Effectiveness of biodiversity offsets: an assessment of a controversial offset in Perth, Western Australia

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Abstract

Environmental offsets are used increasingly as a conservation tool to balance demands of development and environment but there is little evidence that offsets are effective. Our study assessed the effectiveness of the offset package developed for the Roe Highway Extension, in Western Australia, for Carnaby's black cockatoo, red-tailed black cockatoo and southern brown bandicoot. Black cockatoos were accounted for in the offset requirements, while Southern brown bandicoots were accounted for in the mitigation requirements of the approval but not the offset requirements. The development was cancelled after partial clearing and has not been completed. Pre-development consultant surveys were examined in relation to the offset requirements. Fieldwork was conducted at the offset sites to ground-truth habitat qualities where possible. The offset package was then compared to the principles of Australian Commonwealth and State offset policies. We found the offset package did not completely satisfy Commonwealth or State offset requirements, showed inconsistencies with the policies and produced net loss of environmental value. The offset sites provided 64 % of the black cockatoo habitat required by the Commonwealth offset requirements, and was of a lower quality. Similarly, undergrowth vegetation (< 1 m; used by southern brown bandicoots) varied between the development and offset sites, indicating the offset proposal approval criteria 'similar or better quality' was not met. Like for like is not always required by offset legislation, but it was required in the approval criteria for this development project. The offset sites had previously been deemed unfit for development by the EPA, resulting in little additionality, a fundamental factor in ensuring true gains to compensate for the loss. To improve the suitability of offsets as a conservation tool we strongly encourage a checking process to confirm ecological outcomes of an offset, a contingency plan for if the offset doesn't provide sufficient ecological outcomes, greater consideration of requirements of species affected and stricter adherence to the wider principles of offsets. The use of biodiversity offsets is nearly inevitable given current development policies and processes; however, the application of offsets can be substantially improved to reduce further net loss of environmental value.

Keywords: offsets, Black Cockatoo, ground-truthing, ecological effectiveness

1. Introduction

Environmental offsets are an increasingly popular conservation tool, used to compensate for unavoidable residual environmental damage by increasing environmental value elsewhere (Maron et al. 2016). However, there is much controversy over the effectiveness of this tool (Bull et al. 2013), with little research on how offsets have worked in practice.

The IUCN recently adopted an international policy for offsets, providing a guidance framework (IUCN 2016). This international policy is not yet in practice, meaning countries using offsets have developed individual offset policies (Maron et al 2018). These policies have several consistent principles, including the mitigation hierarchy, which requires that offsets are only employed if appropriate avoidance and reduction actions are insufficient (Bull et al. 2013; Gardner et al. 2013; Miller et al. 2015). Governing agencies must also decide whether the use of an offset is appropriate, as some areas are of such high environmental value that they cannot be suitably offset (Norton 2009). Another core principle is the concept of 'no net loss', or 'net gain', of biodiversity value (Maron et al 2018). To compensate for clearing, an offset should at least maintain, or ideally increase, the initial environmental value of an area (IUCN 2016). To do this, offsets commonly provide for either creation or restoration of habitat, or land acquisition for protection of an area of habitat that may otherwise be threatened (Moreno-Mateos et al. 2015). However, the gain offered by land acquisiton depends on whether there is an overall decline or gain in biodiversity in the area and what would have otherwise happened to the area now being conserved (Bull et al. 2014). Any potential benefit depends strongly on the type and quality of habitat at the impacted site and the offset site (Maron et al. 2010). The offset must be tailored to the area being cleared so that it is suitable in the type of offset offered and the environmental gain made.

In practice, providing habitat of comparable environmental value can be problematic (Hayes and Morrison-Saunders 2007) as ecosystems are seldom directly comparable (Gibbons and Lindenmayer 2007). A system for establishing the baseline environmental value of an area should be established, as well as the ecological currency to determine the value of the transaction and the definition of success (Quétier and Lavorel 2011). When deciding on an offset, the context around the development and offset should also be considered. An evaluation of other past, present and future development projects nearby will assist when deciding on the baseline environmental value against which gain may be measured (Bull et al. 2014). This biological assessment must then be combined with legal and political factors, adding a further level of complication. Governing bodies must provide a solution that caters for the often-conflicting objectives of development projects and environmental protection (Maron et al. 2012). Previous results show offset implementation is not always effective in this purpose (Lindenmeyer et al. 2017). Even where offsets have been considered effective, it has been noted that this has only been made possible by implementing the maximum level of offsetting recommended followed by intensive monitoring (Pickett et al. 2013).

Offset policies in Australia are present at the Commonwealth, State and local government level. Commonwealth requirements are determined in accordance with the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and the EPBC Act Environmental Offsets Policy (Commonwealth policy) (Australian Government 2012). They provide protection for Matters of National Environmental Significance, which includes nationally threatened species and Endangered or Critically Endangered ecological communities (Australian Government 2012).

In Western Australia (WA), State offset requirements are created in accordance with the WA Environmental Offsets Policy (State policy) and the Environmental Protection Act 1986 (EP Act) and encompass all significant environmental impact (Government of Western Australia 2014). Both State and Commonwealth regimes apply the mitigation hierarchy (Australian Government 2012; The Government of Western Australia 2011). Ideally, Commonwealth and State approval processes are

undertaken simultaneously, but proposals must be presented to authorities concurrently (Government of Western Australia 2014).

A recent study found that, based on internal reporting processes, only 39% of offsets in WA were successful in completing their proposed outcomes and noted that field assessment of offsets is lacking, meaning a true assessment of ecological benefit was not possible (May et al. 2017). Here we examine a recent case study that provided the opportunity to examine in detail the ecological effectiveness of an offset package in relation to a road development in metropolitan Perth.

2. A case-study on assessing offset effectiveness: The Roe 8 Project

Roe 8 involved a five kilometre extension of the Roe Highway through a section of Beeliar Regional Park (Aecom 2016) in Perth, Western Australia (Figure 1). This required the clearing of 97.85 ha of native remnant vegetation and impacted 6.8 ha of conservation category wetlands ("Wetlands which support a high level of attributes and functions" (Department of Biodiversity, Conservation and Attractions 2014)). This included high quality foraging and potential nesting habitat for nationally threatened species, including forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*) and Carnaby's black cockatoo (*Calyptorhynchus latirostris*), (Government of Western Australia 2015). The impact on these species triggered the EPBC Act, requiring these species to be accounted for in the approval conditions of the proposal. The resulting offset requirements focused on the acquisition and subsequent protection of land to provide compensatory habitat for forest red-tailed black cockatoo and Carnaby's cockatoo (Table 1). The Final Public Environmental Review described the process involved in deciding a suitable offset, which included a review of State and Commonwealth policies and guidance statements, global definitions, field assessments and advice from State and Commonwealth governments, including ratio requirements. This review provided a proposed offset stating the amount of vegetation to be cleared as 79 ha (38ha intact) of native vegetation, including 78 ha of black cockatoo habitat, requiring an offset of at least 468 ha of black cockatoo habitat (Aecom 2011b). The EPA finalised the significant residual impacts as 97.85 ha of remnant native vegetation, including 78 ha of black cockatoo habitat, recommending 234 ha of Carnaby's cockatoo habitat and 219 ha of forest red-tailed black cockatoo habitat (Environmental Protection Authority 2013). The final approval document required 523 ha of black cockatoo habitat under Commonwealth offset requirements and 234 ha under State offset requirements. Approximately 69 ha were cleared before a change in government resulted in cancellation of the project (further explained below). Following this cancellation, a proposed amendment has been made to the proposal reducing the total construction area to 81.2 ha (Government of Western Australia, 2018). This did not define the habitat within this area, which is necessary for calculating an offset for this amendment.

There was also concern for the southern brown bandicoot (*Isoodon obesulus*, quenda), a State-listed conservation priority species, present at the development site. As part of the mitigation process, provisions were created for the translocation of quenda to a suitable location, but they were not specifically accounted for in the either the Commonwealth or State offset requirements. We evaluate habitat for quenda here in order to display the level of compensation offered to species not specifically catered for in offset provisions.

The State also required a wetland rehabilitation plan at the development site and weed management plans for *Typha orientalis* and *Zantedeschia aethiopica* (Arum lily) (Government of Western Australia 2015).

The thresholds for success of offsets are explained differently at the State and Commonwealth levels, but both require a maintenance or improvement of environmental value. State offset policy requires a "proportional" and "like for like" offset that will "compensate" for residual damage (The Government of Western Australia 2011). The State offset requirements are satisfied once the land

has been acquired and the approved management plans for each offset have been implemented. Commonwealth offset policy requires that the offset "*improves or maintains* the viability of the protected matter" (Australian Government 2012). Therefore, the offset package should ensure that the quality of habitat at the offset sites must be, or become, at least equivalent to the area being cleared. Under the Commonwealth requirements, the property is to be managed by the state conservation department for 20 years, with funds to be provided by the proponent. Management strategies included: pest control; weed control; maintenance of and creation of fire breaks and fences; and a quenda survey. There was no rehabilitation plan and the management plans did not include actions to increase the abundance or condition of the native vegetation or foraging habitat for black cockatoos.

Roe 8 was strongly contested due to the high environmental value of the area to be cleared and due to its value to the local community (Gaynor et al. 2017). In a case taken to the Supreme Court of Western Australia, it was found that approval of the proposal was inconsistent with the Environmental Protection Authority's (EPA) published policies, in that offsets are not appropriate for areas of such environmental importance. This was later overturned, in favour of the proposal, with a ruling that it was not mandatory for the EPA to follow its own policies (Senate Environment and Communications References Committee 2017). Initial clearing began in December 2016. However, a change in government in March 2017 resulted in the cancellation of the project and a cessation of clearing, with the result that about 69 ha of the development site had been cleared but the rest remained intact.

This controversial development provides a good opportunity to assess the proposed ecological effectiveness of an offset in Western Australia. Although the development site was not completely cleared, assessing the ecological effectiveness of the offset remains a useful exercise. The development was cancelled due to a change in State Government rather than an environmental process, and would likely have proceeded had the change not occurred. Indeed, the ability to reassess the environmental values of the portion of the development site that remained uncleared provided a stronger comparison than would have been possible through relying only on the pre-development surveys, as ground-truthing of the vegetation was possible. The proposed offset had been secured and offset management plan provided, and this offset remains on the Western Australia offset register. The environmental approval for the development has been revoked and an application made by the proponent to amend the area to be developed, which would involve a smaller area of land is involved in the construction. A rehabilitation program is being developed for the remaining area. However, this amendment has not been finalised (Government of Western Australia 2018). The environmental value of the development site, as assessed from the information provided in pre-development surveys, was compared to the potential environmental value offered by the offset site. We examined the following:

1. Are the habitats at the development site and the offset site comparable in type and quality, based on the requirements of Carnaby's cockatoo, forest red-tailed black cockatoo and quenda?
2. What was and would have been lost at the development site and did the offset sites provide adequate compensation for this?
3. Did the offset policy for State and Commonwealth provide sufficient guidelines and protection to prevent net loss of environmental value?

3. Methods

3.1 Study area and indicator species

The study area consisted of three sites: the area within the development envelope (development site) and the two sites acquired to satisfy the offset requirements (Figure 1). One offset site is next to Lake Clifton (Lake Clifton), south of Perth, comprising a total of 522.4 ha across three adjoining lots

(Aecom 2016). The second offset site is a single lot totalling 101.6 ha in Nirimba, in the Peel region, approximately 59 km south of Perth (Nirimba) (Aecom 2016). Lake Clifton was assessed as providing 459.6 ha of black cockatoo habitat and 7.1 ha of conservation category wetland, and Nirimba was assessed as providing 69.6 ha of black cockatoo habitat and 11.7 ha of conservation category wetland. To provide an assessment of the impact and compensation provided for species with different levels of conservation protection, we examined the habitat variables likely to be important to the forest red-tailed black cockatoo, Carnaby's cockatoo and quenda in detail.

Black cockatoo habitat was defined in the Commonwealth offset requirements as any area of habitat with a vegetation community that included *Banksia attenuata, Banksia menziesii, Banksia illicifolia, Banksia littoralis, Xanthorrhoea preissii, Eucalyptus marginata* (jarrah)*, E. gomphocephala* (tuart)*, Corymbia calyophylla* (marri) and *Allocasuarina fraseriana* (sheoak) (BC tree species) (Australian Government 2015). This definition was applied in this study as it included preferred habitat tree species for forest red-tailed black cockatoo and Carnaby's cockatoo and was an accurate representation of the vegetation to be cleared at the development site (Aecom 2011a; Shah 2006).

Quenda habitat was defined as the undergrowth (under 1m in height) present, with a higher density of undergrowth considered a more favourable habitat (Department of Environment and Conservation 2012).

3.2 Comparing habitat between development and offset sites: desktop survey of prior work

To evaluate effectiveness, the expected loss to occur at the development site was compared to the expected gain at the offset locations in relation to the habitat requirements of the three focal fauna species. Initially, a desktop survey of publicly available information was conducted, which involved the extraction of information sourced from surveys conducted by Main Roads Department and consultants as part of the approvals and development process. The surveys are explained below, and these data provided a baseline data set for initial assessment of habitat. A summary of the information extracted is provided in Table 2.

Two pre-development vegetation surveys and one pre-development vertebrate fauna survey (fauna survey) completed at the development site were used to provide baseline data for initial assessment of habitat present at the development site (Table 2). One vegetation survey was conducted between September to November in 2009 and April to November 2010 (collectively the '2009 survey') (Aecom 2011a). This provided a total of 77 non-permanent 10x10m quadrats, used to confirm vegetation communities present (n = 41 quadrats in 2009; n = 36 quadrats in 2010) and encompassed a wider survey area than the development site. The plant species were recorded within each quadrat, as well as the percent cover and height of these species. The raw vegetation measurements were not provided for 11 quadrats in the 2009 survey, so a total of 66 quadrats were used to provide baseline data for the initial assessment (n = 30 within the development site; n = 36 outside the development site) (Aecom 2011a) (Table 2). It should be noted that Aecom, who conducted the surveys, were one of the development contractors for the Roe 8 project, an apparent conflict of interest that counters the principle of transparency in the process.

The second pre-development vegetation survey at the development site was completed in 2015 to provide pre-impact baseline vegetation data in the immediate vicinity to monitor the impact of the development project on the surrounding vegetation (Ecoscape (Australia) Pty Ltd 2016). This consisted of 49 permanent 10x10m quadrats along the border of the development site, within native vegetation communities. The quadrats were paired, with 25 quadrats within a 15 m buffer zone surrounding the project envelope, and 24 in adjacent locations outside of this buffer zone. The plant species and percent cover, height and density of these species was recorded within each quadrat. The fauna survey provided information on the vertebrate fauna and habitat present in and around the development site (Table 2).

A pre-development survey undertaken in 2016 at the offset sites provided an initial assessment of the habitat present to assess whether there was sufficient habitat to satisfy State and Commonwealth offset requirements (Aecom 2016; Table 2). The Lake Clifton survey included 63 quadrats, measuring 10x10 m (n = 30 inside the offset boundaries; n = 33 outside the offset boundaries). The plant species and percent cover and height of these species were recorded within each quadrat. An assessment was also made of the quality of the black cockatoo foraging habitat available at Lake Clifton. Draft assessment criteria established by the Department of Environment had been finalised into a scoring table by the pre-development consultant, based on key habitat features for black cockatoos. An initial desktop assessment by the pre-development consultant identified 35 sites to represent areas of black cockatoo habitat in Lake Clifton. Quadrats measuring 50x50 m had been established at these sites to complete the scoring assessment and an initial score was established, with points being added or removed based on the ecological attributes of the habitat present in each quadrat. A final score represented the value of the habitat (high, quality, valued, low).

No raw vegetation data from the quadrats in the vegetation assessment at Nirimba were publicly available. The area of black cockatoo foraging habitat was provided, based on the presence of one or more black cockatoo foraging species in the vegetation community, but no foraging habitat quality assessment had been completed (Table 2).

The quality of black cockatoo foraging habitat was not assessed at the development site in the pre-development surveys. We assessed the quality of black cockatoo foraging habitat at the development site using the foraging habitat scoring table from the Lake Clifton foraging habitat assessment. Quadrats from the 2009 survey at the development site that fell within potential black cockatoo foraging habitat were identified (n = 34) and used as reference sites for the foraging habitat quality assessment. The smaller size of the quadrats from the 2009 survey (10x10 m) compared to the Lake Clifton survey (50x50 m) was compensated for by using GIS mapping. The locations from the 2009 survey were located and a 50x50 m square from this location was outlined. Vegetation communities (from the 2009 survey) and potential breeding trees (from the fauna survey) were inserted into the GIS map. The distance to the ecological attributes used in the Lake Clifton survey to assess foraging habitat, such as water bodies and roost sites, were measured and used in conjunction with the vegetation communities present to provide a score. All GIS mapping in this project was completed using QGIS version 2.18.7.

3.3 Groud-truthing of habitat between development and offset sites

Field surveys were conducted with the purpose of ground-truthing the information collected from pre-development surveys where possible (assessment surveys). Further information necessary to confirm the habitat present at the development and offset sites was also collected, including raw quadrat data for Nirimba and the presence and abundance of quenda diggings. The information obtained in the assessment surveys was compared with the pre-development surveys to assess the accuracy of the information collected in the pre-development surveys in three areas: 1) the composition and relative abundance of black cockatoo tree species; 2) the density of understory vegetation, using two strata levels (0-30 cm and 30 cm-100 cm); and 3) mapping of vegetation communities present. This was to confirm the information from the pre-development surveys could be relied upon for analysis. The methodology employed in the pre-development surveys was applied as closely as possible to replicate the process. However, inconsistencies in previous methodology limited the ability to compare sites. This, combined with time and logistical constraints, meant the methods were adapted where necessary. The process that was used is detailed below.

At the development site, a sample of quadrats from the 2009 and 2015 development site surveys was selected to complete the assessment survey (n = 17). The 2009 survey quadrats were entered into a GIS map with the vegetation community. Quadrats that fell within the offset boundaries that had not been cleared and represented different vegetation communities were chosen for ground-truthing

(n=8). If all quadrats from a vegetation community had been cleared, a quadrat from the 2015 survey was chosen to represent this community (n = 9). Vegetation communities that were completely cleared or recorded as significantly degraded in the pre-development surveys were not included. The development site assessment survey was completed in September 2017, matching the season of the pre-development surveys (Aecom 2011a; Ecoscape (Australia) Pty Ltd 2016).

At each location, a quadrat measuring 10x10 m was established, with the pre-development coordinate as the north-west corner. The following information was recorded within the quadrat:

- A photo from the northwest corner facing southeast;
- The percent foliage cover, number of individuals and average height of any black cockatoo tree species within the quadrat;
- The percent cover of undergrowth from 0-30 cm, and 30-100 cm; and
- The number of quenda diggings present, in four categories (No diggings present, 0-10 diggings, 10-20 diggings, 20 or more diggings);

A lower level of sampling had been undertaken in the Lake Clifton pre-development survey than in the pre-development surveys at the development site, as the offset sites were not required to have the same level of sampling (Aecom 2016). All quadrats (n = 30) within the actual boundaries of the Lake Clifton offset were ground-truthed in our survey, which encompassed all vegetation communities and accounted for the larger size of Lake Clifton in comparison to the development site. For Nirimba, the initial survey provided a map of quadrat locations, but only three quadrat locations were within the offset boundaries, accounting for three out of five vegetation communities (Aecom 2016). We located these three quadrat locations as closely as possible, and two more quadrat locations were inserted to account for the remaining vegetation communities (n = 5). Using similar 10x10 m quadrats, the same information was collected as in the development site assessment survey.

To determine whether the information in the pre-development surveys could be relied upon for analysis, the community composition of black cockatoo tree species (n = 8 species) was compared between the data from the quadrats in the assessment surveys and the data from the equivalent quadrats in the pre-development surveys (n = 30 quadrats from Lake Clifton offset site, n=17 quadrats from development site), using percent cover data. This was completed by permutational Multivariate Analysis of Variance (perMANOVA) using distance matrices in the statistical programme R (version 3.3.1; R-vegan function Adonis) (Oksanen et al. 2017). Due to the high number of quadrats without any black cockatoo tree species, a dummy species, at a value of 1, was included so quadrats that had no target species were represented (Clarke et al. 2006). In addition, the density of undergrowth (recorded as % cover between 0-30 cm and 30-100 cm; n = 53 quadrats) was compared between assessment surveys and pre-development surveys using a t-test (R, version 3.3.1). The data collected from the Nirimba assessment survey was then combined with the data from the Lake Clifton survey (offset data set). Information missing from the Lake Clifton survey was supplemented with the data from the Lake Clifton assessment survey where necessary.

3.4 Habitat assessments

Applying the same method as above, a perMANOVA was used to compare the community composition and relative abundance of black cockatoo tree species between the data from the 2009 survey (n = 30 quadrats) and the offset data set (n = 35 quadrats). This was to compare the relative abundance of each tree species within the vegetation community and the composition of the habitat available. The data were also transformed using log and presence-absence transformations, to account for the presence of less well represented species. Individual t-tests were completed on the black cockatoo tree species (n = 8).

To assess whether habitat differed during the years between initial and final surveys at the development site, the community composition of black cockatoo tree species (based on abundance

estimates from baseline data; n = 31 quadrats for 2009 survey, n = 48 quadrats for 2015 survey; 8 species in total) were examined between the 2009 survey and 2015 survey data sets by perMANOVA. In addition, the density of undergrowth (recorded as % cover between 0-30 cm and 30-100cm; n = 31 quadrats for 2009 survey; n = 48 quadrats for 2015 survey) was compared between survey years using a t-test.

The abundance of quenda diggings recorded in the assessment surveys at the offset sites were compared to the abundance of diggings recorded in the development site assessment survey to provide an estimate of the comparative density of quenda at each site.

The vegetation information recorded in the assessment surveys was used to confirm the vegetation communities present at both the development site and offset sites. Using the field calculator tool in QGIS (version 2.18.7), the amount of black cockatoo habitat present at the offset sites was calculated.

3.5 Assessing fulfilment of offset requirements at a policy level

The results from the above ecological assessment, in conjunction with the offset requirements, were compared with the principles of the State and Commonwealth policies to review whether these principles were considered in the offset requirements, as follows:

State

- Whether appropriate avoidance and mitigation measures were present in the approval document;
- If there was consideration of whether an offset was appropriate due to the high environmental value of Beeliar Regional Park;
- Whether the requirements were appropriate and reflective of the significance of the impact. This requires the proposed offset package to provide sufficient additional environmental gain to compensate for the residual environmental loss caused by the development project. It may not be possible for the offset to be exactly like-for-like but it must be relevant to the significant impact (Government of Western Australia 2014);
- Ground-truthing the pre-development information provided and completing a comparison of the habitat present to assess whether robust environmental information was used; and
- Reviewing the future projections for the offset site to assess whether a long-term view was taken to ensure an enduring offset that satisfies projected environmental outcomes.

Commonwealth

- If there was an overall maintenance or improvement of black cockatoo habitat by comparing the black cockatoo habitat to be cleared, with the intended habitat to be gained at the offset;
- Reviewing the offset package to assess whether:
    - The offset was a predominately direct offset;
    - More environmental compensation was offered to affected species with higher statutory protection and a higher level of residual impact;
    - An allowance in case of failure of the offset was provided;
    - Maintenance or improvement of resources for black cockatoos was accounted for to ensure future viability of their population;
    - The offset provided sufficient additional conservation gain for black cockatoos. This must be additional to any conservation actions or gain already required, to ensure adequate compensation is provided for the loss caused by the development project.

- Reviewing local management plans to assess whether actions were additional to those in previously implemented management strategies; and
- There was transparency of process to allow review and monitoring of the offset package by reviewing whether all information was publicly accessible.

4. Results

4.1 Review of methodology for pre-development survey effort

The methodology used in the pre-development surveys had inconsistencies that made an accurate comparison of the development and offset sites difficult:

The timeline from the first pre-development survey (2009) to final approval of the Roe 8 project proposal (2016) was almost eight years. It appears that no further vegetation assessments were undertaken within the development site after 2011, a period of six years (Aecom 2011a, 2016; Ecoscape (Australia) Pty Ltd 2016). Further, the EPA guidelines required a level 2 survey because of the significant impact at the development site, but required only a level 1 survey at the offset sites because there was no significant impact occurring (Aecom 2011a). This resulted in a higher level of sampling at the development site, which was a smaller area, making an accurate comparison between sites difficult. Pre-development sampling was also incomplete at Nirimba (Aecom 2016), resulting in inaccurate vegetation mapping. The information that was provided from the pre-development surveys concentrated on a wider survey area than that within the development site and offset boundaries (Aecom 2011a, 2016). Although important to consider the surrounding areas, the future tenure of these areas is not certain and is not being directly impacted.

Finally, for the assessment of potential breeding habitat for black cockatoos, transects were used to locate significant trees at the development site. Quadrats were used at Lake Clifton and no assessment was completed at Nirimba, meaning it was not possible to compare the amount of potential breeding habitat present (Aecom 2011a, 2016).

4.2 Survey comparisons

The composition and relative abundance of black cockatoo tree species was not significantly different between the pre-development surveys and the assessment surveys for the development site (perMANOVA: pseudo-F = 0.84; $P = 0.49$) or for Lake Clifton (perMANOVA: pseudo-F = 0.02; P 0.28). The undergrowth between 30-100 cm was also not significantly different between the pre-development surveys and the assessment surveys for the development site ($t = -1.4$; $P = 0.17$) and Lake Clifton ($t = 0.48$; $P = 0.63$). This allows the data from the pre-development surveys for these aspects to be relied upon for comparison of the type and quality of habitat at the development and offset sites.

The composition and relative abundance of black cockatoo tree species was not significantly different between the 2009 data set and the 2015 data set (perMANOVA: pseudo-F = 0.85; $P =$ 0.59). The level of undergrowth was also not significantly different in the 2009 survey than the 2015 survey between 0-30 cm ($t = -1.3$; $P = 0.17$) and 30-100 cm ($t = 0.67$; $P = 0.5$). Therefore, the vegetation did not change significantly over time.

4.2.1 Black cockatoo habitat

Approximately 336.4 ha of black cockatoo habitat was mapped at the offset sites using the information collected in the assessment surveys. This is only 64% of the amount of black cockatoo habitat that was said to be at the offset sites in the pre-development surveys. A large section of the vegetation at the Lake Clifton consists of the vegetation community MsTd (Mid to tall heathland to closed heathland of *Melaleuca systena* over low forbland of *Trachyandra divaricata* and other non-native species (Aecom 2016)), which does not include any black cockatoo trees species (Aecom 2016). Vegetation mapping of Nirimba was not completely accurate and resulted in a larger area of

marri dominated vegetation being recorded in the pre-development survey than actually present (Aecom 2016). Approximately 24 ha of marri dominated vegetation was mapped at the offset sites, compared to approximately 34.9 ha of marri dominated vegetation at the development site. Marri is a key food species for forest red tailed black cockatoo.

The quality of black cockatoo foraging habitat was higher at the development site as there was a proportionately larger amount of high quality black cockatoo foraging habitat compared to the offset sites (Table 3). More high quality foraging habitat was available for Carnaby's cockatoo than for forest red tailed black cockatoo at the offset sites (Table 3). A portion of the high quality habitat identified in the pre-development survey at Lake Clifton consists of a vegetation community that is not considered black cockatoo habitat under the Commonwealth definition. It has been included as black cockatoo habitat for the purposes of this quality assessment for consistency with the foraging habitat assessment process in the pre-development surveys. Parts of the offset sites were also both previously farm land (Aecom 2016; ENV Australia Pty Ltd 2009). Comparatively, the development site had not previously been used as farmland but rather included high quality remnant native vegetation, within a regional park (Aecom 2011b).

The community composition and relative abundance of black cockatoo tree species was significantly different between the development site and the offset sites (Table 4). The main difference between the development site and offset sites lay in a significantly higher amount of *Banksia attenuata* ($t = 2.91$; $P = 0.006$*) and *B. menziesii* ($t = 2.16$; $P = 0.039$*) at the development site. There were also higher levels of *B. illicifolia*, *B. littoralis*, jarrah and sheoak, with jarrah ($t = 3.35$; $P = 0.002$) and sheoak ($t = 2.68$; $P = 0.01$) becoming significantly higher with a presence absence transformation. No marri was recorded at the Lake Clifton offset site in any survey. This indicates that the type of habitat at the offset sites is different to that at the development site. The development site also provided a higher abundance of the food tree species for black cockatoo species. Despite the difference in type and quality of black cockatoo habitat, no rehabilitation plan was established at the offset sites. The proposed management strategies also did not provide for an increase in the quality of black cockatoo foraging habitat (Aecom 2016).

4.2.2 Quenda habitat

The undergrowth between 30-100 cm at the development site was significantly denser than at the offset sites ($t = 2.69$; $P = 0.009$). This difference was more pronounced when comparing the 2015 survey at the development site to the offset sites ($t = 4.6$; $P = <0.001$). The undergrowth was 19% denser at the development site between 30-100 cm than the offset sites. A higher average number of diggings was recorded at the development site than the offset sites (Figure 2). The higher density of diggings recorded at the development site indicates that the development site potentially has a higher number of quenda or they are more concentrated, due to the smaller size of the area.

4.3 Compensation provided for the loss at the Roe 8 development site

The habitat acquired satisfied the State land acquisition requirements in its size (Government of Western Australia 2015) but not the Commonwealth land acquisition requirements. The habitat at the offset sites was not of an equivalent quality, as required by both sets of offset requirements. Lake Clifton was part of a section of land assessed for subdivision previously, where the EPA stated clearing of the land would not meet their objectives for biodiversity and recommended incorporation of the site into Yalgorup National Park. Proposed offsets were considered in this proposal indicating clearing of Lake Clifton would likely result in referral and potential creation of further offsets (Environmental Protection Authority, 2011). The offset area was also within the areas proposed for acquisition under the Perth and Peel Green Growth Plan for 3.5 million (Government of Western Australia 2015). Therefore, irrespective of the quality of the habitat at the offset sites, they were unlikely to be cleared and in a counterfactual situation would have been preserved without being an

offset. This means the requirement of additionality is not satisfied, which is a fundamental principle of both State and Commonwealth offset policy.

The offset requirements resulted in protection of a large area of potential habitat for quenda. The fauna management plan (Strategen Environmental Pty Ltd 2016) required affected quenda to be translocated to a new site and monitored post-translocation. A large number of the individuals (n = 133) were translocated to Lake Clifton (Alice Reaveley, Fauna Conservation Manager, DBCA, pers comm) but this habitat was significantly different to the habitat at the development site.

5. Discussion

The use of offsets is increasing globally but there is little empirical evidence to support their effectiveness (Lindenmayer et al. 2017), and this is also the case in Western Australia (May et al. 2017). This study addresses this knowledge gap by using an example of a recent development project to determine whether offsets are producing ecologically effective results in Western Australia. Our study complements that of Lindenmayer et al. (2017) by focusing on a similar development trigger for offsets but involving different offset types. The case study examined did not meet either State or Commonwealth offset targets, and potentially represents that offsets were not applied in accordance to policy. We consider effectiveness in the context of the three aspects of the offset process that we examined.

5.1 Ecological attributes of the offset package

We have not examined here the logic behind the areas (based on offset ratios) and work included in the offset package. The package did not provide any new habitat, but rather changed the conservation status of existing areas. Given these caveats, how did the offset perform? We found less black cockatoo habitat in the offset sites than in the initial surveys. The original conclusion seemed to be more generous due to black cockatoo habitat being defined using various literary sources, rather than the Commonwealth definition. This resulted in the inclusion of an area dominated by a vegetation community that did not include any black cockatoo tree species (Aecom 2016). Consistency in the definition of black cockatoo habitat between offset requirements and assessment process would reduce the chance of inaccurate representation of habitat. Further, equivalent habitat was not provided at the offset sites for Carnaby's cockatoo and forest red tailed black cockatoo. The minimal amount of high quality habitat in comparison to the size of the offsets decreases its value further, as increased foraging energy from black cockatoos is required to locate high quality foraging habitat. Without a rehabilitation plan, or management plans that address black cockatoo habitat, there is no opportunity for this habitat to improve in quality.

Quenda are particularly vulnerable to fragmentation on the Swan Coastal Plain. They are also a territorial species (Senate Environment and Communications References Committee 2017), that becomes locally adapted to its habitat (Cooper 1998). The difference in habitat at the offset sites compared to the development site means any translocated animals would need to be monitored closely to ensure their survival, as per the fauna management plan (Strategen Environmental Pty Ltd 2016). A rehabilitation plan would also be beneficial in this case to increase the density of undergrowth above 30 cm at the offset sites as the high number of diggings present at the development site indicates that these individuals prefer a high density of undergrowth between 30 cm and 100 cm.

5.2 Review of the ecological attributes of the Roe 8 offset package in relation to the proposed offset requirements

The lack of field verification of the offset package has resulted in minimal ecological benefit from the offset. The value of the offset is apparent only on paper, a limitation of offset processes that has been identified previously (May et al. 2017). The actual ecological attributes of the offset properties

only provide sufficient black cockatoo habitat to satisfy the State requirements. The habitat also does not satisfy the element of equivalence necessary under both sets of offset requirements. Further to this, quenda were not accounted for in the offset requirements, despite being a State conservation significant species (Senate Environment and Communications References Committee 2017).

Reviews of other offset packages have reported mixed results for offset success. An assessment of the use of nest boxes created as part of an offset in in southern Australia reported that there was little to no use of the nest boxes by the species they were developed for, resulting in minimal net gain from this offset (Lindenmayer et al. 2017). An offset program for threatened green and gold bell frogs in Sydney confirmed no net loss but highlighted the importance of ecological monitoring post-implementation (Pickett et al. 2013). These studies support the need for a review of the ecological effectiveness of an offset after satisfaction of the offset requirements.

5.3 Review of the principles of the State and Commonwealth policy in relation to the Roe 8 offset requirements and resulting offset package

The approval document for Roe 8 provided both avoidance and mitigation measures prior to the required offset package, in accordance with the mitigation hierarchy. However, it could be argued an offset was not appropriate for this project due to the high environmental value of the area, particularly in an increasingly fragmented landscape (Senate Environment and Communications References Committee 2017). The subsequent decision not to continue with the project also indicates the highway extension was not essential. Although this appears to show successful avoidance of net loss, avoidance only occurred because of a political change, rather than an environmental process, demonstrating the influence of government on environmental decision making. Offsetting processes should be exempt from becoming a government bargaining factor and decisions should be based on sound environmental information.

The offset package does not appear to reflect the significance of the impact at the development site. Further aspects of the offset package such as the arum lily and *T. orientalis* management plans were deemed to be duplications of pre-existing management actions (Senate Environment and Communications References Committee 2017). Weed management plans for these species had already been established in this area (Department of Conservation and Land Management, 2006). The habitat acquired under the land acquisition requirement was already present and was of a different quality and composition. There was no rehabilitation plan and the management plans did not provide for an increase in the quality of habitat for key species. This resulted in no additional environmental gain from this acquisition, outside of the habitat being reserved for conservation purposes. Additional gain is essential to ensure compensation for environmental loss due to the development project.

The habitat requirements of Carnaby's cockatoo and forest red tailed black cockatoos featured heavily in the offset requirements, reflective of their conservation status, with the land acquisition strongly influenced by these habitat requirements. This should have provided relevant compensation for these species, but this was not the result. Other species, such as quenda, were only accounted for in the requirement for the area to be of a similar assemblage of flora and fauna (Australian Government 2015; Government of Western Australia 2015). As a result, animals were translocated to an area with a different composition of undergrowth than the development site.

The Commonwealth requirements for black cockatoo habitat were more general than the State requirements and did not specify factors such as breeding or foraging habitat. Pre-development surveys were publicly available and a public review process was undertaken, showing a desire for transparency. The offset package consisted of a predominantly direct offset and proportionately higher consideration was given to species with greater statutory protection. The acquisition of land was additional to current actions in that this land is now being reserved for conservation purposes. However, a previous assessment of the site by the EPA, however, indicated development of the land

would not meet EPA's objectives for biodiversity and a proposed development required consideration of offsets of its own. It was recommended to be consolidated into Yalorup National Park. This advice indicates the area was unlikely to be cleared, arguably resulting in no additionality (Environmental Protection Authority, 2011), a core principle within Commenwealth offset policy. An area of high quality habitat was exchanged for an area of comparatively lower quality habitat, with little improvement planned. The process from the point of initial surveys to the fulfilment of the offset requirements also lacked timeliness.

The State requirements were in line with the principles of offsets generally (IUCN 2016; The Government of Western Australia 2011) but had certain elements that limited their effectiveness. Some requirements were not tailored to the development site specifically. For example, the wetlands acquired were not of a similar type (Aecom 2016; Syrinx Environmental Pl and V&C Semeniuk Research Group 2011). Further, there was no provision for further action if the offset should fail in providing sufficient compensation.

No net loss of environmental value is a core principle in the use of offsets (Maron et al. 2018) and typically the threshold used to determine success. In this case, despite specific compensatory requirements for black cockatoos, difficulties arose relating to the definition of black cockatoo habitat and method of assessment. Inconsistencies in these factors during the pre-development assessment of offset sites resulted in offset requirements not being fulfilled, meaning net loss occurred even when a species was accounted for specifically. The inability for offsets to account for the numerous unspecified ecological factors will then result in further net loss (Bigard et al. 2017), as demonstrated by the translocation of quenda to a significantly different habitat. Land acquisition offsets can offer environmental gain but only when the result is preservation of a higher quality area for conservation purposes and there is a risk of this land being cleared or degraded in the future, or where rehabilitation occurs (Gibbons and Lindenmayer 2007). The acquisition must provide an additional gain otherwise, as in this case, loss of environmental value is a likely result.

5.4 Conclusion

Offsets aim to compensate for the residual damage after clearing, ensuring no net loss of environmental value. Our findings suggest that the Roe 8 offset package was not successful in satisfying the State and Commonwealth offset requirements and ecological outcomes, resulting in a net loss of environmental value. The offset package can be seen as a rushed and expedient solution in a highly politicised and controversial development planning process (Gaynor et al. 2017). Offsets, when implemented in this fashion, provide an illusion of compensating for the loss of valued places and biodiversity, but do not deliver and are easily influenced by political decisions. Offset policy is likely to continue to be used in future development processes. However, this case study indicates the principles behind offsets were not reflected in the actual ecological outcomes. More broadly, offset packages that consist mainly of changing the conservation status of existing areas of native vegetation may not actually physically add more habitat: the change is simply on paper and may or may not affect the long-term persistence of these areas. The offset still results in an *actual* loss of native vegetation in the area to be developed. In addition, the area to be lost often has social as well as ecological value, as is the case with the Roe 8 site. Offsetting the loss of a site that is highly valued by local residents by changing the conservation status of other more distant sites does not compensate for the local loss of amenity, connection with nature and the like – factors not even considered in developing the offset package. There is also no environmental compensatory value when the change in conservation status is not required to protect the offset sites in the future, providing no additional gain.

These limitations need to be addressed to ensure there is no further net loss of environmental and social values in the future. Suggestions for improving future offset packages include: a checking

process to confirm ecological outcomes of an offset, a contingency plan or provision for if an offset does not provide sufficient ecological outcomes, greater consideration of the necessary ecological requirements of species affected, and stricter adherence to underlying principles in offset requirements and ecological outcomes. Otherwise offsets will merely provide a convenient way in which biodiversity conservation is subverted by ongoing human alteration of the planet.

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724 **Figure headings**

725

726 Figure 1. Location and extent of development site and the two offset sites. Maps modified from
727 original survey documents (Aecom 2011a, 2011b, 2016). In the left picture, a red outline shows the
728 development site boundary. The right picture shows the offset sites, Lake Clifton having a pink
729 outline and Nirimba a red outline.

730

731 Figure 2. Percent of quadrats at the development site and offset sites with bandicoot diggings present
732 and abundance of diggings per quadrat.

733

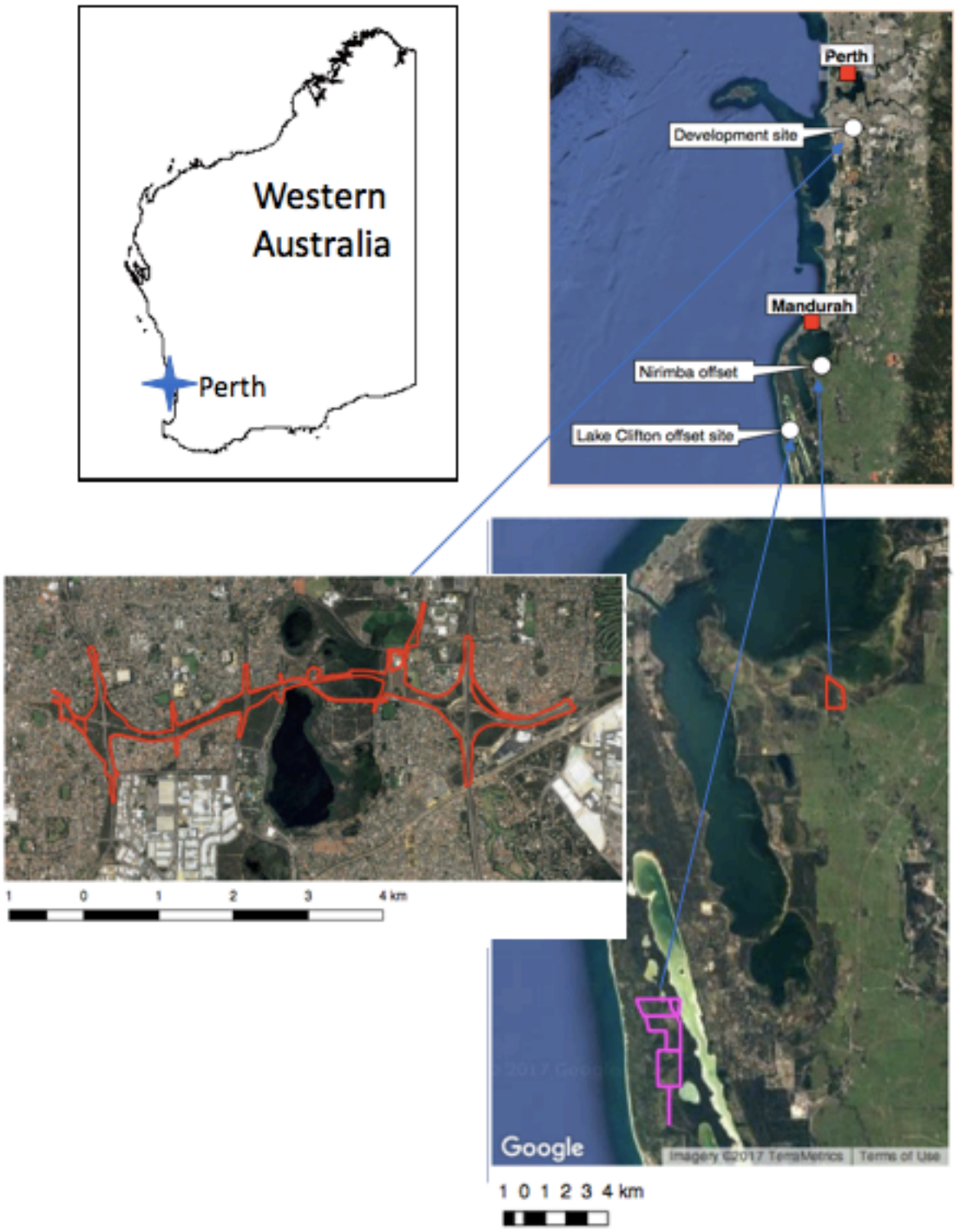
Western Australia
Perth
Perth
Development site
Mandurah
Nirimba offset
Lake Clifton offset site
1 0 1 2 3 4 km
Google
1 0 1 2 3 4 km

Figure 1

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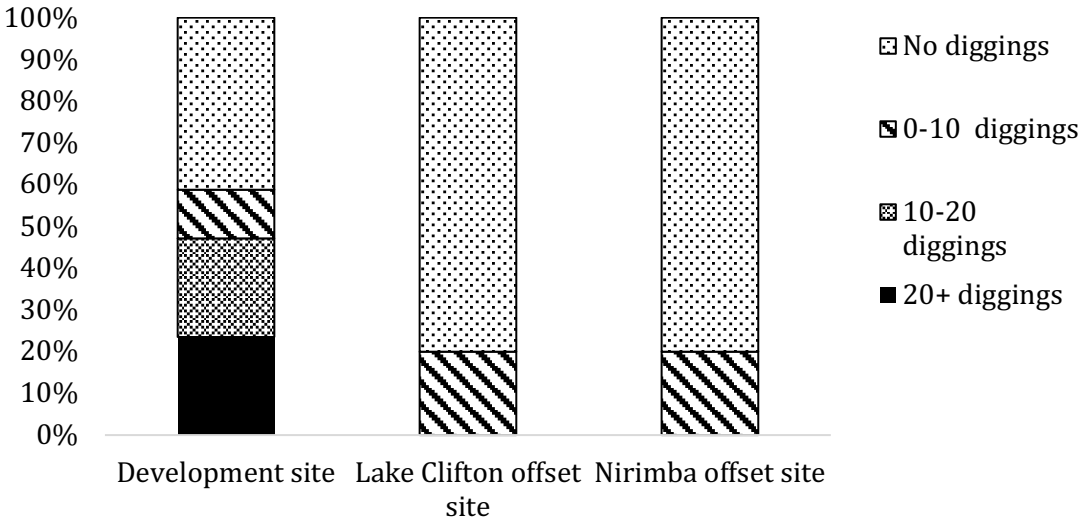

742

743 Figure 2

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745

746 Table 1. Summary of the Commonwealth and State offset requirements for the Roe
747 Highway Extension

Habitat to be lost	Corresponding State offset requirement	Corresponding Commonwealth offset requirement
97.85 ha remnant native vegetation	234 ha land similar or better than the vegetation association impacted, unless rehabilitation plan in place	N/A
78 ha foraging habitat for Carnaby's Cocktoo	234 ha of Carnaby's cockatoo foraging habitat	N/A
73 ha foraging habitat for Red-tailed Black Cockatoo	219 ha of Red-tailed Black Cockatoo foraging habitat	N/A
2.5 ha potential black cockatoo nesting habitat	7.5 ha black cockatoo potential breeding habitat	N/A
Impacts to 6.8 ha of wetlands, including conservation category wetlands	7 ha Conservation Category Wetlands areas and appropriate buffer	N/A
Loss of black cockatoo habitat		- 523 ha of black cockatoo habitat with similar or better quality than the black cockatoo habitat being impacted by the development - Management funding provided within 5 years to maintain the quality of black cockatoo habitat at the offset property for 20 years

748
749 Table 2. Pre-development surveys used to create baseline data set for initial assessment
750 of development and offset sites and the information extracted from each survey

Survey source	Information taken from survey
2009 survey: AECOM, April 2011. Roe Highway Extension Kwinana Freeway to Stock Road: Vegetation and Flora Assessment Phase 2. Unpublished report prepared for South Metro Connect, Perth, WA.	• Percent cover of each black cockatoo tree species (n=8) within each quadrat; • percent cover of vegetation between 0-30 cm and 30-100 cm within each quadrat; • GIS mapping of vegetation communities present in the DS; and • quadrat locations.

2015 survey: Ecoscape (Australia) Pty Ltd, 2016. Roe Highway Extension Baseline Flora and Vegetation Condition Survey.	• Percent cover of each black cockatoo tree species (n=8) within each quadrat; • percent cover of vegetation between 0-30 cm and 30-100 cm within each quadrat; • GIS mapping of vegetation communities present in the DS; and • quadrat locations.
Lake Clifton survey and Nirimba survey: Aecom, 2016. Roe Highway Extension: Land Acquisition and Management Plan. Aecom, Perth.	Survey for the Lake Clifton offset site: • percent cover of each of 8 black cockatoo tree species within each quadrat; • percent cover of vegetation between 0-30 cm and 30-100 cm within each quadrat; • GIS mapping of vegetation communities present and quadrat locations; and • amount (in ha) of foraging habitat present for each quality value. Survey for the Nirimba offset site: • GIS mapping of vegetation communities present at Nirimba; • position of quadrats from the pre-development vegetation survey; and • amount of foraging habitat present
Fauna survey: Phoenix Environmental Sciences, February 2011. Vertebrate Fauna Survey for the Roe Highway Extension Project. Unpublished report prepared for South Metro Connect, Perth, WA.	• Location of potential breeding trees for black cockatoos in the development site (DBH > 500 mm; potential nesting hollows suitable for black cockatoos); • area described as black cockatoo foraging habitat; and • known and potential roosting sites for black cockatoos within 6 km of the development site
Fauna management plan: Strategen Environmental Pty Ltd, 2016. Roe Highway Extension: Fauna Management Plan. Main Roads, Perth, Australia	• Translocation plan for quenda

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753 Table 3. Amount of black cockatoo foraging habitat (ha) at development and offset sites
754 as defined by guidelines in Appendix One.

Site	High	Valued	Low	Other	Total
		Carnaby's cockatoo habitat			
Development site	78.00	0	0	19.85	97.85
Lake Clifton	71.90	81.70	343.20	25.60	522.40
Nirimba	69.39	0	0	32.21	101.60
		Red-tailed black cockatoo			

Development site	73.00	0	0	25.75	98.75
Lake Clifton	11.88	0	188.27	322.25	522.40
Nirimba	42.90	0	0	58.70	101.60

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756
757

Table 4. Results of perMANOVA comparing community composition and relative abundance of black cockatoo tree species between the development site (based on the 2009 survey and 2015 survey) and the combined offset sites

2009 survey			
Comparison	DF	R2	*P*
Within the boundaries of the development site and the offset boundaries			
No transformation	1	0.065	0.005 **
Log transformation	1	0.092	0.001 ***
Presence absence transformation	1	0.152	0.001 ***
Including the survey area surrounding the development site and the offset sites			
No transformation	1	0.085	0.001 ***
Log transformation	1	0.091	0.001 ***
Presence absence transformation	1	0.161	0.001 ***
2015 survey			
Comparison	DF	R2	*P*
Within the boundaries of the development site and the offset boundaries			
No transformation	1	0.039	0.018 *
Log transformation	1	0.055	0.005 **
Presence absence transformation	1	0.077	0.001 ***
Including the survey area surrounding the development site and the offset sites			
No transformation	1	0.060	0.001 ***
Log transformation	1	0.085	0.001 **
Presence absence transformation	1	0.104	0.001 ***