STATUS AND DISTRIBUTION OF THE WEDGE-TAILED EAGLE ON THE FLEURIEU PENINSULA, SOUTH AUSTRALIA, IN 2005

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ABSTRACT

From June to December 2005 the Fleurieu Peninsula in South Australia was systematically surveyed for Wedge-tailed Eagle *Aquila audax* breeding activity, an area of approximately 1,540 km^2. Eagle territories were found distributed throughout the region with breeding sites typically placed in remnant eucalypt woodland on the main river valley escarpments, or on steep gully slopes in tributaries.

Twenty-nine occupied territories were identified within the study area, of which 28 were confirmed as active. Another six localities were identified as possible territories where eagle pairs were present but a nest site was not found. Active nest sites were found to average 6.6 km apart (range 2.4–13.4 km) and, using 'nearest neighbour' proximity distances between active nest sites, the average home range of pairs was calculated to be *c.* 34 km^2 (range 18.1–75.5 km^2).

From an estimation of hatching dates among active pairs in this study, most pairs had commenced egg-laying/incubation by mid-July (range *c.* 6 July–16 August), and most young had fledged by mid-December. Productivity outcomes were determined for 23 active territories, with 0.91 young fledged/active nest and 1.11 young fledged/successful nest. Two young were fledged in each of two territories.

Between September 2003 and the conclusion of this study in December 2005, a small number of Wedge-tailed Eagle mortalities (n = 4) were reported at the one established windfarm in the region. In each case injuries sustained were attributed to collision with turbine blades or associated infrastructure and this equates to 1.71 deaths/year (or 0.07 deaths/turbine/year) at the site. Elsewhere in 2005, two other mortalities were attributed to electrocution at power distribution poles.

Persecution of eagles in the region was found to be largely non-existent, with the greater majority of landowners valuing the presence of resident pairs. Because of the proximity and frequency of various human activities, 10 of the territories, or 34%, were considered to be in highly disturbed habitat settings. However, it would appear that the Wedge-tailed Eagle has largely adapted to environmental and landscape change coincident with agricultural development on the Fleurieu Peninsula.

INTRODUCTION

Like other agricultural areas of South Australia, the Fleurieu Peninsula and adjacent southern Mount Lofty Ranges have undergone extensive clearance of native vegetation since European settlement to facilitate agricultural development (Nance and Speight 1986). This dramatic landscape modification has impacted the region's biodiversity, reducing or degrading habitats, and causing the regional extinction of some species and severe population decline among others.

Among the species reported to have been affected by these changes are the White-bellied Sea-Eagle *Haliaeetus leucogaster* and the Wedge-tailed Eagle *Aquila audax*. The White-bellied Sea-Eagle is reported as having declined over much of its range in South Australia and is known to occur at only one locality on the Fleurieu Peninsula (Dennis and Lashmar 1996; T. Dennis unpubl. data). Although common in arid areas of the State, the Wedge-tailed Eagle has also been reported as uncommon and having suffered population decline in the southern Mount Lofty Ranges and Fleurieu Peninsula region (Paton, Carpenter and Sinclair 1994a,b), possibly by as much as 20% (Barrett *et al.* 2003). Eagle pairs remain on their established territory throughout the year and are particularly vulnerable to disturbance at nesting sites (Olsen 2005).

Because of its geographical position, topography, and exposure to prevailing winds, Fleurieu Peninsula has attracted a number of windfarm development proposals in recent years. It is noteworthy that soaring raptors, such as large eagles, are known to have been affected by poorly sited windfarm developments elsewhere (Langston and Pullan 2003). At the one established windfarm in the Fleurieu region a small number of Wedge-tailed Eagle mortalities, attributed to collision with turbine blades or associated infrastructure, occurred in the first two years of operation (Lane and Associates 2005; Tarong Energy 2005; Department for Environment and Heritage regional records). In the impact assessment process associated with these developments, neither State Government agencies nor Birds SA (South Australian Ornithological Association) was able to provide authoritative data on the current status or population distribution of the Wedge-tailed Eagle in the region, or the conservation implications for the species if mortalities continued.

To overcome this knowledge gap, Birds SA commissioned a survey in 2005 to determine the number and distribution of Wedge-tailed Eagle breeding territories on the Fleurieu Peninsula. This study is reported here, providing for the first time a baseline population model for the Fleurieu Peninsula region.

METHODS

Survey area

The Fleurieu Peninsula is defined as the area to the south and west of a line between Port Willunga (*c.* 35°16'S, 138°28'E) and Goolwa (*c.* 35°30'S, 138°47'E). However, to cover likely overlapping Wedge-tailed Eagle territories a small area of the northern Sellicks Hill Range and southern Mount Lofty Ranges was included in this survey by arcing the survey boundary inland to the northeast by approximately five kilometres (Figure 1), making the area covered by the survey approximately 1,540 km^2.

Community involvement

Awareness of the project and its objectives was cultivated through co-operation from the Landcare advisory staff of the Adelaide and Mt Lofty Ranges Natural Resource Management Board (NRMB) based at Normanville and Mt Pleasant. They have an established rural community communication network reaching most landowners and resident primary producers throughout the Fleurieu Peninsula region.

In addition, articles were published in the regional rural community newsletter *Small Talk* (distribution of 28,500), *Birds SA Newsletter* and Fleurieu Birdwatchers group newsletter *Birdwatch*; a poster was placed on community noticeboards and distributed electronically to rural networks throughout the region; and a specific project email address was established (eagleobs@bigpond.com).

Background data

Background data consulted for the survey included: published articles in the literature; Australian National Wildlife Collection Oology database of early egg-collection sites for South Australia; South Australian Museum records; Birds SA records; and the National Nest Records Scheme through Birds Australia, Melbourne. These records, examined and used where appropriate, and contact with regionally based ornithologists, naturalists, and particularly landowners, proved invaluable for locating former breeding sites in areas still frequented by eagles.

Definitions

For this study the following definitions were used:

Home range—the extended area around the core territory that included favoured hunting and loafing areas, sometimes shared with neighbouring conspecific birds.

Territory—the space around a nest site (or sites) that is defended against conspecific birds and other species during the breeding season.

Occupied territory—locality where a pair was observed on at least two occasions, soaring over an area and performing territorial display flights where one or more recently built-up and lined nest structures were found, but where an active nest was not found.

Active territory status was assigned to a locality when either:

- an active nest site was located, e.g. incubation was observed, young were in the nest or had recently fledged and were nearby;
- an obviously recently vacated or deserted nest site was located, e.g. accumulated faecal spray and prey remains were littered below the platform;
- recently fledged young were observed on the wing with adults near to a suspected nest site, but the nest site was not found; or
- a pair was observed on at least two occasions, soaring over an area together late in the breeding season with one carrying prey, followed by a fast and direct low-level flight (by a bird with prey) toward a suspected nest location.

Successful territory—a territory where young were fledged.

Unconfirmed territory—a locality where a pair or a single adult was observed on at least two occasions soaring late in the breeding season (mid-October to mid-December), performing territorial display flights in the same area and distant from known active territories, but where nest searches were unsuccessful and fledged young were not seen.

Habitat disturbance

Each eagle territory was arbitrarily assessed for likely disturbance factors based mainly on proximity to human activities. These included: assessment of the intensity of agricultural and/or horticultural activities nearby; proximity to roads, tracks and walking trails; recreation activities; presence of overhead electricity transmission lines; and proximity to industry, residences or other occupied infrastructure.

Territories were classified as:

Low disturbance—when the nest site was in a relatively remote setting, e.g. no roads, tracks, walking trails or dwellings within 500 m; nest was not visible from roads, tracks, walking trails or dwellings; few people were likely to approach the nest site during breeding season.
Moderate disturbance—when the nest site was in a relatively semi-remote setting; people may gain access to within photography or missile range; roads, tracks, walking trails or dwellings occur within 500 m of nest; nest is visible from roads, tracks, walking trails or dwellings; some people, vehicle or machinery movements occurred within 500 m of nest site during breeding season.
High disturbance—when the nest site was in a relatively disturbed or developed setting; nest was clearly visible from roads, tracks, walking trails or dwellings; frequent people, vehicle or machinery movements occurred within 500 m and in full view of nest during breeding season.

Survey timing and strategies to minimise disturbance

Searching for occupied territories occurred from late June 2005 to mid-September. During this period extended observations were made throughout the survey area from vantage points overlooking likely habitat, using a high-resolution spotting scope and binoculars to minimise disruption to normal behaviours. During this time, expected territorial behaviours included display (territorial) flights and carrying nesting material. Nest search effort and approach was deliberately postponed until mid-October (through to mid-December) when active nests would contain developing young, hunting and prey-carrying flights would be frequent and obvious, and sensitivity to approach lessened (Olsen 2005).

When nest sites were located, observation of nest contents was conducted from a distant elevated position. When nest sites were approached, data-gathering time was kept to a minimum (<5 minutes) and the area vacated as soon as possible to allow the adults to resume normal behaviour.

The precise location of nest sites was determined by a hand-held GPS (Global Positioning System) unit, or in difficult terrain, by compass bearing and estimate of distance from a fixed point (determined by GPS). In each of the small number of latter cases, the offset position selected was <250 m distant from the nest and the equivalent GPS location calculated, using 30.8 m = 1" of Latitude and 25.2 m = 1" Longitude (adjusted for longitudinal convergence *c.* 35° south of the Equator).

RESULTS AND DISCUSSION

Resident population

Twenty-nine occupied territories were confirmed distributed throughout the study area (Figure 1). Twenty eight of these territories were rated as active, where:

- incubation behaviour, nestlings, or recently fledged young were observed ($n = 18$);
- obvious recently fledged young were observed on the wing with adults in an occupied territory but no active nest found ($n = 3$);
- pairs were present exhibiting territorial behaviour and a lined nest was found which showed signs of use ($n = 4$);
- territorial displays and direct prey-carrying flights were observed near typical nesting habitat late in the season in territories where an active nest had not been located ($n = 3$).

In addition to the confirmed territorial pairs, eagles were present and observed conducting territorial display flights more than once during the breeding season at a further six localities (Figure 1). However, non-paired males are also known to perform these flights (Olsen 2005), fledged young were not observed and nest searches in these locations were unsuccessful and therefore the status of these locations remains inconclusive. Four more territories were identified immediately adjacent to the study area in the southern Mount Lofty Ranges region (Figure 1), but were considered unlikely to overlap.

Early in the breeding season, in localities that were later determined to be between or on the edge of occupied territories, sub-adult eagles (assessed from plumage characteristics) were periodically observed, including one group of three. In addition, a few presumed non-territorial adults were observed in locations >10 km from known nest sites, particularly along the apparent corridors of aerodynamic lift over coastal cliffs on the southern coastline and escarpments along the Sellicks Hill Range. No sub-adults were recorded anywhere in the study area during the latter part of the breeding season (from late October to mid-December), most likely due to increased hunting activity over a wider area of the home-range by resident pairs with young,

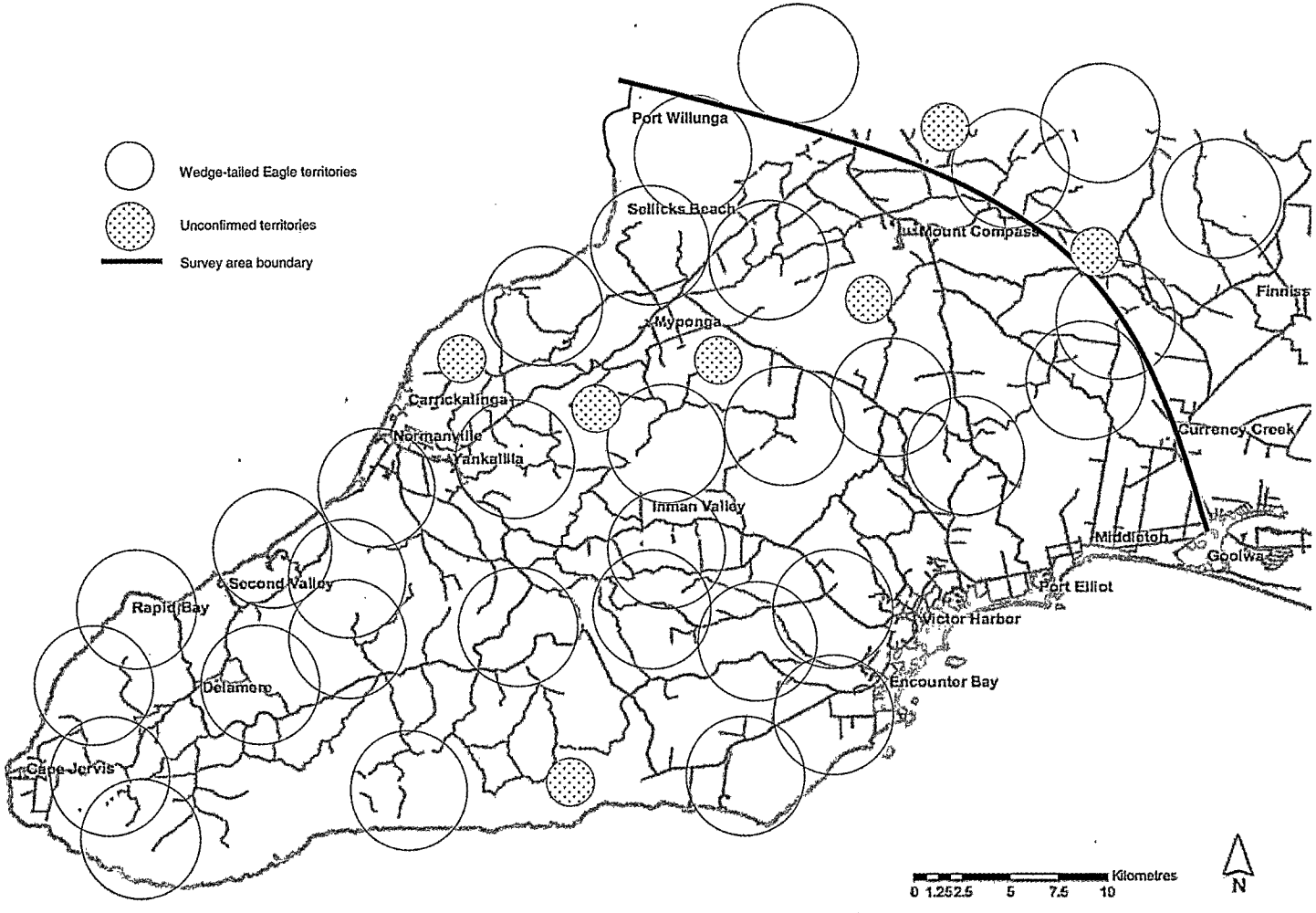

Figure 1. Map of the Fleurieu Peninsula showing the distribution and likely dimension of 29 active Wedge-tailed Eagle territories found within the survey area boundary in 2005 (represented by the larger circles), with an additional three active territories found nearby in the southern Mount Lofty Ranges. The smaller stippled circles represent probable, but unconfirmed, additional territories.

resulting in interlopers being driven off.

The precise locations of active nest sites were lodged with Birds SA in a confidential report (Dennis 2005) and the National Nest Record Scheme database administered by Birds Australia. To protect the interests of private landowners and ensure nest site security is retained, these precise locations are not reported here.

Nest-site selection

Topographic and vegetation characteristics were recorded at 30 nest sites. Most sites (25) were placed mid-slope on relatively remote, steeply sloping (*c.* 30°–65°) hillsides or gullies; four were high in large gum trees *Eucalyptus* spp. on the bank of a watercourse, and one was found in an atypical setting within a small copse (*c.* 4 ha) of remnant woodland surrounded by open pasture on flat terrain. Nests within or on the edge of remnant natural bushland (14) were invariably in a dominant older tree, with the nest platform having partial canopy cover and placed at or slightly above the level of surrounding foliage. The remaining nest trees, although similar in terms of canopy cover, were found in more open woodland settings with little or no understorey (7), or in grazed pasture (9). Among the latter, one tree was found to contain two nest structures, one of which was active.

Estimated nest height (above ground level) averaged 10.3 m (range 4.5–18 m). With the exception of nests in creek lines, nest aspect was found to vary, even among those within the same territory. Most sites were exposed to morning sun: north to northeast (2), east to northeast (7), east to southeast (5), south to southeast (4), south to southwest (3) and west to southwest (3).

Examples of Wedge-tailed Eagle habituation to human activity and infrastructure were found, including: an active nest that was <400 m from the nearest tower within the windfarm precinct at Starfish Hill (Figure 2), the same nest being active in 2004 (H. Thompson *in litt.*); another active nest that was *c.* 250 m from a farmhouse and sheds, but down-slope and out of view; and a third nest that was built in the early 1990s *c.* 400 m distant and in full view from a farmhouse and sheds, fledging young in most years since, including 2004 (V. Arthurs pers. comm.).

Breeding season

Likely breeding season commencement (egg-laying) was calculated from an estimate of nestling age at seven nests. This was based on a photographic index of known-age young showing the various stages of feather eruption and development (A. Lashmar unpubl.), which was used to determine an approximate hatching date. At three nest sites the actual fledging date was recorded. These young were scored as aged 84 days (known hatching to fledging 77–84 days) to allow for the asynchronous hatching (incubation commences with the first egg laid) and the disparity between male and female fledging age recognised for the species (Olsen 2005). From these calculated hatching dates, an incubation period of 43 days (Olsen 2005) was deducted to obtain approximate egg-laying dates (±5 days).

By applying this method at 10 active nests, egg-laying commencement was calculated to have ranged from 6 July to 16 August and spanned 42 days. However, if the two August egg-laying dates (Table 1) are excluded as possible clutch replacement events, which occur 30–40 days after egg loss (Brandon 1938), the main egg-laying period of early to mid-July is consistent with studies elsewhere in south-eastern Australia (Marchant

Figure 2. Site FP07 showing the proximity of an active Wedge-tailed Eagle nest (high in the tree at foreground) to the turbine towers at Starfish Hill windfarm.

and Higgins 1993).

At the three nests where fledging dates were obtained (8 November, 12 November and 5 December) these events were separated by 28 days.

Territory size

Overall territory size among Wedge-tailed Eagle populations varies widely between climatic regions, from an estimated 30–35 km^2 in temperate south-eastern Australia (Leopold and Wolfe 1970) to 40–48 km^2 in semi-arid and >100 km^2 in arid areas of Western Australia (Ridpath and Brooker 1986), and *c.* 80 km^2 in Tasmania (Bell and Mooney 1999). However, as with other *Aquila* spp. these differences are likely to be in response to prey abundance and availability rather than climatic factors or actual spatial requirement (Newton 1979; Steenhof, Kochert and McDonald 1997). No attempt was made to determine the influence of prey dynamics on the size of eagle territories in this study.

A simple division of the study area (1,540 km^2) between the numbers of territorial pairs identified (29) equates to 53.1 km^2/pair. However, this is over-simplified and likely to overestimate the area of home range required, as much of the landscape in the study area is highly modified for silviculture, horticulture and viticulture, and therefore highly unlikely to provide hunting range or the breeding-habitat character required by large eagle species. To provide an estimate of territory area in this study, all located active nest sites (n = 24) were plotted onto 1:50,000 topographical maps, and using the averaged mid-point distance to three 'nearest neighbour' active nests as a radius (r) of probable spatial 'ownership', a theoretical circular territory dimension was calculated for each (πr^2). The distance between nests averaged 6.6 km (range 2.4–13.4 km), providing an estimate of core territory area of 34.3 km^2 (range 18.1–75.5 km^2).

Productivity

Thirty-one young (including one from just outside survey area) were recorded. Of these, 14 were recently fledged close to a nest site and three were close to fledging, e.g. fully feathered and actively wing exercising on the nest platform or nearby branches; four were observed on the wing with both adults in a known occupied territory where the active nest site was not found; and the remainder were recorded at various stages of development early in the breeding season.

Although it was logistically beyond this study to determine productivity outcomes from all territories, data were obtained from 23 territories with an active nest (Table 2). Among these, four (17%) apparently failed or were deserted early in the season and 21 young fledged from the remainder. Two of these territories each fledged two young. Therefore, productivity for these territories was 0.91 young/active territory (n = 23) and 1.11 young/successful territory (n = 19).

Prey

Throughout the survey area rabbits were common and several landowners commented on their numbers being higher than for many years. The abundance of this prey may have resulted in additional territories being established in 2005.

Table 1. The temporal span of the Wedge-tailed Eagle breeding season over Fleurieu Peninsula in 2005. The symbol '+' represents the 3–5 day hatching period, which is asynchronous. A row of symbols '•' (at four 'weeks' per month) indicates the approximate period from egg-laying to fledging (±5 days), determined by estimating the age of young at 10 nest sites.

Site	July				August				September				October				November				December				January
FP01				•	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•			
FP02				•	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•			
FP05						•	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•	
FP07			•	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•				
FP09	•	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•						
FP10	•	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•						
FP13							•	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•
FP26		•	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•					
FP29	•	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•						
n/a*				•	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•			

* nest just outside study area

Table 2. Location, status and productivity (determined for 23 active sites) among Wedge-tailed Eagle territories found on Fleurieu Peninsula in the 2005 breeding season.

Locality	Number of territories			Number of young fledged
	Occupied	Active	Successful	
Southern coastal area (Goolwa to Cape Jervis)	5	5	3	3
Western coastal area (Cape Jervis to Normanville)	5	5	4	4
Western coastal area (Carrickalinga to Port Willunga, including Sellicks Hill Range)	3	3	1	3
Yankalilla River catchment	4	4	2	2
Myponga River catchment	1	1	1	1
Hindmarsh River catchment	2	1	1	2
Inman River catchment	6	6	5	5
Currency Creek catchment	2	2	1	1
Finniss River catchment	1	1	1	0
Totals	29	28	19*	21*

Some opportunistically located prey items were identified from remains found at ground level around active nest platforms or nearby feeding perches, by examination of regurgitated pellets and from observed prey-carrying flights. These (n = 56) included:

Mammal—Rabbit *Oryctolagus cuniculus* (8), Brown Hare *Lepus capensis* (2), Fox (juvenile) *Vulpes vulpes* (2), Common Ringtail Possum *Pseudocheirus peregrinus* (1), Feral Cat (juvenile) *Felis catus* (1), (14 mammals, 25% of prey by number).

Reptile—Eastern Bluetongue Lizard *Tiliqua scincoides* (3), Eastern Bearded Dragon *Pogona barbata* (4); (seven reptiles, 13% by number).

Bird—Sulphur-crested Cockatoo *Cacatua galerita* (2), Galah *Cacatua roseicapilla* (5), Pacific Black Duck *Anas superciliosa* (2), Australian Wood Duck *Chenonetta jubata* (6), Black Swan (juvenile) *Cygnus atratus* (1), juvenile corvid sp., most likely Little Raven *Corvus mellori* (14), Australian Magpie (juvenile) *Gymnorhina tibicen* (5); (35 birds, 63% by number).

Mortality

Although it was beyond the scope of this study to measure all mortality among the Wedge-tailed Eagle population on the Fleurieu Peninsula, the following incidents since mid-2003 illustrate some of the hazards facing the species in a modified environment:

- On 1 September 2003 an injured eagle was found near a wind turbine at Starfish Hill windfarm (Tarong Energy 2005). The bird was examined by a local veterinarian, but owing to extensive injuries it was subsequently euthanased (Department for Environment and Heritage [DEH] regional records).
- On 17 September 2003 a decapitated eagle carcass was found near the same turbine tower at Starfish Hill windfarm (Tarong Energy 2005; DEH regional records).
- On 27 April 2004 an eagle carcass was found underneath a 40 m anemometer mast at Starfish Hill windfarm, and was presumed to have been killed by collision with the mast support cables a short time earlier (Lane and Associates 2005).
- On 16 February 2005 an injured immature eagle was found *c.* 50 m from a turbine tower at Starfish Hill windfarm, but eluded capture (Lane and Associates 2005; DEH regional records).
- On 20 January 2006 two eagle carcasses were found beneath an electricity transmission pole near Stringybark Campsite in Deep Creek Conservation Park (DEH regional records).

No other mortalities, or incidents of eagle persecution, have been reported or investigated in recent years for the region (J. Bracken, DEH District Ranger, pers. comm.).

If the number of eagle mortality and injury incidents (n = 4) associated with the one windfarm site in the survey area is considered for the period 1 September 2003 (when most turbines were operating and the first injury was reported) to 31 December 2005 (*c.* 852 days or 2.33 years), a minimum population-impact rate of 1.71 deaths/year (0.07 deaths/turbine/year) is obtain-

Table 3. General location of Wedge-tailed Eagle territories categorised for disturbance on Fleurieu Peninsula in 2005.

Locality	Disturbance category		
	Low	Moderate	High
Southern coastal area (Goolwa to Cape Jervis)	3	–	2
Western coastal area (Cape Jervis to Normanville)	2	1	2
Western coastal area (Carrickalinga to Port Willunga, including Sellicks Hill Range)	–	2	1
Yankalilla River catchment	4	–	–
Myponga River catchment	–	1	–
Hindmarsh River catchment	1	–	1
Inman River catchment	3	2	1
Currency Creek catchment	–	–	2
Finniss River catchment	–	–	1
Totals	**13**	**6**	**10**

ed. However, bird-strike (all species) reporting is primarily based on the vigilance of company staff working on the site, and the results of trials to determine the rate of carcass removal by scavengers are not yet available (J. Ware, Tarong Energy, pers. comm.).

Habitat disturbance

Studies on *Aquila* and *Haliaeetus* species world-wide have consistently shown that large long-lived eagles readily desert a nesting attempt and show little or no nest defence, most likely as a strategy to ensure their own survival rather than survival of eggs or young (Newton 1979; Bell and Mooney 1999), and that human disturbance, in all its forms, during critical stages of the breeding season is the most significant cause of nest failure (Richardson and Miller 1993; Olsen 1998). Many of the 29 Wedge-tailed Eagle territories identified in this study were found to be exposed to various levels of human activities and disturbance. Six territories (21%) were rated as moderately disturbed and ten (34%) as occurring in highly disturbed habitat settings (Table 3).

As eagle persecution has now largely disappeared in southern Australia, the greatest compounding factor and threat to the survival of large eagle species is habitat degradation (Olsen 2005). In the Fleurieu Peninsula region this appears to be occurring insidiously over time through change of land-use. For example, subdivision of large properties with low-intensity grazing regimes into smaller holdings inevitably results in denser settlement and increased human activity in the landscape. However, it is apparent from the distribution and density of occupied territories found in this study, and from the level of productivity from active territories, that the Wedge-tailed Eagle on Fleurieu Peninsula has to date, largely adapted to environmental and landscape change coincident with agricultural development and human activities.

ACKNOWLEDGMENTS

My thanks to the many people from State or non-government resource and advisory agencies and especially to the rural community of the Fleurieu Peninsula, who have contributed in some way to the project by providing local knowledge, valued observations, property access, or simply came along and opened gates! These included:

Southern coastal area—Brenton Lush, Tony Johnson, Peter Biddle, Noris Ioannou, Volker Scholz and Stuart Southcombe (DEH), Chris and Karen Royans, Kristy Royans, Geoff Evans*, Phyl Whellam* and Judith Dyer* (*Fleurieu Birdwatchers Group), Nigel Crompton, Leanne Symons and Jack England. *Western coastal area* —Jim Stacey, Greg Wittlesea, Lou Wittlesea, Daryl Grosser, Paul Brown, Robert and Sue Bean, Mick McGrath, Rory and Annabel Fitzpatrick, John Croser, Jeff Ware and Mark Grothe (Tarong Energy), Hilary Thompson, John and Sally Crowe and Harry Holmes. *Yankalilla River catchment* – Laurie Lush, Robert Cox, Keith and Helen Shanahan, Geoffrey Bradford (Dept. of Water, Land and Biodiversity Conservation, DWLBC), Robin Delvin and Virginia McMillan (DEH), and Marcus Pickett (Conservation Council of South Australia, CCSA). *Myponga River catchment*—Bob Magor, Robin and Carol Cox de Vore, Craig Martin, Ben and Allison Paxton, Jeff Brittain, Tanya Schneyder (Greening Australia), Jane Hicks, and Rob Gilbert. *Hindmarsh River catchment*—Richard and Gwen Willing, Jeff Green, Marg Dent, Andrew Moylan (Forestry SA), Barbara King, Geoff Davis, Keith Michelmore (SA Water) and Ian Strathearn. *Inman River catchment*—Jacob Stephens, Ivan Ashby, Ken Duggan, Adrian Lush, Steve Cossey, Richard Littlely, John Crompton, Paul Stephens, Glenn Stephens, Sue Ellers, Michael Millard, Angela Panozzo, Henry Nott and Tanya Milne (DWLBC). *Currency Creek catchment*—Bill Keen, Kym and Brenda Bishop, Mathew Bonnett (Primary Industries and Resources South Australia, PIRSA), Mark Higgins, Jeff Higgins

and Tim Vale (CCSA). *Finniss River catchment*—Robert and Dolores Amos, David and Cheryl Mountford, John and Liz Tregenza, Maxie Ashton, Michelle Murray, Nick Crouch, Jason van Weenen (DEH), Vern Arthers, John Thonard, Mike Connor, Trevor Connor, Joyce Stone, Mick Harwood, Kevin Parkin, Jenny Brown and Amanda Paech.

Special thanks are also due to: Lisa Blake (PIRSA, Landcare Advisory Officer) and Liz Mathews (NRMB coordinator) and Sophie Piron for support and publicity through the Normanville Catchment Resource Centre; Nicole Bennett (PIRSA, and editor of *Small Talk*), Graham Carpenter (DWLBC and Birds SA) for access to the Birds SA Nest Record database, Verle Wood (Fleurieu Birdwatchers) for IT skills in preparing the project flyer; Chris Bowey (Victor Harbor Council) for providing the project base map; Ian Mason (CSIRO) for access to the Australian National Wildlife Collection Oology records; Mike Weston and Andrew Silcocks (Birds Australia) for access to the national Nest Record Scheme database and for supporting volunteer input to the project; Helen Dennis for logistical support and editing skills; Ross Brittain and Janette Diment for assistance in the field; Peter Shaughnessy (South Australian Museum) and Hilary Thompson for constructive comments on an early manuscript draft; and in particular Birds SA for instigating the survey and support throughout.

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Received 10 May 2006; accepted 7 October 2006