlaid on drooping sheoak woodland and nesting habitat mapping (Figure 1), and field staff then conducted surveys in feeding and nesting habitat that was either within or on the edge of the burn area, where accessible. Field staff recorded the approximate area of live sheoak, if it was found in burnt patches, and the severity of the burn was also recorded. Known nest trees were visited and it was recorded whether they had survived the bushfire event. ArcGIS was then used to compile a new spatial layer that incorporated all the information from the surveys, and areas of live drooping sheoak woodland and standing nest trees were then calculated.

Figure 1. A map of Kangaroo Island showing the 2019-2020 bushfire burn area (red) and GBC feeding and nesting habitat (yellow).

The Kangaroo Island GBC population can be loosely divided in to 7 flocks, however there is known to be some movement between flocks, particularly of younger non-breeding birds. However breeding pairs in flocks tend to be sighted in the same areas, and this was the basis for the original flock region map (Figure 2). Mapping of flock regions was then used to calculate the amount of live drooping sheoak woodland and intact nest trees in different flocks regions so that the impact of the 2019-2020 bushfires on different flocks could be quantified.

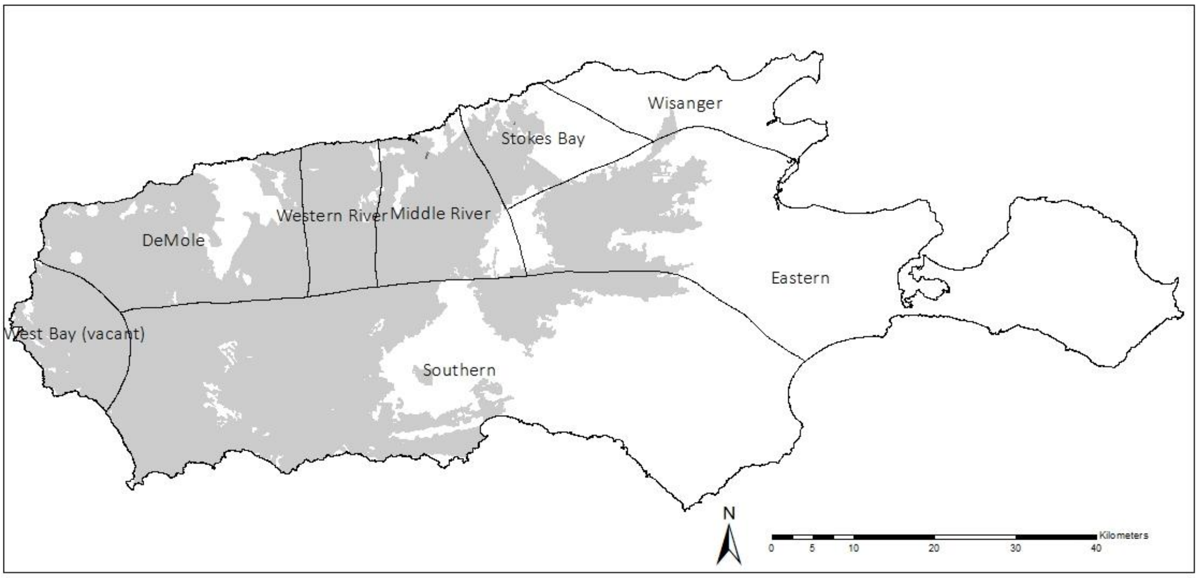

Figure 2. Map of flock regions on Kangaroo Island, as defined by Mooney and Pedler (2005), with the Eastern flock region expanded to include all of the Dudley Peninsula reflecting recent range expansion of GBCs in this flock. Light grey represents the 2019-2020 bushfire burn area.

Carrying capacity for GBCs on Kangaroo Island

Initial estimates of the carrying capacity for GBCs on Kangaroo Island were based on work by Pepper (1997) which estimated cone density of sheoak woodlands to be 835,000 cones/ha. Based on this cone density, Crowley *et al.* (1997) estimated that 1 GBC required approximately 3 ha of drooping sheoak woodland feeding habitat. The assumptions of this method for calculating carrying capacity are:

- Only 13% of cones are of the maturity preferred by GBCs for feeding
- Around 10% of trees are suitable for feeding on by GBCs
- The average cone intake is 100 cones per bird per day.

Later work by Chapman and Paton (2002) revised cone density estimates to 334,000 cones/ha, which equates to 1 GBC requiring 7.48 ha of drooping sheoak woodland to support it year round, which is also the figure used in recent work on climate change modelling of the GBC population

(Harris *et al.*, 2012). For this study, we have used the more conservative estimate of 1 GBC per 7.48 ha, as used by Harris *et al.* (2012), to determine an approximate carrying capacity pre and post-fire for the whole of Kangaroo Island. As cone density can vary with both rainfall and soil type (Chapman 2005), there is uncertainty with any carrying capacity estimates based on static cone density. We have also made the assumption that cone density is the same across the entire island and does not differ between remnant and revegetated sheoak stands. Although these assumptions may not reflect true cone density across the island, calculating carrying capacity in this manner will allow for comparison with the pre-fire estimate calculated by Harris *et al.* (2012).

Results

Impacts to drooping sheoak feeding habitat

Prior to the 2019-2020 bushfires, there was 4885 ha of mapped remnant drooping sheoak woodland habitat on Kangaroo Island. Of this, 2252 ha (46.1 %) of sheoak woodland was verified to be unburnt through a combination of spatial analysis and on-ground surveys of habitat within the mapped burned area (Country Fire Service, Figure 3). A further 1875 ha (38.4 %) of sheoak woodland did not contain trees with live foliage, and therefore was burnt to an extent that it will no longer be available as a food source to GBCs until it regenerates. A further 758 (15.5 %) ha was unable to be accessed, however as it also occurred within the burned area mapping provided by the Country Fire Service, it is likely this habitat no longer contains live feeding habitat based on the surveys conducted in other patches. Therefore, we estimated that 2633 (53.9 %) of drooping sheoak woodlands were likely burnt to an extent that they will not be available to GBCs as a food source until they regenerate (Figure 3).

Of the seven major GBC flocks on Kangaroo Island, six of those had feeding habitat within their home range burnt during the 2019-2020 bushfires. The flocks that have the least live feeding habitat remaining after the 2019-2020 bushfires are the Middle River, Southern and Western River flocks, all of which have an estimated 85 ha or less of live remnant feeding habitat available in their home range post-fire. The four other major flocks all had > 256 ha of live feeding habitat available in their home range post-fire. Sheoak woodland feeding habitat loss was less severe in eastern parts of Kangaroo Island, and the De Mole area where a large unburnt area along the coast was present post-fire (Figure 1).

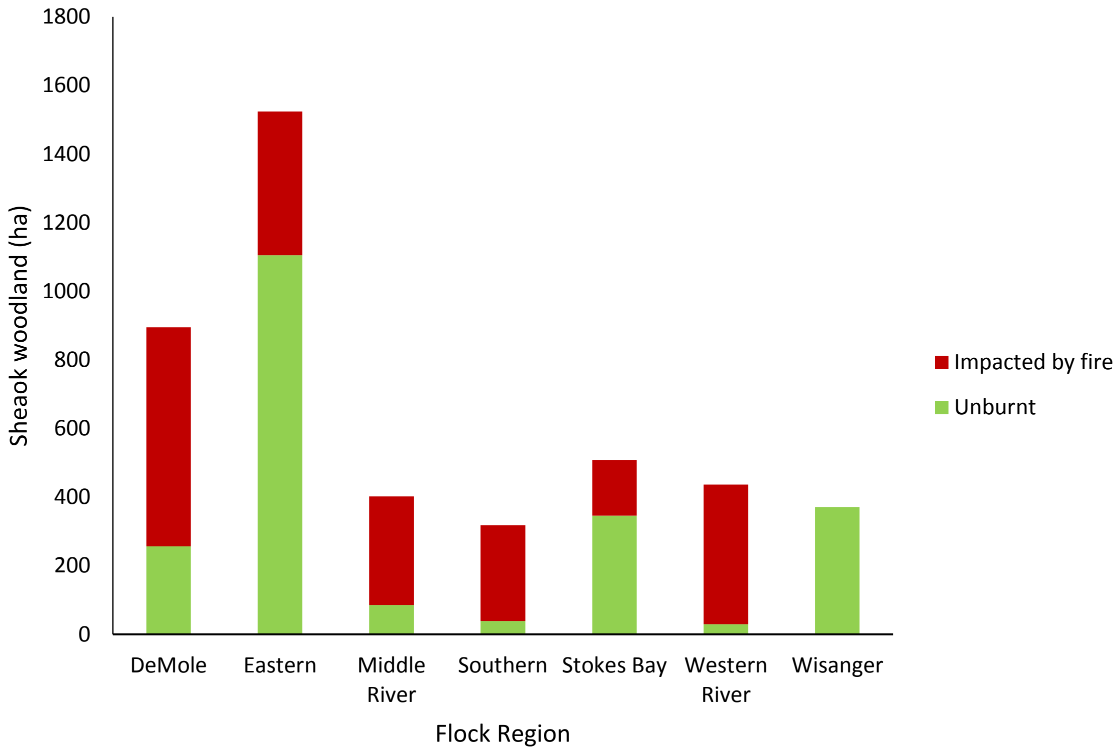

Figure 3. The amount of drooping sheoak (*Allocasuarina verticillata*) woodland that was unburnt during the 2019-2020 bushfires (green) and known to be burnt (red) based on surveys in February and March 2020. Habitat that is assumed burnt is within the mapped fire scar, however has not been able to be accessed as yet.

Impacts to known nest trees

Prior to the 2019-2020 bushfires, there were approximately 283 known nests that were believed to be functional for use by GBCs. These nests comprised 160 natural hollows that have been previously used by GBCs, 111 PVC nest boxes and 12 timber nest boxes. In total, 38.5% of known nests were destroyed by the 2019-2020 bushfires, and this comprised 44.4 % of known natural hollows, 29.5 % of PVC nest boxes and 50 % of timber nest boxes installed by the recovery program. The flock region that lost the greatest proportion of known nests was the Stokes Bay flock, which lost 57.7 % of known nests) (Figure 4).

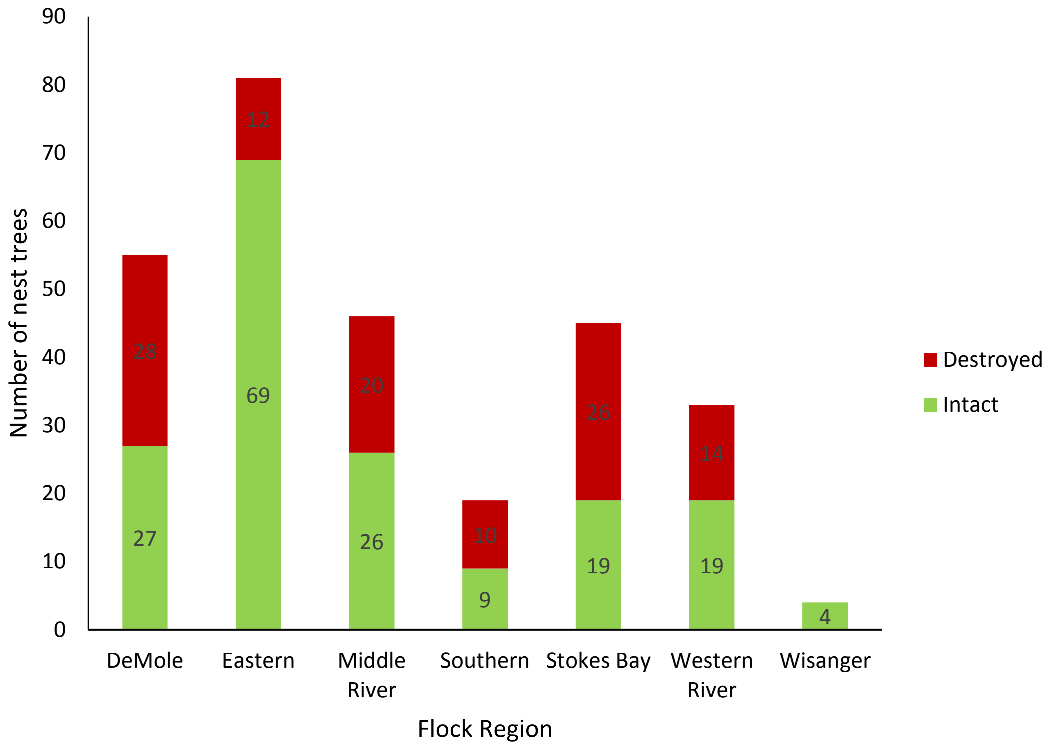

Figure 4. GBC nests destroyed in the 2019-2020 bushfires by flock region. This is based on natural nests that have been previously used by GBCs, and all PVC and timber nest boxes installed for GBCs.

Carrying capacity of GBCs on Kangaroo Island

Prior to the 2019-2020 bushfires, the estimated carrying capacity for GBCs on Kangaroo Island was around 653 individuals, as estimated by Harris *et al.* (2012). Following the 2019-2020 bushfires, it is estimated that the remaining mapped remnant sheoak woodland on Kangaroo Island could support 301 individuals using the assumptions outlined by Crowley *et al.* (1999) and Chapman and Paton (2002). Revegetated sheoak, of which there is estimated to be approximately 230 hectares (Morgan *et al.* 2013; Recovery Program, unpublished data), could support an estimated 32 individuals. During surveys undertaken during this study, other private plantings that were unknown to the GBC Recovery Program were identified. It has also been discovered that some areas of remnant drooping sheoak woodland are as yet unmapped, and are therefore not included in this estimate. Because of the uncertainty surrounding the amount of unmapped planted and remnant drooping sheoak on Kangaroo Island, any carrying capacity calculated using mapped sheoak alone as we have done will likely be an underestimate. Therefore the estimated carrying capacity of 333 birds should be considered a minimum carrying capacity, due to the existence of both revegetated and remnant sheoak that have not been accounted for. This carrying capacity is based on the habitat immediately post-fire, and will increase significantly as habitat regenerates and further revegetation is carried out.

Post-fire, 83 % of the live remnant drooping sheoak woodland feeding habitat is now located on the eastern end of Kangaroo Island (Figure 1). Based on the loss of remnant feeding habitat, four occupied flock regions will have had a significant reductions in their estimated carrying capacities as a result of the 2019-2020 bushfires: DeMole, Middle River, Southern and Western River flock regions (Figure 4). Four flock regions (DeMole, Eastern, Stokes Bay and Wisanger) still have significant amounts of unburnt feeding habitat, therefore will likely continue to support large breeding flocks of GBCs (Figure 4). Revegetation efforts that have commenced in 2020 will also increase the available feeding habitat over time and increase carrying capacity for GBCs on Kangaroo Island.

Discussion

The 2019-2020 bushfires have resulted in an estimated 54 % reduction in the available remnant drooping sheoak feeding habitat, and hence there is likely a reduction in the carrying capacity for GBCs on Kangaroo Island until burnt habitat regenerates. Some flock regions were more affected than others, and the response of surviving birds to loss of feeding habitat is unlikely to be known for some time. However, in general, most unaffected remnant feeding habitat is now located on the eastern half of Kangaroo Island. In addition to this loss of feeding habitat, 38.5 % of known natural nests and nest boxes were destroyed during the bushfires. In general, nesting habitat was less impacted by the bushfires than feeding habitat. This is because scorched *Eucalyptus* trees can still support nest hollows and nest boxes, however scorched sheoaks do not hold seed and therefore have no value as a food source until the vegetation regenerates.

Some survivors in flock regions that lost large amounts of feeding habitat appear to be staying within their flock region for now, and feeding on what live drooping sheoak trees are left. If food resources become scarce in the coming months, we anticipate that some survivors may move to other flock regions where feeding habitat is more plentiful. As of April 2020, post-fire band-resighting data had not yet detected any birds from western flocks moving to eastern Kangaroo Island. Birds are still being observed, and have started breeding, within flock regions heavily impacted by the bushfires, with good success where feeding habitat is available (Berris *et al.* 2020). Nesting attempts are currently being monitored to determine if lack of food resources leads to nest failures or abandonment. It will also be important, especially during the post-fire recovery period, to verify whether the current method used to calculate carrying capacity is indeed accurate, or whether assumptions about cone density on Kangaroo Island and cockatoo feeding behaviour need to be refined. Anecdotal observations post-fire are that GBCs in some areas are feeding on more than 10% of the sheoaks in live patches. If the number of trees fed on is increased to 20%, this would double the carrying capacity estimate, which highlights the uncertainty surrounding the carrying capacity we have calculated.

Drooping sheoak trees are serotinous, meaning they require an environmental trigger to release seeds from their cones. Desiccation by fire or heat has been observed to result in seed release (Moncur *et al.* 1997; Pepper 1997), as has removal of cones from trees and the subsequent drying of the cone once it is detached. Seeds of species that adopt this strategy are released and germinate into seedlings post-fire (Cameron 2006; Lamont *et al.* 2012) and adult trees can also regenerate through basal shooting from the roots (Ashton and Spalding 2001; Kirkpatrick 2004). Post-fire, we have already begun to observe both basal shooting and, in some cases, sheoak trees have been observed to be re-sprouting through epicormic shoots. The intensity of the fire varied across the island; some sheoaks were merely scorched and others were completely burnt. It will be important to monitor how a serotinous species such as the drooping sheoak regenerates post-fire in areas exposed to different fire intensities, and whether fire intensity leads to differences in regeneration success of sheoak.

It is expected drooping sheoak will regenerate in areas that were burnt, and be suitable for use by GBCs in approximately 10-20 years (Mooney and Pedler 2005; Department of Environment, Water and Natural Resources 2015). There is some evidence to suggest that frequent fires (ie less than 20 years between fires) can be detrimental to sheoak persistence in the landscape (Pepper 1997). Therefore it would be preferable that areas that burnt in the 2019-2020 bushfires do not burn again in the next 20 years. Monitoring of sites burnt in the 2019-2020 bushfires, in particular monitoring of time to peak cone production post-fire in drooping sheoak, will improve our understanding of the optimal fire frequency in drooping sheoak woodlands to encourage persistence of drooping sheoak. It will also be important to ensure regenerating drooping sheoak woodlands are protected from stock grazing, as grazing by introduced herbivores, including cattle and sheep, has been shown to impact sheoak regeneration (Pepper 1997; Masters *et al.* 2018).

A limitation of this survey is that it is not known whether the methods we used to calculate carrying capacity accurately reflect the cone density and feeding behaviour of GBCs in 2020. The assumptions of our estimate are the same as those used by Crowley *et al.* (1999) and Harris *et al.* (2012), and include a static cone density spatially and temporally on Kangaroo Island, assume that only 13% of cones on trees are suitable for feeding on by GBCs and that GBCs only feed on 10% of sheoaks in a patch. In reality, cone density is highly variable, and can vary in response to rainfall and soil type (Chapman 2005). There is a significant rainfall gradient on Kangaroo Island, with the western end of the island receiving almost double the rainfall of some eastern parts of the island. There are also annual and seasonal variations in rainfall that could influence flowering and seed production in sheoaks (Chapman 2005). Therefore cone density could vary significantly depending on the location and the rainfall in the previous 12 months, or the timing of rainfall. Further studies are needed to better understand the relationship between rainfall, soil type and cone density. Feeding habitat quality, given by Clout's index, is also known to decline for drooping sheoaks as they age (Delzoppo 2018). As studies on GBC feeding behaviour and sheoak food quality on which cone densities / ha were based were undertaken around 20 years ago, ageing stands of remnant sheoak are likely to have declined in food value since these studies were completed. Reduced profitability due to ageing sheoak stands has also not been factored into the carrying capacity for GBCs calculated in this study, nor has the possibility of increased profitability of young planted stands. Anecdotal observations post-fire of chewings under sheoak trees also indicates that in some areas more than 10% of trees are being fed on. If GBCs were assumed to feed on 20% of trees in a patch, this would double the carrying capacity estimate. Despite these limitations and the high uncertainty around our carrying capacity estimate, at the very least it provides a comparison between two time periods, before and after the 2019-2020 bushfires.

Loss of nesting habitat was less severe than expected, and many nest trees have survived the fire, even in areas where neighbouring trees were destroyed. The loss of nesting habitat is somewhat less of a concern than the loss of feeding habitat, as nesting habitat is relatively quick and easy to replace with nest boxes. GBCs readily use nest boxes, and around 60% of monitored breeding pairs have been recorded using nest boxes in recent years (Berris *et al.* 2018). There have also been observations of GBCs using previously unused natural nest hollows in 2020, and anecdotal observations suggest that hollows may have been created during the fire when branches fell from some trees. Feeding habitat however is estimated to take 10-20 years to recover post-fire (Mooney and Pedler 2005), while planted sheoak takes between 6-10 years before it is suitable for use by GBCs (M. Barth, pers. obs.). Protection of remaining drooping sheoak woodlands and revegetation from further fires is clearly a high priority in the immediate future. Nest boxes can be installed to replace lost nesting habitat, however nest boxes require annual maintenance and there is the possibility that GBCs may still move to other flock regions if food is low. As it would not be time efficient for the program to install nest boxes that do not get used, it is recommended that nets box installations only be undertaken in places where there is adequate feeding habitat available to GBCs and birds are observed to be persisting over the next 12 months.

It is important to note that without protection of nests from possum predation, the Kangaroo Island GBC population is likely to decline due to a lack of recruitment to replace annual mortality (Garnett *et al.* 1999). Therefore protection of nests from possum predation continues to remain a high priority post-fire for the recovery of this species post-fire. By protecting nests from brushtail possums, and from competitor species such as little corellas and feral honey bees, the Recovery Program can help to ensure strong recruitment of GBCs during the post-fire recovery phase.

Management Recommendations

The loss of 54 % of remnant feeding habitat and 35 % of known nest trees is likely to have a significant impact on the Kangaroo Island glossy black-cockatoo population. It is recommended that the following management actions are carried out post-fire:

- remaining unburnt feeding habitat is protected from further fires or degradation;
- burnt sheoak woodlands are protected from stock grazing to encourage strong regeneration;
- revegetation is undertaken in a strategic manner to increase the amount of drooping sheoak woodland feeding habitat available to GBCs on Kangaroo Island;
- nest boxes are installed in areas where there is ample feeding habitat in close proximity to nests and population monitoring indicates there may be a hollow shortage; and
- nest sites continue to be managed to reduce predation on and competition with GBC nests.

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