Mine-site revegetation monitoring detects feeding by threatened black-cockatoos within eight years. Jessica Lee¹, Hugh Finn¹ and Michael Calver¹ (¹School of Biological Sciences and Biotechnology, Murdoch University, Murdoch, WA, 6150, Australia; Email: h.finn@murdoch.edu.au).

Key words: black-cockatoo, habitat restoration, mine-site rehabilitation, time lag

Author Contact for Submission: Hugh Finn; School of Biological Sciences & Biotechnology, Murdoch University, Murdoch, WA, 6150; Ph: 9360 2250; Fax: 9360 6303; Email: h.finn@murdoch.edu.au
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Introduction

Wildlife may return to restored habitats once revegetation begins providing key resources such as food and shelter, a process that may require decades (Vesk et al. 2008). Such time-lags are a concern in Western Australia’s Jarrah-Marri Forest, where bauxite and gold-mining operations clear and then restore feeding habitat for three nationally threatened black-cockatoos: Carnaby’s Black-Cockatoo *Calyptorhynchus latirostris* (CBC), Baudin's Black-Cockatoo *Calyptorhynchus baudinii* (BBC), and Forest Red-tailed Black-Cockatoo *Calyptorhynchus banksii naso* (FRTBC) (Chapman 2007, Nichols & Grant 2007). Although post-mining restoration of Jarrah-Marri Forest habitat has been well-studied (e.g. Supplement to Issue 15:4 of *Restoration Ecology*), no published studies have indicated when black-cockatoos return to feed within restored habitats and if time-lags relate to species’ diet and foraging ecology.

Within the Jarrah-Marri Forest, CBC consume flowers and seeds of proteaceous shrubs (e.g. *Banksia* and *Hakea* spp.), eucalypts (Jarrah *Eucalyptus marginata* & Marri *Corymbia calophylla*), and non-native Pine (*Pinus* spp.); FRTBC feed mostly on Jarrah and Marri; and BBC are typically Marri specialists (Johnstone and Kirkby
We describe an on-going study of the feeding ecology of the three black-cockatoos within mine-site rehabilitation areas in the Jarrah-Marri Forest, and present initial findings that black-cockatoos can begin feeding in these areas within eight years.

**Site details**

The study site is at Newmont Boddington Gold (NBG), a gold-mining operation 120 km southeast of Perth and adjoining the eastern margin of the Jarrah-Marri forest between the 700 and 800 mm isohyets. Rehabilitation areas ($n = 24$) at NBG cover 190 ha (in total), and were established between 1998-2002 using rehabilitation protocols similar to those at other mine sites in the region (see overview in Koch 2007). Plant species used occur in the surrounding forest, with mid-storey and shrub species including Sheoak (*Allocasuarina fraseriana*) and proteaceous shrubs (*Banksia* and *Hakea* spp.), and canopy-forming species including Jarrah, Marri, and Wandoo (*E. wandoo*). Most rehabilitation areas at NBG have a well-developed layer of proteaceous shrubs with interspersed regenerating Jarrah and Marri stems of a height (5-12 m) and stem diameter that makes them sufficiently robust to support individuals of all three black-cockatoo species.

**Methods**

We collected data on the feeding of black-cockatoos within rehabilitation areas at NBG using field observations and vegetation sampling. On-going behavioural observations began in November 2007. We surveyed rehabilitation sites bi-monthly, recording black-cockatoo group size, activity, and foods used.
Vegetation sampling occurred in winter 2009; subsequent sampling is planned for summer and winter 2010. We sampled within nine rehabilitation areas at NBG, with each area containing five interior (>25m from any edge) plots and five exterior plots ($n = 90$ total plots). Plot sizes are: 10 m × 10 m for interior plots and 5 m × 20 m for exterior plots; all plots are separated by ≥75 m.

For each plot, we collected data on vegetation composition, structure, and phenological status, and on the presence/absence and characteristics of black-cockatoo feeding residues. Feeding residues vary by plant species, but include branches, seed husks, flowers, and eucalypt fruits that are broken, cracked open, or show distinctive signs of manipulation by black-cockatoos (T. Kirkby, Western Australia Museum, personal communication). It is generally possible to determine the black-cockatoo species leaving the residue, either by the plant species fed upon (e.g. only CBC feed on certain proteaceous shrubs at NBG) or characteristics of the feeding trace (e.g. FRTBC shear Marri fruits, while BBC pry seeds out, leaving the fruit intact).

**Results and Discussion**

There are two preliminary findings. Firstly, rehabilitation areas at NBG are starting to provide food for black-cockatoos, with CBC eating seeds from proteaceous shrubs (*Banksia* and *Hakea* spp.) and BBC and FRTBC eating seeds of regenerating Marri. Secondly, all three species fed in rehabilitation areas established as recently as 2002, indicating that food resources can start to become available within eight years post-revegetation.
Vegetation sampling in winter 2009 suggested differences in the feeding activity of the three black-cockatoos within rehabilitation areas. CBC feeding residues were observed in 53 of 90 (58.9%) plots, BBC in 27 plots (30%), and FRTBC in 6 plots (6.7%). CBC fed on the largest number of stems \( n = 172 \) mainly from two species: *Banksia squarrosa* \( n = 110 \) stems, 64%) and *Hakea undulata* \( n = 45 \) stems, 26%). BBC fed on 54 Marri stems and FRTBC on 8 Marri stems. We observed no Jarrah feeding residues. Numbers of interior and exterior plots with feeding residues were similar for all three species: CBC – 28 interior/25 exterior; BBC – 16 interior/11 exterior; and FRTBC 2 interior/4 exterior.

Possible explanations for the absence of Jarrah feeding residues in plots include: food preference, energetic and nutritional differences in seeds from regenerating Marri and Jarrah (Cooper et al. 2002), the timing of sampling, and structural differences in regenerating Marri and Jarrah stems. It cannot be explained by the absence of Jarrah fruits as 22% of Jarrah stems contained fruits: cf. 52% of Marri stems.

We observed CBC and BBC feeding in 15 of the 24 rehabilitation areas at NBG, with the youngest areas established in 2002 [CBC: \( n = 24 \) observations; BBC: \( n = 10 \) observations]. FRTBC were not observed feeding within rehabilitation areas, although they were observed feeding in forest areas immediately adjacent to them. Group sizes for feeding CBC and BBC were similar, except for occasional large assemblages of CBC [CBC: mean group size = 16.9 \pm 4.1, range = 2-72; BBC: mean group size = 11.8 \pm 2.9, range = 3-25]. These group sizes correspond with the small group sizes for birds observed feeding in remnant forest areas at NBG (J. Lee, unpublished data). As
field observations only began in November 2007, we cannot determine if black-cockatoos fed within rehabilitation areas before then.

The lack of FRTBC feeding activity within rehabilitation areas is curious, given frequent observations of the species at NBG from 2007-9 (J. Lee, unpublished data). The problem is not a lack of food, because BBC feed on Marri stems in rehabilitation areas. There may be differences in perceived predation risk, as anecdotal observations suggest that FRTBC are more sensitive to the presence of predators than are the other two species. Raptors occurred in seven of the 34 observations of black-cockatoos within rehabilitation areas, and chased black-cockatoo flocks on two occasions. If FRTBC do perceive the rehabilitation areas at NBG as more dangerous than undisturbed forest habitat, they may only use these areas at a later successional stage, when older age-class trees offer better concealment and vantage points.

Implications for management

These findings demonstrate that mine-site restoration in the Jarrah-Marri forest begins providing food resources for black-cockatoos within eight years. As clearing, mining, and revegetation operations generally take two or three years for bauxite mines in the Jarrah-Marri Forest (Koch 2007), food resources are effectively removed from a mined area for at least a decade. Further research will compare the energetic value of food sources in rehabilitation areas with those in undisturbed forest habitat to address the question of the equivalence or otherwise of the food value of the rehabilitated vegetation compared to the remnant vegetation. More generally, the findings suggest that proteaceous shrubs and Marri would be valuable elements to establish early in
restoration projects to help restore black-cockatoo feeding habitat in south-western Australia (Cale 2003, Chapman 2007).

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