tool for managing threatened species within feral-proof fenced reserves.

Both species tested in this study used the one-way gates, suggesting that gates may be a useful tool for regulating populations within fenced reserves. Interspecific differences in gate preference suggest that gates could be designed to suit the preference of a particular species' behaviour, a valuable tool if one species is more abundant than another. Technology already in use for water point management (Finch *et al.* 2006) identifies animals (>10 kg) to species level allowing some species to enter gates and not others could be adapted for use with smaller animals. A higher number of Bilby individuals used the one-way gates compared to Bettong individuals, perhaps due to innate behavioural differences. For example, the Bilby is an adept digger, that uses numerous burrows and disperses widely during dry conditions (Lavery & Kirkpatrick 1997), compared with the Bettong that is more sedentary and burrow-specific (Sander *et al.* 1997).

Wooden gate housings used in these trials were warping and disintegrating after just 3 months in the field, highlighting the need for gates to be constructed out of resilient materials such as aluminium or galvanised steel to withstand conditions such as extreme temperatures, rain, wind, sand build-up and direct sunlight. Placement is also a necessary consideration to maximise the chance of fenced animals finding and using gates and to minimise animals on the outside gaining access. Observations of Bettong and Bilby individuals within the Arid Recovery Reserve show that these species are adept at foraging and traversing along fence lines, but *in-situ* tests are needed to determine if gate usage varies between corners and straight stretches of fence line. To encourage animals to utilise gates, food could be laid to lure animals through the gate. Fence corners and posts have also been identified as key areas that are targeted when feral animals (particularly feral Cat and Fox individuals) are trying to escape or enter a fenced reserve (Moseby & Read 2006).

Prototypes of the preferred gate designs (vertical and horizontal) are currently being constructed out of resilient materials and tested on feral Cat and Rabbit individuals outside the Arid Recovery Reserve to ensure that pest species cannot gain access through the gate exit points. Gates are too small for entry by Fox individuals independent of their mother.

Once testing is complete and the one-way gates are deemed 'feral-proof', experimental gates will be installed initially along internal fence lines within the Arid Recovery Reserve and monitored *in situ* using remote cameras to determine the long-term resilience of the gates and the number and species using them. If successful, one-way gates may be a useful tool for facilitating natural dispersal and assisting with population reduction within fenced reserves during periods of over-abundance. In other periods, when movement of animals is not warranted (e.g. in cases of a population crash or where feral animals are present in high density outside the fence), we envisage that the gate design will be able to be locked so that dispersal is controlled and adaptively managed.

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5.35

Mine-site revegetation monitoring detects feeding by threatened black-cockatoos within 8 years. Jessica Lee, Hugh Finn and Michael Calver (School of Biological Sciences & Biotechnology, Murdoch University, Murdoch, West Australia 6150, Australia; Tel.: 9360 2250; Fax: 9360 6303; Email: h.finn@murdoch.edu.au).

Key words: *black-cockatoo*, *habitat restoration*, *mine-site rehabilitation*.

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* and Marri *Corymbia calophylla*) and non-native Pine (*Pinus spp.*); FRTBC feed mostly on Jarrah and Marri; and BBC are typically Marri specialists (Johnstone & Kirkby 1999, 2008; Cale 2003; Cooper *et al.* 2003; Chapman 2007). 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 8 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 and 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 (>25 m 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, pers. comm. 2009). 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 by the 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. First, 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. Second, all three species fed in rehabilitation areas established as recently as 2002, indicating that food resources can start to become available within 8 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 six 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 ± 4.1, range = 2–72; BBC: mean group size = 11.8 ± 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, unpubl. data 2008, 2009). 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 2007–2009 (J. Lee, unpubl. data). The problem is not 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 8 years. As clearing, mining and revegetation operations generally take 2 or 3 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 with 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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POLLUTION ISSUES & SOLUTIONS

7.4

Development of a method for identifying elevated vitellogenin gene expression in the Sydney Rock Oyster (*Saccostrea glomerata*) as an indicator of endocrine disruption on the Sunshine Coast. Kelli Anderson[1], Fiona Burnell[1], Anne Roiko[1], Megan Andrew[2], Wayne O'Connor[3] and Abigail Elizur[1] ([1]Faculty of Science, Health and Education, University of the Sunshine Coast, Sippy Downs, Queensland 4556, Australia; Tel: +61 7 54594813; Fax: +61 7 5456 5010; Email: aelizur@usc.edu.au; [2]School of Environmental and Life Sciences, University of Newcastle, Callaghan, New South Wales 2308, Australia; [3]NSW Industry & Investment, Port Stephens Fisheries Institute, Taylors Beach, New South Wales 2316, Australia).

Key words: *bioindicator,environmental monitoring*, *gene expression*, *Sydney Rock Oyster*, *vitellogenesis*.

Introduction

Environmental oestrogens are a diverse group of natural and synthetic chemicals that include some surfactants, pharmaceuticals, pesticides, cosmetics, plastisers and other chemicals found in agricultural, industrial and sewage effluent (Matozzo *et al.* 2008). Environmental oestrogen contamination can result in significant reproductive, developmental and other physiological problems for exposed organisms and have therefore become a global concern (Matozzo *et al.* 2008).

Environmental oestrogens mimic the action of endogenous oestrogens, mainly 17β-estradiol, which, in some species of bivalve, appears to be a major promoting