Diet and status of the Wedge-tailed Eagle *Aquila audax* at Lorna Glen Conservation Reserve, Western Australia.

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EXECUTIVE SUMMARY

In late 2011 an investigation into the ecology of the wedge-tailed eagle (*Aquila audax)* commenced at Lorna Glen Conservation Reserve in the Murchison/Gascoyne region of Western Australia. This study aimed to determine the location of breeding territories, examine nests for activity and collect prey remains from active nests to determine eagle diet. The diet study specifically aimed to determine possible impacts of eagle predation on mammal reintroductions to Lorna Glen.

A preliminary field survey was conducted during October 2011 to assess the status of eagles at Lorna Glen. This study was planned for 7-10 days but was cut short by bad weather. However, wedge-tailed eagles were confirmed as a breeding resident, with nine sightings over three days indicating at least three and perhaps more than five breeding pairs are present. Three nests were located, with only one being active in 2011. Nests were constructed 6-7m above the ground in the tallest trees available: two in *Acacia pruinocarpa* and one in *Grevillea berryana*. A newly fledged eaglet was observed with its parents near a recently active eagle nest about 2 km north-east of the fenced enclosure. A suite of prey remains collected from this nest comprised 26 individuals of 14 vertebrate prey animal species: 10 mammals, two birds and two reptiles. The mammals taken included three reintroduced species: golden bandicoot (n=4), mala (n=1) and boodie (n=1), as well as feral species (European rabbit, n=5; feral cat, n=1). Reptiles including goannas (*Varanus spp.*, n=6) were also eaten. The impact of eagles alone on mammal reintroductions is probably low, however when considered together with predation by other (feral) predators, it may hinder the establishment of vulnerable species such as mala.

Opportunistic observations indicated that at least five other species of raptors are breeding residents at Lorna Glen. The remains of a golden bandicoot (*Isoodon auratus*) were recovered from the nest of one species, the whistling kite (*Haliastur sphenurus*), approximately 15 km east of the fenced enclosure in which most animals reside. Bandicoots have been reported as colonising habitats outside the enclosure.

Further research, including a broad-scale nest search, and possible telemetry of both adult and juvenile (dispersing) wedge-tailed eagles is recommended to gain more information on the ecology of this species at Lorna Glen.

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1 INTRODUCTION

Lorna Glen is a 260 000 ha former pastoral lease property situated across the border of Western Australia's Gascoyne and Murchison regions. The property was acquired by the Department of Environment and Conservation (DEC) in 2000 to be managed as a Conservation Reserve (Dunlop and Morris 2009). Initially, the project focussed on fauna reintroductions following intensive feral predator (cat *Felis catus*, wild dog *Canis familiaris*) control, which were largely successful for common brushtail possum (*Trichosurus vulpecula*) and bilby (*Macrotis lagotis*). However, predator vulnerable species such as mala (*Lagorchestes hirsutus*) did not survive trial translocations in 2008, and the decision was made to construct an 1100 ha fenced enclosure, intended as a soft release pen and breeding enclosure for release into the wider Lorna Glen habitat. Golden bandicoot (*Isoodon auratus*) and boodie (*Bettongia lesueur*) were released into the enclosure in 2010 and have been breeding successfully for two years. More recently, Shark Bay mice (*Pseudomys fieldii*) and mala from Trimouille Island were also released into the enclosure.

The reasons for failure to establish after translocation have included predation by feral cats and wild dogs, failure to find sufficient food, exposure following wet/cold periods and predation by birds of prey (raptors). The initial release of mala in 2008 failed (primarily due to cat predation and starvation), and early observations of a second translocation in 2011 indicate raptors may have had some impact on the survival of founder animals. Mala translocated from a habitat with an absence of aerial predators were observed to rest during the day in exposed locations with limited cover, making them easy prey for local raptors (J. Dunlop pers. comm.).

Several species of Australian raptor are likely culprits but the wedge-tailed eagle is known to frequent Lorna Glen, being sighted regularly in the vicinity of the fenced enclosure and occasionally flushed from freshly killed reintroduced mammals inside it. This eagle is the largest and one of the best studied raptors in Australia (Olsen 2005). In southern Australia it is known to feed mainly on the introduced rabbit (*Oryctolagus cuniculus*) and young macropods (*Macropus* spp.), as well as a variety of birds, but it displays a general preference for mammals >500 grams in mass and birds >100g (Brooker and Ridpath 1980; Sharp *et al.* 2002; Olsen *et al.* 2006; Cherriman 2007; Fuentes *et al.* 2007; Parker *et al.* 2007). Its preference for mammals has also lead to studies on the diet of this eagle in areas where remnant populations of threatened mammals occur (Sharp 1997; Richards and Short 1998; Cherriman 2007).

Limited research has been conducted on possible impacts of the wedge-tailed eagle on mammal reintroductions in WA. One study in the Jarrah Forest suggested that eagles had little impact on survival of a variety of native mammals in a 260 ha fenced enclosure in the Perth Hills (Cherriman 2007; 2008*a*), although this was forest with patches of very dense understorey and involved mammals displaying a variety of diurnal sheltering behaviour. There is anecdotal evidence from the Avon-Wheatbelt region that raptors including wedge-tailed eagles feed regularly on animals in reintroduction enclosures (Friend and Beecham 2004, B. Macmahon pers. comm.), and have caused the failure of some numbat translocations (T. Friend pers. comm.). On the other hand, evidence from some habitats with established diverse mammal assemblages shows many threatened mammal species cope with continuous wedge-tailed eagle and other raptor predation, for example on Bernier Island (Richards and Short 1998) and at Tutanning Nature Reserve

(Cherriman 2008*b*). However, the impact of wedge-tailed eagles on mammal reintroductions, and how this may differ in varying habitats, remains largely unknown.

In light of this information, the DEC commissioned Insight Ornithology to conduct an investigation into the ecology of the wedge-tailed eagle at Lorna Glen Conservation Reserve, with a focus on the number of breeding birds present and their diet.

This report contains the results of an initial field survey, which forms part of the broader study at Lorna Glen. The aims of the initial field study were as follows:

- To determine the status (whether breeding resident, visitor, vagrant, etc) of the wedge-tailed eagle at Lorna Glen and locate as many nests as possible.
- To quantify the diet of the wedge-tailed eagle at Lorna Glen, especially in relation to the 1100 ha fenced enclosure.
- To gather preliminary information on whether post-release monitoring (radio-tracking, trapping) of reintroduced mammals reveals their presence to raptors.

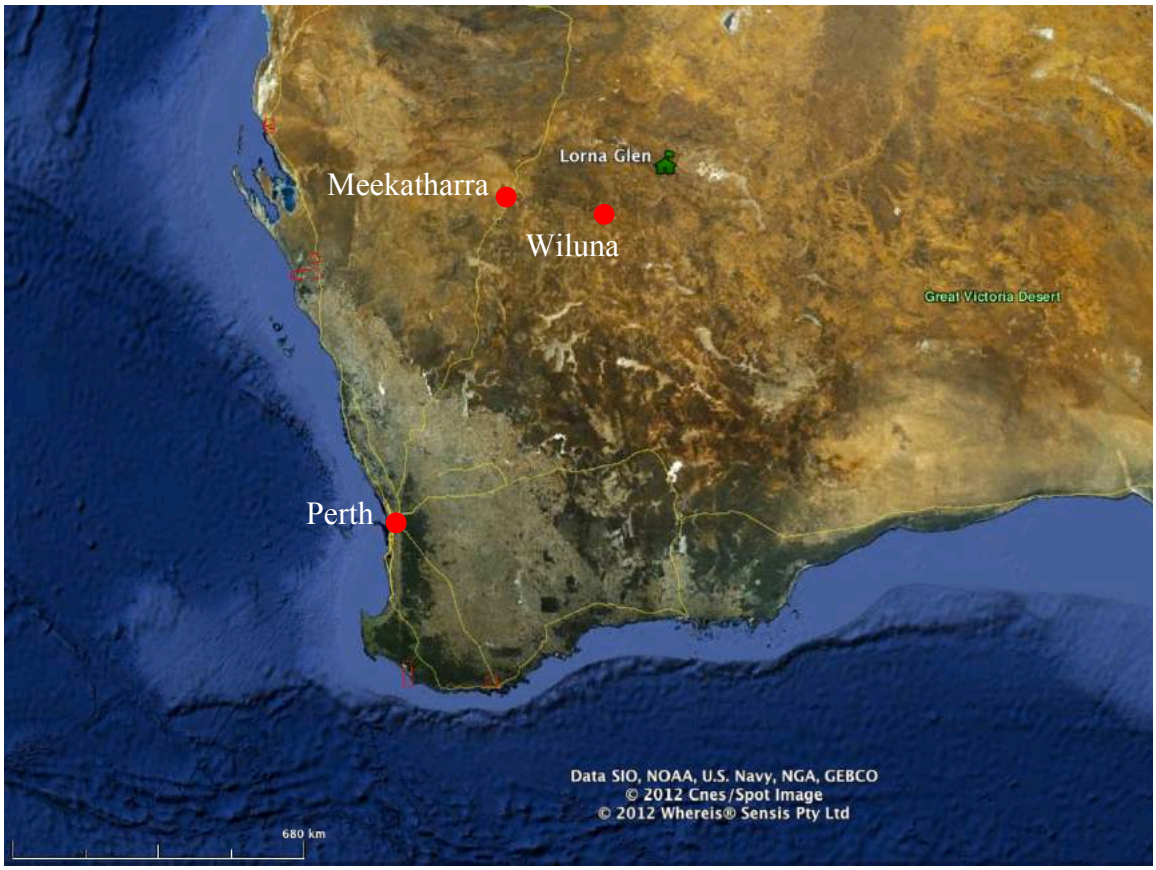

Figure 1. Map of Western Australia showing location of Lorna Glen Conservation Reserve and major towns.

2 METHODS

2.1 Study Area

Lorna Glen Conservation Reserve is located approximately 150 km east north-east of Wiluna in Western Australia (Figure 1). The vegetation in this region consists mainly of mulga (*Acacia aneura*) plains, open areas of samphire, spinifex (*Triodia* spp.) grassland and occasional drainage lines of river red-gum (*Eucalyptus camaldulensis*; Dunlop and Morris 2009).

2.2 Personnel

The following personnel were involved in the preparation of this report:

- Mr Simon Cherriman *BSc. Hons (Env. Biol.), MSciComm. (Nat. Hist. Film.)*
- Ms Gillian Basnett *BSc. (REM), MSc., MSc. (Res.)*

The field survey was undertaken by Simon Cherriman and Gillian Basnett and the report was prepared by Simon Cherriman.

2.3 Field Survey

The field survey was conducted on 28th – 31st October 2011. This was a much shorter period than the initially planned 7-10 days but the trip was cut short by an unexpected storm. Weather conditions were usually fine or partly cloudy with daily temperatures around 30˚C, and frequent evening thunderstorms. Activities undertaken during the field survey included the following:

2.3.1 Wedge-tailed eagle Nest Searching

Surveys were conducted by systematically driving internal roads and access tracks and searching vegetation either side of the road for wedge-tailed eagle nests. These are large structures of sticks which are usually conspicuous in open landscapes such as that at Lorna Glen (Ridpath and Brooker 1987). Particular attention was given to ridges and drainage lines containing tall trees which are favoured sites for eagles (Silva and Croft 2007). These areas usually occurred away from roads and were thus visited and searched on foot.

2.3.2 Diet Analysis

Prey remains (e.g. bones, fur and feathers) and regurgitated pellets were collected from all located wedge-tailed eagle nest sites to acquire information on diet. Eagle dietary material was analysed in the laboratory at DEC's Science Division in Woodvale following the methods of Cherriman (2007), which involved:

1) Identification of prey remains to genus, and if possible, to species, using a reference collection of animal skeletal material and bird feathers.
2) Quantification of a minimum number of individual prey animals using the prey remains.
3) Analysis and identification of material in regurgitated pellets using the skeletal reference collection for bones/feathers, and the Hair ID Interactive CD (Triggs and Brunner 2002) for mammalian hair.
4) Combining data from prey remains and pellets *only* when material in pellets could be used to reliably quantify numbers of animals within a pellet, and when animal

parts could be considered in context of prey remains data to eliminate any possibility of 'double-counting' individuals.

2.3.3 Opportunistic Observations

Observations of wedge-tailed eagles and other raptors were made at all times. Notes were made on the location, number and behaviour of birds sighted. Where possible, wedge-tailed eagles were aged using plumage colour (see Ridpath and Brooker 1986*a*). Observations of adult eagles, especially those seen in pairs during the breeding season, can often indicate the location of a breeding territory containing nests. Thus, thorough searches for eagle nests were initiated in areas where sightings of such adult pairs were made.

Past records of wedge-tailed eagles inside and in close proximity to the fenced enclosure were also compiled to gain insight into behaviour prior to this study. These came mostly from conversations with DEC Technical Officers who had worked extensively at Lorna Glen.

3 RESULTS

3.1.1 Wedge-tailed eagle Status

The length of the field survey was cut short by unpredicted bad weather, therefore during this time mainly the southern region of Lorna Glen was traversed in detail. Figure 2 shows the roads and tracks that were visited, as well as the locations of wedge-tailed eagle sightings and nests.

Figure 2. Location map showing tracks driven (white) and walked (yellow) during wedge-tailed eagle nest surveys, location of wedge-tailed eagle sightings (pin icon), and nests (tree icon) at Lorna Glen Conservation Reserve, October 2011. Three categories of wedge-tailed eagle sighting are shown: adult pair (red), adult single (yellow) and juvenile single (orange).

Despite the shortened field time, wedge-tailed eagles were seen daily and were found to be a breeding resident at Lorna Glen. Nine eagle sightings were made in total; these comprised seven records of breeding adult pairs, one of a single adult and one of a juvenile (newly fledged) eagle. There was no way of distinguishing between individual adult birds but based on experience, the location of nests (see below), the distance between each sighting, and conversations with DEC Technical Officers N. Hamilton and J. Dunlop, these early observations indicate that at least five or six breeding pairs reside at Lorna Glen.

3.1.2 Nests

Three wedge-tailed eagle nests were located during the nest searching surveys (Figures 3, 4 and 5). The characteristics of these nests are shown in Table 1 and their locations in Figure 2. Nests were 6-7 m above the ground, usually on a ridge or breakaway with a commanding view over the surrounding landscape. Two nests were built in Gidgee (*Acacia pruinocarpa*), a tall tree common in the Gascoyne and Murchison regions.

Table 1. Characteristics of three wedge-tailed eagle nests, and prey species identified as eagle food at each nest, at Lorna Glen Conservation Reserve in October 2011. * = introduced species

		Nest Number		
CHARACTERISTICS		**1**	**2**	**3**
Easting		342747	327309	333957
Northing		7089819	7102443	7105900
Tree Species		*Grevillea berryana*	*Acacia pruinocarpa*	*A. pruinocarpa*
Approximate Height (m)		6	6	7
Status		inactive	inactive	active
FOOD				
Prey Species				
MAMMALS:				
Echidna	*Tachyglossus aculeatus*			1
Golden Bandicoot	*Isoodon auratus*			4
Burrowing Bettong (boodie)	*Bettongia leseuri*			1
Rufous Hare-wallaby (mala)	*Lagorchestes hirsutus*			1
Red Kangaroo (juv.)	*Macropus rufus*			1
unidentified Kangaroo	*Macropus rufus/robustus*	1	1	1
Total Macropods				*4*
*Feral Cat	*Felis catus*			1
*Rabbit	*Oryctolagus cuniculus*	1		5
	Total Mammals:	**2**	**1**	**15**
BIRDS:				
Crested Pigeon	*Ocyphaps lophetes*			1
Australian Ringneck	*Barnardius zonarius*			1
Tawny Frogmouth	*Podargus strigoides*	1		
Australian Magpie	*Cracticus tibicen*	1		
Little Crow	*Corvus bennetti*			1
Unidentified Bird				2
	Total Birds:	**2**	**0**	**5**
REPTILES:				
Goanna	*Varanus gouldii/panoptes*			5
Centralian Bluetongue	*Tiliqua multifasciata*			1
	Total Reptiles:	**0**	**0**	**6**
	TOTAL:	**4**	**1**	**26**

Figure 3. Site photo showing wedge-tailed eagle Nest 1 (A) and nest contents (B) at Lorna Glen Conservation Reserve, October 2011.

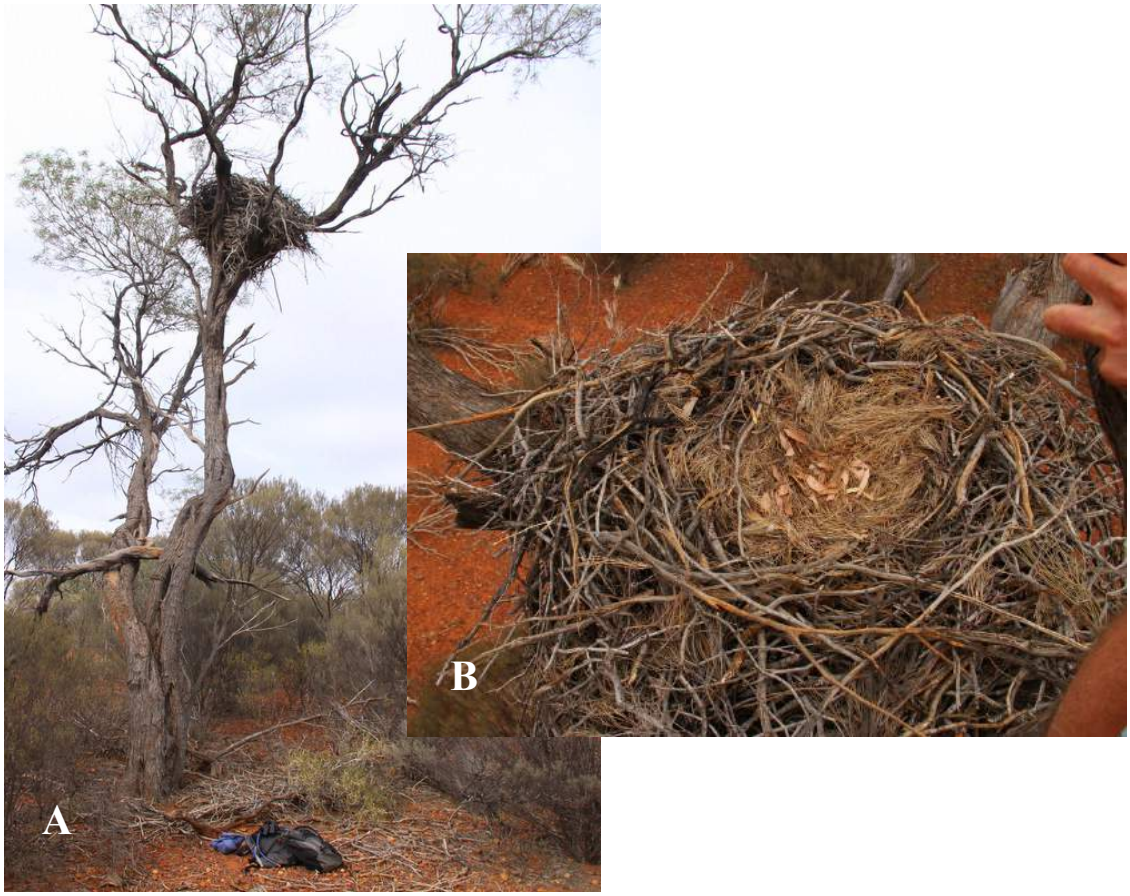

Figure 4. Site photo showing wedge-tailed eagle Nest 2 (A) and recently (<2 years) lined nest cavity (B) at Lorna Glen Conservation Reserve, October 2011.

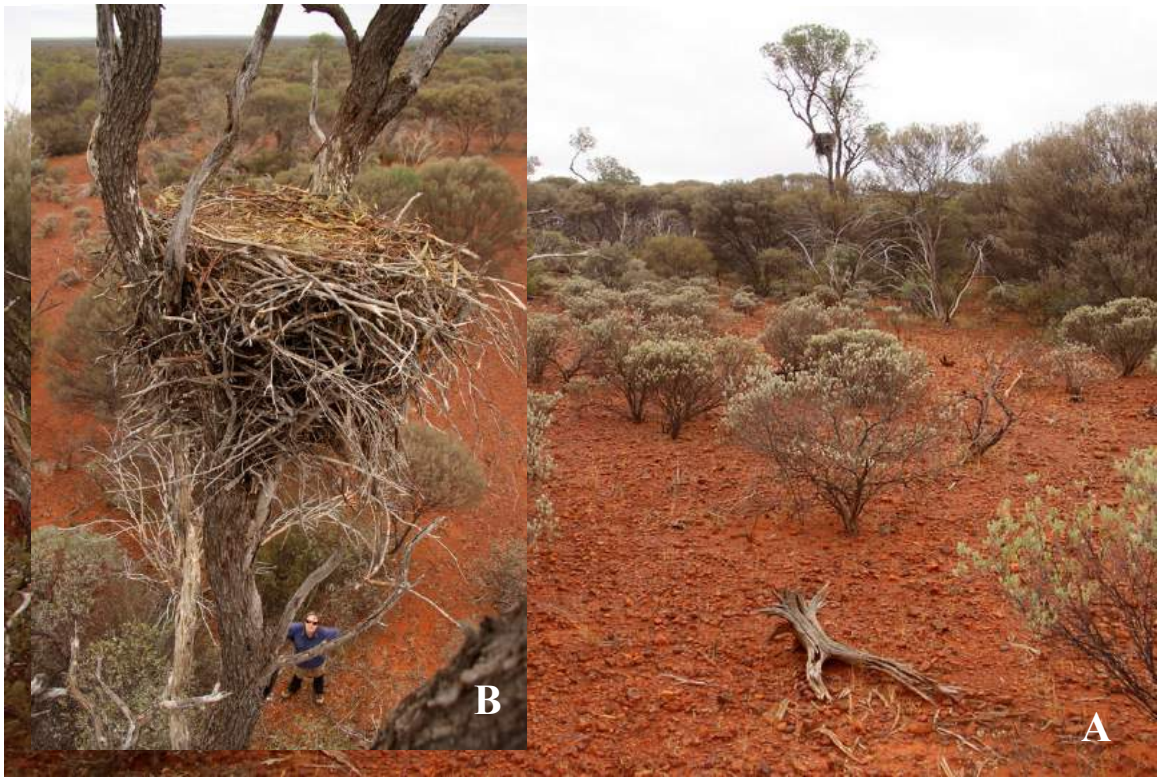

Figure 5. Site photo showing wedge-tailed eagle Nest 3 (A) and recently occupied nest cavity (B) at Lorna Glen Conservation Reserve, October 2011.

3.1.3 Diet Analysis

Table 1 shows the number of each species of prey animal identified from prey remains and pellets collected from each wedge-tailed eagle nest. Nest 3 yielded the most prey data, and reintroduced mammals including mala, boodie, and golden bandicoot were all found to be prey of this pair of wedge-tailed eagles. Feral species including rabbits and a cat were also eaten.

Nests 1 and 2 contained relatively few prey remains and no pellets. The species which were identified included juvenile Macropods, rabbit and two birds.

3.1.4 Opportunistic Observations

Several observations of wedge-tailed eagles provided by DEC Technical Officers are presented below. These provide background information about eagle predation of various mammal species in relation to the fenced enclosure.

2nd February 2010, ~0900h

A dead echidna was located against lower skirting mesh of the fence on the north-eastern edge of the enclosure. The echidna had been eviscerated from the ventral side and the inner fleshy content almost entirely eaten, probably by a large raptor (like a wedge-tailed eagle) with the ability to avoid the spines and consume the fleshy underside. It was uncertain whether the echidna had become entangled in the fence, or whether a predator had used the fence to 'corner' and kill it.

29th March 2010, ~0700h

Three wedge-tailed eagles were observed perched in a dead tree inside the fenced enclosure, close to the boodie warren. Based on plumage, the eagles were a family trio (adult pair + juvenile), the latter probably being a fledgling from a breeding event in 2009.

4th June 2010, 0730h

An adult wedge-tailed eagle was flushed from the carcass of a boodie inside the fenced enclosure. The boodie appeared freshly killed (it was still warm) and the eagle had partially plucked the pelt, consumed the eye and began feeding on flesh inside the mouth.

29th August 2010, ~0640h

An adult female (from photographs) wedge-tailed eagle was observed to follow DEC vehicles involved with mammal trapping, driving inside the fenced enclosure. The eagle watched closely from a perch in a nearby eucalypt tree as scientists removed mammals from cage traps, then flew behind the vehicle to perch in another tree close to unchecked traps.

Four species of diurnal raptor other than the wedge-tailed eagle were recorded during the field survey. These included the following: little eagle *Hieraaetus morphnoides* (breeding resident, one active nest), whistling kite *Haliastur sphenurus* (breeding resident, three active nests) black-breasted buzzard *Hamirostra melanosternon* (breeding resident, two active nests), brown falcon *Falco berigora* (status uncertain). Prey remains and pellets were collected from some of these raptor nests to give information on diet of these species, but these remains were not analysed in the same detail as those from wedge-tailed eagle nests. Among those collected, the skull of a golden bandicoot was located at a whistling kite nest situated approximately 15km east of the fenced enclosure.

4 DISCUSSION

4.1.1 Wedge-tailed eagle nesting records, status and movements

The site, situation and characteristics of wedge-tailed eagle nests reported at Lorna Glen were similar to those reported in other studies (e.g. Ridpath and Brooker 1987 – see Cherriman 2007 for a full review). Only one nest (Nest 3) had been recently active; this nest was located about 2 km from the fenced enclosure and appeared to be several years old. Based on the apparent age of sticks comprising the nest, and the amount of fallen nesting material below it, this nest was probably built prior to the construction of the fenced enclosure in 2010. A large quantity of prey remains and regurgitated pellets were collect from this nest, and from below six perch trees closely associated with it. Perch trees such as these are an important habitat component for breeding eagles (Olsen 2005). They are usually located <100 m from an active nest, and are used by both adult eagles 'servicing' the nest (i.e. delivering prey, removing old prey remains, performing parental duties, etc; S. Cherriman pers. obs.). Locating such trees is useful for future studies as eagles will sometimes use them for roosting, and may regurgitate pellets at such sites during different times the year (i.e. even when not breeding).

Nest 1 was very old and deteriorated and had not been used by breeding eagles for some time (at least 4-5 years). One eagle was observed perched on this nest a few days prior to the field survey (K. Brennan pers. comm.), and some scats were present below the nest,

indicating it is still used occasionally as a roosting/feeding platform. Nest 2 had been partially rebuilt and lined with fresh leaves sometime in the last two years, a behaviour which could be attributable to territoriality and/or an intention to breed (Olsen 1995). Although not recently active, both these nests could be useful as future breeding sites, as wedge-tailed eagles are known to refurbish old nests, and to use them as feeding platforms at any time (Ridpath and Brooker 1987). Other nests are almost certainly present throughout the landscape and could be located in future field surveys. The number of breeding eagles undoubtedly exceeds three pairs and probably exceeds the maximum of five to six pairs observed in this field survey. These birds are likely to be relatively sedentary in their territories, and there are probably several non-breeding 'floaters' which may traverse widely in the landscape. In areas of erratic rainfall such as Lorna Glen, breeding adult pairs usually remain in their territory even in periods of severe drought, when they choose not to breed (Robertson 1987). Future work is required to gain more information on eagle nesting density at Lorna Glen.

The one juvenile eagle was sighted only a few hundred metres from a recently active nest and had almost certainly fledged from this nest only a week or two prior to the field survey. Juvenile eagles such as this bird undergo a 'post-fledging' period, which usually lasts several months. During this time the young eagle relies on its parents for food, who gradually teach it to hunt for itself, staying in close proximity to a high density of food (S. Cherriman pers. obs.). It is therefore likely that this 'family trio' will remain in the vicinity of the fenced enclosure, where medium-sized mammals are prevalent, perhaps as late as mid-2012. The record of another such 'family trio' noted in March 2010 indicate the eagle pair nesting close to the enclosure have reared at least two young in the last three years. It is likely these birds disperse large distances (Ridpath and Brooker 1987) but further research is required to gain information on movements of juvenile birds.

4.1.2 Eagle diet

Information on wedge-tailed eagle food acquired from the diet analysis at Nest 3 and the observations provided by DEC staff indicates eagles may prey readily on introduced mammals inside the fenced enclosure. A larger sample size is required to give a comprehensive picture on eagle diet in this region, but the findings of this field survey are consistent with previous research on the species in Australia (see Cherriman 2007 for full review). The record of the predated mala was from a regurgitated pellet which contained a microchip, ID No. 132304, providing identification of this individual as animal MSE11, an adult male with a release weight of 1335 grams. This does not entirely prove the animal was killed by an eagle, only brought to the nest by one, but given eagles prefer live prey during breeding (Marchant and Higgins 1993; Olsen 2005), an eagle-induced death is highly likely. Mala are known to be predator-vulnerable and have often been observed sheltering in sparse, seemingly unsuitable vegetation diurnally (J. Dunlop pers. comm.), making them easy targets for eagles.

The golden bandicoots and boodie recorded as eagle prey at Nest 3 and the boodie predation event observed by DEC staff are not unusual. Wedge-tailed eagles readily prey upon nocturnal species, possibly flushing them or taking them after being flushed by another species from diurnal cover (Burnett *et al.* 1996; Cherriman 2007), or perhaps even taking animals as they are released from monitoring traps in daylight (Richards and Short 1998). This is especially likely when adult birds follow DEC vehicles during mammal operations (see observations in 'Results' section). Also, both these species have been recorded active in daylight hours: a boodie was recorded by a motion-sensitive

camera, foraging in late afternoon (1750h) on 29th August 2010; a golden bandicoot was detected by a motion camera entering a cage trap during mid-morning (~1000h) in December 2010. These observations suggest individuals such as those above would be vulnerable to eagles foraging in daylight.

Predation by eagles probably contributed to the translocation failure of mala in 2008, along with predation by terrestrial species (especially cat; Miller *et al.* 2010) which had easy access to mala prior to the fence being built. It remains to be seen whether 2010-released mala will continue to survive but current signs indicate the fenced enclosure has prolonged the life of founder animals and provides at least some evidence that wedge-tailed eagles are not alone responsible for all deaths. The presence of several medium-sized mammal species (which are increasing in abundance) probably acts as a buffer to the targeting of vulnerable species such as mala, as wedge-tailed eagles are thought to prey on animals according to relative abundance (Ridpath and Brooker 1986*b*). Golden bandicoots have faired well since release into the enclosure and there is evidence (e.g. tracks) of colonisation into the broader landscape (J. Dunlop pers. comm.), which makes them a further target for eagle food away from the enclosure. Indeed, the golden bandicoot preyed upon by whistling kites (see Section 3.1.4 'Opportunistic Observations' in Results above) was probably taken from around the kites' nest, *c.* 15 km east of the fenced enclosure; kites are unlikely to travel this distance from their nest for food.

5 CONCLUSIONS AND RECOMMENDATIONS

The field study conducted in October 2011 is considered a preliminary investigation on wedge-tailed eagle ecology at Lorna Glen, especially since this initial study was shorter than first planned. In light of the above information, the following recommendations are noteworthy:

- Conduct a follow-up study to locate more eagle nests at Lorna Glen and gain further insight into eagle nesting characteristics and diet.
- Trap and monitor the movements of both adult and juvenile eagles to gain information on dispersal, habitat use, including visitations to the fenced enclosure.

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