CORELLA

Volume 40 Number 3 September 2016

Journal of
The Australian Bird Study Association

Registered by Australia Post
Print Post Approved – PP226018/0008

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All papers published in Corella are subject to peer review by two referees.

Postal address of the Association is:

PO Box 1867, Penrith BC NSW 2751

Printer: Arrow Print, 5 Robertson Place, Penrith, NSW 2750

eISSN 2203-4420 / ISSN 0155-0438

Corella, 2016, 40(3): 53-60

Monitoring the Rufous Scrub-bird *Atrichornis rufescens* in the New England region

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Received: 30 April 2014

A locally-based monitoring survey of the Rufous Scrub-bird *Atrichornis rufescens* in the New England region was undertaken during three breeding seasons from 2010 to 2013 to establish baseline numbers of territories. Twelve kilometres of transects were established in the Horseshoe Road area in known Scrub-bird habitat and surveyed 10 times. Twelve 'territories' were identified based on male birds calling on three separate occasions from the same site. It required seven surveys to identify the 12 territories and all of them remained occupied at the completion of the survey in 2013. Monitoring of this species is possible due to the conspicuous calling of male Scrub-birds; they were detected on 64 percent of systematic surveys of known territories. The habitat along Horseshoe Road appears to be of high quality for the Rufous Scrub-bird as numbers of territories were similar to surveys undertaken using similar methods in what is considered high quality habitat in the Barrington Tops and Wiangaree areas. A comparison with previous surveys involving different methods in the Horseshoe Road area from 1997 to 2004 indicated that territory numbers are stable (12 now compared with 13 previously) and that 75 percent of current territories are in the same location as previously.

INTRODUCTION

The decline of biodiversity globally (Butchart *et al.* 2010) and in Australia (Ritchie *et al.* 2013) increasingly necessitates monitoring programs that can identify the declining elements of biodiversity, the severity of the declines and ideally guide management responses to address the declines. Long-term datasets are likely to become an increasingly important resource in monitoring biodiversity (Magurran *et al.* 2010), but designing a cost-effective program that delivers reliable long-term data is a formidable challenge.

A strong-inference (Burton 2012) or question-driven (Lindenmayer and Likens 2010) approach to monitoring emphasises rigorous study design and is at the very least an aspiration for many monitoring programs. With a multitude of monitoring programs needed, however, it is difficult to obtain sufficient resources to cover them all to an exacting standard, and scientific specialists and statisticians are not always available. At the other end of the spectrum, locally-based monitoring (Burton 2012) is typically less expensive and carried out by local personnel. It is also prone to failure for reasons such as lack of focus or a poor design that diminishes confidence in the results. Reid *et al.* (2013) give some Australian examples of unsuccessful locally-based monitoring, while Lindenmayer and Likens (2010) list a host of factors that may derail monitoring programs.

The Rufous Scrub-bird *Atrichornis rufescens* is a relictual Gondwanan species of high elevation wet forests of northeastern New South Wales (NSW) and far southeastern Queensland (QLD). It is an appropriate subject for monitoring because it is: a rare and extraordinary species (Chisholm 1951; Ferrier 1984; Higgins *et al.* 2001, Gole and Newman 2010); considered to be endangered (Garnett *et al.* 2010; BirdLife International 2012); formally listed as a threatened species in NSW, QLD, nationally and internationally; and potentially at risk, as a mountain-top relic, to decline from rising temperatures as a result of climate change. Another important reason for monitoring is that while the species is generally thought to still be declining (Garnett *et al.* 2010; BirdLife International 2012), there is little hard evidence available.

Monitoring is a cornerstone of the Important Bird Area (IBA) program of BirdLife International and BirdLife Australia (Dutson *et al.* 2009; BirdLife International 2013). IBAs are sites of global bird conservation significance and the Rufous Scrub-bird is a key species of five Australian IBAs, including the New England IBA in northeastern NSW. To fulfil the monitoring requirements of the IBA program a monitoring program was established in 2010 for the species in three IBAs; Gloucester Tops, Scenic Rim (Newman *et al.* 2014) and New England.

Monitoring the Rufous Scrub-bird presents a particularly challenging dilemma. Strong inference is most needed for rare and threatened species, but these are precisely the species for which this type of monitoring is extremely difficult to achieve (Pavlacky *et al.* 2012). For example, a previous monitoring program for the species (Ekert 2005b) was discontinued in 2005 following the loss of funding and issues regarding its effectiveness (Cunningham and Welsh 2000; EcoLogical 2009).

This study did not receive any specific funding and was undertaken with part-time contributions from staff of the NSW Office of Environment and Heritage and local volunteers. It is an example of locally-based monitoring and adhered to the injunction that IBA monitoring "…must be simple, robust and cheap…produce useful data, but avoid unnecessary sophistication…[and] involve the local community in collecting data" (Birdlfe International 2006, p.9).

The aim of the monitoring was to establish baseline data for the distribution of the Rufous Scrub-bird along transects established in the Horseshoe Road area, within or adjacent to the New England IBA. Horseshoe Road was chosen because Scrub-birds were known to occur in the area, it is accessible, and as a comparatively low elevation and isolated occurrence, decline is reasonably likely. Surveys were carried out from 2010 to 2013 and a comparison of the results is made with previous surveys (1997 to 2004) in the same area.

METHODS

Male Rufous Scrub-birds hold territories from which they call consistently, particularly in the breeding season. Surveys were carried out between September and December, which is the period shown by Ferrier (1984) and Stuart *et al.* (2012) to encompass the peak calling rate. The survey method used was adopted from Ferrier (1984) and Newman and Stuart (2011). All Scrub-birds heard or seen along a predetermined one-kilometre transect were recorded using a GPS and estimate of the perpendicular distance and direction from the transect. Territories were identified by clusters of records obtained from repeated surveys.

Only a small number of observers (either singly or in pairs) who were experienced in the identification of Rufous Scrub-bird calls were used. Surveys were conducted in the morning, starting at dawn or soon after and continued until about 11 am. Transects were walked in 30 minutes. This rate (2 km/hr) was similar to the 2.5 kilometres per hour walked by Ferrier (1984). Each transect was surveyed a total of 10 times. Call playback was not used systematically, based on the experience of Ferrier (1984) and earlier monitoring surveys by the NSW National Parks and Wildlife Service (NPWS). However, playback was used opportunistically outside of the formal survey.

A 'territory' was defined as a site where a Rufous Scrub-bird was heard calling on at least three occasions, with each record at least one month apart. A site was considered to be roughly one hectare based on the area reported by Ferrier (1984) in which a territorial male spends 95 percent of its time (1.13 ha). This definition is similar to that used by Newman and Stuart (2011) in the pilot stage of their Scrub-bird surveys of Gloucester Tops, although they used the less stringent criteria of two records at least three weeks apart. After the first year of their study, they used the more exacting criteria that territories should be occupied in successive years to be considered permanent (Newman *et al.* 2014).

Originally, fourteen transects were established in the Horseshoe Road area (Fig. 1), centred on known Rufous Scrub-bird habitat. They were located along roads in five areas: Boot Hill (1 transect), Bellbucca Road (2 transects), Mt Killiekrankie (3 transects), Kilprotay Road (6 transects) and League Scrub (2 transects). All transects contained habitat that was previously known to support Scrub-birds. However, when Scrub-birds could not be located at League Scrub, the two kilometres of transects at this location were discontinued (thereby leaving 12 km in total).

Rufous Scrub-bird data from the current and previous surveys such as the systematic NPWS surveys of 1999, 2001, 2002 and 2004 were collated and, where necessary, entered into the *Atlas of NSW Wildlife*, as well as a number of opportunistic records.

RESULTS

It required 22 visits to systematically survey all transects 10 times. Systematic surveys were conducted over three breeding seasons from 4 November 2010 to 12 February 2013. Scrub-birds would call during light rain and light wind, and would continue calling throughout the day unless there was moderately strong wind or bright sunshine (when calling rates would decrease, although not stop completely). On sunny days, surveys ceased by about 11 am. On one occasion, a survey was carried out in the late afternoon. The earliest time in the season that a survey was undertaken was on 4 September and all surveys were completed by 21 December, with the exceptions of two surveys carried out in early February 2013 to complete the study.

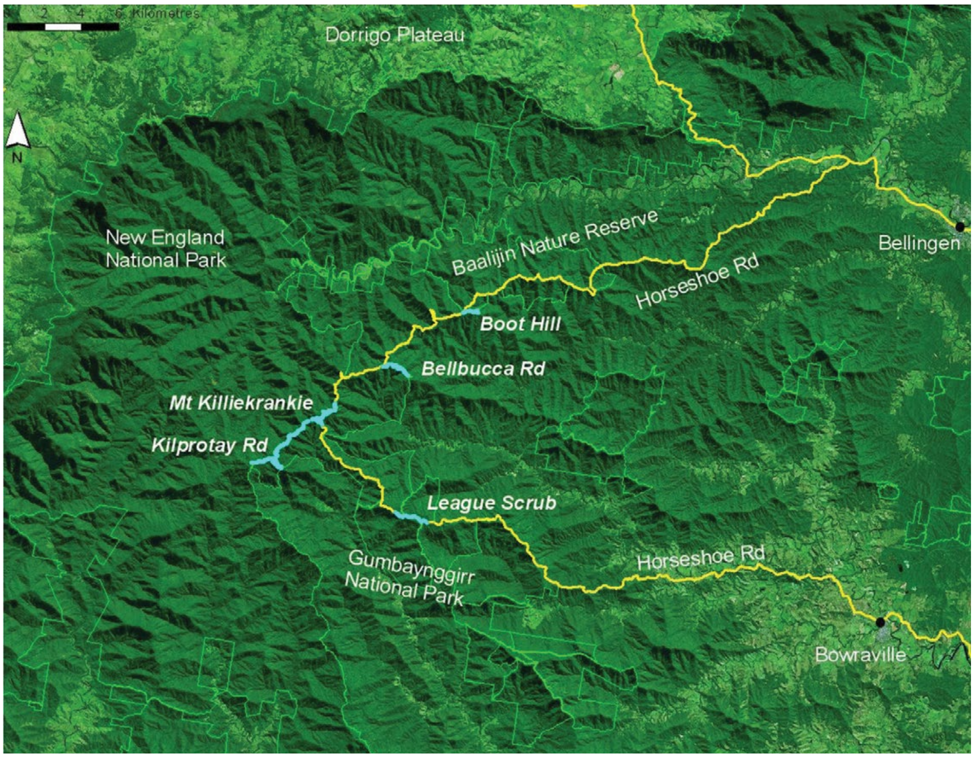

Figure 1. *The Horseshoe Road study area showing the location of the transects in blue.*

The two kilometres of isolated transects at League Scrub may no longer contain Rufous Scrub-birds as considerable survey effort was expended in the area (five systematic surveys and many non-systematic visits) without success. League Scrub also had a relatively high incidental visitation rate for this region due to the presence of an old camp site, but no recent sightings have been reported. Systematic surveys were discontinued at League Scrub after five surveys due to the absence of Scrub-birds and the high logistical cost of visiting the area. League Scrub data were subsequently excluded as this study is focussed on areas that are currently occupied by the species.

Call playback was not used in the systematic surveys. However, extensive opportunistic use of playback indicated that birds sometimes respond, occasionally quite vigorously. The use of this technique could be reconsidered in future if it can be conducted without significant disruption to the birds.

Twelve territories were identified (Fig. 2) based on the definition of three records at a site more than one month apart. All territories were occupied in more than one season.

Territories were at least 300 metres apart. Records were tightly clustered at each territory (Fig. 3). They occurred within an area of about one hectare, consistent with the male territory size estimated by Ferrier (1984).

The average estimated distance of the territories from the transects was 40 metres. The most distant territory was estimated at 80 metres and closest at 20 metres. Two of the closest territories included the transect itself (i.e. crossed the road).

Scrub-birds were successfully located on 64 percent of systematic surveys at the 12 territories (Table 1) during systematic surveys (120 surveys; 77 records).

The accumulation rate of Rufous Scrub-bird records and territories with increasing numbers of surveys is displayed graphically in Figure 4.

Three opportunistic visits were conducted outside the preferred calling season (31 March 2013, 8 July 2013 and 18 July 2013). Territories were visited on 26 occasions and birds detected 13 times (i.e. a 50% detection rate). This rate is not directly comparable with the 64 percent detection rate achieved in the breeding season as a significantly longer period of time was spent at territories during the opportunistic surveys (about twice as long). Nine of the 12 known territories were confirmed to be occupied during these surveys.

All the records were based on calls, although the bird was also seen on five occasions. There were no occasions where more than one male was heard calling at a time. On three occasions, contact calls were heard between two birds (one male). Species mimicked included the Superb Lyrebird *Menura novaehollandiae*, Australian King Parrot *Alisterus scapularis*, Australian Logrunner *Orthonyx temminckii*, Eastern Yellow Robin *Eopsaltria australis*, Grey Shrike-thrush *Colluricincla harmonica*, Golden Whistler *Pachycephala pectoralis*, Grey Fantail *Rhipidura albiscapa*, White-browed Scrub-wren *Sericornis frontalis*, Yellow-throated Scrub-wren *Sericornis citreogularis*, White-throated Treecreeper *Cormobates leucophaea*, Lewin's Honeyeater *Meliphaga lewinii* and Green Catbird *Ailuroedus crassirostris*.

A dense rainforest understorey beneath canopy gaps characterised at least part of all the territories (Fig. 5).

A significant number of systematic and non-systematic surveys were previously conducted along the Horseshoe Road from 1997 to 2004, particularly those by Ekert (2000, 2002, 2005a, 2005b) and Seccomb (unpub.). Clearly, with the

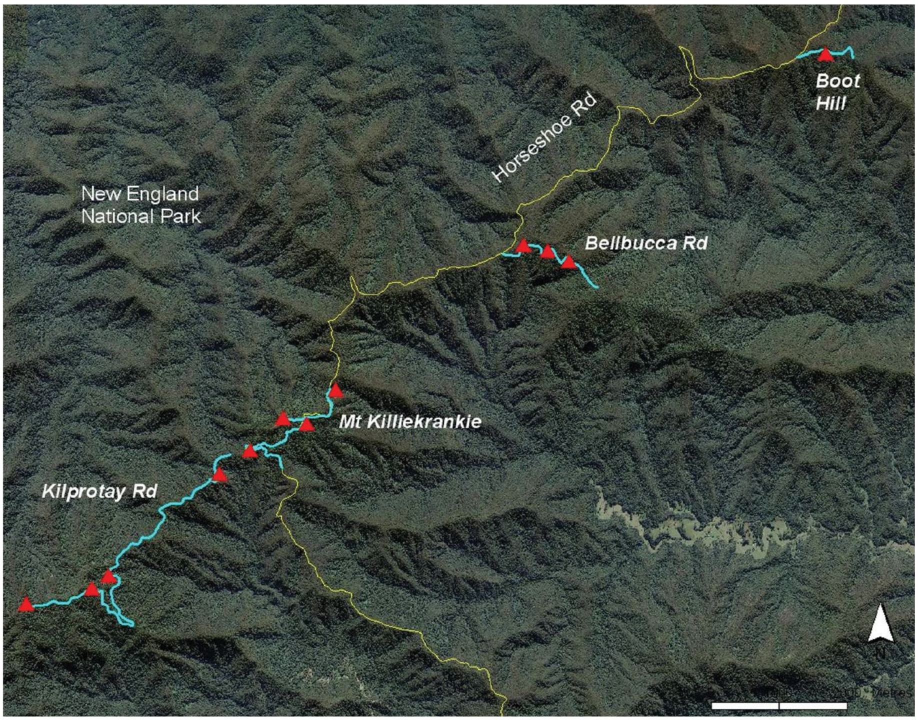

Figure 2. *The location of the 12 Rufous Scrub-bird 'territories' found in the systematic surveys (red triangles).*

Table 1

Results of the 2010–13 Rufous Scrub-bird systematic surveys. A 'Y' denotes the detection of a Scrub-bird. Killiekrankie transect KK01 and Bellbucca Road transect BB01 both contained two territories. The two transects at League Scrub (LS01 and LS02) were discontinued after five surveys.

Transect Number	Territory Number	Survey Number 1	2	3	4	5	6	7	8	9	10	% Recorded
BH01	Boot Hill-1	Y	Y	Y	Y	–	Y	–	Y	–	–	60
BB01	Bellbucca Rd -1	Y	–	Y	–	Y	Y	Y	Y	Y	Y	80
BB01	Bellbucca Rd -2	Y	–	–	–	Y	Y	Y	Y	Y	–	60
BB02	Bellbucca Rd-3	Y	Y	–	–	Y	Y	–	Y	–	–	50
KK01	Killiekrankie-1	–	Y	Y	Y	Y	Y	Y	Y	Y	–	80
KK01	Killiekrankie-2	–	–	–	–	Y	Y	Y	Y	–	–	40
KK02	Killiekrankie-3	–	–	Y	–	Y	Y	Y	Y	Y	–	60
KK03	Killiekrankie-4	–	–	–	–	Y	Y	Y	Y	Y	Y	60
KP01	Kilprotay Rd-1	Y	Y	Y	Y	–	Y	Y	–	Y	Y	80
KP02		–	–	–	–	–	–	–	–	–	–	0
KP03		–	–	–	–	–	–	–	–	–	–	0
KP04	Kilprotay Rd-2	Y	Y	Y	Y	Y	–	–	–	Y	–	60
KP05	Kilprotay Rd-3	Y	–	Y	Y	Y	–	–	Y	Y	–	60
KP06	Kilprotay Rd-4	–	Y	Y	–	Y	Y	Y	Y	Y	Y	80
LS01		–	–	–	–	–						0
LS02		–	–	–	–	–						0
Mean %:												**64**

Figure 3. *Detail of the three territories identified at Bellbucca Road, illustrating the typical tight clustering of the 2010–2013 survey records. These territories are about 350 metres apart, with two of them crossing the road. The image also shows the common occurrence of territories in wet gullies.*

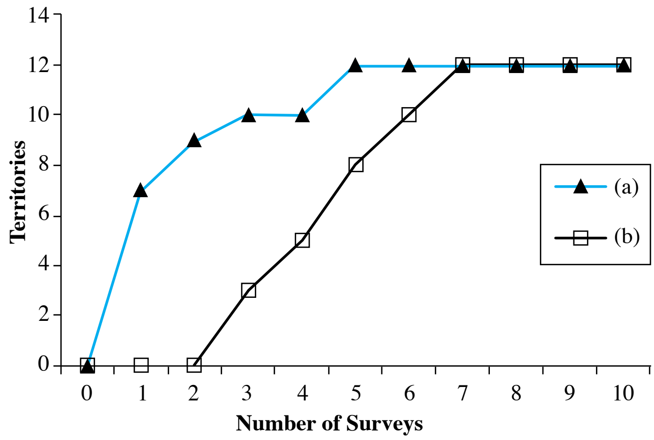

Figure 4. *The number of surveys taken to detect Rufous Scrub-birds at territories: (a) first detection of a territory, (b) third detection of a territory. No new territories were found after five surveys. Seven surveys were sufficient to define territories for the purposes of this study (i.e. obtain three records at a site).*

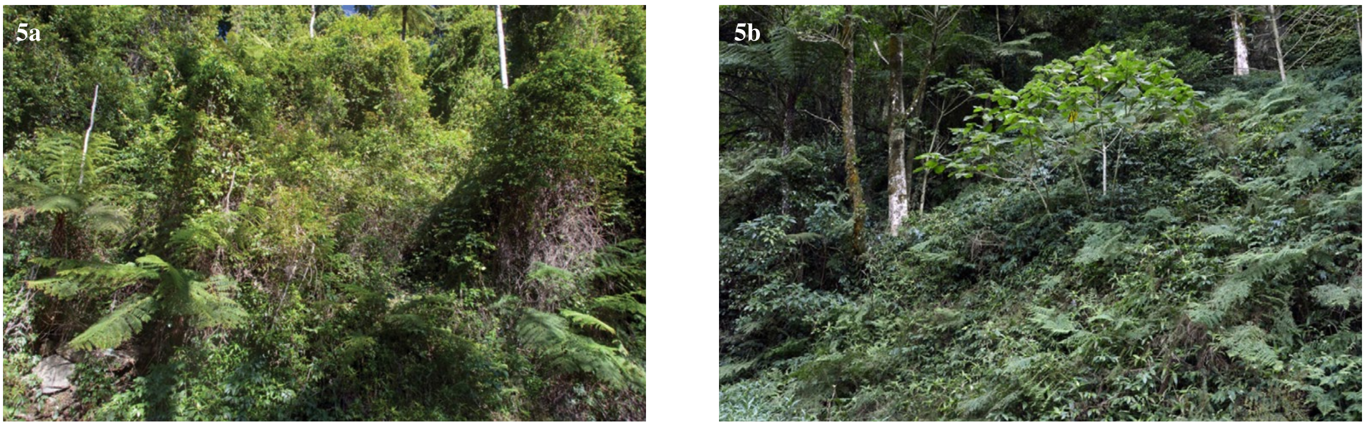

Figure 5. *Dense understorey typical of Rufous Scrub-bird territories: (a) territory KP04 and (b) territory KK04 in New England National Park.*

Table 2

An approximate comparison of Rufous Scrub-bird territories from 1997–2004 with those from 2010–2013, within 150 metres of the 2010-2013 transects. All territories were defined by containing three records at a site (about 1 ha), obtained at least one month apart. The elevation of each territory was taken from a point approximately in the centre of each minimum convex polygon. There were 75 records of Scrub-birds in the 1997–2004 dataset and 105 in the 2010–2013 dataset.

1997-2004 Territories (13 in total)	**2010-2013 Territories (12 in total)**	**Territories in common**	**Approx. elevation (m)**
Boot Hill A	Boot Hill 1	1	750
Bellbucca A	Bellbucca 1	1	800
Bellbucca B			775
Bellbucca C	Bellbucca 2	1	800
	Bellbucca 3		775
Killiekrankie A	Killiekrankie 1	1	775
Killiekrankie B	Killiekrankie 2	1	950
	Killiekrankie 3		850
Killiekrankie C			825
Killiekrankie D	Killiekrankie 4	1	775
Kilprotay A	Kilprotay 1	1	750
Kilprotay B			750
Kilprotay C	Kilprotay 2	1	875
Kilprotay D			875
	Kilprotay 3		950
Kilprotay E	Kilprotay 4	1	925
		Total: 9	**Average: 825**

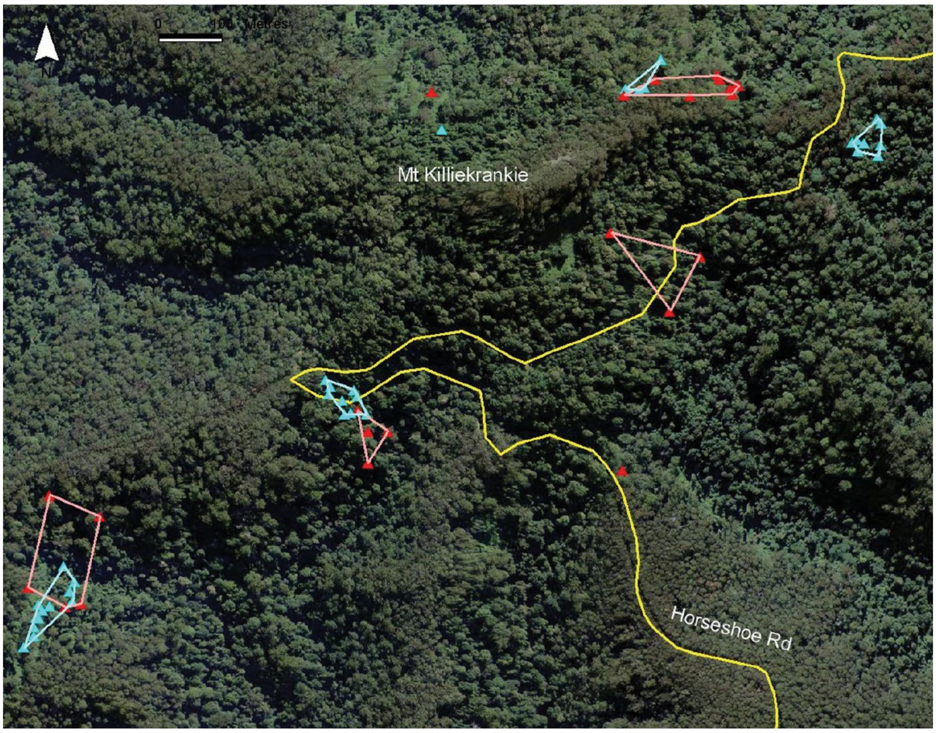

Figure 6. *An example of how the 2010–2013 territories (blue minimum convex polygons bounding blue records) were compared with 1997–2004 territories (red minimum convex polygons bounding red records). This detail from the Mt Killiekrankie area shows three territories considered not to have changed (overlapping polygons), one old territory no longer occupied (isolated red polygon) and one current territory not previously occupied (isolated blue polygon).*

confounding methods, it is not possible to rigorously compare the results of these surveys with the current survey. However, to enable an approximate comparison, the same rules were applied to the records from the older surveys to identify 'territories' (i.e. three records at a site at least one month apart) within 150 metres of the 2010–2013 transects (Fig. 6). The results are listed in Table 2, which also shows the approximate elevation of each of the territories.

DISCUSSION

I believe that the Rufous Scrub-bird surveys carried out in New England are a successful example of locally-based wildlife monitoring that has produced reliable baseline data on the distribution of male territories. The approach does not require major resources, develops and retains local expertise and is simple and repeatable. However, the approach is not without its shortcomings.

A particularly significant issue is that the location of the transects were not randomly selected. Instead, known Rufous Scrub-bird habitat was deliberately targeted where it occurred along roads. Most habitat in the area is not occupied by Scrub-birds and there were insufficient resources to survey randomly-selected sites (most of which are likely to be unoccupied), particularly sites that occurred off-road in the typically steep and impenetrable terrain. The upshot is that the results cannot be extrapolated from the transects surveyed to the wider region.

An element of random site selection was included in a previous Rufous Scrub-bird monitoring project (1999 to 2004) across the range of the species to enable broad predictions to be made regarding population changes (Ekert 2000, 2002, 2005a, 2005b). That study highlighted the difficulties faced in implementing a strong-inference approach to monitoring this species. Logistical and methodological issues (Cunningham and Welsh 2000; EcoLogical 2009) and the failure to secure ongoing annual funding led to the discontinuation of the project.

The current program was designed with the benefit of hindsight from that experience within the constraint of limited resources. It is much more restricted in geographic scope, will not be repeated annually, uses only a small number of highly competent volunteers, is not designed to be extrapolated to other very diverse and complex environments and the low implementation costs increase the likelihood of sustainability. It is possible to produce useful data on a low budget in the tradition of some other successful bird monitoring projects (e.g. Recher and Serventy 1991).

The Rufous Scrub-bird is a conspicuous species, particularly in the breeding season, due to the consistent calling of male birds. The method used here required walking one kilometre in 30 minutes. Consequently a calling bird would have been audible for about 15 minutes, since calls can be heard up to 250 metres away (Ferrier 1984; pers. obs.). Despite this relatively short duration, birds were recorded on 64 percent of systematic surveys of territories. This demonstrates the consistent male calling behaviour without which the species would be impossible to monitor.

From the three opportunistic surveys conducted outside the breeding season, it was apparent that under suitable conditions birds continue to call quite consistently. However, it was subjectively observed that the frequency and duration of calling was diminished at these times of the year (pers. obs.). This observation is in accordance with the findings of Ferrier (1984) and Stuart *et al*. (2012) and further justifies the focus on the breeding season as the best time to survey for Rufous Scrub-birds.

Ferrier (1984) warned that comparisons based on the use of relative measures (from survey data) can be derailed by the exceptionally complex and variable issues of detectability. He analysed aspects of detectability in great detail, demonstrating the difficulties faced in trying to resolve this notoriously challenging problem. Examples of the issues that affect detectability in the Horseshoe Road area include the complex topography (steep falls and rises from the road, saddles, crests and valleys), variation in vegetation (rainforest, open forest, vine thickets, cleared gaps), variable weather conditions, variation in observer ability and the large variation in the calling behaviour of individual birds. It is well beyond the resources and scope of this study to tackle all of these issues in an explicit way, although the method takes some of them into account (such as only surveying under suitable weather conditions and only using experienced observers). However, I believe that the territories have been identified with a sufficient level of confidence that will enable substantial changes to be detected in future, for the following reasons:

(i) The study included opportunistic visits to territories in addition to the systematic surveys and the additional data gained greatly increased the confidence in the validity of the territories identified. The definition used for a territory of three records at a site at least one month apart would, at a minimum, require only three surveys over two months. In practice, however, the average number of records at each territory was in fact eight (a maximum of 11 and minimum of four).

(ii) Confidence in the identification of territories was also gained from the tight clustering of records, and the very low number of incidental records where territories were not confirmed (four only, all distant from the transect).

(iii) All territories were occupied for more than one season and in the final season of the study, all 12 were still occupied. It is highly likely that sites consistently occupied over this length of time are in fact occupied territories.

(iv) Rufous Scrub-birds can be effectively surveyed within about 150 metres of a transect (Ferrier 1984). The territories identified in this project were close to the transect, on average 40 metres away (not dissimilar to the average distances estimated by Ferrier at Barrington Tops of 48 m and Wiangaree of 57 m). Territories close to roads are much easier to access, identify and verify than distant territories.

(v) No new territories were identified in the last three of the 10 systematic surveys conducted. While there is no guarantee that every territory was detected, it is unlikely that territories close to the transect were missed.

In the Barrington Tops area, Newman and Stuart (2011) identified 1.1 Rufous Scrub-bird territories per kilometre (22 territories in 20 km of transect) and in the same area Ferrier (1984) found 1.2 territories per kilometre (22 territories in 18 km). Ferrier also identified 1.3 territories per kilometre (23 territories in 18 km) at Wiangaree. This study found 1.0 territory per kilometre (12 territories in 12 km). Strict comparisons of different areas is not valid owing to the dramatic differences that can occur in the patchy spatial arrangement of habitat and differences between studies in methods, particularly those of site selection. However, the similarity in these results in areas considered to be high quality Scrub-bird habitat at least gives an indication that there are currently reasonably strong numbers along the Horseshoe Road transects.

The comparison with previous surveys (1997–2004) indicates that at least 16 territories are likely to have been used over the period from 1997 to 2013. The number of occupied territories appears reasonably stable with 12 now occupied compared with 13 in 1997–2004. Nine of them do not appear to have changed. Three territories are now occupied that may have been unoccupied previously, while birds are now absent from four territories that were previously occupied. Elsewhere, more dramatic fluctuations in territory occupation have been observed; in Gloucester Tops, perhaps in response to drought (Newman *et al*. 2014) and in Werrikimbe in response to fire (P. Redpath pers. comm.).

Seven of the territories identified in this study are located in a section of New England National Park that was created in 1997, four are located in Gumbaynggirr National Park (created in 1999) and one adjacent to Baalijin Nature Reserve and protected from logging from about 1999. Many of the territories are located in old logging gaps containing dense post-logging regrowth, such as vine thickets. With all territories now reserved from logging, in the long term these regrowth gaps may return to mature forest and some of the sites may become less suitable habitat. Conversely, other sites may become more suitable as leaf litter, log debris and ground-level humidity all increase.

The average elevation of the Rufous Scrub-bird territories is 825 metres, which represents relatively low elevation habitat for the New England region and elsewhere. A species of cool, high altitude, fragmented habitat may be susceptible to climate change through rising temperatures, with range contraction beginning at the lower, hotter elevations. There is some anecdotal evidence of a general altitudinal retreat (Ferrier 1984), including in the Horseshoe Road area at League Scrub where birds were last recorded in 2002 and could not be re-located after five systematic surveys and numerous opportunistic visits. Range contraction to higher elevation has also occurred due to clearing or disturbance of low elevation habitat in far northeastern New South Wales.

The effects of drought, fire, logging and climate change on Rufous Scrub-bird habitat are highly complex (Ferrier 1985 discusses some of these). The concomitant successional changes in vegetation add further layers of complexity. Therefore, despite the apparent stability of Scrub-bird territories observed in this study, more volatile patterns of habitat occupancy could easily occur in future.

ACKNOWLEDGEMENTS

This project was initially conceived as a continuation of the Gondwana Rainforests World Heritage Area monitoring program and then morphed into a collaboration with the BirdLife Australia IBA monitoring program. People involved in both these programs are thanked for their interest and support. The survey would not have been possible without the enthusiastic field assistance from Peter Higgins, Shane Ruming, Jill Smith, Karen Caves, Mal Dwyer and Peter Richards. They are very sincerely thanked for their efforts. The manuscript was greatly improved by thoughtful comments from several reviewers, particularly Mike Newman. The Ecosystems and Threatened Species unit of the NSW Office of Environment and Heritage (OEH) at Coffs Harbour is also thanked for allowing Mick Andren, Shane Ruming and Jill Smith to participate in the project. The views expressed are those of the author and not necessarily those of the OEH.

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Shadows of change: Square-tailed Kites *Lophoictinia isura* nesting in the Bendigo area of Victoria

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Received: 26 February 2015

The Square-tailed Kite *Lophoictinia isura* is an uncommon Australian endemic raptor that has been infrequently recorded breeding in Victoria. We review the historic record of the species for the Bendigo area of north-central Victoria and show that it has increased markedly since about 2000. A survey for nests in remnant box-ironbark forest during the 2014–15 breeding season revealed ten concurrently-active nests and 34 old nests. Density was estimated to be 10.8 pairs per 1000 square kilometres overall and 25.8 pairs per 1000 square kilometres in forest blocks. Nine of ten nests fledged young, yielding a minimum of 1.6 and maximum of 1.8 fledglings per nest. These densities and success rates are as high as or higher than previously reported for the species, showing that the Bendigo forests provided outstanding habitat for the species at least in the study year. We suggest that optimal forest habitat for the species may be as much defined by the scarcity of predators of kite nestlings and adults, and of territorial competitors, as the abundance of food. Notes are provided on nests and kite behaviour. We briefly explore two hypotheses for the species' increase, both of which involve or may involve changes to the abundance of aggressive or competing raptor species.

INTRODUCTION

As a specialist canopy-forager of sclerophyll woodland, open forest and heath, the Square-tailed Kite *Lophoictinia isura* is one of Australia's more widespread yet uncommon endemic raptor species (Debus and Czechura 1989). The species is notable for its low wing-loading (large wing area relative to body mass) which enables it to float seemingly effortlessly just above and around the forest canopy from which it captures live birds, especially nestlings, insects and other small food items (Debus 2012). The species is partially migratory, with most breeding recorded in spring and summer in the southern two-thirds of its range and being sighted more often in the north of Australia as a non-breeding visitor during the austral winter (Marchant and Higgins 1993; Barrett *et al*. 2003).

In Victoria, the species is regarded as a rare seasonal visitor. Debus and Silveira (1989) reviewed all 58 available records made in the state over the 34 years since 1965, and reported that only three or four pairs were known to nest. This is perhaps slightly more records than indicated by Emison *et al*. (1987), with observations in 36 10 minute by 10 minute cells and breeding in only two. Borella and Borella (1997) have since reported a pair returning to and nesting annually in the Ararat area of western Victoria, Binns *et al*. (1991) an aggregation of five individuals in the Ballarat area, and Loyn (1997) reported the species in the far east of the state. With a population thought unlikely to exceed 50 pairs (Debus and Silveria 1989), the Square-tailed Kite is listed as *Threatened* in Victoria under the Flora and Fauna Guarantee and *Vulnerable* on the state's Advisory List (Vic. Govt. 2015).

In this paper we briefly review records of the Square-tailed Kite in the Bendigo area of north-central Victoria which strongly suggest that the species has become more abundant since about 2000. We also report a survey of nesting in the area during the 2014–15 breeding season in which 10 active nests and 34 old nests were found, suggesting at least 11 breeding territories, most of which were persistent over at least several years. We further provide information on nest density, habitat, position, structure, timing and fledging success, along with notes on behaviour.

METHODS

Study area

The area searched is centred on the city of Bendigo (36°46'S, 144°16'E), Victoria, and embraced most of the forest areas that ring the city within 30 kilometres. Searches extended north to include the southern Whipstick Forest and all of the Wellsford Forest, east to the Campaspe River, south-east to include the Kimbolton Forest on the shores of Lake Eppalock, south to and including the Pilcher's Bridge Forest and west to Bullock Creek, with an extension to include the Knowsley Forest east of the Campaspe River. A supplementary search area extended farther north to include the central and northern Whipstick Forest, including the Kamarooka Forest. Of the cluster of forests that encircle Bendigo, the outer Shelbourne and Lockwood State forests were not included. A polygon around the main study encompasses 1027 square kilometres, of which 425 square kilometres (41.4%) is forested. Most of this forest is on Crown land, though with considerable area of regenerating forest on private land. A polygon around the supplementary study area is

351 square kilometres, of which 134 square kilometres (38.3%) is forested (including mallee).

The Bendigo area has a mean annual rainfall of approximately 500 millimetres. Soils in valley floors and some farmland areas are deep and fairly fertile, but forests are generally on infertile sedimentary rises. Elevations range from 150 to 450 metres above sea level, with most of the forests on low rises from 175 to 325 metres above sea level. Forests in the area are known generically as box-ironbark forests. They comprise dry open forests to 20 metres tall along gullies and 10 metres tall on ridges. Most of the forests are dominated by Yellow Gum *Eucalyptus leucoxylon*, Red Ironbark *E. tricarpa* and Grey Box *E. microcarpa*. Along gullies mainly in the south of the study area, Yellow Box *E. melliodora* is prominent, with Red Stringybark *E. macrorhyncha*, Red Box *E. polyanthemos* and Long-leaved Box *E. goniocalyx* dominant on ridgelines in the south.

Field survey

All searches and most observations were conducted by JLR. BRC provided detailed observations at one nest and a few observations at a second. After stumbling upon an active nest on 8 September 2014, systematic searching started on 9 September 2014 and continued, with some re-checking of active nests, until 12 February 2015. Searches were conducted on most days during this period, an estimated 120 days in total and at an estimated average of eight hours per day, approximately 1000 hours in total. Perhaps 95 percent of this time was spent searching for nests and five percent checking active nests. Of this, an estimated 30 hours was spent searching in the supplementary area.

Searches were conducted through most Crown Land forest patches in the study area, and less intensively in the supplementary study area. Forest edges and interiors were searched. In areas with steep ridges, searches were concentrated in gullies. Searches were conducted on foot and from a car driving at idle speed (~5 km/hr). Searches were intensified in areas where an old nest believed to be that of a Square-tailed Kite was found, or where kites were seen or reported by others. The search image was for stick nests in the top half of trees among branches that could potentially support a moderately substantial nest. These were judged as potentially those of a Square-tailed Kite or not, based on prior experience with three kite nests and many nests of other raptor species in the area including Wedge-tailed Eagle *Aquila audax,* Little Eagle *Hieraaetus morphnoides,* Whistling Kite *Haliastur sphenurus,* Black Kite *Milvus migrans*, Brown Goshawk *Accipiter fasciatus,* Collared Sparrowhawk *Accipiter cirrocephalus* and Brown Falcon *Falco berigora*. See Results for a description of Square-tailed Kite nests.

Upon finding a potentially active nest, it was checked for the presence of a bird. If none were found, the ground below was checked for whitewash and freshly-broken sticks that could warrant further checks. Once activity was confirmed, subsequent checks were mostly confined to the period when large nestlings or fledglings were present. Checks were conducted from about 40 metres away, and were generally for about five minutes though on occasions for up to three hours whilst remaining in the one place. Sitting adults were never flushed from the nest, and adults mostly approached the nest directly, ignoring the observer.

Nests and sightings were plotted on 1:25 000 topographic maps. These were re-plotted on a master 1:100 000 topographic map for the calculation of inter-nest distances. The distance of nests from forest edges was assessed by re-plotting them on Google Earth.

RESULTS

Historical records in the Bendigo area

For the purpose of this brief review, the Bendigo area is considered to be within a 50-kilometre radius of the city of Bendigo. When the Bendigo Field Naturalists Club (1976) reviewed the birds of the area and listed all species seen to date based on the observations of experienced observers over several decades, no sightings of Square-tailed Kites were available. When this list was updated and republished (Bridley 1991), there was a single sighting, at Sedgwick in 1982. A single kite was seen at Muckleford in 1986 (DCF observation, in Binns *et al*. 1991), and there were two sightings of one kite there in about 1996 (JLR observation).

JLR moved to Strathfieldsaye in 1972 and was then already an experienced observer of raptors. His first sighting there was in 2000. Since that sighting he has seen kites every year, from one to about a dozen sightings/year, all being of single birds except two together on one occasion. JLR and other observers have reported kites in the Bendigo area on numerous other occasions since 2000 but mostly since 2010. Sightings have been in and on the edge of forest blocks, in well-treed agricultural and rural residential areas, and several in peri-urban areas. Most observations outside forest blocks were within one kilometre of a forest block.

Kites were photographed at a nest in 2012–13, and a nest with two young and an adult close by was found about 50 metres away in the 2013–14 season. The identity of the birds was on both occasions confirmed by JLR. We are aware of two other nests just outside the Bendigo area, one in about 2002 and the other in about 2010. All nests were in forest blocks.

Nests in 2014–15

Ten active Square-tailed Kite nests were found in the study area and none in the supplementary area. Kites were sighted on 17 occasions away from the vicinity of active nests but within the study area (15 solitary, 1 duo, 1 trio), and none were sighted in the supplementary area. These sightings were variously within forest blocks, on the edge of forests, or in well-treed areas up to 1.5 kilometres from forest blocks. Sightings of birds and old nests suggested that an eleventh pair may have been present. Assuming 11 breeding pairs, the density of birds in the study area was one pair per 93.3 square kilometres (10.8 pairs/1000 km^2) and in the forested portion of the study area, one pair per 38.7 square kilometres (25.8 pairs/1000 km^2). The mean distance between active nests based on seven unique distances was 7.06 kilometres, with a range from 4.75 to 8.7 kilometres.

Nine Square-tailed Kite nests produced advanced nestlings (Fig. 1), defined as having well-developed juvenile feathers with little or no down evident, and one nest failed. Three nests contained one advanced nestling, three contained two advanced nestlings and three contained three advanced nestlings (for ten nests, mean 1.8

Figure 1. *Square-tailed Kite nest, Bendigo area, with two young. The young on right has already fledged and returned to the nest, and that on the left fledged for the first observed time about one hour after the photo was taken. Note flat structure of nest with many protruding and hanging sticks, a feature of nests of this species.* Photograph: John L Robinson, 8 Jan. 2015.

young/nest, SD = 1.03). Fledging, defined as young seen flying in the vicinity of the nest or perched in a tree nearby other than the nest tree (Fig. 2), was confirmed for nine nests and all but two of the young (for ten nests, mean 1.6 fledglings/nest, SD = 0.97). No evidence of loss of nestlings was noted or inferred, and the two nestlings not confirmed as fledging may well have done so.

The nest that failed was attended on about 27 September, but on 8 November there was no observed attendance, and no fresh whitewash or freshly-broken sticks below the nest. A report was received second-hand that a "large eagle" was killed in about late September on a road, the nearest point to the nest being 1.1 kilometres. Both parents at a nearby Wedge-tailed Eagle nest survived so are not implicated.

Twenty-nine active nests of five other raptor species were found in the study area during the study period, of which only those of the Collared Sparrowhawk and Little Eagle were within one kilometre of an active Square-tailed Kite nest (Table 1). It is emphasized that this is not an adequate survey of nests of these other species because habitat both within and outside forests not considered suitable for Square-tailed Kites, or not accessible, was not surveyed. Of note, eight active nests of the Brown Goshawk were located, none close to a Square-tailed Kite nest, and five of these in the Kimbolton Forest where no Square-tailed Kite nest was found – only one kite was seen – in spite of considerable search effort.

Thirty-four old nests attributed with considerable confidence to the Square-tailed Kite were found (Fig. 3, see description of nests below). Seven of these were within 100 metres of an active Square-tailed Kite nest, and three more within 200 metres.

Figure 2. *Advanced fledgling of the Square-tailed Kite. This bird fledged at least three weeks prior, and a week later had apparently left the vicinity of the nest. Note that fledglings lack the pale face of adults.* Photograph: Barrie R. Cooper, 21 Jan. 2015, Bendigo area.

Figure 3. *Disused nest (use not observed) of the Square-tailed Kite, Bendigo area.* Photograph: John L. Robinson, 8 Jan. 2015.

Table 1

Relationship between active Square-tailed Kite nests and active nests of other raptors.

Other raptor species	***n*** nests	Distance from kite nests if less than 1 km away (m)
Brown Goshawk *Accipiter fasciatus*	8	–
Collared Sparrowhawk *Accipiter cirrocephalus*	8	150, 150, 500, 750
Wedge-tailed Eagle *Aquila audax*	1	–
Little Eagle *Hieraaetus morphnoides*	9	120, 300
Brown Falcon *Falco berigora*	3	–

Table 2

Attributes of Square-tailed Kite nests (10 active, 34 old) in the Bendigo area, 2014–15.
Internest distances measured from Google Earth; nest-site characteristics estimated.

Attribute type	Attribute	Active nests	Old nests
Distance from forest edge (m)	Mean	625	790
	Range	95–1120	100–1200
Nest tree species (n)	*Eucalyptus camaldulensis*	1	1
	E. leucoxylon	3	3
	E. melliodora	2	4
	E. microcarpa	1	10
	E. tricarpa	3	16
Nest height (% of tree height)	Mean (n = 10, 33)	62	63
	Range (n = 10, 33)	50–85	50–75
Supporting branch diameter (cm)	Mean (n = 9, 31)	17	15
	Range (n = 9, 31)	8–30	5–30

Fledging behaviour and timing of nests

Most useful dates relate to advanced nestlings and fledglings. Interpretation of fledging dates is complicated by two factors: infrequent observations, and evidence that young remain near nests and return to nests after fledging. At three nests, fledglings were observed in the vicinity (within 150 m but often much less) 27, 42 and 44 days after at least one young had fledged. At four nests young were observed returning to the nest after having flown away from it. In three of these cases they returned to be fed.

Four active nests were found in September (8th to 27th) and in all four of these an adult was sitting. The first observation of fledged young was on 27 December (four nests). The last observation of young on the nest was on 30 January. Based on stages of development of nestlings and fledglings, it is assumed that most young fledged in late December, but one nest contained one downy and one half-coloured nestling on 20 December and fledging may have occurred in mid-January about three weeks after the other nests. Using an estimate of 100 days from laying to fledging (based on c. 40 days for incubation – Bischoff *et al*. 2000; Lutter *et al*. 2004 – and c. 60 days for nestlings – Barnes *et al*. 2001), eggs may have been laid in mid-September in most nests but as late as early November in one. However, based on observations of sitting birds and that young may have fledged some time before being first observed away from the nest, laying occurred earlier in some.

Nest position and structure

Square-tailed Kite nests were found in the gently undulating foothill box-ironbark forests along minor gullies and valleys, flat areas, on gentle slopes and in saddles between low hills. In all cases, the site was protected from wind. None was near a permanent watercourse and one, marginal to a forest block (see below), was close to a seasonal watercourse – there are no such watercourses within the forested portion of the study area. Based on a definition of *cleared land* as a clearing of more than five hectares, nests were all within forest blocks of at least 12 square kilometres and not close to the edge (Table 2) (but see marginal exception below). With a few exceptions, they were also away from the edge of minor clearings within forest blocks, and none were placed in isolated trees. The marginal exception was an active nest (with an old nest close by) in a small treed roadside reserve connected by almost continuous tree cover to a forest block 400 metres away.

Nests were found in trees of five eucalypt species (Table 2), all common to abundant species in forest blocks except for River Red Gum *Eucalyptus camaldulensis*. In five of six nest clusters, all nests were in the same species, but in most of these the best options (support, shelter) in the immediate vicinity were all of the same species. Nest trees were not necessarily the largest present; several were in notably small trees. Nests were mostly placed between an estimated half to two-thirds of the way up the tree on main supporting branches that were estimated to mostly be between 10 and 25 centimetres in diameter (Table 2). A variety of branch situations were used, but three most commonly: a vertical tri-fork; on the cusp of the point where an angled large branch bent to horizontal (Figs. 1,3) and with either a major fork or minor branches to stabilise the nest; and where branches diverged at an angle from a major more-or-less vertical branch such as the main trunk. One nest was in a dead clump of mistletoe, possibly Box Mistletoe *Amyema miquelii,* which had been growing on a 75 millimetres diameter branch of a Yellow Gum. Compared to nests of other raptors, those of the Square-tailed Kite were generally lower in the tree, and were shallow, loose structures composed of sticks typically about 0.8 metres long and mostly 10–15 millimetres in diameter at the thicker end, often protruding beyond the main structure (Figs. 1,3) and frequently falling to the ground below.

Observations of behaviour and food

Interactions near nest with other species

At both sites where there was an active Little Eagle nest nearby (120 and 300 m away), Square-tailed Kites departing from their nest never flew off in the direction of the eagle nest or fledged eagle nestlings. However, at both sites the Little Eagle was repeatedly observed flying over the kite nest, but at height above the canopy and taking no evident interest in it. On one occasion during a previous year, a Wedge-tailed Eagle passing below the forest canopy about 70 metres from the kite's nest was dived at from a few metres above at least four times, the kite calling as it attacked. Corvids were rarely noted inside the forest in the vicinity of kite nests. When ravens (*Corvus* sp.) called about 200 metres away from a kite nest with young from which the adult kite was perched about 80 metres away, the adult immediately flew, gliding in circles around the nest but well above the forest canopy where it would have been visible; the ravens immediately stopped calling.

Bonding behaviour

At one nest, adults were observed allopreening on 16 November and copulating on 24 December. At the same nest on 8 January, BRC observed an adult fly in carrying a stick and perch near the nest. Its partner flew in from nearby, the stick was exchanged, and the birds perched in physical contact (Fig. 4). The pair fledged two young, one no later than 28 December and the other no later than 31 December, so these behaviours were not associated with pair establishment or egg production.

Food and feeding behaviour

Square-tailed Kites were observed three times catching or attempting to capture prey. A kite descended into the canopy of a tree and emerged with what appeared to be a large but not well-feathered nestling; it was immediately chased by two Red Wattlebirds *Anthochaera carunculata*. In a previous year, a kite was observed going to a nest of a Fuscous Honeyeater

Figure 4. *Pair-bonding Square-tailed Kites after exchanging the stick.* Photograph: Barrie R. Cooper, 8 Jan. 2015, Bendigo area.

Lichenostomus fuscus, but it was unclear whether a food item was obtained. A kite was observed to capture a lizard 25 centimetres in length, possibly a Jacky Lizard *Amphibolurus muricatus*, from the foliage of a Red Ironbark. Kites were additionally observed carrying identifiable food items on 13 occasions. Of these, 12 were birds, possibly young Red Wattlebirds, young Noisy Miners *Manorina melanocephala,* young woodswallows *Artamus* sp. and a bronze-cuckoo *Chalcites* sp., and one was a long green item resembling a large stick insect (Phasmatidae). Kites were often observed carrying items with their talons, but twice in their beak. On one occasion when an adult dropped an item, and one on which a food item was dropped while being transferred to a fledgling, an adult flew to the ground to retrieve the item. At one and possibly two nests, kites were observed to regurgitate food into the nest, and on one of these the other adult then appeared to feed the regurgitate to the young. A headless nestling pigeon was found on the ground in the vicinity of fledged young. Pellets were not systematically examined, but identifiable items observed in about 30 of them included beetle elytra and feathers of lorikeets (probably Musk Lorikeet *Glossopsitta concinna*). Nests of small honeyeaters and one of the Varied Sittella *Daphoenositta chrysoptera* were found on the ground below the kite nest or nearby.

DISCUSSION

Habitat, abundance and success in the Bendigo area

Square-tailed Kites in the Bendigo area nest in box-ironbark forests that are neither near permanent or semi-permanent watercourses or major valleys, nor grow on fertile soils, though it is likely that hunting is concentrated in more productive patches within these forests. The city of Bendigo is ringed by blocks of remnant box-ironbark forest which was almost entirely felled during the gold rushes of the 19th century and has since regrown. These forests are currently subject to fire management and silvicultural practices which are often considered to be adverse for wildlife. Nests were not consistently placed in larger trees. Use of regrowth forests for both nesting and foraging has also been reported by several authors, notably Kavanagh *et al.* (2001), and Debus (1996) reported a nest in mistletoe in a "pole" tree. It is plausible that large, old trees and/or forests of such trees may be avoided because hollow trees harbour predators such as the Lace Monitor *Varanus varius*, Barking Owl *Ninox connivens* and Powerful Owl *N. strenua*. Nests of the Square-tailed Kite may be particularly vulnerable to predation by Lace Monitors because of their position on major branches well below the canopy, positions as also noted by Kavanagh *et al.* (2001), and because adults lack the body mass and strength to fight them off. Few such older trees remain in the box-ironbark forests occupied by Square-tailed Kites in the Bendigo area, and the resulting low density of hollow-dwelling mammalian prey is the likely reason for the scarcity of large owls (JLR personal observation).

It cannot be asserted with certainty that no active nests were missed, and private property and the few major watercourses in the study area were not searched. However, the fairly even spread of the concurrently active nests across most forest blocks, with inter-nest distances ranging from 4.75 to 8.7 kilometres, suggests that most active nests were indeed found. Nests in semi-open areas such as along watercourses should be more readily detected by other observers yet there are no reports of nests, and fewer observations of birds, in such areas. Most larger blocks of private land in the area are either agricultural or support forest regrowth that is still rather low ('scrubby') with only scattered canopy trees. Old kite nests but no active nest were found in one forest block, and kites were sighted in the area, suggesting one additional territory in which nesting may have gone undetected or the nest failed early in the season. Two additional forest blocks, the Eppalock and Kimbolton forests, match others for area but no active or inactive kite nests were found and only one bird was sighted notwithstanding extensive search effort; we interpret this as indicating that no nesting occurred there.

While the kites unquestionably also hunt in well-treed areas outside forests, forests appear in this area to be essential for them. Our data suggest that a suitable forest block of about 30 square kilometres can, in conjunction with adjacent well-treed areas, support a successful breeding pair of Square-tailed Kites. Inter-nest distances and the size of inferred home ranges found in this study are at the smaller end of those suggested by Marchant and Higgins (1993) in their review of the literature, and smaller than those reported by Lutter *et al.* (2004) for the Port Macquarie district of New South Wales. Thus, the density of nesting Square-tailed Kites in the Bendigo district, at least in the year of study, appears to be at the high end of any previously reported.

With nine of ten nests fledging young and at a rate of at least 1.6 fledglings per nest attempt, breeding of the Square-tailed Kite was markedly more successful than reported in any previous study. Kavanagh *et al.* (2001) reported a maximum of one fledgling per nest, and Lutter *et al.* (2004) 0.7 fledglings per nest attempt. We do not know whether the success observed in this study is typical for the Bendigo area or a feature of the study year. A likely key food resource for these kites are nestlings of the Red Wattlebird *Anthochaera carunculata*, the adult wattlebirds being attracted into these forests periodically by the nectar of flowers of the Red Ironbark and Yellow Gum in particular. Flowering of these eucalypts varies greatly from year to year (McGoldrick and Mac Nally 1998; Keatley and Hudson 2007). However, the intensity of flowering in the study year was unexceptional, so this alone cannot explain the high success rate observed.

Consistent with previous reports (summarised by Marchant and Higgins 1993; also Debus 1996 and Barnes *et al.* 2001), we found nests of the Little Eagle and Collared Sparrowhawk fairly close to those of Square-tailed Kites. However, and contrary to the observations of Barnard (1934), our observations suggest possible aversion between the Square-tailed Kite and Brown Goshawk. Brown Goshawks can be aggressive in defence of their nests (Aumann 1988a), whereas the Square-tailed Kite is generally not. It is plausible that the prevalence of Brown Goshawks in the Kimbolton Forest, with five active nests found, may have rendered the forest unsuitable for the Square-tailed Kite.

It has been suggested that the Square-tailed Kite is a habitat specialist requiring passerine-rich forests (e.g. Debus and Czechura 1989). This argument may seem self-evident; clearly, the species needs adequate areas of forest and forest edge in which to hunt and which support adequate levels of prey to sustain the kites. However, the Bendigo forests in which we found Square-tailed Kites nesting successfully are relatively dry and on infertile soils, and do not (currently at least) support large numbers of passerines (see below). We suggest a shift in emphasis in interpretation of its habitat requirements to one in which its occurrence within suitably large forest tracts is heavily constrained by predators of nestling and adult kites, and competitors for territorial space. This perspective is amenable to testing with further observation throughout the species' range. It also suggests to us plausible reasons why it has arrived and increased in the Bendigo area in the last decade or two, as discussed below.

Why has the Square-tailed Kite increased in the Bendigo area?

The record seems unequivocal that the Square-tailed Kite has increased in abundance in the Bendigo area particularly over the last decade or two. This parallels an increase in reporting rates in New South Wales of about 60 percent over the 20 years to 2006, with the increase concentrated in the north-east of the state (Cooper *et al.* 2014). In the Bendigo area, it may be argued that observers were less experienced and overlooked the species in earlier times, but this seems to us to be most unlikely. Bendigo has a long tradition of experienced birdwatchers dating back to at least the 1950s (BFNC 1976). Furthermore, JLR has been an experienced and periodically active observer of raptors in the district for over 50 years yet did not observe a Square-tailed Kite there until around 1996.

These observations prompt speculation as to the drivers of change. We here briefly explore two possible hypotheses. We begin by noting that the increase in Square-tailed Kites has occurred against a background of declining abundance in their main food, forest or woodland birds, during the drought that lasted from 1997 to 2009. This decline is widely held by observers and has quantitative support, at least for many woodland-dependent passerines (Mac Nally *et al*. 2009). Though a few potential avian food species have increased in the Bendigo area in recent decades, most notably the Crested Pigeon *Ocyphaps lophotes,* these increases have mostly not occurred in and around the forest blocks occupied by the Square-tailed Kite. Thus, an increase in food supply does not appear to be the driving force of decadal-scale change.

The first possibility is that climate change has favoured the Square-tailed Kite. Climate modelling and its projection to future climate scenarios by Jeremy Vanderwal (pers. comm.) suggests an intensification of climatic suitability for the Square-tailed Kite along the inland slopes of the Great Dividing Range in south-eastern Australia (see Franklin *et al*. 2014 for modelling methods). A decrease in winter rainfall, offset partly by an increase in summer rainfall and consistent with climate change predictions for the area (Suppiah *et al*. 2007), appears already to have occurred, though longer time trends are needed to confirm this. It is unclear by what mechanism this change might positively affect the survival and reproduction of Square-tailed Kites. Recent prolonged drought in the area reduced forest health and primary productivity (Bennett *et al*. 2013). An utterly speculative possibility is that this may reduce competition for Square-tailed Kites from other raptors. Debus and Silveira (1989) suggested that some or most Square-tailed Kites leave Victoria in autumn-winter because of windy wet weather to which they are exposed due to their low wing-loading, combined with a shortage of nestlings to feed on at that time. It may also be possible that slightly warmer, drier winters have facilitated year-round persistence and subsequent success in the Bendigo area, but this too is without supporting evidence.

An alternative, more tangible hypothesis relates to the indirect effects of the arrival of rabbit calicivirus to the area in 1996 (Coman 2010). European Rabbits *Oryctolagus cuniculus* have declined markedly in much of the Bendigo area since then, persisting in numbers in the Bendigo area only in wooded pastoral areas and adjacent forests in and near granite and basalt country somewhat farther to the south-east of Bendigo such as near the Kimbolton Forest where no kite nests, and a number of Brown Goshawk nests, were found. In strong temporal and geographic parallel to the change in rabbit numbers, JLR has observed a marked decline in abundance and nesting of the Brown Goshawk in box-ironbark forests closer to the city of Bendigo. The Brown Goshawk has also declined in New South Wales in recent decades (Cooper *et al*. 2014). In southern Victoria, Rabbits comprised over 50 percent by mass of the diet of Brown Goshawks (Aumann 1988b), and were particularly prominent in the diet during winter and spring before and during the breeding season. We suggest that the decline of rabbits has driven a decline in the Brown Goshawk which has in turn created an opportunity for the Square-tailed Kite (and also the Collared Sparrowhawk) through reduced interspecific aggression and perhaps also reduced competition for food (birds).

ACKNOWLEDGEMENTS

Anne Bridley, Lance Costin, Michael Gatt, Daryl Fleay, Dale Gibbons, Pam and John Lands, Greg License, Barry MacDonald, David Merrick, Chris Tzaros, Ray Wallace and Ronnie Whitford kindly provided observations of kites and/or their nests. Lyndall Rowley provided observations and assisted with the literature review.

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Postscript

In the 2015/16 breeding season, eleven concurrently-active nests of the Square-tailed Kite were located in the same study area by JLR. Two of the eleven failed. The nine nests from which young fledged yielded at least 19 fledglings with the fate of two additional young being uncertain.

This occurred notwithstanding deepened drought conditions. It demonstrates that the surprising number of Square-tailed Kite nests found in the 2014/15 season, and their high success rate, was not a "one-off" event.

Corella, 2016, 40(3): 69-75

Long-term population trends in the vulnerable Lesser Noddy *Anous tenuirostris melanops* at the Houtman Abrolhos, Western Australia

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Received: 23 April 2015

Estimated numbers of breeding pairs of the Lesser Noddy (Houtman Abrolhos) *Anous tenuirostris melanops* are reported from 14 surveys made between 1986 and 2014. Numbers on the three breeding islands, Pelsaert, Wooded and Morley, have fluctuated between years and within colonies. Total estimated numbers of breeding pairs for the Houtman Abrolhos population have varied from c. 77 000 in 1986 to *c.* 48 000 in 1993 and 2007; however, in most cases a lower number in one year has been followed by higher numbers in succeeding years. There has been decline in numbers since 1986, with both 2013 and 2014 both having relatively low estimates. Lesser Noddies nest only in Grey Mangrove *Avicennia marina* low forests and there has been considerable mangrove dieback during the past two decades, with Morley Island being particularly affected. The subspecies clearly meets IUCN Red List criteria for *Vulnerable*, and if a precautionary approach is taken to evaluation, could meet criteria for *Endangered.*

INTRODUCTION

The Australian subspecies of the Lesser Noddy *Anous tenuirostris melanops* nests in Grey Mangroves *Avicennia marina* on three islands in the Houtman Abrolhos, off Geraldton, Western Australia. Because of the very small 'Area of Occupancy' during breeding (less than 4 ha) and declining numbers, it is listed as *Vulnerable* under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), and because more recent data showed a significant decline, as *Endangered* under the *Wildlife Conservation Act 1950* (WA). In *The action plan for Australian birds 2010* (Garnett *et. al.* 2011) it was evaluated as Endangered B2ab(iii,v) using IUCN Red List Categories and Criteria. It also meets Vulnerable D2, having a population with a very restricted area of occupancy and plausible threats (mangrove decline, and decline in food supply due to changes in the strength of the Leeuwin Current).

Estimates of the number of breeding pairs on each island were provided by Burbidge and Fuller (1989, 2004), Fuller *et al*. (1994) and Surman and Nicholson (2009a), with the last of these showing a significant decline in numbers of breeding pairs. In this paper we report the unpublished data of Surman and Nicholson (2009a) and counts since that time, and examine trends in the size of the breeding population. While, in recent years, we attempted to make quadrat counts near the peak of the season, this was not always possible for logistical reasons. Thus, comparing data on nests in use is of limited value and the best estimate of the number of breeding pairs is calculated using nests in use plus those under construction. We also report on mangrove dieback and how it may have affected Lesser Noddy breeding pair estimates.

METHODS

Transects have been maintained through all breeding colonies since 1986 (Burbidge and Fuller 1989). A total of ten transects on Pelsaert Island, three transects on Morley Island and five transects on Wooded Island were surveyed (Figure 1). One additional transect was added on Morley Island to increase sampling rate after significant death of mangroves there (see below). All nests two metres each side of a central permanently-marked line (the Transect) were counted. Each transect was broken down into continuous five metre long sections, with the result that each survey quadrat (4 x 5 m) covered 20 square metres. Each transect commenced at one edge of the mangal and bisected a section to the opposite edge, usually orientated roughly in a west to east direction (Figure 1 and Table 1).

From 1986 to 1999 nest counts took place on five occasions and all occupied nests (egg or chick) or nests judged to be under construction or to have been recently used during that breeding season were counted. Surman (1997) quantified the status of nests in order to better assess the status of breeding, differentiating nests containing old nesting material from previous seasons with those of the current season including nests under construction or refurbishment. Data from the 2006/07, 2007/08, 2008/09, 2013/14 and 2014/15 breeding seasons included nests with an assigned status as follows:

1. Old – existing nest containing material from previous nesting seasons
2. Sargo – nests recently refurbished with fresh brown algae (Sargassaceae)
3. Ulva – nests recently added to with brown algae and lined with sea lettuce (*Ulva lactuca*, Ulvophyceae)
4. Egg – nests containing an egg or an adult incubating an egg
5. Chick – nests containing a chick, these were also categorised by age class
6. Chick guano – recently constructed nests with a guano ring along outer edge
7. Dead Chick – nests containing a dead chick
8. Abandoned – nests containing an addled, cracked or abandoned egg.

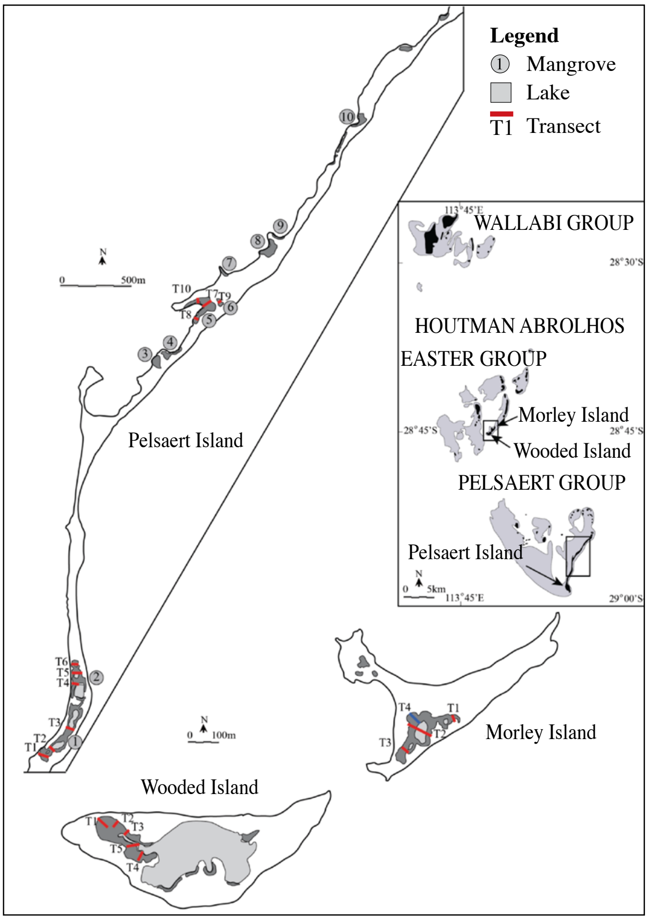

Figure 1: *Location map showing the three islands surveyed (Wooded, Morley and Pelsaert) and the approximate location of survey transects monitored.*

The estimated number of breeding pairs for a breeding season was calculated using nests from categories 2 to 8 above. As nesting is not synchronised, the inclusion of nests relined with fresh marine algae allowed an indication of pre-laying activity and prediction of those nests likely to contain an egg at a later date. For breeding seasons since 2006/07, we also calculated nests in use at the time of the quadrat counts; these were the sum of categories 4 to 8. The total number of Lesser Noddy nests was estimated by multiplying the mean density of nests for each colony and extrapolating this to the total area of mangroves occupied in that colony for that year (Table 3).

Lesser Noddy pairs use a single nest in a breeding season, and can re-lay in that nest if the initial breeding attempt fails (Surman and Wooller 1995); thus a second breeding attempt in one season does not result in over-estimating the number of breeding pairs.

Visit dates relating to new data reported here were:

- 2006/07 breeding season: Pelsaert Island 3–5 December; Wooded Island 11 December; Morley Island 12 December 2006.
- 2007/08 breeding season: Pelsaert Island 18–20 November; Wooded Island 23 November; Morley Island 24 November 2007.
- 2008/09 breeding season: Pelsaert Island 21–24 December; Wooded Island 14 December; Morley Island 15 December 2008.

Table 1

The location, number and size of monitoring transects on Pelsaert, Morley and Wooded Islands, Houtman Abrolhos.

Island	Transect	No. of Quadrats	Length (m)
Pelsaert	1	13	65
	2	7	35
	3	8	40
	4	11	55
	5	13	65
	6	10	50
	7	14	70
	8	5	25
	9	3	15
	10	5	25
Total	**10**	**89**	
Wooded	1	8	40
	2	6	30
	3	5	25
	4	4	20
	5	6	35
Total	**5**	**29**	
Morley	1	10	50
	2	13	65
	3	8	40
	4*	6	30
Total	**3**	**37**	

* Transect No. 4 was added in 2014, shown in Fig. 1 in blue

- 2013/14 breeding season: Pelsaert Island 12 to 13 November; Morley Island 7 December; Wooded Island 8 December 2013.
- 2014/15 breeding season: Pelsaert Island 24–27 November Morley 17 November; Wooded 18 November 2014.

Prior to 2006, estimates were based on the total area of mangroves calculated from aerial photographs, with quadrats containing unsuitable habitat included in calculations. From 2006, areas used in calculations were the estimated area of live mangroves, with quadrats containing unsuitable habitat (i.e. dead mangroves or no mangroves) omitted from calculations.

Areas of live mangroves were estimated using polygons over aerial photographs taken during each survey using fixed-wing aircraft and aerial photographs overlaid on Google Earth using the Landgate (Western Australian Land Information Authority) application 'Locate'.

RESULTS

Estimates and standard errors of the number of breeding pairs and, for later years, the estimated number of nests in use, for each colony, and the summed means for islands with more than one colony, are presented in Table 2 and Figure 2.

Estimated numbers of breeding pairs have fluctuated within and between islands. Numbers of breeding pairs on Pelsaert

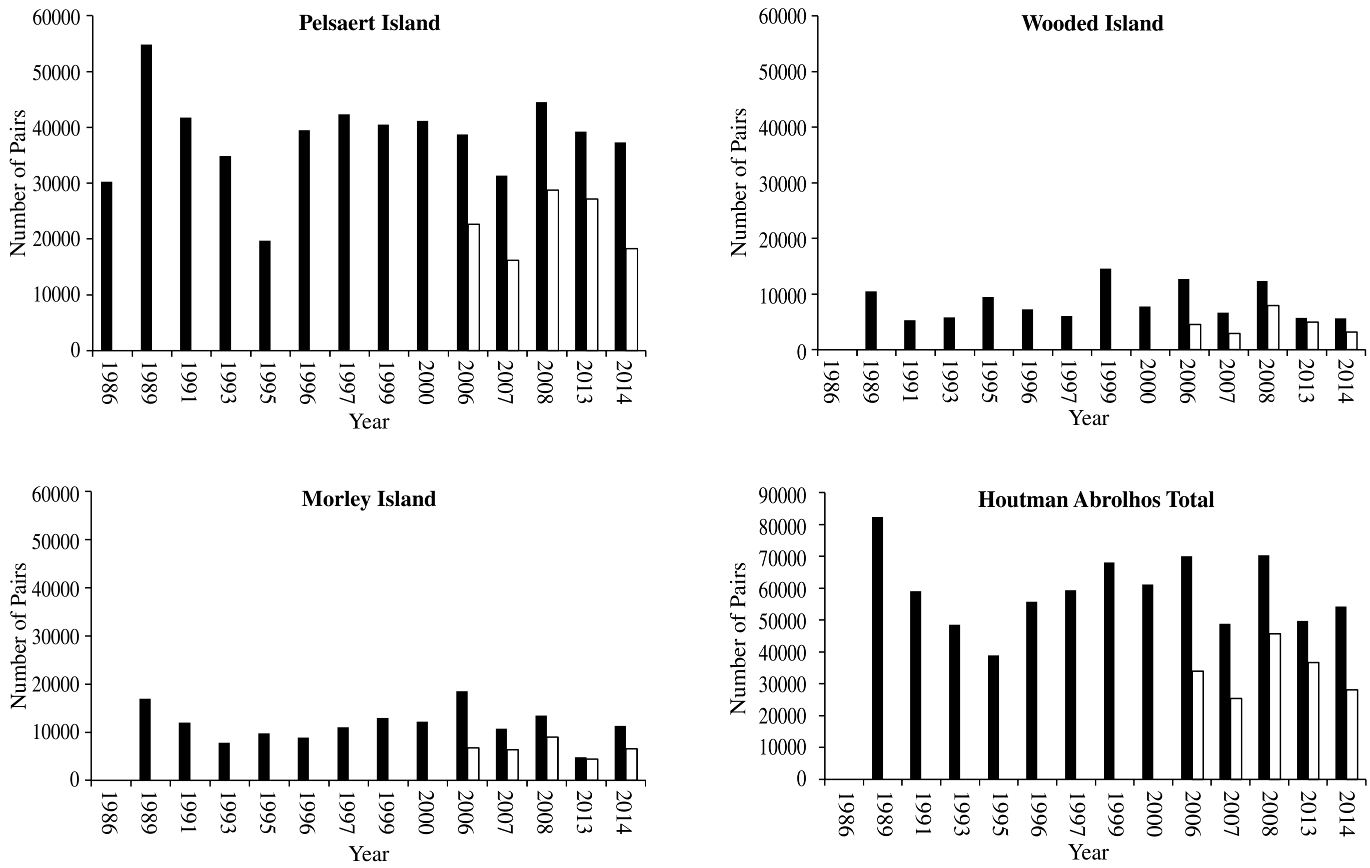

Figure 2: *Summed means of estimated number of breeding pairs of Lesser Noddies for each island and for the whole Australian population. Hollow bars are nests in use at the time of the estimate.*

Island, which has the largest colonies, were relatively stable between 1991 and 2006, were lower in 2006, but recovered in 2007. In 2013 numbers were again close to the levels estimated between 1991 and 2006, but the 2014 estimate was lower. On Wooded Island, there have been major fluctuations with estimates between 1989 and 1997 being between *c*. 5300 and *c*. 9500 breeding pairs. However, in 1999 the estimate was greater than 14 000 but was only *c*. 3200 in 2000. Estimates in 2006 and 2008 were greater than 12 000 pairs; however, in 2007 the estimate was only *c*. 6700. Morley Island has also shown fluctuations with greater than 16 000 estimated in 1989 and 2006, but lower estimates in other years. The 2013 estimate of *c*. 4 700 pairs was the lowest on record.

For the Houtman Abrolhos population, numbers have been relatively stable, but with some years of lower estimates. The estimates in 2006/07 and 2007/08 breeding seasons were low, but similar to 1993. The estimates for 2013/14 and 2014/15 seasons are comparable with those of 1993 and 2007, but this was the first time that two consecutive yearly estimates are low.

Table 3 shows estimated percent of dead and defoliated mangroves in selected years between 1964 and 2014. Although there has been an overall loss of breeding habitat, the percentage of mangrove habitat for each colony that was affected by defoliation or dieback from 1964–2012 (Table 2) has varied, with recovery in some colonies, notably the mangroves in colonies 1 and 2 on Pelsaert Island, which are the largest Lesser Noddy breeding colonies.

DISCUSSION

Trends in numbers of breeding pairs

The 2013/14 and 2014/15 season estimates are some of the lowest on record (Table 2). Whether these numbers reflect a long or short-term decline is unclear. A number of factors may be contributing to population decline, including mangrove dieback (Surman and Nicholson 2009a), ENSO-driven reproductive failures (Surman and Nicholson 2009b) and longer term changes in local oceanography (Surman *et al*. 2012). Surman *et al*. (2012) found that there were significant oceanographic influences upon the timing of breeding of Lesser Noddies, with later breeding between 2001 and 2010 when compared with the previous ten years (1991–2000).

It is notable that the proportion of nests in use on Wooded and Morley Islands was higher in 2013 (counts made 7 and 8 December) than on Pelsaert (counts made 12–13 November).

Change in the extent of useable mangrove

A potential threat to the Houtman Abrolhos Lesser Noddy population is mangrove dieback and defoliation. On Wooded Island the long-term presence of a Pied Cormorant *Phalacrocorax varius* colony in the mangroves has caused extensive mangrove defoliation. Whilst the Pied Cormorant colony shifts location from one year to the next, the foliage of regenerating mangroves is too dense for Lesser Noddies to

Table 2

Estimated number of breeding pairs of Lesser Noddies for Pelsaert, Wooded and Morley Islands, Houtman Abrolhos, Western Australia. Estimates, where calculated, are ± Standard Error (SE). Figures without SE are counts of small colonies. 'Total, all quadrats' is the estimate for Pelsaert Island using all quadrats on that island.

Island	Colony	Year 1989	1991	1993	1995	1996	1997	1999	2000	2006	2007	2008	2013	2014
Pelsaert	**1**	28 900 ± 2325	26 420 ± 3000	20 110 ± 2040	19 700 ± 2260	21 021 ± 2290	24 034 ± 2498	26 036 ± 2457	25 049 ± 2488	14 007 ± 1744	12 377 ± 1474	13 628 ± 2283	15 832 ± 2330	14 357 ± 2178
	2	21 615 ± 2660	14 015 ± 8580	14 760 ± 1385	19 100 ± 1635	18 440 ± 1592	18 310 ± 1921	14 490 ± 1352	16 073 ± 1543	21 366 ± 2001	13 745 ± 1479	14 093 ± 1577	11 759 ± 1491	10 025 ± 1133
	3	0	0	0	0	0	0	0	0	0	0	1940 ±385	0	0
	4	0	16	0	0	0	0	0	0	0	0	2130 ±470	0	0
	5	3480 ± 1090	1 220 ± 660	0	0	0	0	0	0	3193 ± 1051	5245 ± 1003	9043 ± 1320	11 636 ± 1452	7561 ± 995
	6	115 ± 80	86 ± 40	0	0	0	0	0	0	0	0	61	0	3
	7	0	0											
	8	0	0	0	0	0	0	0	0	192	0	3578 ± 337	0	0
	South end	0	0	0	0	40	25	25	0	0	0	0	0	0
Summed means		**54 110**	**41 761**	**34 870**	**38 800**	**39 461**	**42 369**	**40 526**	**41 121**	**38 758**	**31 367**	**45 187**	**39 227**	**31 943**
Total (all quadrats)					**40 821 ± 2997**	**41 061 ±2900**	**43 385 ± 3245**	**40 109 ± 2658**	**41 305 ± 2717**	**42 972 ± 3697**	**32 633 ± 2506**	**45 644 ± 3904**	**40 758 ± 3637**	**31 792 ± 933**
Wooded	**Main**	**6875**	**5345**	**6325**	**8769 ± 1353**	**5906 ±1055**	**5237 ± 928**	**12 837 ± 1859**	**6829 ± 882**	**12 712 ± 2162**	**6709 ± 1300**	**12 936 ± 3798**	**5572 ± 1011**	**5179 ± 985**
	Small				**680**	**1405**	**840**	**1790**	**980**	**0**	**0**	**0**	**200**	**515**
summed means		**6875**	**5345**	**6325**	**9449**	**7311**	**6077**	**14 627**	**7809**	**12 712**	**6709**	**12 396**	**5772**	**5694**
Morley	**Main**	**16 375 ± 2455**	**11 750 ± 2440**	**7665 ± 1535**	**9790 ± 1812**	**8931 ± 1470**	**10 992 ± 1621**	**12 979 ± 1851**	**12 208 ± 1453**	**18 532 ± 2355**	**10 758 ± 1912**	**13 502 ± 2416**	**4713 ± 621**	**11 327 ± 1631**
	Small				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**50**	**20**
summed means		**16 375**	**11 750**	**7655**	**9790**	**8931**	**10 992**	**12979**	**12 208**	**18 532**	**10 758**	**13 502**	**4763**	**11 347**
Houtman Abrolhos														
Summed means		**77 360**	**58 856**	**48 850**	**58 039**	**55 703**	**59 438**	**68 132**	**61 138**	**63 678**	**48 834**	**71 085**	**49 762**	**50 271**

Table 3

The total mangrove area (m²) and percentage of total mangrove habitat for each colony that was affected by defoliation or dieback from 1964-2014. Data estimated from aerial photographs obtained from Landgate (1964 – 2006, 2012), fixed wing aircraft (2007-2008), and a remote drone (2014). Pied Cormorant colony area (PC, % of total mangrove habitat) on Wooded Island is also included. Data for mangrove habitat on non-Lesser Noddy breeding islands included for comparison.

Island	Colony	Area					Year					
		(m²)	1964	1978	1982	1987	1998	2004	2006	2007	2008	2012	2014
Pelsaert	1	16 215	1.4	0.0	0.0	0.0	6.1	4.7	6.5	7.6	7.6	0.9	0.9
	2	12 214	2.4	0.0	0.0	0.0	5.8	13.2	9.8	12.6	12.6	4.6	4.6
	3	3 010	9.2	–	9.9	12.4	11.7	8.7	11.0	6.0	5.3	3.5	3.5
	4	1 783	8.1	–	10.1	0.0	1.2	0.0	3.4	0.0	0.0	0.0	0.0
	5	12 193	11.4	–	10.2	20.7	4.6	2.6	2.4	0.7	0.7	5.5	10.6
	6	1 520	4.8	–	9.2	6.3	6.3	39.2	35.2	11.1	9.2	9.2	9.0
	8	3 965	–	–	58.9	43.2	–	4.5	–	–	3.8	3.4	25.6
Wooded		10 168	12.3	–	10.3	9.2	5.7	18.4	18.5	19.5	10.7	1.7	7.6
	PC		14.0		12.3	13.9	13.2	6.4	6.9	16.4	0.0	7.3	12.8
Morley		11 968	34.0	–	7.1	2.9	2.5	39.6	35.0	46.9	39.3	33.0	30.0
Serventy		2 140					0.0	7.0	0.0				
Burnett		5 540					1.9	5.2	7.0				
Post Office		7 300					1.7	6.1	7.8				
Newman		4 220					0.9	27.1	18.9				

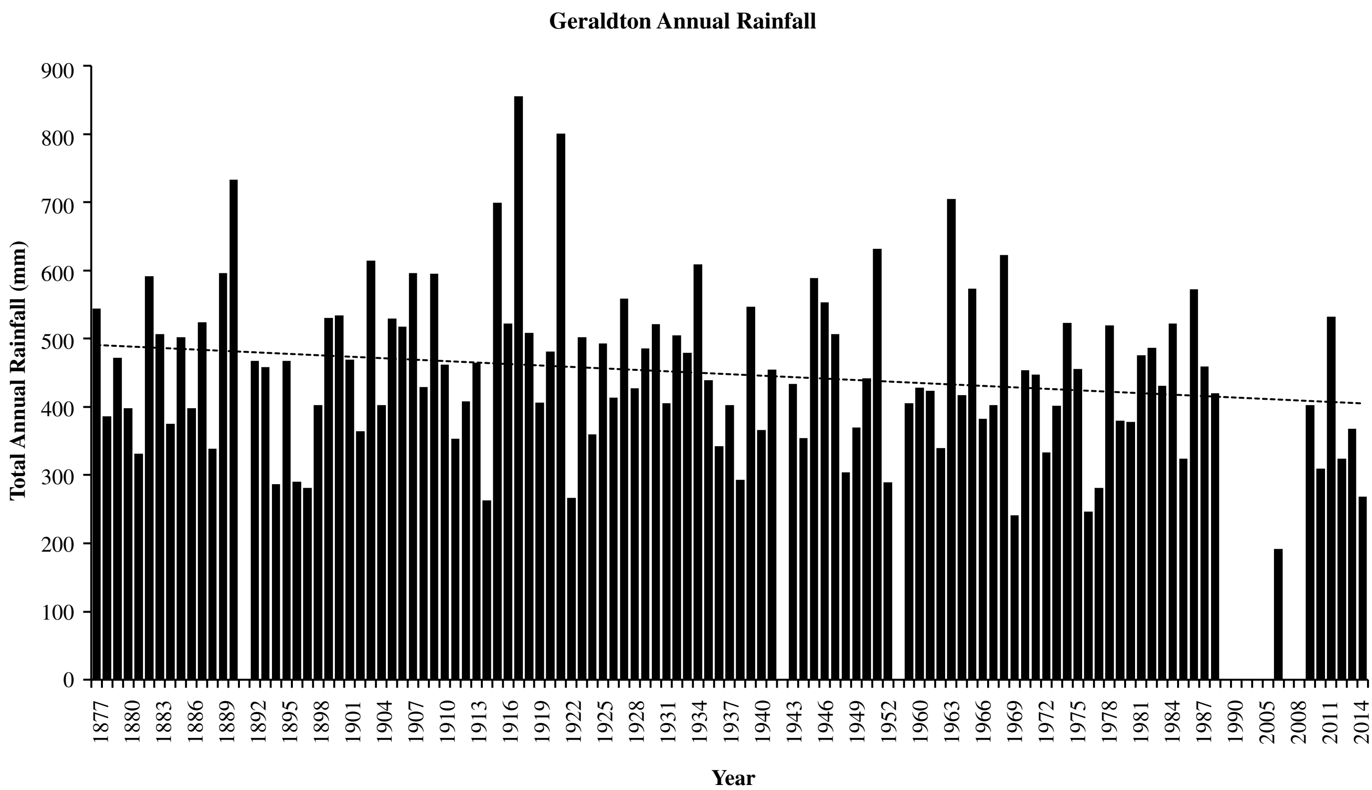

Figure 3: *Annual rainfall at Geraldton from 1877 with linear trendline. Years with incomplete data are omitted. Data from the Australian Bureau of Meteorology.*

recolonise for many years. On most islands, and some areas on Wooded Island, mangrove dieback cannot be attributed to the Pied Cormorant colony.

Table 3 shows that mangrove decline is, to some extent, cyclic. Two hypotheses may explain these changes. Firstly, Lesser Noddy nesting leads to increased nutrient levels from guano deposition; the subsequent defoliation causes the birds to nest elsewhere until the area recovers. This was observed on Pelsaert Island when in 1991/92 Lesser Noddies abandoned Colony 5 (when 20.7% of the mangrove there was defoliated) for 15 years until their return in the 2006/07 season to completely regenerated mangroves (0.7% dieback, Table 3).

Secondly, declining regional rainfall may lead to less flushing of both salt and nutrients from mangrove areas. Rainfall at the closest long-term station, Geraldton (60 km E, Figure 3), shows such a decline in line with much of SW Western Australia. Lower rainfall may explain mangrove decline in part, noting that decline has also occurred on close-by islands where Lesser Noddies do not breed (Table 2).

Mangrove dieback and death has been particularly severe on Morley Island. Biota (2005) noted that when Grey Mangroves exist at the extremes of their physiological tolerance, changes in nutrient level through reduced tidal flushing or sediment build-up often results in mangrove dieback. At the Houtman Abrolhos the trigger for this on Lesser Noddy breeding islands appears to be at least partly due to the build-up of guano excreted by the Lesser Noddy, and the ability of defoliated areas to recover is determined by the levels of tidal flushing.

Observed and predicted sea-level change may adversely impact mangroves at the Houtman Abrolhos. Since 1990, sea levels in SW Western Australia have risen at a faster rate (9 mm/y^{-1}) than elsewhere in Australia resulting in an average 160 millimetres rise in sea levels (Church and White 2011; Steffen and Hughes 2013). Predicted rates of increase by century end (500–1000 mm, NTF 2011) will presumably lead to further coastal erosion and loss of mangrove habitat. The three breeding islands are protected from winter storms by a coral reef and lagoon to the west, but not to the prevailing summer strong southerly winds.

Oceanographic effects

Long-term oceanographic variability is known to have negatively impacted both timing of breeding and reproductive success in the Lesser Noddy and other seabird species at the Houtman Abrolhos and further afield (Dunlop *et al.* 2002; Surman *et al.* 2012). ENSO events in 1997, 2002 and 2004 led to delayed onset of breeding and near catastrophic breeding failures in Lesser Noddies, Brown Noddies *Anous stolidus* and Sooty Terns *Onychoprion fuscatus*, and in very low breeding participation in the Wedge-tailed Shearwater *Ardenna pacifica* (Surman *et al.* 2012).

The strong link between ENSO events and breeding failures in seabirds appears to be decoupling with poor breeding seasons being also observed in non-ENSO years (Surman 1998; Surman and Nicholson 2009b). It would appear that the environmental trigger for the arrival of prey, perhaps as a result of a delayed autumn sea surface temperate (SST) peak (Caputi *et al.* 2009), has shifted and has led to consistently later breeding. Whilst the resident Lesser Noddy was found to be the most resilient to change of four species studied (Wedge-tailed Shearwater, Sooty Tern, Brown Noddy and Lesser Noddy - Surman *et al.* 2012) the cumulative impact of consecutive poor breeding seasons may inevitably lead to a reduction in the numbers of young entering the breeding pool.

Movement between islands

Changes in population sizes at various islands or colonies may be in part the result of movement of Lesser Noddies between mangrove areas. Wooded and Morley islands are situated very close to each other in the Easter Group, with the distance between the colonies (*c.* 600 m) being less than the distance between colonies 2 and 5 on Pelsaert (*c.* 3 km, Figure 1). Pelsaert Island colonies, however, are a minimum of 27 kilometres south of those on Wooded and Morley Islands. On Pelsaert Island, new small colonies of Lesser Noddies were established in some years and abandoned later (Table 1). The two major colonies on Pelsaert Island (1 and 2, Figure 1) have been occupied continuously since 1989, however smaller colonies (3 – 8) have only contained breeding birds in some years. Whilst Lesser Noddies are generally site-faithful (Surman and Wooller 1995), several birds banded at Colony 2 on Pelsaert Island have been observed nesting at Colony 5, three kilometres distant.

Conservation status of the Lesser Noddy (Houtman Abrolhos)

Lesser Noddies have been reported on islands at Ashmore Reef in small numbers (<120) in 2009 and 2010 and four were recorded nesting there in April 2010 (Clark *et al.* 2011). Houtman Abrolhos Lesser Noddies disperse during the non-breeding period across waters from Cape Leeuwin to North West Cape (Surman, unpublished geolocator data). This was confirmed recently when Lesser Noddies were observed roosting at night on Bernier Island, Shark Bay (Colleen Sims, *pers. comm.*). Lesser Noddies have also been reported occasionally at various places along the SW coast, usually associated with storm fronts (Higgins and Davies 1996). These records suggest that the only significant breeding colonies in the eastern Indian Ocean occurs at the Houtman Abrolhos.

Garnett *et al.* (2011), using IUCN Red List categories and criteria version 3.1 (IUCN 2001) evaluated the Australian subspecies of the Lesser Noddy as Endangered B2ab(iii,v). This requires that the Area of Occupancy (AOO) be less than 500 square kilometres and that it is severely fragmented or known to exist at no more than five locations and that there be a continuing decline in area, extent and/or quality of habitat and number of mature individuals. The AOO is *c.* four hectares, being the area of the colonial breeding mangroves (there are other small mangrove forests in the Houtman Abrolhos that are not used by Lesser Noddies for breeding; however, the total area of these is less than the area used in recent decades) and the subspecies breeds in three locations. However, data presented in Figure 2 and Table 2 indicates that there is not a 'continuing decline' in the number of mature individuals. It is unclear whether there is a 'continuing decline' in the 'area, extent and/or quality of habitat' (the mangroves) although mangrove dieback is persisting at several sites.

The Lesser Noddy (Houtman Abrolhos) meets *Vulnerable* under criterion D2, having a very restricted AOO and fewer than five locations and plausible threats (mangrove decline, sea surface temperature changes leading to changes in food availability, sea level rise) such that it is capable of becoming *Critically Endangered* within a very short time period. Therefore, whether to evaluate as *Endangered* or *Vulnerable* may depend on how precautionary an assessor decides to be.

ACKNOWLEDGEMENTS

We particularly thank John Blyth, Anthony Desmond, Tony Docherty, Lisa Nicholson, Shae Surman and Paul Warnock for their assistance in the field. Transport was kindly provided by the crews of *Hero*, *Reef Seeker*, and the Department of Fisheries (DoF) patrol vessels *PV Houtman* and *PV Chalmers*. We thank the Western Australian Department of Parks and Wildlife and the DoF for permission to conduct research at the islands (under Regulation 23 Licence BB003360). The DoF Saville-Kent Centre, M. Davidson, B. Humphries and J. Macfarlane of Chimera Pearls kindly provided accommodation. This research was in part funded by the Parks and Wildlife-managed project 'Back from the Brink', with funding provided through the Northern Agricultural Catchments Council from State and Commonwealth funds.

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Morphological sexing of babblers: comments on Lambert and Blackmore (*Corella* 39, 2015)

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Received: 13 January 2016

I found the discriminant function presented in Lambert and Blackmore's (2015) paper on morphological sexing of Grey-crowned Babblers *Pomatostomus temporalis* unusable and the results were incomplete.

In birds and other higher vertebrates, the male is larger than the female in most species (i.e. 'normal' sexual size dimorphism; Amadon 1959; Andersson 1994). Male Grey-crowned Babblers in central western New South Wales averaged longer in head-bill length than females. The pooled means (calculated from Table 2 in Lambert and Blackmore 2015) are: females 54.9 mm (n = 81) and males 57.8 mm (n = 109). Lambert and Blackmore proposed a univariate discriminant function to sex individual babblers in the field:

D = 0.776 × head-bill length (mm) – 43.920

Discriminant scores (D) and head-bill length are inter-convertible using the discriminant function. For males, the proposed cut-off of D > 1.017 gives:

Head-bill length > (1.017 + 43.920) ÷ 0.776 = 57.9 mm

which is slightly larger than the male pooled mean. For females, the cut-off of D < 1.610 gives:

Head-bill length < (1.610 + 43.920) ÷ 0.776 = 58.7 mm

However, for normal sexual size dimorphism, the female cut-off cannot be larger than the male cut-off. Birds measuring between 57.9 and 58.7 mm are not hermaphrodites! I suspect that a minus sign was omitted and the correct female cut-off could be D < –1.610, which is equivalent to:

Head-bill length < (–1.610 + 43.920) ÷ 0.776 = 54.5 mm

and slightly smaller than the female pooled mean.

The two cut-offs contain a range where sex is indeterminate: D = –1.610 to 1.017 or head-bill length = 54.5 to 57.9 mm. However, Lambert and Blackmore (2015) simply reported 87.1% accuracy for their discriminant function without detailing the numbers of birds sexed correctly, indeterminate and incorrect.

Next, Lambert and Blackmore (2015) compared discriminant function sexing to using head-bill length alone. They reported 64.7% accuracy (123 of 190 birds sexed correctly) for head-bill length alone, 33.7% in the 'overlap range'(64 birds) and 1.6% errors (3 birds). However, the head-bill length cut-offs (the overlap range) used were not specified.

Lambert and Blackmore (2015) could assist Corella readers and correct and more fully explain their results. They could explain the probability cut-offs behind the discriminant score cut-offs and interpret them using head-bill length. They could also discuss the advantages and disadvantages of using two cut-offs versus one cut-off and the problem of overlapping measurements and indeterminate results. Lambert and Blackmore (2015) stated repeatedly that their morphological sexing error rates may be acceptable 'for some studies'. They could give some examples where low rates of indeterminate or erroneous sexing results might be acceptable.

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Morphological sexing of babblers: a response to Totterman

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The primary aim of our study (Lambert and Blackmore 2015) was to demonstrate that Grey-crowned Babblers *Pomatostomus temporalis* cannot be reliably sexed by the size of morphological characters, as has been previously reported (Counsilman and King 1977). The authors are grateful to Totterman for noting the typographical omission of the minus sign in our cut-off for female Grey-crowned Babblers. The correct cut-off for females should indeed have been reported as D< -1.610. From our test dataset of 31 birds, 87.1% (27/31) were sexed correctly, with four falling into the overlap range. We used a classification DFA (without the stepwise process) to sex the birds using head-bill length alone. We report the proportion of birds sexed correctly to demonstrate the superior reliability of the stepwise DFA model, and consider publication of the cut-offs generated by the inferior classification model to be irrelevant; head-bill ranges and overlaps are already presented in Fig. 3.

We do not consider that a more detailed evaluation of the method of discriminant function analysis was warranted in our original paper, which is only concerned with the question of whether the method can be applied to sex Grey-crowned Babblers with certainty. However, we do note that the DFA was a stepwise function that selected the head-bill length as the best sexing measurement with two cut-off points due to the overlap in morphology. Whilst we reiterate that molecular techniques should be used to resolve sex in this species, estimates of gender with a high error rate may be tolerable in ecological studies of abundance and presence or studies where the breeding unit, as opposed to group composition, is the focus.

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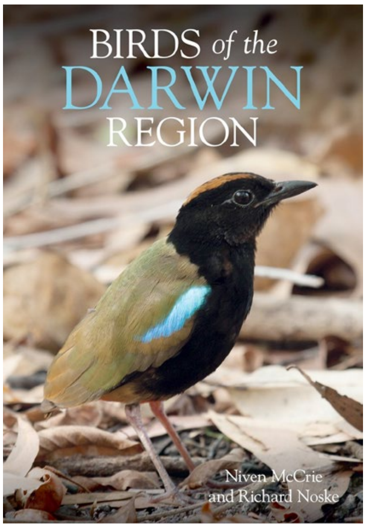
Book Review



Birds of the Darwin Region

Niven McCrie and Richard Noske, 2015. CSIRO Publishing. Paperback, 464 pp, colour photographs, maps, graphs. ISBN: 9781486300341. RRP $79.95.

Darwin, Australia's smallest capital city, is situated in the north-west Top End of the Northern Territory on the shores of the Timor Sea, a region subject to a monsoonal climate with distinct 'wet' and 'dry' seasons. This climate shapes local habitats and hence its fauna. The Top End is world-famous for the extensive floodplains and wetlands of Kakadu National Park, but the Darwin region itself holds a diversity of habitats, and a diversity of bird species. Darwin's 323 resident birds, seasonal migrants and visitors, and vagrants are treated in detail in a new book, *Birds of the Darwin Region*.

Neither a field guide nor a site guide, the book serves more as a specialised reference source summarizing local occurrence and ecology, and will be of interest to academics, amateur ornithologists and birdwatchers. The value of this book largely lies in its documentation of locally-specific information, which has nowhere else been summarized in this manner. Information on wide-ranging species contained in Australian field guides and other reference sources often originates from southern and eastern Australia, but ecology, particularly breeding, can differ considerably in the monsoonal tropics.

The introductory sections of the book cover a brief history of ornithology in Darwin, local climate, the avifauna (including bird movements and breeding in a seasonal context) and habitats. These sections provide a solid grounding in topics that influence the distribution and occurrence of birds within the region. An 'About this book' section follows, outlining the data sources used to create distribution maps and seasonality charts for each species.

Each species account opens with a brief summary of global range, broad habitats, status in the Darwin region, and breeding season. It would have been useful to include any threatened species listings in this opening information (sometimes included in the species account text). A colour photograph is provided for most species, although a few photos are inexplicably lacking (King Quail and Grey-headed Honeyeater are two examples), and likely could have been sourced from local photographers. The photographs are generally of high quality, and so it is a shame that they are small and not a more prominent feature of each species account considering the size of the volume.

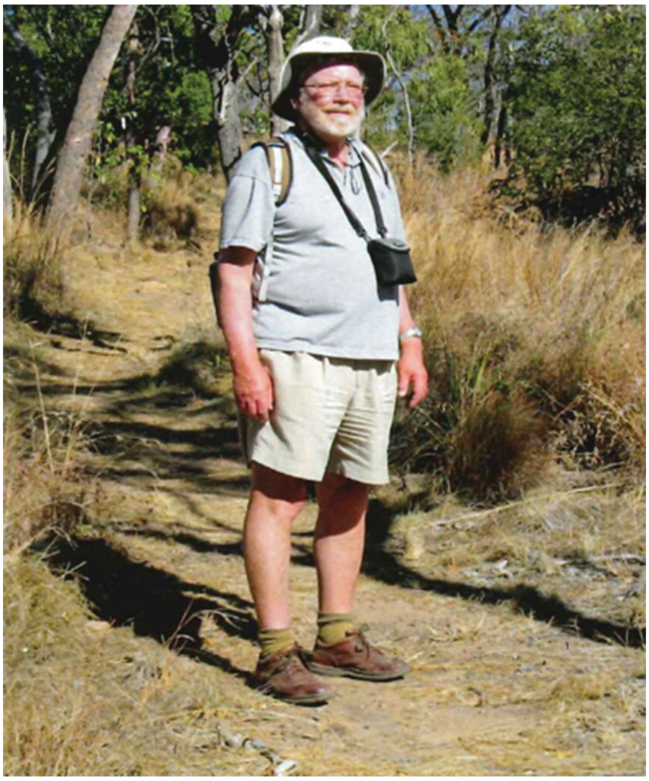
A map of occurrence and chart of seasonality is provided with each species account for all but the vagrant species. A considerable amount of data has gone into creating the maps and charts, but the maps themselves are difficult to quickly interpret. Rather than displaying point records, the maps use a grid system with black and grey dots of different sizes to indicate reporting rates for a species within an individual grid. The maps don't contain any labels or location names and so require constant reference to the 'About this book' section to understand where birds occur, especially for anyone not familiar with the layout of Darwin. An alternative mapping approach may have been more illustrative. The seasonality charts are more useful, and provide a quick visualization of wet and dry season occurrence. The text within the species accounts is extensive, summarising details of local distribution, habitat, seasonality and breeding through comprehensively reviewing records and literature.

Interstate birdwatchers may find the book of interest in relation to the occurrence of Darwin's specialist species, for example Darwin is the sole Australian locality in which to reliably and regularly see Little Ringed Plover (an uncommon migrant as specified in the book, as opposed to its previous branding as a vagrant to Australia). Darwin's northern location (closer to Indonesia than to any other Australian capital city) has seen some 61 vagrant species recorded. The city therefore arguably rivals any Australian location for vagrant species, and the short species accounts of vagrants, along with accounts of 11 unconfirmed birds which follows the main species treatments in the book, will likely be of particular interest to birdwatchers. Perhaps most importantly though, *Birds of the Darwin Region* will hopefully serve to encourage researchers to identify knowledge gaps worthy of study, and local birdwatchers and amateur ornithologists to accurately document and publish new information specific to the region.

The authors, like many writing about the northern Australian environment, flora and fauna, state that habitats are near-pristine, and in the case of birds, that Darwin hosts no established exotic species. These factors are important for ensuring a persisting natural bird community, but the former point is somewhat misleading, and while importantly the Top End's major waterways remain largely intact, the region, including Darwin, is far from pristine. Weeds, fire management and feral animals (in particular pigs and water buffaloes) are all changing the landscape and its habitats, and have had considerable negative impacts on a number of bird species. Furthermore, the current rhetoric around the large-scale development of northern Australia, with Darwin at its epicentre, will place further pressure on habitats and birds. In this context, *Birds of the Darwin Region* provides a valuable reference source to understand and monitor bird populations and their response to a rapidly-changing urban landscape

Peter Kyne
Darwin NT

OBITUARY



DAVID PURCHASE (1934 –2015)

Secretary, Australian Bird and Bat Banding Scheme 1967-1984

David (Dave) Purchase was an unassuming and gentle man who will be best remembered by the Australian ornithological world as a meticulous administrator and a strong supporter of amateur researchers and bird banders in particular.

For Australian bird and bat banders during 20 years from the 1960s to the 1980s Dave was the bird and bat banding scheme. His calm ways and methodical administration saw the fledgling organisation he took over in 1967 have two million banded birds recorded by 1984 with about 10 percent of these being re-traps,

The Australian Bird Banding Scheme began officially in 1953 as a technical service run by the CSIRO in collaboration with the State and Territory fauna authorities while the Australian Bat Banding Scheme was officially launched by the CSIRO Division of Wildlife Research in 1960.

David Purchase came to Australia from the UK as a single young man on the SS Largs Bay. He first worked on a farm at Richmond near Sydney. The fledgling town of Canberra needed young workers so Dave moved and joined CSIRO in 1957. Here his first job was with the 'rabbit team'. He developed an interest in caving and joined the newly formed Canberra Speleologists. The first bats banded in Australia were in 1957. Dave, the naturalist, combined his caving interests and started banding bats at Wee Jasper in 1958.

In 1960 Dave wrote the first (of many subsequent) Annual Report of the Australian Bat Banding Scheme. In that year the Bird and Bat Banding Schemes were combined and managed together.

In 1962 Dave resigned from the Wildlife Section in Canberra and was appointed as a Biologist with the Australian National Antarctic Research Expeditions (ANARE), and spent a total of 29 months, between December 1962 and March 1966, on Macquarie Island. Here he worked on the Royal Penguin – a long-term population study involving a large-scale banding programme. He also took the opportunity to study aspects of population regulation in the Southern Skua.

On returning to Canberra from the sub-Antarctic, Dave was to commence a career that he would follow for the rest of his working life. Dr Harry Frith, the doyen of Australian wildlife research and Chief of the CSIRO Division of Wildlife Research, recognised Dave's particular skills and appointed him Secretary of the Australian Bird-banding and Bat-banding Scheme (ABBS) on January 1, 1967.

The unassuming Dave committed himself to the meticulous task of the Secretary of ABBS for almost two decades. To Dave, in the way public service was viewed in his day, he saw his appointment as Secretary of the ABBS an honour and privilege. It was not a stepping stone to the next job or a line on a CV.

The Secretary's role was not without its challenges. It is easy to look at today's mature scheme and underestimate the challenges of its creation.

Firstly, there were the technical issues of band design, manufacture and supply. Then there were the administrative tasks of record keeping (pre- and then post-computers) and logistics. And of course there was the business of managing the multitude of personalities involved in bird and bat research. These ranged nationally from the professional scientists, some with little knowledge of birds, to the enthusiastic amateurs. What a theatre!

Dave's diplomatic skills were partly the reason we now have one national banding scheme. In the early days, state authorities were going their own way. We could easily have had a plethora of banding schemes across the continent in the various states and institutions. Federation has some virtues.

In 1984, the CSIRO transferred the Australian Bird and Bat Banding Schemes (ABBBS) to the Australian National Parks and Wildlife Service (ANPWS). While Dave had the opportunity to transfer with the ABBBS to the public service agency he chose to step aside. After starting with the infant scheme 24 years earlier and running from 1967 he felt that working in a new organisation was not for him.

As a budding 16 year old birdo living in the ACT in 1970, I became a licensed (B Class) bird bander and had the great good fortune to be able to have easy access to the machine room of the Australian Bird-banding and Bat banding Scheme at CSIRO

Wildlife Research in Canberra. I was able to benefit from Dave's unstinting encouragement. It was Dave's encouragement of inexperienced banders that energised the scheme and gave so many young would-be ornithologists their professional or amateur start.

Whilst I was a bird bander, it was through Dave's contributions through Canberra Ornithologist Group (COG) that I really got to know him. I knew Dave in the earliest years of COG (then an RAOU Branch). Dave was in Macquarie Island when COG was formed in 1964 but he became actively involved in 1967. I joined in 1970. The fledgling club started a journal in 1968, the Canberra Bird Notes (CBN) and Dave was its first editor. Ten years later, I was editor and as always found Dave's advice and encouragement sound and freely given.

Last year, in Dave's eightieth year, COG celebrated its 50th anniversary. There were a lot of different activities and one was the production of an anniversary edition of the CBN. Dave wrote a history of the Canberra RAOU Branch for the 1964-2014 CBN 50th anniversary issue. This contribution is a wonderful legacy to Dave's attention to detail, word craft and meticulous record keeping. The article and the issue are significant historic records in the life of Canberra and its birds in the second half of the 20th century.

For me, Dave was the passionate ornithologist, bird recorder, editor, bird club companion and eager sharer of information with young people. Many younger amateur and professional ornithologists today are the better for his long-term unselfish support.

Life is lived in many parts, and while here I have addressed Dave's professional contribution, I recognise that Dave's greatest pride was his family. I acknowledge Dave's life partner the late Shirley, their daughter Robin, grand children Anton and Marissa and son-in-law Frank.

Dave loved words. I hope these words do credit to a life well-lived.

It is a mark of Dave's life-long passion that his family elected to have donations in respect of Dave's passing be made to the Canberra Birds Conservation Fund

Neil Hermes

Corella 40(3): 79

RECOVERY ROUND-UP

This section is prepared with the co-operation of the Secretary, Australian Bird and Bat Banding Schemes, Australian Nature Conservation Agency. The recoveries are only a selection of the thousands received each year; they are not a complete list and should not be analysed in full or part without prior consent of the banders concerned. Longevity and distance records refer to the ABBBS unless otherwise stated. The distance is the shortest distance in kilometres along the direct line joining the place of banding and recovery; the compass direction refers to the same direct line. (There is no implication regarding the distance flown or the route followed by the bird). Where available ABBBS age codes have been included in the banding data.

Recovery or longevity items may be submitted directly to me whereupon their merits for inclusion will be considered.

Hon. Editor

The following abbreviations appear in this issue:

AWSG - Australasian Wader Study Group.
SOSSA – Southern Ocean Seabird Study Group.
VWSG - Victorian Wader Study Group.

Common Bronzewing *Phaps chalcoptera*

090-48745. Adult (1+) female banded by R. P. Allen at Dixon Property, 15 km SW of Grenfell, NSW on 9 Mar. 2003. Recaptured, released alive with band at banding place on 14 Mar. 2009, over 6 years after banding.

(This is the oldest recorded for the species.)

Peaceful Dove *Geopelia striata*

062-20460. Adult (2+) banded by the Broome Bird Observatory at Coconut Well, 10 km N of Broome, WA on 4 Oct. 1992. Recaptured, released alive with band at banding place four times the last occasion on 4 Jun. 2011, over 18 years 8 months after banding.

(This is the oldest recorded for the species.)

Wonga Pigeon *Leucosarcia picata*

100-31304. Immature (1) banded by G. J. Logan at Townsend near Maclean, NSW on 28 Aug. 1998. Recaptured, released alive with band at banding place on 4 Aug. 2008, over 9 years, 11 months after banding.

(This is the oldest recorded for the species.)

Great-winged Petrel *Pterodroma macroptera*

083-15132, Adult (1+) banded by SOSSA at sea off Tomakin, NSW (35^0 50' 00"S 150^0 15' 00"E) on 9 Feb 2003. Recaptured, released alive with band on East Island, New Island, New Zealand (37^0 41' 00"S 178^0 35' 00" E) on 8 Apr. 2011, over 8 years, 2 months after banding. 2523 km E.

(This is the longest movement recorded for the species.)

Eastern Osprey *Pandion cristatus*

280-14940, plus coloured metal band LBlue. Nestling, male banded by G. P. Clancy south of the Broadwater, Clarence River, NSW on 1 Nov. 2001. Band number read in field (bird not trapped) at Ulladulla, NSW on 8 Apr. 2016, over 14 years, 5 months after banding. 701 km SSW.

Beach Stone-curlew *Esacus magnirostris*

111-02559. Nestling, male banded by G. P. Clancy at Red Rock Estuary, NSW on 24 Nov. 2009. Band number read in field (bird not trapped) eleven times the last occasion at Sandon Estuary south of Brooms Head, NSW on 22 Mar. 2016, over 6 years, 3 months after banding. 35 km N.

Black-winged Stilt *Himantopus himantopus*

072-55113. Immature (1) banded by AWSG at Beaches Crab Creek Road, Roebuck Bay, Broome, WA on 28 May 1994. Recaptured, released alive with band at banding place on 21 Feb. 2016, over 21 years, 8 months after banding.

(This is the longest movement recorded for the species)

Greater Sand Plover *Charadrius leschenaultii*

051-85866. Immature (1) banded by AWSG at Beaches Crab Creek Road, Roebuck Bay, Broome, WA on 23 Mar. 1996. Recaptured, released alive with band at banding place on 25 Feb. 2016, over 19 years, 11 months after banding.

Black-tailed Godwit *Limosa limosa*

072-81988. Adult (2+) banded by AWSG at Beaches Crab Creek Road, Roebuck Bay, Broome, WA on 18 Nov. 2002. Recaptured, released alive with band at banding place on 24 Feb. 2016, over 13 years, 3 months after banding.

Bar-tailed Godwit *Limosa lapponica*

072-33180. Immature (1) banded by AWSG on the Shores of 80 Mile Beach, WA on 12 Mar. 1994. Recaptured, released alive with band at banding place on 16 Feb. 2016, over 21 years, 11 months after banding.

Eastern Curlew *Numenius madagascariensis*

091-24367. Adult (3+) banded by AWSG at Beaches Crab Creek Road, Roebuck Bay, Broome, WA on 29 Oct. 2001. Recaptured, released alive with band at banding place on 22 Feb. 2016, over 14 years, 3 months after banding.

Great Knot *Calidris tenuirostris*

(a) 062-33249. Adult (2+) banded by AWSG on the Shores of 80 Mile Beach, WA on 3 Apr. 1996. Recaptured, released alive with band at banding place on 13 Feb. 2016, over 19 years, 10 months after banding.

(b) 062-33838. Adult (3+) banded by AWSG on the Shores of 80 Mile Beach, WA on 21 Aug. 1998. Recaptured, released alive with band at banding place on 13 Feb. 2016, over 17 years, 5 months after banding.

Curlew Sandpiper *Calidris ferruginea*

041-92766. Adult (2) banded by AWSG at Beaches Crab Creek Road, Roebuck Bay, Broome, WA on 12 Aug. 1998. Recaptured, released alive with band at banding place on 20 Feb. 2016, over 17 years, 6 months after banding.

Little Tern *Sternula albifrons*

042-73973 plus Leg Flag (plain colour): RD Orange. Banded by VWSG at Barry Beach, Corner Inlet, Vic. ($38^0$42'00"S, $146^0$23'00"E) on 18 Mar. 2015. Band number read in field (bird not trapped) at Imazu, Yodoe, Yonago, Tottori Prefecture, Japan ($35^0$28'00"N, $133^0$26'00"E) on 7 May 2016. 8352 km NNW.

Crested Tern *Thalasseus bergii*

071-95368. Nestling banded by the VWSG on Mud Island, Port Phillip Bay, Vic. on 17 Dec. 1988. Band number read in field (bird not trapped) twice the last occasion at Flat Rock, East Ballina by S. McBride on 10 Apr. 2016, over 27 years, 3 months after banding. 1330 km NE.

Silver Gull *Chroicocephalus novaehollandiae*

081-40538. Nestling banded by W. C. Wakefield on Spectacle Island, Frederick Henry Bay, Tas. on 19 Nov. 1989. Band number read in field (bird not trapped) at Salamanca Place, Hobart on 8 Jun. 2016, over 26 years, 6 months after banding. 22 km W..

Brown Gerygone *Gerygone mouki*

019-75276. Adult (1+) banded by A. & A. Leishman at Camden Airport, NSW on 9 Aug. 2010. Recaptured, released alive with band at banding place three times, the last occasion on 25 Jun. 2016, over 5 years, 10 months after banding.

Grey-headed Honeyeater *Lichenostomus keartlandi*

025-54438. Adult banded by C. P. S. de Rebeira at Roberts Bore, Great Sandy Desert, WA, on 30 Jun. 2004. Recaptured, released alive with band at the banding place on 15 Jul. 2009, over 5 years after banding.

(This is the oldest recorded for the species.)

Bell Miner *Manorina melanophrys*

042-96991. Immature (1) banded by A & A Leishman at Camden Airport, NSW on 19 Apr. 2014. Recovered with injured wing at John Street, Camden, NSW on 17 Feb. 2016, bird taken into care, later died. 1.5 km ESE.

Noisy Miner *Manorina melanocephala*

062-98419. Adult (1+) banded by D. McKay at Burrendong Arboretum, near Wellington, NSW on 5 Dec. 2009. Recaptured, released alive with band at banding place by C. Leon on 21 Nov. 2015, over 5 years and 11 months after banding.

Western Wattlebird *Anthochaera lunulata*

051-45751. Immature (1) Banded by T. G. D. Shannon at Yanchep National Park, WA on 4 Jun. 1989. Recaptured, released alive with band at banding place on 26 Nov. 2000, over 11 years, 5 months after banding.

(This is the oldest recorded for the species.)

Rufous-throated Honeyeater *Conopophila rufogularis*

025-57045. Adult (1+) banded at the Broome Bird Observatory, 18 km E of Broome, WA on 6 Oct. 2000. Recaptured, released alive with band at banding place on 7 Nov. 2012, over 12 years, 1 month after banding.

(This is the oldest recorded for the species.)

Golden Whistler *Pachycephala pectoralis*

035-26507. Adult (2+) female banded by A. & A. Leishman at Camden Airport, NSW on 18 Aug. 2008. Recaptured, released alive with band at banding place five times, the last occasion on 25 Jun. 2016, over 7 years, 10 months after banding.

Notice to Contributors

Manuscripts relating to any form of avian research will be considered for publication. Field studies are preferred particularly where identification of individual birds, as by banding, has formed an integral part of the study. Some broad areas of research which do not necessarily require individual identification include morphometric analyses, techniques, species diversity and density studies as well as behavioural investigations. Behavioural, plumage and breeding studies can be conducted in captivity but must provide basic ornithological knowledge rather than avicultural interest.

Manuscripts are classified as either major articles (more than 1,500 words) or minor articles (500 to 1,500 words). Minor articles need no summary. Shorter notes relating to almost any aspect of ornithology are welcomed but must adhere to the aims of the Association. Species lists or sightings which are not discussed in relation to historical evidence or scientific parameters are not suitable for publication in *Corella*. Authors proposing to prepare Seabird Island items should contact the Assistant Editor,Seabird Islands, and obtain a copy of the guidelines.

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Manuscripts:

A guide to the format required for tables, figures and manuscripts can be attained by reference to a recent edition of the journal and more specifically to the Publication Style found on the ABSA website.

Articles or notes should be sent via email to the editor as a .doc or .rtf file or typewritten and submitted in triplicate via post. Double spacing is required with typing on one side of the paper only. Margins of not less than 25 mm width at the left hand side and top, with similar or slightly smaller at the right hand side of the page are required.

All pages of the manuscript must be numbered consecutively, including those containing references, tables and captions to illustrations, the latter placed in after the text. No underlining and no abbreviations should be used within the text.

The *Style Manual for Authors,Editors and Printers* (6th edition 2002; John Wiley & Sons Australia, Ltd.) is the guide for this journal. Spelling generally follows the Macquarie Dictionary.

Nomenclature and Classifications follow:

Christidis, L. and Boles, W. E. (2008). 'Systematics and Taxonomy of Australian Birds'. (CSIRO: Collingwood, Victoria).

Proper nouns, particularly place and bird names must commence with a capital letter.

Headings are as follows: **HEADING – capitals and bold** (e.g. **RESULTS)**

Sub Heading – lower case and italics (e.g. *Ecology*)

Referencing:

References to other articles should be shown in the text – '. . . Bell and Ferrier (1985) stated that . . .'or '…. this is consistent with other studies (Jones 1983; Bell and Ferrier 1985).'– and in the Reference Section as:

Bell, H. L. and Ferrier, S. (1985). The reliability of estimates of density from transect counts. *Corella* 9: 3-13.

Jones, J. C. (1983). 'Sampling Techniques in Ornithology.'(Surrey Beatty and Sons: Chipping Norton, NSW.)

Figures (Maps and Graphs) and Tables:

The printable area of the page is 18 cm x 27 cm; double column figures/tables will be 18 cm across; single column figures/ tables will be 8.5 cm across; widths between one column and double column can also be accommodated.

The captions for figures should be typed up onto a page separate from the figure.

Maps

Maps should be clear and relevant to the study and can be submitted in a variety of formats (.tif, .eps, .pcx) but the recommended one is a high resolution .jpg file (colour is acceptable). In some instances simply listing the latitude and longitude may suffice instead of a published map. Maps should only show necessary information. Excessive labelling(including names of towns, roads, rivers) will clutter the figure making it difficult to locate key place names. Photocopies of original hand drawn maps are not suitable for publication. They should be submitted only initially. When the paper is accepted for publication, the originals must be submitted so that they can be scanned into an appropriate electronic format.

Graphs

Lines should be thick and dark and any fill used should show a clear distinction between sets of data (colour fills are acceptable). Borders around the graph and the key are not necessary. The recommended format is an .xls file – this makes it very easy to adjust fills, thickness of lines etc, if necessary.

Where possible, please present the figure at final size. Figures that seem satisfactory when they are large, can present problems when they are reduced. Remember that if the figure has to be reduced for publication the figure will reduce equally in all dimensions i.e. both width and height will reduce. This can cause some problems, such as: (i) Line graphs where the lines are very close together can lose clarity. (ii) The typeface will reduce. Please ensure that the final typeface size AFTER reduction will be a minimum of 10 times Times New Roman typeface.

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FOR MORE DETAILED INFORMATION OR ASSISTANCE IN THE PREPARATION OF FIGURES PLEASE CONTACT THE PRODUCTION EDITOR.

CORELLA

Volume 40 Number 3 September 2016

P.O. Box 1867, Penrith BC, NSW 2751