Effects of human disturbance during residential developments on the productivity of White-bellied Sea-Eagle in the Hunter Region, New South Wales

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Two pairs of White-bellied Sea-Eagle *Haliaeetus leucogaster* attempting to nest <400 m from residential developments in the Hunter Region, New South Wales were monitored during the 2016 breeding season and productivity outcomes recorded. The Chisholm sea-eagles flushed from the nest when construction vehicles were driven past and their nest was unsuccessful. The Fletcher sea-eagles did not respond to human disturbance and their nest was successful (one young fledged). However, the Fletcher nest was later removed for road construction. These results reinforce the need for site-specific management actions to mitigate White-bellied Sea-Eagle population decline in the Hunter Region.

INTRODUCTION

Breeding of the White-bellied Sea-Eagle *Haliaeetus leucogaster* is from June to December in southern Australia and eggs are laid from June to September (Marchant & Higgins 1993). Paired sea-eagles build a large nest of sticks lined with leaves, grass or seaweed, 3-40 m above the ground in a tall, live eucalypt *Eucalyptus* sp. (on the mainland), usually within 1 km of a major water body (Emison & Bilney 1982; Marchant & Higgins 1993; Debus 2008; Corbet & Hertog 2011; O'Donnell & Debus 2012). They often reuse and add to the same nest in consecutive years and may have more than one nest in their territory (Marchant & Higgins 1993). Sea-eagles lay 1-3 eggs (usually 2). The incubation period is 40-42 days, the nestling period is 81-84 days and the post-fledging period of dependence is 2-3 months (Debus 2019).

Breeding success of sea-eagles is subject to fluctuations due to natural (Corbet & Hertog 2011) and human threats (Emison & Bilney 1982; O'Brien & Lacey 2016). Human threats include land clearing, coastal development, loss of foraging resources, recreational activities, entanglement in fishing gear, non-target poisoning and deliberate persecution (NSW Government 2021a). They have adversely affected sea-eagles in Queensland (O'Donnell & Debus 2012; Debus *et al*. 2014), New South Wales (NSW) (Spencer & Lynch 2005; Debus 2008; O'Donnell & Debus 2012; Debus *et al*. 2014), Victoria (Emison & Bilney 1982; Bilney & Emison 1983; Clunie 2003; O'Brien & Lacey 2016), Tasmania (Thurstans 2009), South Australia (Dennis & Lashmar 1996; Dennis 2004; Dennis & Baxter 2006; Dennis *et al*. 2011a; Dennis & Detmar 2018) and the Northern Territory (Corbet & Hertog 2011).

Human disturbance may lead to White-bellied Sea-Eagle population decline (Dennis & Detmar 2018). It adversely affects the productivity of sea-eagles (Emison & Bilney 1982; Clunie 2003; Shephard *et al*. 2005; Debus *et al*. 2014; Dennis & Detmar 2018), especially during courtship and nest building and repair; egg-laying and early incubation; and incubation and the early nestling period (Dennis *et al*. 2012). Furthermore, the level of human disturbance adversely affects production of eggs, success of active nests, frequency with which occupied territories successfully fledge young in a season and proportion of territories in which two young fledge in a year (Dennis *et al*. 2011b).

When human disturbance of established nests has been unavoidable (e.g. during road construction), mitigation measures have sometimes been attempted. However, these mitigation measures, which include relocation of a nest to an artificial platform, removal of nests to encourage rebuilding and establishment of buffer zones, have not been successful in the long term (Debus *et al*. 2014).

In Australia, the White-bellied Sea-Eagle is protected as a marine species under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). In NSW, the

White-bellied Sea-Eagle was listed as Vulnerable under the Threatened Species Conservation Act 1995 (TSC Act) in 2016. It is now listed as Vulnerable under the Biodiversity Conservation Act 2016 (BC Act), which replaced the TSC Act in 2017 (NSW Government 2021a). It has been assigned to the landscape species management stream under the Saving our Species (SoS) program because it "is distributed across relatively large areas and is subject to threatening processes that generally act at the landscape scale (e.g. habitat loss or degradation), however, requires management at a site level with a focus of conserving key nesting sites" (NSW Government 2021b). The SoS program aims to ensure that the White-bellied Sea-Eagle is secure in the wild in NSW, that its NSW geographic range is extended or maintained and that its conservation status under the BC Act is maintained (NSW Government 2021b). The Biodiversity Offsets Scheme (BOS) and the Biodiversity Assessment Method 2020 (BAM) were established under the BC Act. The BOS is the framework for offsetting unavoidable impacts on biodiversity from development (NSW Government 2022a) and the BAM is used to assess impacts on threatened species and their habitats (NSW Government 2022b).

The White-bellied Sea-Eagle is a usual resident of the Hunter Region, NSW. The population is thought to be stable (Williams 2021), although the exact number of breeding pairs and suitable territories is not known. However, human disturbance during residential developments has adversely affected the breeding success of sea-eagles in other parts of NSW (Debus *et al.* 2014). Therefore, the aim of this study was to determine whether residential construction activities would negatively affect the breeding success of sea-eagles in the Hunter Region. The objectives were to 1) record whether the nests were successful or unsuccessful, and 2) document the response of sea-eagles to residential construction activities <400 m from their nests. This paper presents observations of two pairs of White-bellied Sea-Eagle in one breeding season (2016) at Chisholm and Fletcher in the Hunter Region.

METHODS

On 13 June 2016, a White-bellied Sea-Eagle nest was discovered at Chisholm (32º45'S, 151º38'E) near Newcastle, NSW (**Figure 1**). The habitat was open farmland with scattered eucalypts. Excellent foraging habitat containing waterfowl and shorebirds was available at Morpeth Wastewater Treatment Works (MWTW) and its surrounding ephemeral flood plain (~1.5 km from the nest) (Newman & Lindsey 2016). The nest was in the fork of a eucalypt with dead branches 20+ m in height (**Figure 2**). The nest tree was on private land but only ~45 m from a boundary fence separating the private land from a new residential development. At the beginning of this study, the nearest construction activities were ~320 m from the nest tree. Residential lot markers were on the grassed slope between Twister Street and the nest tree, however, construction of Percher, Rockmaster and Wiretail Streets (~238, ~138 and ~114 m respectively from the nest tree) had not begun (**Figure 1**).

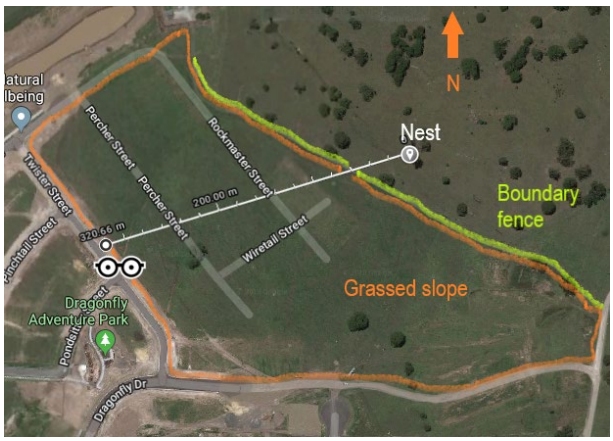

Figure 1. A White-bellied Sea-Eagle nest at Chisholm (0 end of ruler) was ~320 m from the nearest human disturbance (residential construction activities) in June 2016. My observation point in my car is shown (glasses sticker) (Google, 2016a).

Figure 2. A pair of adult White-bellied Sea-Eagles was observed on a nest at Chisholm on 13 June 2016.

On 5 July 2016, a White-bellied Sea-Eagle nest was discovered at Fletcher (32º52'S, 151º38'E) in Newcastle, NSW (**Figure 3**). The habitat was a cleared infrastructure corridor (power lines) ~500 m wide between strips of remnant bushland and new residential developments. Good foraging habitat containing waterfowl was available at Pambalong Nature Reserve and Hunter Wetlands National Park (both ~2.6 km from the nest). The nest was in the fork of a living eucalypt 20+ m in height (**Figure 4**). At the beginning of this study, the nearest construction activities were in The Outlook Estate ~365 m from the nest tree (**Figures 3**, **5**).

Figure 3. A White-bellied Sea-Eagle nest at Fletcher (0 end of ruler) was ~365 m from the nearest human disturbance (residential construction activities) in July 2016. My observation point in dense bushes is shown (glasses sticker) (Google, 2016b).

Figure 4. A juvenile White-bellied Sea-Eagle with an adult was observed on a nest at Fletcher on 21 November 2016.

Field observations were made opportunistically from concealed locations ~320 m from the Chisholm nest (glasses sticker, **Figure 1**) and >200 m from the Fletcher nest (glasses sticker, **Figure 3**). They were made 3-11 times per month in the breeding season, June to November (**Table 1**) using binoculars (Barska 10-30 x 50 mm Gladiator Zoom). From August, field observations of the Chisholm nest were mostly made on the weekends because the continual construction activities on weekdays made access to the site difficult. Field observations of the Fletcher nest were mostly made on weekdays from ~1600 h. Total time observed was 37.5 h (Chisholm) and 30.4 h (Fletcher) (**Table 1**).

Figure 5. Construction activities were taking place ~365 m from a White-bellied Sea-Eagle nest at Fletcher on 1 August 2016.

Table 1. Number of visits to, and combined observation time for, two active White-bellied Sea-Eagle *Haliaeetus leucogaster* nests in the Hunter Region, NSW. (No. = number; h = hours)

Month	**Chisholm nest**		**Fletcher nest**	
	Visits (No.)	**Time observed (h)**	**Visits (No.)**	**Time observed (h)**
June	4	4.7	0	0
July	5	6.0	3	4.8
August	5	6.8	3	3.0
September	6	5.3	6	9.6
October	11	13.6	5	4.8
November	3	1.1	9	8.2
Total	**34**	**37.5**	**26**	**30.4**

Photographs were taken with a Canon 7D with an EF 100-400 mm F/4.5-5.6L IS lens. The construction vehicles shown in **Figures 5** and **6** were de-identified because I assumed that the company had all relevant approvals to work near the nests during the breeding season.

Figure 6. Two excavators were being driven <100 m from an active White-bellied Sea-Eagle nest (see **Figure 2**) at Chisholm on 18 August 2016.

In this study, a nest was considered active if an adult sea-eagle appeared to be in an incubating posture on it (a nesting attempt was made) (Bilney & Emison 1983). Further signs that a nest was active included the presence of both adults in the nest, and delivery of food or leaves (fresh nesting material) to the nest (**Table 2**). A nest was considered successful if at least one young fledged and unsuccessful if no young fledged (Bilney & Emison 1983). Both nest sites were assigned to the high disturbance category used in other studies because there were people, roads, tracks and dwellings within 200-500 m of the nest during the breeding season (Dennis 2004).

RESULTS

Chisholm

On 13 June 2016, two adult sea-eagles were observed calling in duet on a guard-roost (vantage point in the territory), copulating and visiting a large nest (**Figure 2**). Subsequent visits by me confirmed that the nest was active until at least 17 September (**Table 2**). From 25 September, the adults were not observed in the nest but they were still in the territory. Juveniles were not observed in the nest or territory.

Table 2. Observation days on which there were signs that two White-bellied Sea-Eagle *Haliaeetus leucogaster* nests in the Hunter Region, NSW were active. (Sign: T = one or both adults in territory but not in nest; D = call in duet; C = copulate; ON = one adult in nest; BN = both adults in nest; F = food delivery (Chisholm, fish; Fletcher, waterbirds); L = leaves delivery (fresh nesting material); JN = juvenile in nest; JT = juvenile in tree)

Month	Chisholm nest		Fletcher nest	
	Day of month	Sign	Day of month	Sign
June	13	D; C; BN		
	25	T; D		
July	9	T; D	5	T
	18	ON	19	T
	23	ON	26	T
August	18	BN	1	ON
	20	BN	15	T
	21	BN; L	29	ON
	27	BN		
	28	D; BN		
Septem-	4	D; BN; F	1	T
ber	10	BN	5	ON
	11	ON	15	T
	17	D; BN	19	T; F
	25	D; T	26	BN; F
			30	T; F
October	1	T	5	T
	2	T; L	6	ON
	3	T	11	ON; F
	9	T	18	T
	29	T	20	T
Novem-	12	T	2	ON
ber			11	T; F; JN
			15	JN
			17	T; JN
			21	ON; JN
			24	JT
			25	T; JT
			28	JT

On 13 July 2016, the first evidence of construction activities (soil pile, materials, construction vehicle) on the grassed slope was observed. Subsequent visits revealed that drainage, road and then house construction was proceeding between ~0800and 1700 h on weekdays. Early in the breeding period, disturbance was mainly from movements and sounds made by construction vehicles and workers. The sea-eagles flushed from the nest whenever construction vehicles were driven past (**Figure 6**) and sometimes returned to the nest within 15 minutes after construction vehicles were turned off for the day (**Table 3**). Late in the breeding period, disturbance was mainly from movements and sounds made by tradespeople, power tools, cars and walkers.

Fletcher

On 5 July 2016, a White-bellied Sea-Eagle was observed flying over a territory containing a large nest. Subsequent visits revealed that the nest was active (**Table 2**) and on 11 November, a juvenile was observed in the nest (**Figure 4**). On 24 November, the juvenile perched in the nest tree and on 28 November, it perched in a different tree and then flew into denser bushland.

During observations, the continual sounds made by construction vehicles in The Outlook Estate (**Figure 5**) were not sudden or excessively loud. The sea-eagles were not observed responding to construction activities. People movements in the infrastructure corridor were rare and transient.

Table 3. Human disturbance and response characteristics at a White-bellied Sea-Eagle *Haliaeetus leucogaster* nest at Chisholm, NSW.

Date (2016)	Human disturbance	Distance of disturbance from nest (metres)	Duration of observed disturbance (minutes)	Response of White-bellied Sea-Eagle
18 July	Construction vehicles	60	75	One adult flushed repeatedly from the nest
30 July	Construction vehicle	200	75	Neither adult seen
18 August	Construction vehicles	60	30	Both adults returned to the nest after construction vehicles turned off at ~5:00 pm
28 September	Construction vehicles Power tools People	60-150	26	Neither adult seen

DISCUSSION

This study found that two active White-bellied Sea-Eagle nests situated <400 m from residential construction activities had different outcomes: the more highly- and frequently-disturbed Chisholm nest was unsuccessful and the Fletcher nest was successful. As seen at Chisholm, a nest will probably be unsuccessful if sea-eagles are subjected to sudden new disturbance (e.g. new, closer construction activities). However, as seen at Fletcher, a nest may be successful if sea-eagles are habituated to routine disturbance (e.g. construction activities that commenced before the breeding season) (Debus *et al.* 2014).

The distance from the disturbance to the nest and the intensity and duration of the disturbance near the nest are likely to have played a major role in breeding outcomes. The finding that the Chisholm sea-eagles only responded to disturbance that was <320 from the nest supports the recommendation that a minimum buffer zone of 250 m should be maintained when a nest is close to existing developments (NSW Government 2021b). The proximity of chronic disturbance to the Chisholm nest (sometimes <100 m) from July onwards is likely to have contributed to the unsuccessful nesting attempt (Debus *et al*. 2014). Conversely, the farther distance of similar chronic disturbance from the Fletcher nest (>365 m) and the apparent decrease in loudness is likely to have contributed to the successful nesting attempt.

The nest site characteristics may have played a role in breeding success. The unsuccessful Chisholm nest in a tree with dead branches located in farmland with scattered trees was level with, and in clear view of, construction activities (**Figures 1**, **2**). The successful Fletcher nest in a living tree in remnant bushland (**Figures 3**, **4**) was on higher land than the construction activities, and partly visually screened from them. Nest sites with little or no visual screening are particularly vulnerable to disturbance from human activity and approach (Dennis & Detmar 2018). The outcomes of these two nesting attempts support Bilney & Emison (1983), who found that sea-eagles nesting in pastures with scattered large trees fledged only 0.2 young per occupied territory and sea-eagles nesting in remnant stands of secluded, dense, tall open forest fledged 1.2 young per occupied territory.

Access to suitable foraging habitat is not thought to have played a role in breeding success. Both pairs had access to excellent foraging habitat. Interestingly, the Chisholm sea-eagles were observed with one fish prey item while the Fletcher pair was observed with four waterbird prey items (family Rallidae). This may be because of differences in the type, abundance or accessibility of prey in each foraging habitat. It may also be because the Chisholm nest was located closer to the nearest major water body. The finding that the Fletcher nest was successful is consistent with Bilney & Emison (1983), who found little difference in the productivity of territories that were less than 1 km and territories that were 2-20 km away from coastal lakes.

Since 2016, both pairs may have had only a limited number of years to breed successfully in their territories because of ongoing large-scale land clearing for residential developments. Prior to 2016, the Chisholm pair was suspected to have bred in a previous (first) nest in the ephemeral wetlands near MWTW (Newman & Lindsey 2016) and since 2016, were known to have bred in a third nest (Ann Lindsey pers. comm.). However, land clearing and house construction are currently occurring near the second and third nests. In 2017, the Fletcher infrastructure corridor was cleared for residential development. By September 2018, the active Fletcher nest, nest tree and surrounding trees had been removed for the construction of Wonnai Street. Extensive land clearing is currently occurring between Fletcher and Minmi. The human disturbance during these residential developments is likely to have displaced both pairs of sea-eagles to sub-optimal habitats (Emison & Bilney 1982; Dennis & Detmar 2018).

Why construction activities were undertaken less than 100 m from an active nest during the breeding season at Chisholm and why an active nest was removed at Fletcher are questions that remain to be answered. Sadly, these White-bellied Sea-Eagle pairs just missed out on protections afforded by the TSC Act, BC Act, SoS program, the BOS and the BAM (Luke Foster pers. comm.). The NSW Scientific Committee made a Final Determination to list the White-bellied Sea-Eagle as a Vulnerable species in NSW under the TSC Act and gazetted this conservation status on 16 December 2016. The BOS and BAM 2017 (NSW Government 2022c) came into force under the BC Act, which commenced on 25 August 2017 (NSW Government 2022d). The results of human disturbance on the two active nests described here highlight the importance of legislation for land management and biodiversity conservation, especially in urban areas in heavily populated coastal south-eastern Australia.

The main limitation of this study is that only two breeding pairs of White-bellied Sea-Eagle were observed, so there is insufficient comparative data from which to draw extensive conclusions. However, the observation that an active nest was unsuccessful after being subjected to continual residential construction activities during the breeding season supports previous findings in larger studies (Debus *et al*. 2014; Dennis & Detmar 2018). Possible future studies in the Hunter Region include estimating the number of breeding pairs, identifying and protecting nest sites and maintaining and improving suitable habitat (Clunie 2003).

CONCLUSIONS

Human disturbance during residential developments can lead to sea-eagles abandoning active nests. It is critically important that breeding sites in the Hunter Region are identified and assessed in accordance with the BAM so that buffer zones can be applied to minimise disturbance and prevent clearing. Otherwise, the White-bellied Sea-Eagle population in the Hunter Region may decline.

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