Science for Saving Species

Research findings factsheet

Project 5.1

Threatened Species Recovery Hub

National Environmental Science Programme

Better offsets for Western Australia's black-cockatoos

Background

Biodiversity offsets are commonly used to compensate for unavoidable development impacts on species or ecosystems by aiming to create an equivalent benefit for the same species or ecosystem elsewhere. In Australia, offsets are routinely prescribed as conditions of approval for proposed development that will impact species or ecological communities listed as threatened either nationally under the *Environment Protection and Biodiversity Conservation Act 1999*, or under state and territory laws.

To ensure an offset compensates for the impact of development, we need to be able to quantify how much benefit an offset action will provide for a species or ecosystem at the site level. For many poorly-understood species and ecological communities, however, important knowledge gaps exist. This makes it hard to know what type and how much offset action is needed to offset a given impact.

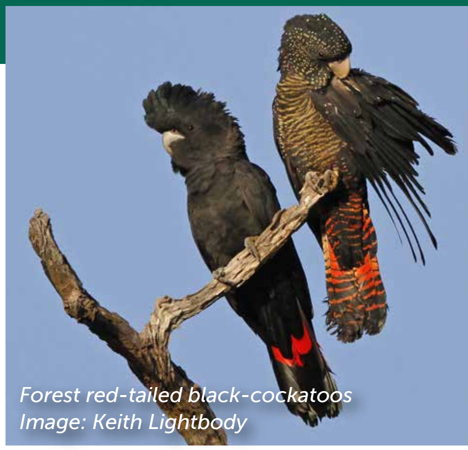
Carnby's black-cockatoo in flight. Image: Tony Kirkby

This project developed an approach for eliciting the knowledge of threatened species experts in a structured way, so as to guide estimates of both the benefits and the costs of alternative offset approaches. Although it doesn't replace field-based studies, it can help decision-makers ensure that offset decisions are based on the best available information at the time, and help identify how much uncertainty there is about the effectiveness of particular offset actions. We tested the approach using several case study species that commonly trigger offset requirements, and for which developing appropriate offset proposals is considered challenging. Here, we describe the approach and findings for three taxa of black-cockatoos in Western Australia: Baudin's, Carnaby's and forest red-tailed black-cockatoos.

Figure 1:


Baudin's black-cockatoo at nest
Image: Tony Kirkby


Carnaby's black-cockatoo at nest
Image: Keith Lightbody


Forest red-tailed black-cockatoos
Image: Keith Lightbody

Declining black-cockatoos in Western Australia

There are three threatened taxa of black-cockatoo in Western Australia (Figure 1), all of which have a recovery plan in place. Black-cockatoos in WA were locally common until the 1950s, when all three taxa began to decline.

All three taxa are long-lived, obligate hollow breeders with a low reproductive output. They have some overlap in feeding requirements. Baudin's black-cockatoo *Calyptorhynchus baudinii* feeds on jarrah and marri species, Carnaby's black-cockatoo *Calyptorhynchus latirostris* on proteaceaous (banksia, grevillea and hakea) and myrtaceaous species, and forest red-tailed black-cockatoos *Calyptorhynchus banksii naso* on marri, jarrah and other native and introduced species. They may occur in small to large flocks, comprised of single species, or co-occur with other black-cockatoos, during non-breeding periods.

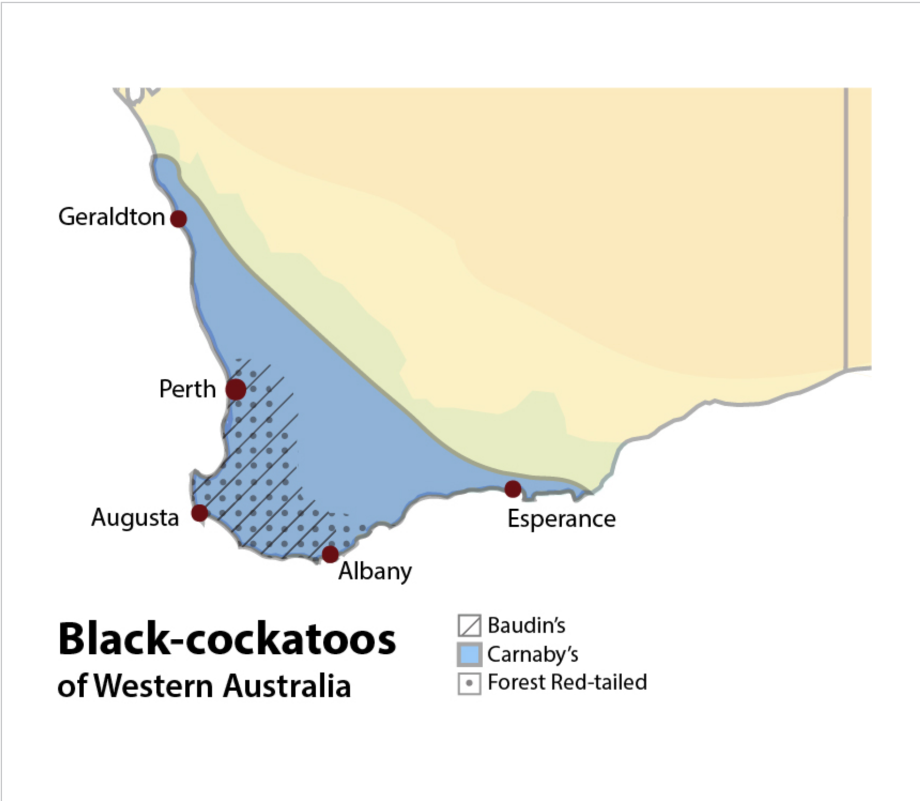


Figure 2: Distribution of Baudin's, Carnaby's and forest red-tailed black-cockatoos in south-west Western Australia (Source: Threatened Species Recovery Hub).

Baudin's black-cockatoo and forest red-tailed black-cockatoo

Baudin's black-cockatoo is listed as Endangered under the EPBC Act, and is endemic to south-west WA (Figure 2). The forest red-tailed black-cockatoo, one of five subspecies of red-tailed black-cockatoos in Australia, is listed as Vulnerable under the EPBC Act and is found in south-west WA (Figure 2). Baudin's and forest red-tailed black-cockatoos have a combined recovery plan in place.

Baudin's and forest red-tailed black-cockatoos have been declining as a result of widespread logging. Many nest trees were felled as part of timber harvesting operations, and this loss is likely to continue as a result of mining activity, timber harvesting, and fires. The principal threat they face is a shortage of suitable hollows for breeding. Other threats affecting Baudin's and forest red-tailed black-cockatoos are competition for nest hollows with other birds and introduced bees, loss of feeding habitat, vehicle strike, illegal shooting (of Baudin's) and reduced food and water availability due to climate change.

Carnaby's black-cockatoo

Carnaby's black-cockatoo is found only in south-west WA (Figure 2), and listed as Endangered under the EPBC Act. Carnaby's black-cockatoos have been declining, with the principal threat being loss and fragmentation of foraging habitat, which includes native proteaceaous (e.g. Banksia, Grevillea and Hakea spp.) communities as well as pine plantations. The remaining foraging habitat may be too far from breeding habitat, or degraded due to salinisation, weed invasion, dieback or fire. Other threats affecting Carnaby's black-cockatoos include loss of breeding habitat, competition for nest hollows with other birds and introduced bees, reduced food and water availability due to climate change, vehicle strike, disease, and illegal shooting and, historically, nest robbing for the illegal bird trade.

Current offset approaches

Carnaby's black-cockatoos trigger more offsets under the EPBC Act than other threatened species in Western Australia. The most common offset type for Carnaby's black-cockatoo is land acquisition for conservation. Other offsets include those focused on vegetation management (rehabilitation, restoration and revegetation), threat management actions (dieback disease control, installation of fencing, weed management, feral animal control), research and education. The current offset approaches for Baudin's and forest red tailed black-cockatoos have received less research attention but are broadly similar to the offsets used for Carnaby's black-cockatoos.

A recent review on biodiversity offsets for Carnaby's black-cockatoo proposed that a stewardship program which funds private landholders who carry out conservation management and maintain bush on properties could provide an alternative option for biodiversity offsets (Richards et al. 2020). While we did not specifically consider a stewardship program in this project, we included management actions that could feasibly be included in such arrangements, such as installation of artificial nest hollows, feral species control, weed control and fire management.

The recent review on biodiversity offsets for Carnaby's black-cockatoos also showed that offsets implemented to date have resulted in a net loss of habitat for the species. Threatening processes are still impacting remaining habitat and potential offset sites of all three WA black-cockatoos, meaning that measures that arrest the adverse impacts of habitat loss are needed.

Engaging experts to improve outcomes

Black-cockatoos are highly mobile and move widely across the landscape; they may use different areas and different vegetation types at different times of the year, and readily move from forests to agricultural and urban areas. This mobility, and their reliance on a small number of food plants and on hollows of a particular size and structure, poses challenges for long-term conservation.

We elicited information about the effectiveness and cost of a series of management activities for foraging and breeding habitats (summarised in Figure 3) that may benefit WA black-cockatoos, based on expert knowledge. To do this, we first identified candidate management actions based on interviews with two key WA black-cockatoo experts. Next, we used a structured expert elicitation protocol involving two rounds of online anonymous surveys with 17 WA black-cockatoo experts. Experts provided quantitative estimates of the benefits of a range of management actions at two hypothetical offset sites which had different types of habitats, site conditions and past land management (Box 1).

We asked experts to envisage the outcomes for WA black-cockatoos in each hypothetical offsets site after 20 years if current management did not change (called the baseline or 'do nothing' scenario), and if particular management actions, or combinations of these actions, were implemented. By comparing the estimated outcomes with and without the management actions, we could identify the estimated benefit for black-cockatoos. We also explored the costs and cost-effectiveness of these alternative strategies.

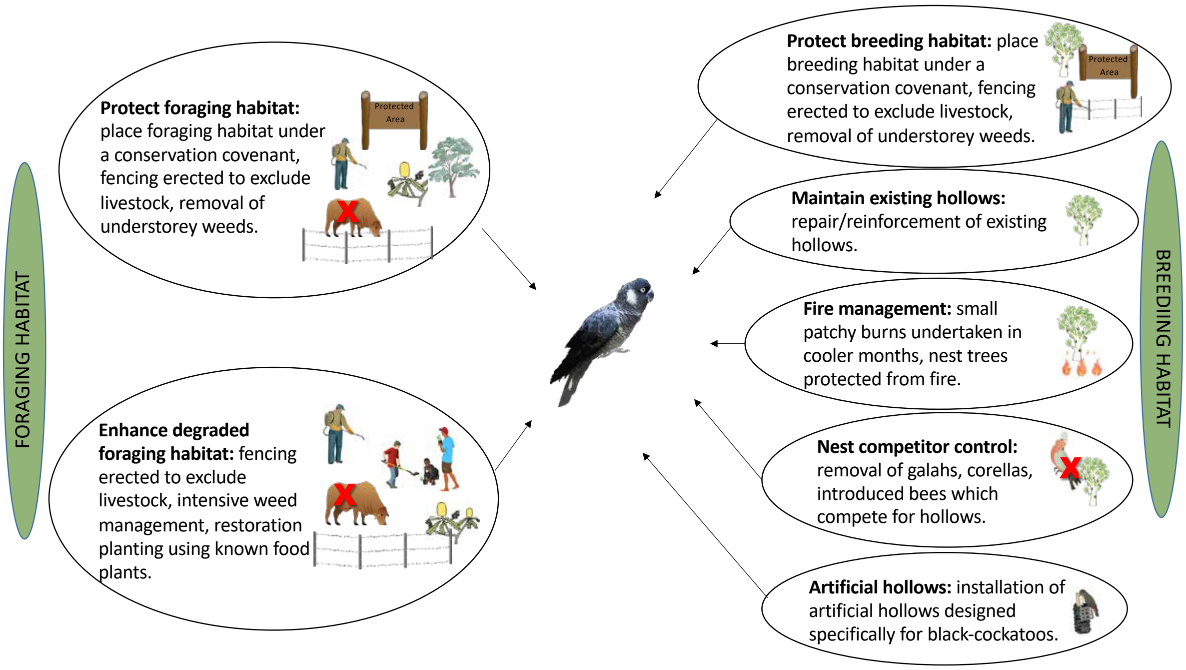
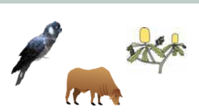
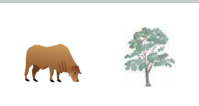


Figure 3: Potential management actions that could benefit WA black-cockatoo populations. Experts considered how these actions, alone and in different combinations, would benefit WA black-cockatoos at two different hypothetical offset sites (see Box 1).

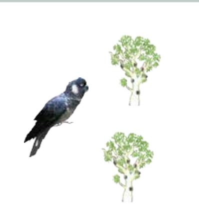
Box 1: Hypothetical offset sites and benefit indicator

Management actions are likely to differ in their benefit to black-cockatoos at different types of sites. We therefore asked experts about outcomes of different management actions (Figure 3) after 20 years at five different hypothetical offset sites, each 50 ha in size, with different starting conditions (foraging habitat score, and number of nest hollows where a pair bred successfully) and assumptions.

For foraging habitat, the hypothetical offset sites were:

	1. High-quality foraging habitat: a marri/jarrah and or banksia native vegetation remnant in very good condition.
	2. Medium-quality foraging habitat: a marri/jarrah and/or banksia native vegetation remnant in moderate condition; a range of domestic livestock and sometimes feral herbivores access and graze the site.
	3. Very poor-quality foraging habitat: a predominantly cleared site, containing scattered marri/jarrah/banksia native species; a range of domestic livestock and feral herbivores regularly access and graze the site.

For breeding habitat, the hypothetical offset sites were:

	1. High-quality breeding habitat: a forest remnant on private property, with 50 hollowing bearing trees used annually by WA black-cockatoos. Experts were asked to assume that, at the start of the scenarios, only one species of black-cockatoo was present at the site, all 50 of the nest hollows were being used and nest success (= at least one fledgling from a nest) was 60%, and that there was adequate food, roosting and water resources in close proximity of the site to support breeding.
	2. Medium-quality breeding habitat for black-cockatoos: a site with 25 hollow bearing trees used intermittently by WA black-cockatoos. Experts were asked to assume that there was a moderate level of competition from nest competitors, all 25 nest hollows were being used and nest success was 40%, only one species of black-cockatoo was present at the site, and that there was adequate food, roosting and water resources in close proximity of the site to support breeding.

To estimate the benefits of different management actions, a suitable *benefit indicator* was required. The *benefit indicator* needed to be able to be measured and monitored at the site level, and be highly likely to relate to the viability of the species. For WA black-cockatoos, we used the following benefit indicators:

- Foraging habitat: we developed a linear scoring scale from 0 (no food plants) to 10 (excellent quality foraging habitat, with very high density and productivity of food plants).
- Breeding habitat: the number of nest hollows where a pair of black-cockatoos successfully bred and fledged at least one chick.

Effective offsetting

There are similarities in the results for the three taxa, which are displayed individually (where applicable) below.

Foraging habitat

On average, the experts believed that the baseline ('do nothing') option would result in a decline in the condition of high-quality foraging habitat for all three taxa of WA-black cockatoos, over a 20-year period. This decline was attributable to a range of factors: fire, impacts of grazing, natural attrition of foraging vegetation species, climate change, and dieback.

Of all the combinations of management interventions, the greatest benefit for WA black-cockatoos was expected to be from protection with enhancement through restoration at medium and low-quality sites (Figure 4). However, experts thought that even with these actions, they would not be able to improve the quality of poorer-quality sites to match the high-quality foraging habitat score (8). This highlights the irreplaceability of the remaining high-quality foraging habitat for WA black-cockatoos.

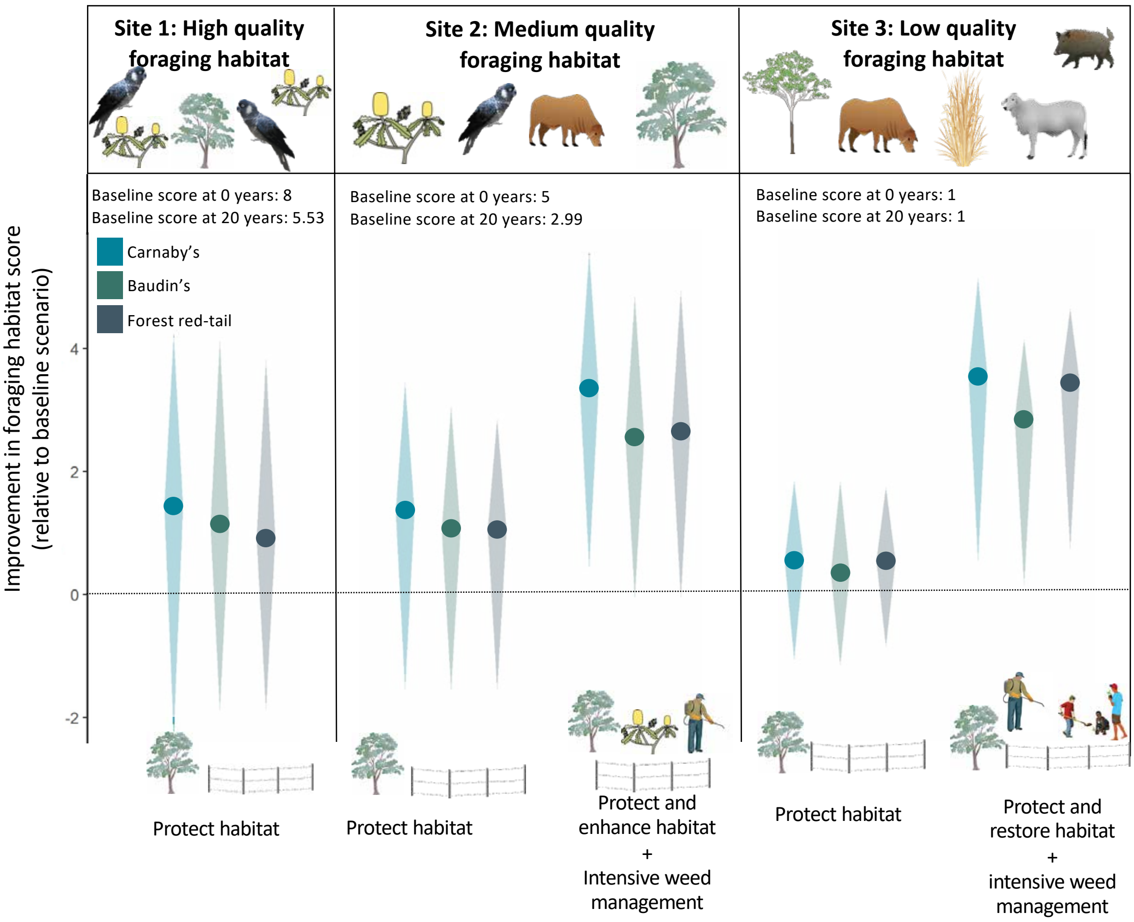


Figure 4: Results of expert elicitation showing the estimated benefit (defined as improvement in foraging habitat score) of different management actions for black-cockatoos after 20 years, relative to a baseline scenario with no active management ('do nothing'). The circle at the widest point in the diamond is the aggregated 'best guess' estimate. Diamonds capture the 90% confidence intervals around expert estimates.

Enhancement of medium-quality foraging habitat for Carnaby's black-cockatoos was believed to be achievable in the 20-year time frame, if there was ongoing resourcing to manage weeds and impacts from native and feral herbivores. Experts noted that Carnaby's foraging habitat is particularly vulnerable to impacts of fire and dieback. The experts commented that it was not possible to establish new foraging habitat for Baudin's and forest red-tailed black-cockatoo within a 20-year timeframe. Marri and jarrah plant communities take a long time to establish and mature, and therefore protection of remaining key foraging habitats for these species is critical.

Experts believed that while WA black-cockatoos could benefit from intensive management of threats and enhancement or restoration of moderate or low-quality foraging habitats, none of the management actions applied at the moderate or low-quality sites would allow them to reach a high-quality foraging habitat score within the time period considered. This suggests that equivalent offsets for impacts on high-quality foraging habitat would be extremely difficult to achieve, as offsets are usually required to reach the same quality score as the impacted site they are compensating for. Experts suggested that protecting and enhancing medium-quality foraging habitat, through supplementary plantings, may be a suitable offset action to consider for sites in close proximity to nesting sites for Carnaby's black-cockatoos, to counterbalance impacts on poor to medium-quality sites (but not high-quality sites).

Breeding habitat

On average, experts believed that the breeding success of WA black-cockatoos would decline in the baseline ('do nothing') scenario, due to the natural attrition of trees with nest hollows (Figure 5). The results suggest that in order to increase the relative success of breeding over 20 years, protection, combined with active management (hollow maintenance and fire management) in existing high-quality habitat are required. These actions were thought to increase the number of successful nests for all three taxa, with an average estimate of 9-10 successful nests gained above the baseline ('do nothing') scenario at sites that started with 30 nests.

The greatest relative benefit for breeding habitat was from a combination of protection, hollow maintenance, fire management, installation of artificial hollows and targeted nest competitor control, in medium quality breeding habitat (starting out with 25 suitable nests), with an average estimated gain (but high uncertainty) of 29-33 successful nests relative to a baseline scenario with no management ('do nothing'). Part of this is attributed to the installation of 50 artificial nest hollows. A recent study has shown that Carnaby's black-cockatoo readily uses artificial nest hollows; trials have also shown that forest red-tailed black-cockatoos will also nest readily in artificial nest hollows if they are installed in the correct areas and are of a suitable design (Johnstone and Kirby 2019). The results suggest that protecting medium-quality breeding habitat, combined with active management, could be effective biodiversity offset options for Carnaby's and forest red-tailed black-cockatoos.

There is less detailed knowledge about the breeding cycles of Baudin's and forest red-tailed black-cockatoos. It is possible these species may not breed annually. Experts also highlighted that little is known about how food quality may affect breeding success. Forest red-tailed black-cockatoos have shifted to introduced food sources, notably *Melia azedarach* (Cape lilac), which may have lower nutritional value than their 'traditional' food sources. Experts also noted that forest-red tailed black-cockatoos will feed on *Eucalyptus caesia* in suburban gardens. Further research is warranted to determine the impact of introduced food sources on breeding success.

Experts highlighted that a critically important factor affecting breeding success of all three species is having adequate foraging habitat in close proximity to the breeding habitat, and that proximity between foraging, foraging and roosting habitats should be a key consideration in the development of offset actions.

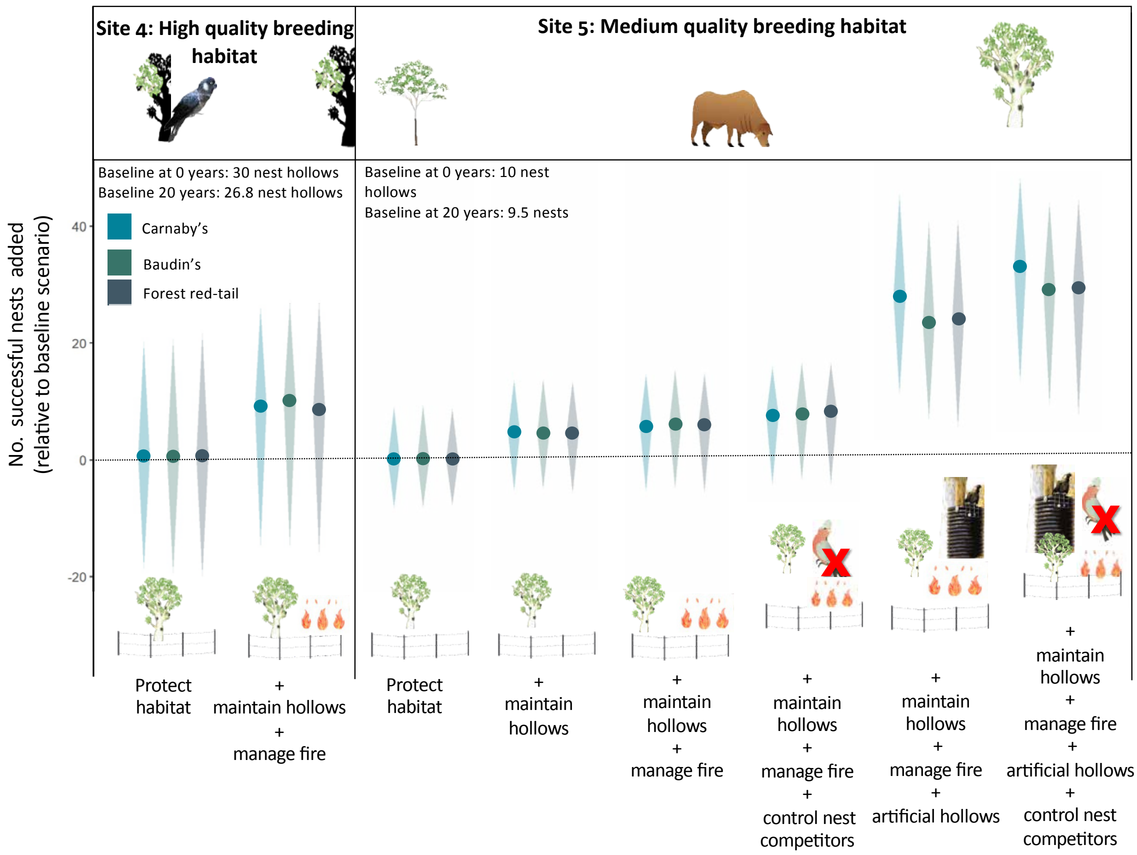


Figure 5: Results of expert elicitation showing the estimated benefit (defined as number of nest hollows where a breeding pair successfully fledged a chick) of different management actions for black-cockatoos after 20 years, relative to a baseline scenario with no management ('do nothing'). The circle at the widest point in the diamond is the aggregated 'best guess' estimate. Diamonds capture the range of 90% confidence intervals around expert estimates.

Cost-effectiveness

The cost estimates apply only to the management scenarios included in the expert elicitation process. While our results can provide a guide for scaling up the area managed to achieve greater benefits for black-cockatoos (as long as other site conditions remained consistent), they cannot be used to scale down – a given fraction of the investment would be very unlikely to achieve an equivalent fraction of the estimated benefit. The cost data were collected from a range of sources, including revegetation costs from existing projects in WA.

We collected cost estimates for the restoration of two types of foraging vegetation (1) Proteaceae and (2) marri/jarrah. We present the cost effectiveness estimates for the three black-cockatoos in terms of their favoured foraging habitat (Proteaceae for Carnaby's, marri/jarrah for Baudin's and forest red-tails). There are similarities in the cost-effectiveness results for the three taxa, which are displayed individually (where applicable) below. Costs for some actions (for example, protection of habitat via a conservation covenant) were considered to be the same across taxa.

Based on the cost data we collected from experts, the cheapest management action for WA black-cockatoos was to protect and manage weeds in high-quality foraging and breeding habitat. However, a much more informative metric to consider than cost per action is cost per unit benefit – in other words, how much each additional unit of foraging habitat score, or successful nests gained, was estimated to cost. For WA black-cockatoos, cost-effectiveness was strongly related to the quality of the foraging habitats, with costs increasing in medium-quality habitats and being highest for low-quality habitat.

For foraging habitat, the most cost-effective action (measured as cost per unit of habitat score gained over 20 years) was protection (Figure 6) of high-quality habitat (via conservation covenant). This was estimated to cost \$6,838/year to gain one unit of habitat quality across 50 ha. It should be noted, however, that this is a very small gain, with considerable uncertainty. The least cost-effective option (for Carnaby's black-cockatoo) was protection and restoration of very low-quality habitat, combined with intensive weed management, which cost \$26,699/year per unit of habitat quality gained across 50 ha.

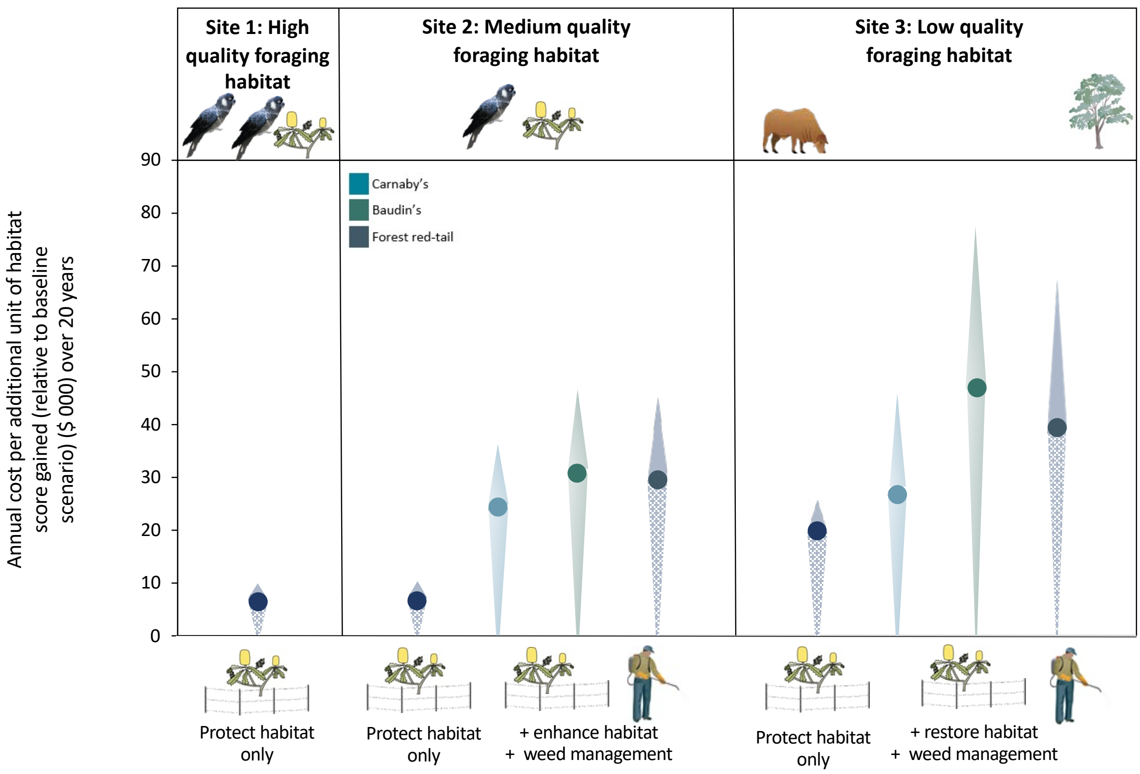


Figure 6: Cost of each management action to gain a single unit in foraging habitat score for black-cockatoos (in 2020 dollars, over 20 years at a 50 ha site). The circle represents the best estimate, and the top and bottom points capture the low and high estimates of cost per additional habitat score. Note: annual cost per habitat score gained was obtained by dividing the total annual costs of the management action by the habitat score experts thought could be added as a result of the management action. Different costs for the three taxa are shown for restoration actions (where cost estimates differed between proteaceaous and marri/jarrah vegetation types).

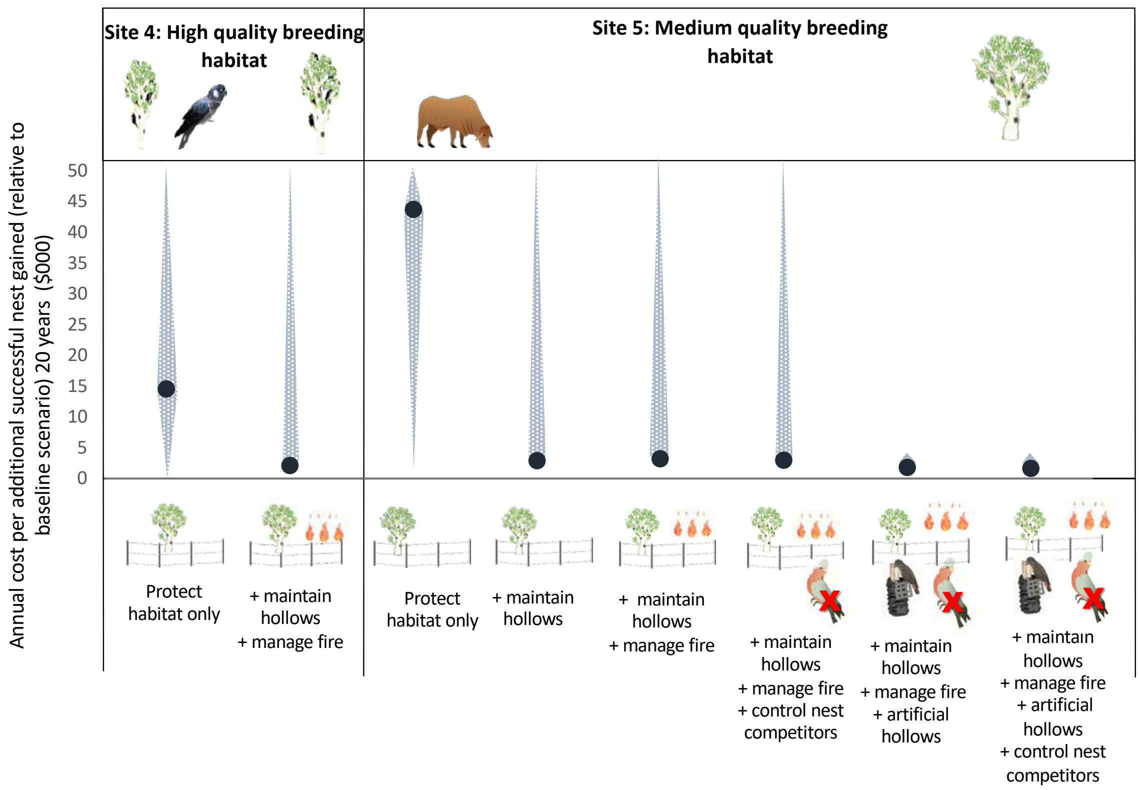


Figure 7: Cost of each management action to gain an additional nest hollow where a breeding pair successfully fledge a chick (in 2020 dollars, over 20 years at a 50ha site). The circle represents the best estimate, and the top and bottom points capture the low and high estimates of cost per additional successful nest. Due to the fact it was possible for a benefit to be less than 0, the upper cost-effectiveness estimates for most actions are non-defined. Note: annual cost per successful nest gained was obtained by dividing the total annual costs of the management action by the number of nests (where a pair successfully breed and fledge at least one chick) experts thought could be added as a result of the management action. shown in the 'enhance habitat' options for the three taxa.

Protection of breeding habitat (Figure 7) alone was regarded as the least cost-effective of the management actions considered for breeding habitat ($14,608/year per additional successful nest for high quality breeding habitat, and $43,825/year for medium quality breeding habitat); all the other management actions estimated costs <$10,000/year per additional successful nest. Note that these estimates are likely highly sensitive to the size of the hypothetical site (50 ha supporting 25 nest hollows as a starting point).

Implications of research

Biodiversity offsets must only occur after all previous steps in the mitigation hierarchy have been considered. The design of better biodiversity offsets for threatened species will remain an ongoing challenge for policy makers, particularly for species where the relative contribution of key threats are poorly known, or for which limited quality habitat remains. A well-designed biodiversity offset is one that is based the principles of the IUCN policy, and incorporates:

- Current ecological knowledge (action plans, recovery plans, management plans, peer reviewed literature, where available) and
- Full consideration of cumulative impacts (geographically and over time).

Expert elicitation is not a perfect tool or solution for addressing issues with biodiversity offsets in Australia. It does not replace the urgent need for empirical studies to evaluate and improve on-ground management approaches. Instead, it provides a relatively quick, inexpensive and repeatable method of obtaining current and best available knowledge in a way that reduces bias, in a form that is useful to inform decision making on biodiversity offsets.

The development of offsets poses an ongoing challenge as the human population and associated development in the south-west Western Australia continues to increase. In many cases, developments may involve clearing small parcels of land that may not trigger offset requirements.

It is essential that cumulative impacts of these developments, and the importance of habitat connectivity, are considered in decision-making regarding offsets for these species.

All three taxa of WA black-cockatoo occur in areas that include agricultural and urban land use. Private landholders are important stakeholders in the conservation of WA black-cockatoos, and there is considerable scope to expand the use of stewardship programs for WA black-cockatoo habitat on private land.

Results from this expert elicitation process suggest:

- effective offsetting for these species rely heavily on avoiding and mitigating impacts to high quality habitat first, since there is very limited scope for impacts to high quality habitat to be offset in a 20 year timeframe;
- it is not possible to establish foraging plants for Baudin's and forest red-tailed black-cockatoo within a 20-year timeframe. Marri and jarrah plant communities take a long time to establish and mature, and therefore protection of remaining foraging habitats for these species is critical;
- protection and management of weeds in high-quality foraging habitat is the most cost-effective action for all WA black-cockatoos, but gains are small;
- there can be some gains in restoring medium and low-quality foraging habitats, but these options are expensive, may not be achievable in a 20 year timeframe, and are unlikely to match the quality of existing high-quality habitat, even with intensive management, within reasonable timeframes. As such, they are not appropriate for offsetting losses of high-quality foraging habitat but may be useful for offsetting losses of low to moderate quality habitat;
- forest-red-tailed black-cockatoos are increasingly using urban landscapes for feeding and the link between food quality and breeding warrants further investigation;
- the retention and active management of high-quality breeding habitat is especially crucial for Baudin's black-cockatoos;
- artificial hollows are regarded as a useful short-term measure for supporting breeding of Carnaby's and forest red-tailed black-cockatoos. If artificial hollows are used as part of a biodiversity offset, they should be combined with restoration of foraging and breeding habitat for long-term success.

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Graphics

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References

Johnstone, R and Kirby, T. (2019). Black Cockatoo Research project: Final report for Housing Authority 2019.

Richards B, Sullivan M, Mawson PR. (2020). A case study of environmental offsets for the endangered Carnaby's cockatoo (*Calyptorhynchus latirostris*) *Pacific Conservation Biology*.

Further reading

BirdLife Australia (2018). Black-cockatoos and your property. https://www.birdlife.org.au/documents/swbc-BCs-and-your-property.pdf

Carwardine J., Martin, T.G., Firn, J., Ponce-Reyes, R., Nicol, S., Reeson, A., Grantham, H.S., Stratford, D., Kehoe, L., Chadès, I. (2019). Priority Threat Management for biodiversity conservation: a handbook. *Journal of Applied Ecology* 56:481–490.

Environmental Protection Authority, Western Australia. (2011). WA Environmental offsets guidelines. Available from: https://www.epa.wa.gov.au/policies-guidance/wa-environmental-offsets-policy-2011-and-guidelines

Hemming, V., Burgman, M.A., Hanea, A.M., McBride, M.F., Wintle, B.C. (2018). A practical guide to structured expert elicitation using the IDEA protocol. *Methods in Ecology and Evolution* 9:169–180

Maron, M., Evans, M.C., Nou, T., Stone, Z.L., Spillias, S., Mayfield, H.M., and Walsh, J.C. (2021). Guidance for estimating biodiversity offset benefits and costs using expert elicitation. Threatened Species Recovery Hub, National Environmental Science Programme, Brisbane. https://www.nespthreatenedspecies.edu.au/media/atsidzbc/5-1-guidance-for-biodiversity-report_v7.pdf

Maseyk, F., Evans, M., and Maron, M. 2017. Guidance for deriving 'Risk of Loss' estimates when evaluating biodiversity offset proposals under the EPBC Act. Report to the National Environmental Science Programme Department of the Environment and Energy. Threatened Species Recovery Hub.

Saunders, D., Dawson, R., Mawson, P.R., and Cunningham, R.B. (2020). Artificial hollows provide an effective short-term solution to loss of natural nesting hollows for Carnaby's Cockatoo *Calyptorhynchus latirostris. Biological Conservation*, 245: 108556.

Further Information

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