RPS

APPENDIX 4

Jindee Fauna Assessment

Jindee Fauna Assessment

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INTRODUCTION

Lot 10 of Jindalee (hereafter known as Jindee) lies north of Quinns Rock, between the extension of Marmion Avenue and the coast, and is currently undeveloped. The proposed Jindee Structure Plan includes provision for public open space for conservation along the coast and within the development, and as part of this planning, Bamford Consulting Ecologists was approached to assess the relative value for fauna of different vegetation types. It was considered that this assessment would provide guidance by identifying the vegetation types and open space layout most favourable for fauna conservation. In particular, the assessment was to compare the value for fauna of coastal vegetation types compared with more inland vegetation types, as the planning called for a narrow coastal zone being compensated by the retention of vegetation in other areas.

In addition to this field-based assessment, a review of available information on fauna in the region was to be carried out in order to identify the faunal assemblage likely to be present, with emphasis on species of conservation significance. A single sampling session cannot be expected to record all species, or to collect sufficient information on even the majority of species to enable detailed analysis of distribution patterns to be carried out.

SITE DESCRIPTION

The Jindee project area supports coastal and near-coastal landforms and vegetation. The coastline consists of sandy beaches with a small limestone headland, with a narrow zone of mobile dunes immediately behind the coast and a broad zone of undulating stabilised dunes inland. The dunes tend to be abrupt but separated by shallow valleys. Soils range from white sands to grey sands and a grey, marl-like substrate, and the high points in the landscape consist of shallow sand and marl over limestone that is exposed in patches. The vegetation has been mapped by RPS Bowman Bishaw Gorham, and vegetation descriptions of the fauna sampling sites are given below.

METHODS

Desktop review

The desktop review was carried out in order to prepare a more or less complete list of species that could potentially occur at the site. Sources of information included publications that provide information on general patterns of distribution of frogs (Tyler *et al.* 2000), reptiles (Storr *et al.* 1983, 1986, 1990 and 1999, Bush *et al.* 1995), birds (Johnstone and Storr 1998), and mammals (Strahan 1995). In addition, specimen records of frogs, reptiles and mammals held by the WA Museum were obtained for the region bounded by 31 .57° to 31.67^{o} S, and 115.65^{o} to 115.75^{o} E. Birds Australia's Atlas database, the Department of Environment and Heritage database of species listed under the Environment Protection and Biodiversity Conservation (EPBC) Act, and the WA Department of Conservation and Land Management (CALM) threatened and priority

fauna database were searched for approximately the same area. A private database maintained by Bamford Consulting Ecologists, with records from the Quinns Rock area dating back to 1974, was also checked as part of this review.

As far as possible, species drawn from these lists are those that are likely to utilise the project area, and therefore species that have been recorded in the general region as vagrants or for which suitable habitat is absent have been excluded. Particularly among the birds, for example, vagrants can be recorded almost anywhere. Seabirds and waterbirds, for example, were excluded unless they would be expected to regularly utilise habitat available within the project area.

Taxonomy and nomenclature for fauna species used in this report generally follow the WA Museum (2001) for amphibians, reptiles and mammals and Christidis and Boles (1994) for birds. Alternative names are given in parenthesis.

Field Programme and site descriptions

Field-work was carried out within the period 30th November 2005 to 8th January 2006. Within this period there were three sampling sessions: 1st-6th December, 18th-20th December, 27th-30th December and 5th-8th January. It had originally been intended to concentrate sampling in early December, but unusually cool conditions that resulted in very low numbers of captures of reptiles led to a change in the plan in an attempt to sample during warm to hot conditions, when reptiles can be expected to be caught in large numbers. Unfortunately, however, weather conditions were unseasonably cool throughout the three sampling sessions.

Sampling was based on a single but disjunct transect that passed east-west across the study area twice (see Figure 1). There were 78 sampling locations along this transect with an interval of 25m between sampling locations, except between locations 5 and 6, 14 and 15, and 75 and 76. These disjunctions were required in order to sample as much of the range of vegetation and landform types as possible. Sampling location numbers, vegetation types sampled and sampling effort are described in Table 1. Coordinates of sampling locations and details of vegetation appear in Appendix 1. Photographs of vegetation types appear in Figure 2.

Sampling methods used at each location were:

- A pitfall trap, consisting of a 40l bucket, 40cm deep and with a diameter of 28cm, with a 6m drift-fence along this. Pitfalls were operated from 1st-6th December, 18th-20th December, 27th-30th December and 5th-8th January, giving a trapping effort of 13 nights at each location, and a total trapping effort of 1014 trap-nights.
- A funnel trap, placed at one end of the drift-fence. Funnel traps were operated only from 1st-6th December, giving a trapping effort of 5 nights at each location, and a total trapping effort of 390 trap-nights.
- Observations of birds within 25m of each location. Attempts were made to count birds within 25m, but because of dense vegetation leading to poor visibility, only the presence of birds was scored. This bird censussing took place on 1st-5th

December, 18th-20th December, 27th-29th December and 5th-8th January, giving 15 census days at each location, and a total effort of 1170 point census days.

- Sightings of the Western Grey Kangaroo were recorded within 50m of each location on the same days when bird censussing was carried out. There were thus 15 occasions at each location when Grey Kangaroos could be observed, and a total effort of 1170 point census days.
- Evidence of the Echidna and Quenda (bandicoot) were recorded within 10m of each location. Since the evidence consisted of foraging holes that were either present at the start of the field programme or appeared during the course of field-work, they were recorded only once.

Traps were checked each morning before 0930 hours. Cage and Elliott traps were not used as there was little evidence that species likely to be caught in these traps were present. Trapping was carried out under Scientific Licence SF005213 and all specimens were released.

TABLE 1. Details of sampling, giving the code numbers of sampling locations in each vegetation/landform type, and the sampling effort in each type. The sampling effort is in trap-nights for pitfall and funnel traps, and census days for censussing. See Appendix 1 for coordinates of sampling locations and additional details on vegetation.

Location Code	Vegetation type	Veg code	Landform type	Sampling effort
1-4	*Eucalyptus foecunda* mallee	1	slope over limestone	Pitfalls: 52 Funnels: 20 Census: 60
5-21	Banksia woodland	2	plain/shallow valley	Pitfalls: 221 Funnels: 85 Census: 255
22-29	*Acacia saligna* shrubland over *Lomandra*	3	low dune	Pitfalls: 104 Funnels: 40 Census: 120
30-37	*Acacia saligna*, *Dryandra sessilis* and *Xanthorhoea* shrubland	4	valley	Pitfalls: 104 Funnels: 40 Census: 120
38-42; 69-71	*Olearia* shrubland over *Lomandra*	5	high dune	Pitfalls: 104 Funnels: 40 Census: 120
43-57; 76-78	*Dryandra sessilis/ Spyridium* thicket (includes *Allocasuarina* thicket at 43-44; *Dryandra, Spyridium* and *Xanthorhoea* at 76-78)	6	valley	Pitfalls: 195 Funnels: 75 Census: 225
58-68	Coastal mixed shrubland (*Dryandra*, *spyridium*, *Acacia*, *Olearia* & *Scaevola*)	7	low dunes, mobile closest to coast	Pitfalls: 143 Funnels: 55 Census: 165
72-75	*Melaleuca cardiophylla* thicket	8	valley and slope with exposed limestone	Pitfalls: 52 Funnels: 20 Census: 60

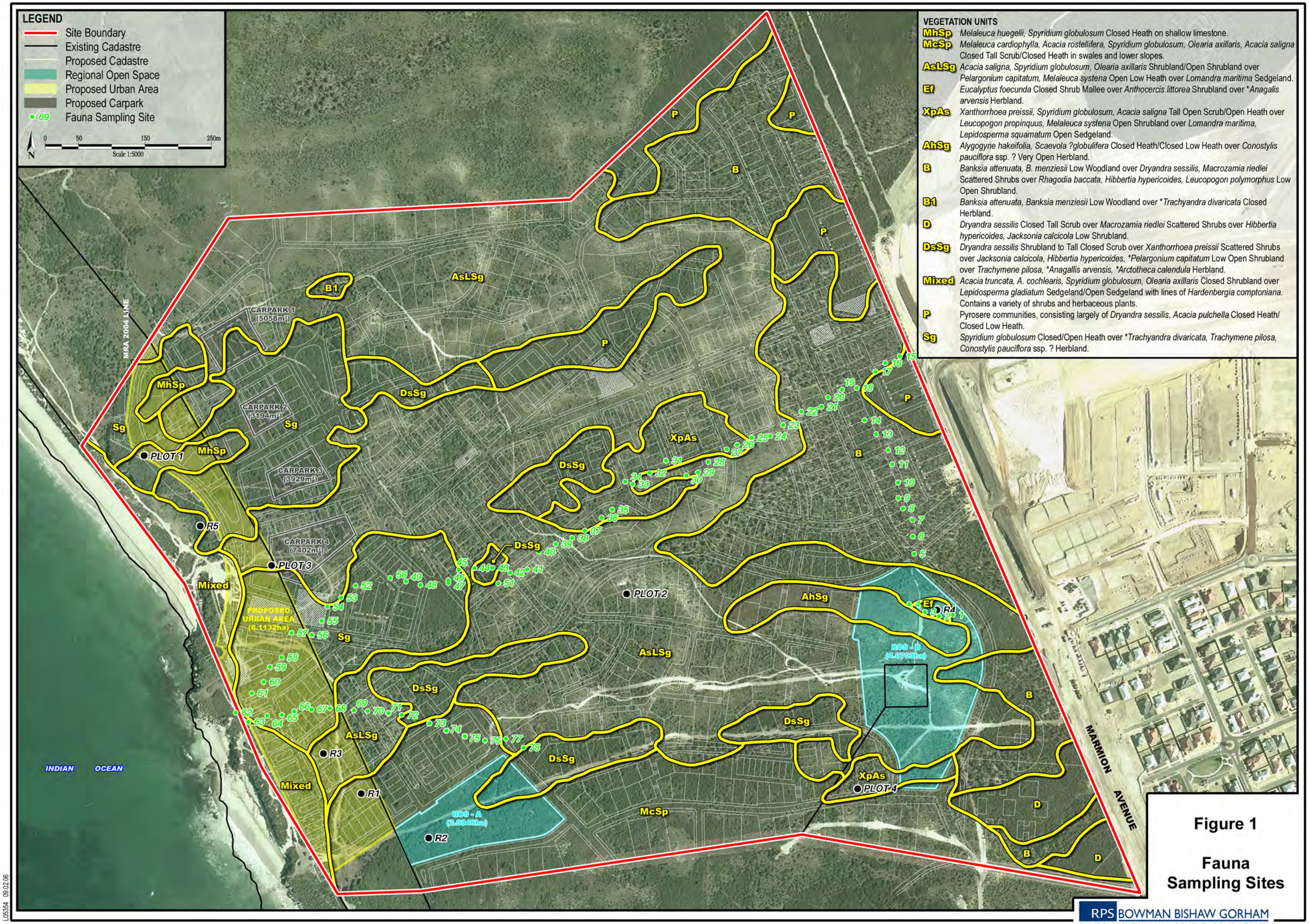

Figure 1

Fauna Sampling Sites

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FIGURE 2. Vegetation types along the fauna sampling transect.

Vegetation type 1 (*Eucalyptus foecunda* mallee) with banksia woodland (type 2) in background.

Vegetation type 2 (banksia woodland).

Vegetation type 3 (*Acacia saligna* over *Lomandra*)

Vegetation type 5 (*Olearia* shrubland over *Lomandra* on high dune)

Vegetation type 6 (*Dryadra sessilis/Spyrifiu globulosum* thicket)

Vegetation type 7 (coastal mixed shrubland)

Vegetation type 8 (Melaleuca thicket)

Assessment of conservation significance

The conservation status of fauna species is assessed under Commonwealth and State Acts such as the *Commonwealth Environment Protection and Biodiversity Conservation Act* (EPBC Act) 1999 and the *Western Australian Wildlife Conservation Act* 1950. The significance levels for fauna used in the EPBC Act are those recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN 2001). The *WA Wildlife Conservation Act* 1950 uses a set of Schedules but also classifies species using some of the IUCN categories. These categories and Schedules are described in Appendix 1.

The EPBC Act also has lists of migratory species that are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). The list of migratory species under the EPBC Act has been revised to include species only, thus excluding family listings (DEH, pers comm.). Those species listed in JAMBA are also protected under Schedule 3 of the *WA Wildlife Conservation Act*. There is a separate list of marine species under the EPBC Act, but this only applies to land and waters under Commonwealth management. Therefore, marine listings are not included in this report.

The Department of the Environment and Heritage (DEH, formerly Environment Australia) has also supported the publication of reports on the conservation status of most vertebrate fauna species: reptiles (Cogger *et al.* 1993), birds (Garnett and Crowley 2000), monotremes and marsupials (Maxwell *et al.* 1996), rodents (Lee 1995) and bats (Duncan *et al.* 1999). The Threatened Species and Communities Section of Environment Australia has also produced a list of Threatened Australian Fauna (Environment Australia 1999), although this list is effectively a precursor to the list produced under the EPBC Act. These publications also use the IUCN categories, although those used by Cogger *et al.* (1993) differ in some respects because this report pre-dates categories reviewed by Mace and Stuart (1994) and revisited since by IUCN (2001).

In Western Australia, the Department of Conservation and Land Management (CALM) has produced a supplementary list of Priority Fauna, being species that are not considered Threatened under the WA Act but for which the Department feels there is cause for concern. Some Priority species, however, are also assigned to the IUCN Conservation Dependent category. Levels of Priority are described in Appendix 1.

Fauna species included under conservation acts and/or agreements are formally recognised as of conservation significance under state or federal legislation. Species listed only as Priority by CALM, or that are included in publications such as Garnett and Crowley (2000) and Cogger *et al.* (1993), but not in State or Commonwealth Acts, are also of recognised conservation significance. In addition, species that are at the limit of their distribution, those that have a very restricted range and those that occur in breeding colonies, such as some waterbirds, can be considered of conservation significance, although this level of significance has no legislative or published recognition and is based on interpretation of distribution information. The WA Department of Environmental

Protection (2000) used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of Perth Bushplan (DEP 2000).

On the basis of the above comments, three levels of conservation significance are recognised in this report:

- *Conservation Significance (CS) 1*: Species listed under State or Commonwealth Acts.
- *Conservation Significance (CS) 2*: Species not listed under State or Commonwealth Acts, but listed in publications on threatened fauna or as Priority species by CALM.
- *Conservation Significance (CS) 3*: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.

RESULTS

Desktop review; the fauna of the Jindalee study area

Frogs

Only three frog species are thought likely to occur within the project area, and none of these was recorded (Table 2). The lack of frog species during the field survey was surprising given the cool conditions and showers on some days, so it is possible that there are no frogs present. Of the three species expected, the Moaning Frog and Pobblebonk rely on wetlands for breeding but disperse widely as adults. The Turtle Frog breeds terrestrially. All three species are common in woodland on sandy soils within and on the northern outskirts of Perth. A fourth species, the Motorbike Frog *Litoria moorei*, requires more or less permanent water and colonises gardens and especially garden ponds, so may be present in nearby suburbs.

None of the frog species is of conservation significance.

Reptiles

The reptile assemblage may include up to 44 species, of which 22 were recorded during the field survey (Table 3). Species expected but not recorded were mostly those that occur at low population densities and can be hard to catch, such as some of the snakes. However, the absence of a few species from samples, such as the Sandhill Dragon and Dusky Morethia, was unexpected. These are usually abundant north of Perth so they may be scarce or even absent in near coastal areas.

Reptile species of conservation significance are discussed below.

Conservation Significance Level 1

- South-western race of the Carpet Python (Schedule 4 – Other Specially Protected Fauna - of WA Act). Reported to be locally common just north of Perth, particularly in areas of heath and limestone (Bush *et al*. 1995), so likely to be

present. Suitable habitat present between location 75 and location 1. Not found during the survey, but often a cryptic species that rarely enters traps.

Conservation Significance Level 2

- The Black-striped Snake (Priority 3 according to CALM). This species is restricted to the west coast region from just north of Lancelin to Mandurah, but was not found during the survey. It is fossorial and can be difficult to find. How and Shine (1999) have suggested that this species (and other fossorial snakes) requires large areas (>1000ha) of continuous habitat to persist. Therefore, assuming the species is still present, development is likely to lead to its local extinction even with the reservation of some areas.

Conservation Significance Level 3

Species that are of local significance are the geckoes *Diplodactylus alboguttatus*, *Diplodactylus polyopthalmus* and *Underwoodisaurus milii*, and the Jewelled Ctenotus *Ctenotus gemmula*. These species occur on the coastal plain north of Perth in isolated populations but none was caught during the field survey. *D. polyopthalmus* and *U. milii* are associated with limestone areas (Bush *et al.* 1995) and therefore suitable habitat is present between location 75 and location 1. *D. alboguttatus* and the Jewelled Ctenotus occur on sandy soils so it is not possible to specify suitable habitat for them within the Jindee area.

<u>Birds</u>

The assemblage of birds that uses the Jindee site more or less regularly may include 96 species (Table 4), although even among these species there are some that will be intermittent visitors. Included are 11 coastal species that may make regular use of the coastline but would only be affected by the Jindee development indirectly; through increased levels of human activity along the coast.

Only 35 species were recorded during the December/January survey period. As most birds are very conspicuous, species not observed were presumably not present, being either intermittent visitors or migrants. Many of the species that were recorded are residents that have been noted by the WA Department of Environmental Protection (2000) as declining in the Perth area.

Bird species of conservation significance indicated on Table 4 and are discussed below.

Conservation significance level 1

- Carnaby's (Short-billed) Black-Cockatoo (Endangered under the EPBC Act, the Wildlife Conservation Act and according to Garnett and Crowley 2000). Likely to be a regular non-breeding visitor and was observed during the field survey, including a flock of 50 birds feeding in a *Dryandra sessilis* thicket on 19th December. This cockatoo is known to feed on seeding *Banksia* and *Eucalyptus* as well as proteaceous heaths (Johnstone and Storr 1998) and may thus forage in the banksia woodland a well as the *D. sessilis* thickets. Loss of feeding habitat is identified as an important contributing factor to the decline of Carnaby's

Cockatoo in Garnett and Crowley (2000). Further loss of significant regional feeding habitat may constitute a trigger as a controlled action under the EPBC Act and may require assessment by the DEH.

- Peregrine Falcon (Schedule 4 – Other Specially Protected Fauna – of the WA Act). This may be a regular visitor to the area, but there was no site suitable for nesting. As individuals forage very widely, it is the nest site that is of greatest significance for the species' conservation.
- All other birds of Conservation Significance Level 1 are listed as migratory under the EPBC Act (Table 4). Most will be infrequent visitors to the site. Both Ospreys and White-bellied Sea-Eagles are known to nest in Tuart trees around the Peel Inlet, but there are no trees of suitable size on the Jindee site. They nest on the ground or on the tops of high dunes on islands, but are unlikely to do so on the mainland. The Rainbow Bee-eater is almost certain to nest in the study area and will often construct its burrows on slopes that are sparsely vegetated, including slopes around construction sites. Therefore, nesting habitat is not critical for this species in the Perth area. The Fork-tailed Swift is largely aerial while the three sandpipers and the Caspian Tern are restricted to coastal environments. The sandpipers and Caspian tern occur in only low numbers along the northern beaches of Perth.

Conservation significance level 2

- Hooded Plover (Priority 4 according to CALM). This species may be an occasional visitor to the ocean beaches. As with other coastal species, it could be affected by increased levels of disturbance associated with development. Hooded Plovers are rarely seen in Perth beaches, but it is not known to what extent this is due to existing levels of disturbance.

Conservation significance level 3

A total of 31 bird species are considered to be of local conservation significance. The majority of these are identified by the WA Department of Environmental Protection (DEP 2000) as having declined in the Perth area due to impacts associated with urban development. A few of these are birds of prey, but the majority are small birds that rely on woodlands and shrublands where they are either residents (eg. fairy-wrens and thornbills) or seasonal visitors (honeyeaters). The fairy-wrens and thornbills are particularly sensitive to habitat loss and fragmentation, whereas the honeyeaters have a greater ability to access suitable habitat even when it is fragmented by urban development. The majority of the species listed by the DEP (2000) are also noted as having declined Australia-wide by more than 20% in the New Atlas of Australian Birds (Barrett *et al*. 2003). Almost half (14) of the CS3 species were recorded during the field survey. These included 3 fairy-wren species, the White-browed Scrub-wren, 2 thornbills and the White-breasted Robin; all sedentary species that have poor powers of dispersal and thus rely upon continuity of habitat to persist.

<u>Mammals</u>

There are 22 species of mammal that may occur in the Jindee area, including five introduced species (Table 5). This list does not include regionally extinct species (at least

an additional 5 species) while very few of the listed species have actually been documented in the region, so there is great reliance on the general literature in producing this list. Only 3 native species were recorded during the survey and the presence of other species is uncertain. No targeted bat surveys were undertaken, but species such as the two dunnarts, Honey Possum and Noodji are usually readily caught in pitfalls, so may be locally extinct.

Conservation Significance Level 1
No species of recognised conservation significance under legislation are expected. Such species are rare and regionally extinct. There is a remote possibility of the Endangered Chuditch *Dasyurus geoffroii* being present as a vagrant.

Conservation Significance Level 2

- Brush Wallaby (Priority 4 according to CALM and lower risk (near threatened) according to Maxwell *et al.* 1996). Not observed and therefore probably not present, but the Brush Wallaby occurs in native vegetation elsewhere on the outskirts of Perth,
- Quenda (Priority 5– Conservation Dependent – according to CALM). The distinctive diggings of this species were not located, but it occurs nearby, including in the Burns Beach area (M. Bamford unpubl. data). It is commonly associated with dense, low vegetation, so it has the potential to occur across much of the site, especially in the thickets and near coastal shrublands. The lack of diggings, however, suggests that it may be locally extinct.

Conservation Significance Level 3
Almost all native mammal species could be considered of local conservation significance because most species disappear due to urban development. Of those listed as of Conservation Significance Level 3 (see Table 5), only the Moodit was recorded, while the dunnarts, Honey Possum and Noodji may be locally extinct. The bat species have not been included as of local significance because at least some persist in remnant native vegetation in urban areas, while even their presence in a near-coastal area is uncertain.

<u>Invertebrates</u>
This study has not considered invertebrates, but there are several species of conservation significance known from the general region on the basis of CALM's threatened fauna database. These include:

<u>Conservation Significance Level 1</u>

- Graceful Sunmoth *Symenon grantiosa* (Castniidae). Schedule 1 (Endangered) of the WA Act. Known from the Neerabup area to the east. Possibly present in banksia woodlands of the study area.

<u>Conservation Significance Level 2</u>

- cricket *Austrosaga spinifer*. Priority 3. Recorded from heathlands between Perth and Cervantes, but the nature of these heathlands is not known.

- native bee *Hyaleus globuliferus*. Priority 3. Forages on the flowers of Woollybush *Adenanthos cygnorum* and some other species. Woollybush is present in banksia woodland.
- native bee *Leioproctus contrarius*. Priority 3. Apparently dependent upon flowers of Goodeniaceae and known from banksia woodlands at Gnangara.

Patterns of distribution of fauna in relation to vegetation and landform
The numbers of records of each species in each vegetation/landform type is presented in Table 6. Raw data are presented in Appendix 3.

The majority of species were recorded infrequently, and species with few records cannot be subject to meaningful statistical analyses. Such species may have significant patterns of distribution in relation to vegetation type, but such patterns cannot be detected with a small sample size. However, species with at least five records and a pattern of distribution that indicated an association with vegetation type were analysed. This was done with a *chi*-square test to determine if there was a significant difference in the number of records by vegetation type. The *chi*-square test corrects for different sampling effort. Results of these tests are presented in Table 7.

Only four reptile species were caught sufficiently often for analysis to be carried out. Two of these, the Spiny-tailed Gecko and Western Worm Lerista, displayed positive correlations with vegetation type. The Spiny-tailed Gecko was caught significantly more often in vegetation types 6 and 7 than elsewhere, while the Western Worm Lerista was caught most often in vegetation type 4. The gecko was in thicket vegetation, including near-coastal thickets, while the lerista was in an area of mixed shrubland containing *Acacia saligna*, *Dryandra sessilis* and *Xanthorrhoea*. Two other commonly caught reptile species, the Two-toed Skink and Four-toed Lerista, did not have significant patterns of distribution. In the case of the Two-toed Skink, the result was very close to being significant and most specimens were caught in vegetation type 6 (*Dryandra/Spyridium* thicket). With the Four-toed Lerista, however, which was the most-often caught reptile, the *chi*-square value was very low, suggesting a species that is more or less evenly spread across the landscape.

Birds were better represented in the sample than reptiles, with 15 species analysed (Table 7). All but four of these displayed significant patterns, with the sample sizes of those four being small, which may have contributed to this result. There was a range of both positive and negative associations with vegetation type among those species with significant patterns. Vegetation type 2 (banksia woodland) was important for honeyeaters (Red Wattlebird, White-cheeked Honeyeater and Brown Honeyeater), while types 1, 4, 6, 7 and 8 were important for sedentary species such as the three fairy-wren species, White-browed Scrubwren and White-breasted Robin. Vegetation type 3 was important only for the Australian Ringneck, while vegetation type 5 was important for no bird species. The White-browed Scrubwren and the most abundant bird in the study, the Silvereye, were negatively associated with banksia woodland (type 2). This was not a surprising result for the Scrubwren, which favours dense, low vegetation, but it was interesting that the Silvereye was avoiding banksia woodland where other nectar-feeding birds were concentrated to take advantage of flowering *Banksia attenuata*. Possibly the Silvereye was focussing on the fruit of *Rhagodia* bushes that were dispersed through other vegetation types.

While mammals were poorly sampled, two species displayed significant patterns. The Grey Kangaroo was concentrated in vegetation type 3 (*Acacia saligna* shrubland on low

dunes), while the introduced House Mouse was caught mostly in vegetation type 8 (Melaleuca shrubland).

Analysis of all data pooled revealed some general patterns within some taxonomic groups and for fauna overall (Table 7). The strongest associations were negative; ie there were vegetation types that were poor for fauna in general. For reptiles, vegetation type 2 (banksia woodland) was poor, with vegetation type 4 (*Acacia saligna*, *Dryandra sessilis* and *Xanthorrhoea* shrubland) having a slight positive association. For birds, vegetation type 5 (*Olearia* shrubland over *Lomandra* on high dunes) was particularly poor, while vegetation type 1 (*Eucalyptus foecunda* mallee) was good. There was no general pattern with mammals, probably because the patterns of the Grey Kangaroo and House Mouse cancelled each other. For all fauna records, vegetation type 5 was poor, probably reflecting the abundance of bird records, while vegetation type 8 was good, probably because of bird records and those of the House Mouse.

DISCUSSION

The Jindee project area supports a rich vertebrate fauna that is probably largely intact except for some locally extinct mammals. There are few species of high conservation significance because especially among mammals, such species are extinct in the vicinity of Perth. Species of conservation significance level 1 (recognised under legislation) that are likely to rely on the site include the south-west race of the Carpet Python (not recorded but likely to be present) and Carnaby's Cockatoo (recorded and probably a regular feeding visitor). More species of conservation significance level 2 (CALM priority species) and 3 (species of local significance) are expected or were recorded, with many level 3 species because of local extinctions due to nearby urban development. Small, sedentary birds (eg fairy-wrens, thornbills, scrubwrens) are recognised by the DEP (2000) for this pattern of extinction. In a fauna conservation sense, the Jindee area is notable as being on the edge of the main area or urban expansion, so in the region represents the last large area of primary or old growth native vegetation and fauna habitat.

The sampling programme was designed to identify patterns of association with vegetation type in the distribution of fauna. The aim of this was to identify important and less important habitats to guide development plans so that public open space and low density housing could be used for maximum benefit to fauna conservation. The programme was compromised by unseasonable cool weather in December and January, with reptile captures in particular badly affected. Past experience suggested that the trap effort should have yielded about 300 reptile captures, whereas only 126 captures were made. Mammal captures were also very low, but this was probably a true reflection of low mammal densities. Also from past experience, it appears that the levels of abundance of small, terrestrial mammals even in large bushland areas close to Perth are low when compared with levels of abundance in similar habitat away from urban centres. It can be speculated that this is due to high levels of introduced predators (feral Cats and Foxes) on the outskirts of urban areas. With respect to the Jindee project, it probably means that

conservation of small, terrestrial mammals is unachievable. In contrast, reptiles and birds persist in urban bushland to a high degree, particularly if the right habitats are retained and there is linkage between habitat areas.

Despite the low numbers of reptile and mammal captures, there were some distribution patterns evident. More extensive data were collected on birds, but these were compromised by the lack of seasonal records, as some migratory species were scarce or absent, while patterns of habitat usage of other species probably change across the year. These limitations need to be considered when examining patterns of habitat associations in the fauna records. The distribution of fauna in relation to each of the vegetation/landform types is discussed below.

- Vegetation type 1. *Eucalyptus foecunda* mallee (Ef vegetation category as recognised by RPS Bowman Bishaw Gorham). A distinctive, small and isolated vegetation type in the south-east of the site, associated with shallow soils and exposed limestone on the lower slope of a large, stabilised dune. Important for the Splendid and Variegated Fairy-wrens, and one of only three locations where the White-breasted Robin was recorded. These are sedentary species that are sensitive to habitat fragmentation and have declined badly in the Perth area. The White-breasted Robins could be the southernmost on the Swan coastal Plain. Few reptile or mammal records.
- Vegetation type 2. Banksia woodland (B vegetation category as recognised by RPS Bowman Bishaw Gorham). Widespread in the east of the site and an extensive vegetation type north of Perth, associated with undulating deep sands. Important for some honeyeaters that are mobile species and probably visit the woodland seasonally when *Banksia attenuata* is in flower. Also likely to be important for Carnaby's Cockatoo that feed on banksia seeds, although only one record during the field programme. Of low importance for reptiles and also for some birds, notably the White-browed Scrubwren, one of the suite of resident birds that has declined in the Perth area. One of the few areas where the Grey Shrike-thrush was recorded; also a species that has declined in the Perth area.
- Vegetation type 3. *Acacia saligna* shrubland over *Lomandra* (features of both AsLSg and XpAs vegetation categories as recognised by RPS Bowman Bishaw Gorham). Important for the Australian Ringneck and Grey Kangaroo, and one of the few areas where Magpies were seen regularly. These are all species of low conservation significance.
- Vegetation type 4. *Acacia saligna*, *Dryandra sessilis* and *Xanthorrhoea* shrubland (features of both XpAs and DsSg vegetation categories as recognised by RPS Bowman Bishaw Gorham). A complex vegetation type similar to type 3 except lower in the landscape and with some *Dryandra sessilis* and a very different suite of fauna. A good range of reptile and bird species recorded, with this vegetation type important for the Western Worm Lerista, Splendid Fairy-wren and Singing Honeyeater, and for reptiles overall. This was the only vegetation type in which all three fairy-wren species were recorded. It also had a moderate number of records of the White-browed Scrubwren and was one of only two vegetation types with the Inland Thornbill, so rates well for bird species that

have declined in the Perth area. Carnaby's Cockatoo can also be expected to forage in this area. Mammals were poorly represented.

- Vegetation type 5. *Olearia* shrubland over *Lomandra* on high dunes (a low, open form of the AsLSg vegetation category as recognised by RPS Bowman Bishaw Gorham). This vegetation type occupies a broad, central zone within the project area, although is quite variable and some of that mapped as AsLSg by RPS Bowman Bishaw Gorham may be more like vegetation types 3 and 4. Vegetation type 5 was distinctive in being important for no species and having a negative impact on birds and, because birds dominated the database, on fauna overall. However, it did have one of only two records of Jan's Bandy-Bandy), with the second record being classed in vegetation type 7 but with that sampling point actually being on the transition between vegetation types 5 and 7.
- Vegetation type 6. *Dryandra sessilis/Spyridium globulosum* thicket (Sg and DsSg vegetation categories as recognised by RPS Bowman Bishaw Gorham). Vegetation type 6 was important for the Spiny-tailed Gecko and White-breasted Robin, had high numbers of records of the White-browed Scrubwren and Two-toed Skink, and was notable for records of three legless lizard species. Carnaby's Cockatoo can be expected to forage in this vegetation type.
- Vegetation type 7. Coastal mixed shrubland (characteristics of the Mixed and Sg vegetation categories as recognised by RPS Bowman Bishaw Gorham). Effectively a coastal version of vegetation type 6, with some additional floristic elements. Important for the Spiny-tailed Gecko and the only vegetation type where the White-winged Fairy-wren was common. This was the only site where the Line-spotted Lerista was recorded and where two of the three captures of Fraser's Legless-Lizard were made. It was the only area where King's Skink was observed; this species was not captured and in coastal areas around Perth is usually restricted to areas of exposed limestone. The White-browed Scrubwren was common. The only capture of the Moodit was made in vegetation type 7 and while little can be concluded from a single capture, this could be significant as the only capture of a native, small terrestrial mammal.
- Vegetation type 8. *Melaleuca cardiophylla* thicket (McSp vegetation category as recognised by RPS Bowman Bishaw Gorham). This vegetation type supported a low number of species, especially with respect to reptiles, but was important for the White-browed Scrubwren, White-breasted robin and House Mouse; the latter being introduced and therefore of low conservation significance. It was also of interest as having only two of three records of the Inland Thornbill, a single record of the Golden Whistler and records of the Grey Shrike-thrush and Grey Fantail. It was thus a vegetation type with a broad assemblage of locally significant bird species, although there were no records of fairy-wrens. It was the vegetation type that contributed strongly to significant patterns in overall fauna distribution. Vegetation type 8 was associated with an area of stunted plants on very shallow soil over limestone. Although not recorded, the highly significant Carpet Python would be expected in such areas, while the locally significant Barking and Spotted Geckoes are also likely to occur where there is exposed limestone.

From the above review, it is clear that there are strong patterns in fauna distribution and that some vegetation types are more important than others for fauna conservation. Unfortunately from the point of view of planning, different vegetation types are important for different species, so for maximum fauna conservation a range of types needs to be retained. The outstanding vegetation types are types 1, 6, 7 and 8, with types 2 and 4 also notable. Type 3 and particularly type 5 are of least value for fauna within the Jindee project area. The most important vegetation types tend to be near-coastal and associated with valleys, with the exceptions of types 1 and 2.

For conservation planning purposes, retaining examples of the important vegetation types in juxtaposition and with minimal edge to area ratio is likely to be the most beneficial approach and also the easiest to manage. For example, the complex of vegetation types in the south-west of the project area would provide for a wide range of fauna. Ideally, this block could be linked to retained areas of vegetation types 1 and 2 in the east of the project area, and should also be linked to a coastal north-south corridor of native vegetation.

TABLE 2. Frog species that could occur in the Jindee project area, on the basis of available sources of information (see methods). Species recorded during the field survey are indicated. WAM indicates species recorded in the general region by the WA Museum.

Species		Source	Survey
Myobatrachidae (ground frogs)			
Moaning Frog	*Heleioporus eyrei*	WAM	
Pobblebonk	*Limnodynastes dorsalis*	WAM	
Turtle Frog	*Myobatrachus gouldii*		
Total number of frog species expected:		**5**	

TABLE 3. Reptile species that could occur in the Jindee project area, on the basis of available sources of information (see methods). WAM and BCE indicate species recorded in the general region by the WA Museum and Bamford Consulting Ecologists respectively. Lit indicates species reported in the region from the literature. Species recorded during the field survey are indicated (X).

Species		Source	Survey
Gekkonidae (geckoes)			
Marbled Gecko	*Christinus marmoratus*	WAM	X
	Diplodactylus alboguttatus	Lit	
Spotted Gecko	*Diplodactylus polyophthalmus*	WAM	
Spiny-tailed Gecko	*Strophurus spinigerus*	BCE	X
Barking Gecko	*Underwoodisaurus milii*	Lit	
Pygopodidae (legless lizards)			
Javelin Legless Lizard	*Aclys concinna*	WAM,BCE	
Sandplain Worm Lizard	*Aprasia repens*	WAM	
Fraser's Legless Lizard	*Delma fraseri*	Lit	X
Gray's Legless Lizard	*Delma grayii*	Lit	X
Burton's Legless Lizard	*Lialis burtonis*	WAM,BCE	X
Keeled Legless Lizard	*Pletholax gracilis*	Lit	
Common Scaleyfoot	*Pygopus lepidopodus*	Lit	
Agamidae (dragon lizards)			
Western Bearded Dragon	*Pogona minor*	WAM,BCE	X
Sandhill Dragon	*Rankinia adelaidensis*	Lit	
Varanidae (monitors or goannas)			
Gould's Sand Goanna	*Varanus gouldii*	Lit	**X**
Black-tailed Tree Goanna	*Varanus tristis*	WAM	

Table 2 (cont.)

Species		Source	Survey
Scincidae (skink lizards)			
Fence Skink	*Cryptoblepharus plagiocephalus*	WAM,BCE	X
Limestone Ctenotus	*Ctenotus australis*	BCE	X
West Coast Ctenotus	*Ctenotus fallens*	WAM,BCE	X
Jewelled Ctenotus	*Ctenotus gemmula*	Lit	CS3
Odd-striped Ctenotus	*Ctenotus impar*	Lit	
	Cyclodomorphus celatus	WAM,BCE	
King's Skink	*Egernia kingii*	Lit	X
	Egernia napoleonis	WAM,BCE	
Two-toed Skink	*Hemiergis quadrilineata*	WAM	X
Four-toed Lerista	*Lerista elegans*	WAM,BCE	X
Line-spotted Lerista	*Lerista lineopunctulata*	BCE	X
Western Worm Lerista	*Lerista praepedita*	WAM,BCE	X
Dwarf Skink	*Menetia greyii*	WAM,BCE	X
Spotted Morethia	*Morethia lineoocellata*	Lit	
Dusky Morethia	*Morethia obscura*	BCE	
Western Bluetongue	*Tiliqua occipitalis*	BCE	X
Bobtail	*Tiliqua rugosa*	BCE	X
Typhlopidae (blind snakes)			
Southern Blind Snake	*Ramphotyphlops australis*	WAM	
Boidae (pythons)			
Carpet Python	*Morelia spilota imbricata*	WAM	CS1
Elapidae (front-fanged snakes)			
Half-ringed Snake	*Brachyurophis semifasciata*	WAM	X
Narrow Banded Snake	*Brachyurophis fasciolata*	Lit	
Yellow-faced Whip-Snake	*Demansia psammophis*	BCE	X
Bardick	*Echiopsis curtus*	Lit	
Black-naped Snake	*Neelaps bimaculatus*	WAM	
Black-striped Snake	*Neelaps calonotos*	Lit	CS2
Dugite	*Pseudonaja affinis*	WAM.BCE	X
Gould's Snake	*Parasuta gouldii*	WAM	
Jan's Bandy-Bandy	*Simoselaps bertholdi*	WAM	X
	Number of reptile species:	**44**	**22**

TABLE 4. Bird species that could occur in the Jindee project area, on the basis of available sources of information (see methods). BA, WAM and BCE indicate species recorded in the general region by Birds Australia, the WA Museum and Bamford Consulting Ecologists respectively. Lit indicates species reported in the region from the literature. Species recorded during the field survey are indicated (X). Status indicates conservation significance (see Methods; Int. indicates introduced species).

Species		Source	Status	Survey
Dromaiidae (emus)				
Emu	*Dromaius novaehollandiae*	BA, BCE		
Phasianidae (pheasants and quails)				
Stubble Quail	*Coturnix pectoralis*	BCE		
Accipitridae (kites, hawks and eagles)				
Osprey	*Pandion haliaetus*	BA, BCE	CS1	
Black-shouldered Kite	*Elanus axillaris*	BA		
Square-tailed Kite	*Lophoictinia isura*	Lit	CS3	
Whistling Kite	*Haliastur sphenurus*	BA	CS3	
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Lit	CS1	
Spotted Harrier	*Circus assimilis*	Lit		
Brown Goshawk	*Accipiter fasciatus*	BCE	CS3	X
Collared Sparrowhawk	*Accipiter cirrhocephalus*	BA, BCE	CS3	
Wedge-tailed Eagle	*Aquila audax*	BA	CS3	
Little Eagle	*Hieraaetus morphnoides*	BA, BCE	CS3	X
Falconidae (falcons)				
Peregrine Falcon	*Falco peregrinus*	Lit	CS1	
Australian Hobby	*Falco longipennis*	BA		
Brown Falcon	*Falco berigora*	Lit	CS3	
Nankeen Kestrel	*Falco cenchroides*	BA, BCE		X
Turnicidae (button-quails)				
Painted Button-quail	*Turnix varia*	Lit	CS3	
Scolopacidae (sandpipers and stints)				
Ruddy Turnstone	*Arenaria interpres*	Lit	CS1	
Red-necked Stint	*Calidris ruficollis*	Lit	CS1	
Sanderling	*Calidris alba*	Lit	CS1	
Charadriidae (lapwings and plovers)				
Red-capped Plover	*Charadrius ruficapillus*	BA		
Hooded Plover	*Thinornis rubricollis*	Lit	CS2	
Banded Lapwing	*Vanellus tricolor*	Lit		
Laridae (gulls and terns)				
Silver Gull	*Larus novaehollandiae*	BA, BCE		X
Caspian Tern	*Sterna caspia*	Lit	CS1	
Crested Tern	*Sterna bergii*	Lit		

Table 4 (cont.)

Species		Source	Status	Survey
Columbidae (pigeons and doves)				
Rock Dove (Domestic Pigeon)	*Columba livia*	Lit	Int	
Laughing Turtle-Dove	*Streptopelia senegalensis*	BA, BCE	Int	X
Common Bronzewing	*Phaps chalcoptera*	BA, BCE	CS3	X
Brush Bronzewing	*Phaps elegans*	BA	CS3	
Crested Pigeon	*Ocyphaps lophotes*	BA		X
Cacatuidae (cockatoos)				
Short-billed (Carnaby's) Black-Cockatoo	*Calyptorhynchus latirostris*	BA, BCE, WAM	CS1	X
Galah	*Cacatua roseicapilla*	BA, BCE		X
Little Corella	*Cacatua sanguinea*	BA	Int	
Psittacidae (lorikeets and parrots)				
Rainbow Lorikeet	*Trichoglossus haematodus*	BA	Int	
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*	Lit		
Regent Parrot	*Polytelis anthopeplus*	BA		
Australian Ringneck	*Barnardius zonarius*	BA, BCE, WAM,		X
Red-capped Parrot	*Purpureicephalus spurius*	BA, BCE, WAM,		
Rock Parrot	*Neophema petrophila*	Lit	CS3	
Elegant Parrot	*Neophema elegans*	BA, BCE		
Cuculidae (cuckoos)				
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	BA		
Pallid Cuckoo	*Cuculus pallidus*	BA		
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	BA, BCE		
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*	BA		
Strigidae (hawk-owls)				
Southern Boobook	*Ninox novaeseelandiae*	BA, WAM		
Tytonidae (barn owls)				
Barn Owl	*Tyto alba*	BA		
Podargidae (frogmouths)				
Tawny Frogmouth	*Podargus strigoides*	BA		
Caprimulgidae (nightjars)				
Spotted Nightjar	*Eurostopodus argus*	Lit		
Apodidae (swifts)				
Fork-tailed Swift	*Apus pacificus*	Lit	CS1	
Halcyonidae (forest kingfishers)				
Sacred Kingfisher	*Todiramphus sanctus*	BA		
Meropidae (bee-eaters)				
Rainbow Bee-eater	*Merops ornatus*	BA, BCE	CS1	

Table 4 (cont.)

Species		Source	Status	Survey
Maluridae (fairy-wrens)				
Splendid Fairy-wren	*Malurus splendens*	BA, BCE	CS3	X
Variegated Fairy-wren	*Malurus lamberti*	BA	CS3	X
White-winged Fairy-wren	*Malurus leucopterus*	BA, BCE	CS3	X
Southern Emu-wren	*Stipiturus malachurus*	Lit	CS3	
Pardalotidae (pardalotes)				
Striated Pardalote	*Pardalotus striatus*	BA, WAM		X
White-browed Scrubwren	*Sericornis frontalis*	BA, BCE	CS3	X
Western Gerygone	*Gerygone fusca*	BA, BCE		
Inland Thornbill	*Acanthiza apicalis*	BA, BCE	CS3	X
Western Thornbill	*Acanthiza inornata*	BA, BCE	CS3	
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	BA, BCE	CS3	X
Meliphagidae (honeyeaters)				
Red Wattlebird	*Anthochaera carunculata*	BA, BCE		X
Western Wattlebird	*Anthochaera lunulata*	BA, BCE	CS3	
Singing Honeyeater	*Lichenostomus virescens*	BA, BCE		X
Brown Honeyeater	*Lichmera indistincta*	BA, BCE		X
White-cheeked Honeyeater	*Phylidonyris nigra*	BA, BCE	CS3	X
New Holland Honeyeater	*Phylidonyris novaehollandiae*	BA, BCE	CS3	X
Tawny-crowned Honeyeater	*Phylidonyris melanops*	Lit	CS3	
Western Spinebill	*Acanthorhynchus superciliosus*	BA, BCE	CS3	
White-fronted Chat	*Epthianura albifrons*	Lit		
Petroicidae (Australian robins)				
Scarlet Robin	*Petroica multicolor*	BA	CS3	
Red-capped Robin	*Petroica goodenovii*	Lit		
Hooded Robin	*Melanodryas cucullata*	Lit	CS3	
White-breasted Robin	*Eopsaltria georgiana*	BA	CS3	X
Pachycephalidae (whistlers)				
Golden Whistler	*Pachycephala pectoralis*	Lit	CS3	X
Rufous Whistler	*Pachycephala rufiventris*	BA, BCE		X
Grey Shrike-thrush	*Colluricincla harmonica*	BA, BCE	CS3	X
Dicruridae (flycatchers)				
Magpie-lark	*Grallina cyanoleuca*	BA		
Grey Fantail	*Rhipidura fuliginosa*	BA, BCE		X
Willie Wagtail	*Rhipidura leucophrys*	BA, BCE		X
Campephagidae (cuckoo-shrikes)				
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	BA, BCE		X
White-winged Triller	*Lalage sueurii*	WAM, BCE		

Table 4(cont.)

Species		Source	Status	Survey
Artamidae (woodswallows)				
Black-faced Woodswallow	*Artamus cinereus*	BCE	CS3	X
Dusky Woodswallow	*Artamus cyanopterus*	BA	CS3	
Grey Butcherbird	*Cracticus torquatus*	BA, BCE		X
Australian Magpie	*Gymnorhina tibicen*	BA, BCE		X
Corvidae (ravens and crows)				
Australian Raven	*Corvus coronoides*	BA, BCE		X
Motacillidae (pipits and true wagtails)				
Richard's Pipit	*Anthus novaeseelandiae*	BA, BCE		X
Dicaeidae (flower-peckers)				
Mistletoebird	*Dicaeum hirundinaceum*	BA		
Hirundinidae (swallows)				
White-backed Swallow	*Cheramoeca leucosternus*	BCE		
Welcome Swallow	*Hirundo neoxena*	BA, BCE		X
Tree Martin	*Hirundo nigricans*	BA, BCE		
Sylviidae (Old World warblers)				
Rufous Songlark	*Cincloramphus mathewsi*	Lit		
Brown Songlark	*Cincloramphus cruralis*	BCE		
Zosteropidae (white-eyes)				
Silvereye	*Zosterops lateralis*	BA, BCE		X
	Number of bird species:	**96**		35

TABLE 5. Mammal species that could occur in the Jindee project area, on the basis of available sources of information (see methods). WAM and BCE indicate species recorded in the general region by the WA Museum and Bamford Consulting Ecologists respectively. Lit indicates species reported in the region from the literature. Species recorded during the field survey are indicated (X). Status indicates conservation significance (see Methods; Int. indicates introduced species).

Species		Source	Status	Survey
Tachyglossidae (echidnas)				
Echidna	*Tachyglossus aculeatus*	Lit		X
Dasyuridae				
White-tailed Dunnart	*Sminthopsis granulipes*	Lit	CS3	
Grey-bellied Dunnart	*Sminthopsis griseoventer*	Lit	CS3	
Peramelidae (bandicoots)				
Quenda or Brown Bandicoot	*Isoodon obesulus*	BCE	CS2	
Phalangeridae (brushtail possums)				
Brush-tailed Possum	*Trichosurus vulpecula*	BCE		
Tarsipedidae (honey possum)				
Honey Possum	*Tarsipes rostratus*	WAM	CS3	
Macropodidae (kangaroos and wallabies)				
Western Grey Kangaroo	*Macropus fuliginosus*	WAM		X
Brush or Black-gloved Wallaby	*Macropus irma*	Lit	CS2	
Mollosidae (mastiff bats)				
White-striped Bat	*Tadarida australis*	BCE		
Western Freetail Bat	*Mormopterus planiceps*	Lit		
Vespertilionidae (vesper bats)				
King River Eptesicus	*Vespadelus (Eptesicus) regulus*	Lit		
Gould's Wattled Bat	*Chalinolobus gouldii*	Lit		
Chocolate Wattled Bat	*Chalinolobus morio*	Lit		
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	Lit		
Greater Long-eared Bat	*Nyctophilus timoriensis*	Lit		
Muridae (rats and mice)				
House Mouse	*Mus musculus*	BCE	Int.	X
Noodji or Ashy-grey Mouse	*Pseudomys albocinereus*	Lit	CS3	
Moodit or Bush-Rat	*Rattus fuscipes*	WAM	CS3	X
Black Rat	*Rattus rattus*	Lit	Int.	
Leporidae (rabbits and hares)				
Rabbit	*Oryctolagus cuniculus*	BCE	Int.	X
Canidae (foxes and dogs)				
European Red Fox	*Vulpes vulpes*	BCE	Int.	X
Felidae (cats)				
Feral Cat	*Felis catus*	BCE	Int.	X
	Number of mammal species:	**22**		8

TABLE 6. Numbers of records of each species in each vegetation type. See Table 1 and Appendix 1 for details of vegetation descriptions, trap locations and sampling effort. As sampling effort varied between vegetation types, the proportion of effort in each type is indicated in parenthesis.

Species	Vegetation/landform type								
	1 (0.05)	2 (0.27)	3 (0.11)	4 (0.11)	5 (0.11)	6 (0.11)	7 (0.15)	8 (0.05)	
Marbled Gecko				1					1
Spiny-tailed Gecko	1				1	7	6		15
Fraser's Legless Lizard						1	2		3
Gray's Legless Lizard						1			1
Burton's Legless Lizard						1			1
Bearded Dragon		1			1	3		1	6
Gould's Sand Goanna		1							1
Fence Skink		2							2
Limestone Ctenotus				3					3
West Coast Ctenotus		1					1		2
Two-toed Skink	1	1			3	6	1		12
Four-toed Lerista	2	9	4	4	4	7	6	1	37
Line-spotted Lerista							2		2
Western Worm Lerista			1	4	3		1		9
Dwarf Skink	2	3	2	5	1	4	2		19
Western Bluetongue			1						1
Bobtail		1				1			2
Half-ringed Snake		1		2		1	1		5
Yellow-faced Whip-Snake					1		1		2
Jan's Bandy-Bandy					1		1		2
Nankeen Kestrel		2							2
Laughing Turtle-Dove		2	1		1	2	2	3	11
Common Bronzewing			1						1
Crested Pigeon		4	2	1					7
Carnaby's Cockatoo		1							1
Galah		1				1	2		4
Australian Ringneck		6	5		2	1		1	15
Splendid Fairy-wren	3	1		5	2	2	1		14
Variegated Fairy-wren	4			4	2				10
White-winged Fairy-wren		3		1			5		9
Striated Pardalote	1								1
White-browed Scrubwren	2	1		6	4	15	16	9	53
Inland Thornbill				1				2	3
Yellow-rumped Thornbill		1							1
Red Wattlebird	2	18	6	4	1			1	32
Singing Honeyeater	2	4	5	9	3	2	2	1	28
Brown Honeyeater	2	12	2	2					18
White-cheeked Honeyeater	3	22	1	1	1	6	2	2	38

Table 6 (cont.)

Species	Vegetation/landform type								
	1 (0.05)	2 (0.27)	3 (0.11)	4 (0.11)	5 (0.11)	6 (0.11)	7 (0.15)	8 (0.05)	
New Holland Honeyeater		2							2
White-breasted Robin	2					7		3	12
Golden Whistler								1	1
Grey Shrike-thrush		4				2		1	7
Grey Fantail	1				2	1	1	2	7
Willie Wagtail		3	1						4
Black-faced Cuckoo-shrike		1							1
Black-faced Woodswallow	1	3							4
Grey Butcherbird		4	3	2		2			11
Australian Magpie		1	4						5
Australian Raven		1		1		2			4
Richard’s Pipit							1		1
Welcome Swallow		1			1				2
Silvereye	10	21	17	20	8	25	18	9	128
Echidna		1			1	2	2		6
Western Grey Kangaroo		1	5	2	1				10
House Mouse	1	4	1	2		6	2	5	21
Moodit							1		1
N reptile records	6	20	8	19	15	32	24	2	126
N bird records	33	119	49	60	20	71	44	35	431
N mammal records	1	6	6	4	2	8	5	5	37
N fauna records	40	145	63	83	37	111	73	42	
N reptile species	4	9	4	6	8	10	11	2	
N bird species	12	24	13	13	11	15	10	12	
N mammal species	1	3	2	2	2	2	3	1	

TABLE 7. Results of *chi*-square tests on distributions of records by vegetation type for the more commonly recorded species. (Note that the critical value at 5% for 7 degrees of freedom is 14.067). Main source is the vegetation type that contributes largely to a significant result. Where the observed frequency was greatly less than the expected frequency, the vegetation type code is given in parenthesis.

Species	*Chi*-square value	Level of significance	Main source
Spiny-tailed Gecko	20.93	p<0.005	Veg types 6 & 7
Two-toed Skink	12.04	NS	
Four-toed Lerista	0.68	NS	
Western Worm Lerista	18.62	p<0.01	Veg type 4
Laughing Turtle-Dove	13.21	NS	
Australian Ringneck	14.15	p<0.05	Veg type 3
Splendid Fairy-wren	20.71	p<0.005	Veg types 1 & 4
Variegated Fairy-wren	40.88	p<0.005	Veg type 1
White-winged Fairy-wren	14.91	p<0.05	Veg type 7
White-browed Scrubwren	41.72	p<0.005	Veg types (2) & 8
Red Wattlebird	25.92	p<0.005	Veg types 2 & (6)
Singing Honeyeater	18.60	p<0.01	Veg type 4
Brown Honeyeater	21.37	p<0.005	Veg type 2
White-cheeked Honeyeater	23.96	p<0.005	Veg type 2
White-breasted Robin	29.07	p<0.005	Veg types 6 & 8
Grey Shrike-thrush	7.42	NS	
Grey Fantail	7.80	NS	
Grey Butcherbird	7.56	NS	
Silvereye	16.02	p<0.05	Veg type (2)
Grey Kangaroo	20.35	p<0.005	Veg type 3
House Mouse	19.27	p<0.01	Veg type 8
All reptile records	15.20	p<0.05	Veg type 2
All bird records	46.18	p<0.005	Veg type (5)
All mammal records	9.37	NS	
All fauna records	33.47	p<0.005	Veg type (5)

TABLE 7. Numbers of records of the most commonly recorded species, standardised for sampling effort. Values are therefore expressed as the capture rate relative to the lowest sampling effort expended (Vegetation types 1 and 8). Therefore, standardised rates for reptiles and the House Mouse are the number of captures per 72 trapnights, while for birds and the Grey Kangaroo they are the number of sightings per 60 survey events.

Species	Vegetation/landform type							
	1	2	3	4	5	6	7	8
Spiny-tailed Gecko	1				0.5	1.9	2.2	
Bearded Dragon		0.24			0.5	0.81		1
Two-toed Skink	1	0.24			1.5	1.62	0.36	
Four-toed Lerista	2	2.16	2.0	2.0	2.0	1.89	2.16	1
Western Worm Lerista			0.5	2.0	1.5		0.36	
Dwarf Skink	2	0.72	1.0	2.5	0.5	1.08	0.72	
Half-ringed Snake		0.24		1.0		0.27	0.36	
Laughing Turtle-Dove		0.48	0.5		0.5	0.54	0.72	3
Crested Pigeon		0.96	1.0	0.5				
Australian Ringneck		1.44	2.5		1.0	0.27		1
Splendid Fairy-wren	3	0.24		2.5	1.0	0.54	0.36	
Variegated Fairy-wren	4			2.0	1.0			
White-winged Fairy-wren		0.72		0.5			1.80	
White-browed Scrubwren	2	0.24		3.0	2.0	4.05	5.76	9
Red Wattlebird	2	4.32	3.0	2.0	0.5			1
Singing Honeyeater	2	0.96	2.5	4.5	1.5	0.54	0.72	1
Brown Honeyeater	2	2.88	1.0	1.0				
White-cheeked Honeyeater	3	5.28	0.5	0.5	0.5	1.62	0.72	2
White-breasted Robin	2					1.89		3
Grey Shrike-thrush		0.96				0.54		1
Grey Fantail	1				1.0	0.27	0.36	2
Grey Butcherbird		0.96	1.5	1.0		0.54		
Australian Magpie		0.24	2.0					
Silvereye	10	5.04	8.5	10.0	4.0	6.75	6.48	9
Echidna		0.24			0.5	0.54	0.72	
Western Grey Kangaroo		0.24	2.5	1.0	0.5			
House Mouse	1	0.96	0.5	1.0		1.62	0.72	5
N reptile records	6	4.8	4.0	9.5	7.5	8.64	8.64	2
N bird records	33	28.6	24.5	30.0	10.0	19.2	15.8	35
N mammal records	1	1.4	3.0	2.0	1.0	2.2	1.8	5

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APPENDIX 1. Coordinates, vegetation type and landform at each sampling location.

Code	Latitude	Longitude	Vegetation	Landform	Veg code
1	-31.64408	115.69249	Eucalyptus foecunda mallee and mixed herbfield	slope	1
2	-31.6441	115.69227	Eucalyptus foecunda mallee and mixed herbfield	slope	1
3	-31.64404	115.69205	Eucalyptus foecunda mallee and mixed herbfield	slope	1
4	-31.64393	115.6918	Eucalyptus foecunda mallee and mixed herbfield	slope	1
5	-31.64325	115.69189	Banksia woodland	sandplain and valley	2
6	-31.64301	115.69187	Banksia woodland	sandplain and valley	2
7	-31.64279	115.69187	Banksia woodland	sandplain and valley	2
8	-31.64263	115.69172	Banksia woodland	sandplain and valley	2
9	-31.64249	115.69165	Banksia woodland	sandplain and valley	2
10	-31.64228	115.69165	Banksia woodland	sandplain and valley	2
11	-31.64203	115.69156	Banksia woodland	sandplain and valley	2
12	-31.64184	115.6915	Banksia woodland	sandplain and valley	2
13	-31.64162	115.69131	Banksia woodland	sandplain and valley	2
14	-31.64143	115.69113	Banksia woodland	sandplain and valley	2
15	-31.64057	115.6917	Banksia woodland	sandplain and valley	2
16	-31.64066	115.69147	Banksia woodland	sandplain and valley	2
17	-31.64077	115.69131	Banksia woodland	sandplain and valley	2
18	-31.64099	115.69101	Banksia woodland	sandplain and valley	2
19	-31.64101	115.69078	Banksia woodland	sandplain and valley	2
20	-31.64111	115.69056	Banksia woodland	sandplain and valley	2
21	-31.64124	115.69045	Banksia woodland	sandplain and valley	2
22	-31.6413	115.69013	Acacia saligna shrubland over Lomandra	low dune	3
23	-31.64148	115.68984	Acacia saligna shrubland over Lomandra	low dune	3
24	-31.64163	115.68963	Acacia saligna shrubland over Lomandra	low dune	3
25	-31.64165	115.68934	Acacia saligna shrubland over Lomandra	low dune	3
26	-31.64174	115.68911	Acacia saligna shrubland over Lomandra	low dune	3
27	-31.6418	115.68894	Acacia saligna shrubland over Lomandra	low dune	3
28	-31.64197	115.68865	Acacia saligna shrubland over Lomandra	low dune	3
29	-31.64211	115.68848	Acacia saligna shrubland over Lomandra	low dune	3

Appendix 1 (cont.)

Code	Latitude	Longitude	Vegetation	Landform	Veg code
30	-31.64215	115.6883	Acacia saligna, Dryandra sessilis and Xanthorhoea shrubland	Valley	4
31	-31.64204	115.68798	Acacia saligna, Dryandra sessilis and Xanthorhoea shrubland	Valley	4
32	-31.64211	115.68772	Acacia saligna, Dryandra sessilis and Xanthorhoea shrubland	Valley	4
33	-31.64226	115.68745	Acacia saligna, Dryandra sessilis and Xanthorhoea shrubland	Valley	4
34	-31.64246	115.68733	Acacia saligna, Dryandra sessilis and Xanthorhoea shrubland	Valley	4
35	-31.6426	115.68712	Acacia saligna, Dryandra sessilis and Xanthorhoea shrubland	Valley	4
36	-31.64271	115.68695	Acacia saligna, Dryandra sessilis and Xanthorhoea shrubland	Valley	4
37	-31.64288	115.68668	Acacia saligna, Dryandra sessilis and Xanthorhoea shrubland	Valley	4
38	-31.64298	115.68648	Olearia shrubland over lomandra	high dune	5
39	-31.64307	115.68622	Olearia shrubland over lomandra	high dune	5
40	-31.64316	115.68595	Olearia shrubland over lomandra	high dune	5
41	-31.6434	115.68576	Olearia shrubland over lomandra	high dune	5
42	-31.64344	115.68549	Olearia shrubland over lomandra	high dune	5
43	-31.64337	115.68521	Casuarina thicket	base of dune	6
44	-31.64337	115.68493	Casuarina thicket	base of dune	6
45	-31.64339	115.68468	Dryandra sessilis/Spyridium tall (<2.5m) thicket	valley	6
46	-31.64353	115.68451	Dryandra sessilis/Spyridium tall (<2.5m) thicket	valley	6
47	-31.64357	115.68427	Dryandra sessilis/Spyridium tall (<2.5m) thicket	valley	6
48	-31.64359	115.68407	Dryandra sessilis/Spyridium tall (<2.5m) thicket	valley	6
49	-31.64354	115.68384	Dryandra sessilis/Spyridium tall (<2.5m) thicket	valley	6
50	-31.64349	115.68359	Dryandra sessilis/Spyridium tall (<2.5m) thicket	valley	6
51	-31.64358	115.68353	Dryandra sessilis/Spyridium tall (<2.5m) thicket	valley	6
52	-31.64359	115.68304	Dryandra sessilis/Spyridium tall (<2.5m) thicket	valley	6
53	-31.64375	115.68281	Dryandra sessilis/Spyridium tall (<2.5m) thicket	valley	6

Appendix 1 (cont.)

Code	Latitude	Longitude	Vegetation	Landform	Veg code
54	-31.64387	115.68259	Dryandra sessilis/Spyridium low (<1.5m) thicket with clearings of Lomandra	valley	6
55	-31.64406	115.6825	Dryandra sessilis/Spyridium low (<1.5m) thicket with clearings of Lomandra	valley	6
56	-31.64425	115.68234	Dryandra sessilis/Spyridium low (<1.5m) thicket with clearings of Lomandra	valley	6
57	-31.64422	115.68202	Dryandra sessilis/Spyridium low (<1.5m) thicket with clearings of Lomandra	valley	6
58	-31.64455	115.68186	Coastal mixed shrubland (Dryandra, spyridium, Acacia cyclops & Olearia)	low secondary dunes	7
59	-31.64468	115.68167	Coastal mixed shrubland (Dryandra, spyridium, Acacia cyclops & Olearia)	low secondary dunes	7
60	-31.64488	115.68157	Coastal mixed shrubland (Dryandra, spyridium, Acacia cyclops & Olearia)	low secondary dunes	7
61	-31.64503	115.68138	Coastal mixed shrubland (Dryandra, spyridium, Acacia cyclops & Olearia)	low secondary dunes	7
62	-31.64529	115.68112	Scaevola low, very dense shrubland	primary dunes	7
63	-31.64542	115.68132	Scaevola low, very dense shrubland	primary dunes	7
64	-31.64534	115.68162	Scaevola low, very dense shrubland	primary dunes	7
65	-31.64533	115.68185	Coastal mixed shrubland (Dryandra, spyridium, Acacia cyclops & Olearia)	low secondary dunes	7
66	-31.64528	115.68205	Coastal mixed shrubland (Dryandra, spyridium, Acacia cyclops & Olearia)	low secondary dunes	7
67	-31.64526	115.68232	Coastal mixed shrubland (Dryandra, spyridium, Acacia cyclops & Olearia)	low secondary dunes	7
68	-31.64525	115.68261	Coastal mixed shrubland (Dryandra, spyridium, Acacia cyclops & Olearia)	low secondary dunes	7
69	-31.64528	115.68299	Olearia shrubland over lomandra	high dune	5
70	-31.64529	115.68321	Olearia shrubland over lomandra	high dune	5
71	-31.64527	115.68349	Olearia shrubland over lomandra	high dune	5
72	-31.64535	115.68375	Melaleuca thicket	valley and slope of limestone	8
73	-31.6454	115.68399	Melaleuca thicket	valley and slope of limestone	8
74	-31.64548	115.68423	Melaleuca thicket	valley and slope of limestone	8
75	-31.64549	115.68438	Melaleuca thicket	valley and slope of limestone	8
76	-31.64571	115.68506	Mixed thicket (Dryandra, Spyridium, Xanthorrhoea) with clearings of Lomandra	valley slope	6
77	-31.64569	115.68539	Mixed thicket (Dryandra, Spyridium, Xanthorrhoea) with clearings of Lomandra	valley slope	6
78	-31.64581	115.68567	Mixed thicket (Dryandra, Spyridium, Xanthorrhoea) with clearings of Lomandra	valley slope	6

APPENDIX 2. Categories used in the assessment of conservation status.

IUCN categories (based on review by Mace and Stuart 1994**) as used for the Environmental Protection and Biodiversity Conservation (EPBC) Act and the WA Wildlife Conservation Act**.

Extinct. Taxa not definitely located in the wild during the past 50 years.

Extinct in the Wild. Taxa known to survive only in captivity.

Critically Endangered. Taxa facing an extremely high risk of extinction in the wild in the immediate future.

Endangered. Taxa facing a very high risk of extinction in the wild in the near future.

Vulnerable. Taxa facing a high risk of extinction in the wild in the medium-term future.

Near Threatened. Taxa that risk becoming Vulnerable in the wild.

Conservation Dependent. Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.

Data Deficient (Insufficiently Known). Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

Least Concern. Taxa that are not Threatened.

Schedules used in the WA Wildlife Conservation Act.

Schedule 1. Rare and Likely to become Extinct.
Schedule 2. Extinct.
Schedule 3. Migratory species listed under international treaties.
Schedule 4. Other Specially Protected Fauna.

WA Department of Conservation and Land Management Priority species (species not listed under the Conservation Act, but for which there is some concern).

Priority 1. Taxa with few, poorly known populations on threatened lands.

Priority 2. Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.

Priority 3. Taxa with several, poorly known populations, some on conservation lands.

Priority 4. Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.

Priority 5. Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

APPENDIX 3. Sampling results. a. Reptiles

No	C.mar	S.spi	D.fra	D.gre	L.bur	P.min	V.gou	C.pla	C.aus	C.fal	H.qua	L.ele	L.lin	L.pra	M.gre	T.rug	T.occ	B.sem	D.psa	S.ber	N. rec	N spp
1																						0
2		1													1						2	2
3											1				1						2	2
4												2									2	1
5												2						1			3	2
6																						0
7							1	1													2	2
8												1									1	1
9								1				2									3	2
10															1						1	1
11																						0
12												1									1	1
13											1	1									2	2
14												1									1	1
15										1						1					2	2
16						1						1									2	2
17															1						1	1
18																						0
19																						0
20															1						1	1
21																						0
22												1									1	1
23																						0
24															1						1	1
25																						0
26																						0
27																						0
28												1									1	1

Appendix 3a. (cont.)

No	C.mar	S.spi	D.fra	D.gre	L.bur	P.min	V.gou	C.pla	C.aus	C.fal	H.qua	L.ele	L.lin	L.pra	M.gre	T.rug	T.occ	B.sem	D.psa	S.ber	N. rec	N spp
29												2		1	1		1				5	4
30												2			2			1			5	3
31																						0
32														1							1	1
33									3					1				1			5	3
34												2		1	2						5	3
35																						0
36														1	1						2	2
37	1																				1	1
38															1						1	1
39		1				1					1	1		1							5	5
40											1	1									2	2
41												1							1		2	2
42																				1	1	1
43		1																1			2	2
44		1																			1	1
45		1										2			1						4	3
46						1						1									2	2
47											1										1	1
48		1										1			1						3	3
49												1									1	1
50																						0
51																						0
52											2	1			1						4	3
53																						0
54											2										2	1
55						1															1	1
56			1		1	1					1										4	4

Appendix 3a (cont.)

No	C.mar	S.spi	D.fra	D.gre	L.bur	P.min	V.gou	C.pla	C.aus	C.fal	H.qua	L.ele	L.lin	L.pra	M.gre	T.rug	T.occ	B.sem	D.psa	S.ber	N. rec	N spp
57		1										1			1						3	3
58		2																			2	1
59		1											1		1				1	1	5	5
60													1								1	1
61												1									1	1
62												1									1	1
63										1											1	1
64												1						1			2	2
65																						0
66		1									1	1									3	3
67		1	2											1	1						5	4
68		1										2									3	2
69																						0
70											1			2							3	2
71												1									1	1
72												1									1	1
73																						0
74																						0
75						1															1	1
76																						0
77		1		1																	2	2
78		1														1					2	2

APPENDIX 3. Sampling results. b. Birds

No	NaKe	CaCk	Gal	ARnk	CtPig	CoBz	LaTD	WbSw	SpFw	VaFw	WwFw	YrTb	InTb	StP	ReWb	NHHe	WcHe
1								1	1	1							2
2								1	2	1				1			1
3															1		
4										2					1		
5				2	2		1								1	1	3
6		1		1			1								2	1	1
7	1																3
8															1		1
9															1		
10																	
11															1		
12																	
13															1		3
14			1								1				1		1
15					1						1				1		4
16				1				1	1		1						3
17																	
18				1								1			2		1
19	1														2		1
20				1											2		1
21					1										3		
22				1											3	1	
23				1	1										1		
24				1													
25				1													
26				1			1								1		
27						1											
28															1		1
29					1												
30								1									
31																	
32								1							1		
33								1	1						1		
34									1								
35									1	1					2		1
36								2	2	3							
37					1			1			1		1				
38				1					1	1					1		
39								2	1								
40								1									
41																	
42																	
43																	

Appendix 3b (cont.)

No	NaKe	CaCk	Gal	ARnk	CtPig	CoBz	LaTD	WbSw	SpFw	VaFw	WwFw	YrTb	InTb	StP	ReWb	NHHe	WcHe
44																	
45								1									1
46			1	1			1	1									
47								2									
48								1									
49					1		1		1								1
50																	
51																	1
52																	1
53																	
54								1									
55								1									
56								2									1
57								2									1
58								2									1
59								1									
60			1					2			1						
61								2			2						
62											1						
63								2			1						
64																	
65							2	4	1								1
66			1														
67								2									
68								1									
69							1										
70																	
71				1				1		1							1
72							2	1									1
73							1	1									
74				1				4					1		1		
75								3					1				1
76								2									
77								1									
78								1	1				1				
	2	1	4	15	8	1	11	53	14	10	9	1	4	1	32	3	38

Appendix 3b (cont.)

No	SgHe	BnHe	WbRo	GySt	GoWh	GyFt	WiWt	WeSw	RiPt	BfCs	BfWs	GyBb	AuMg	AuRa	Silv	N rec	N spp
1		1	1												2	9	7
2	1	1				1									5	14	9
3															2	3	2
4	1		1								1				1	7	6
5		2		1			1								2	16	10
6		2										1			1	11	9
7		2										1				7	4
8																2	2
9		1													1	3	3
10																0	0
11																1	1
12															1	1	1
13	1	1										1	1		3	11	7
14															1	5	5
15	1	1													4	13	6
16	1	2		1			1				1				4	17	11
17	1									1	1			1	1	5	5
18							1								2	8	6
19		1		1							1	1			1	9	8
20																4	3
21				1				1								6	4
22	1											3	3		2	14	7
23	2												1			6	5
24															2	3	2
25	1	1													2	7	4
26	1						1								2	3	6
27															2	4	2
28															2	7	3
29		1													5	5	3
30															4	4	2
31	2	1													1	7	3
32	3	1													1	6	5
33	3															3	4
34															2	9	2
35												2			2	13	6
36															6	10	4
37	1													1	4	8	7
38	1														3	6	6
39						1									2	1	4
40																1	1
41															1	1	1
42																	0
43															1	1	1

Appendix 3b (cont.)

No	SgHe	BnHe	WbRo	GySt	GoWh	GyFt	WiWt	WeSw	RiPt	BfCs	BfWs	GyBb	AuMg	AuRa	Silv	N rec	N spp
44																	0
45															1	3	3
46												1			3	8	6
47			1												1	4	3
48				1		1									3	6	4
49			1												2	7	6
50																	0
51															2	3	2
52			1													2	2
53			2											1	1	4	3
54			1												1	3	3
55			1													2	2
56														1	2	6	4
57	1											1			1	6	5
58	2														2	7	4
59															2	3	2
60															1	5	4
61															2	6	3
62															1	2	2
63																3	2
64						1									1	2	2
65															1	9	5
66															1	2	2
67																2	1
68															2	3	2
69	2															3	2
70															1	1	1
71						1		1							1	7	7
72	1		1		1											7	6
73															1	3	3
74			1	1		1									4	14	8
75			1			1									4	11	6
76																2	1
77									1						2	4	3
78	1			1											5	10	6
	28	18	12	7	1	7	4	2	1	1	4	11	5	4	123	431	

APPENDIX 3. Sampling results. c. Mammals

Pit No	T.acu	M.ful	M.mus	R.fus	N records	N spp
1						0
2						0
3			1		1	1
4						0
5						0
6						0
7						0
8		1			1	1
9						0
10						0
11						0
12						0
13			1		1	1
14			1		1	1
15	1		2		3	2
16						0
17						0
18						0
19						0
20						0
21						0
22		1			1	1
23		1			1	1
24		1			1	1
25		1			1	1
26		1			1	1
27			1		1	1
28						0
29						0
30						0
31			1		1	1
32		2			2	1
33						0
34			1		1	1
35						0
36						0
37						0
38						0
39		1			1	1
40						0
41						0
42						0
43	1		1		2	2

Appendix 3c (cont.)

Pit No	T.acu	M.ful	M.mus	R.fus	N records	N spp
44						0
45						0
46						0
47						0
48						0
49						0
50						0
51	1		1		2	2
52						0
53						0
54						0
55						0
56			2		2	1
57			1		1	1
58						0
59	1				1	1
60						0
61	1				1	1
62			1		1	1
63			1	1	2	2
64						0
65						0
66						0
67						0
68						0
69	1				1	1
70						0
71						0
72			1		1	1
73						0
74			1		1	1
75			3		3	1
76						0
77						0
78			1		1	1