

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

John L. Robinson<sup>1</sup>, Barrie R. Cooper<sup>2</sup> and Donald C. Franklin<sup>3,4</sup>

<sup>1</sup> 12 Blucher Street, Strathfieldsaye, Victoria 3551, Australia

<sup>2</sup> 10 Battunga Court, Strathfieldsaye, Victoria 3551, Australia

<sup>3</sup> Research Institute for the Environment and Livelihoods, Charles Darwin University, Darwin, Northern Territory 0909, Australia.

Email: don.franklin@cdu.edu.au

<sup>4</sup> Ecological Communications, 24 Broadway, Herberton, Queensland 4887, Australia

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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<sup>2</sup>) and in the forested portion of the study area, one pair per 38.7 square kilometres (25.8 pairs/1000 km<sup>2</sup>). 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 <i>Accipiter fasciatus</i>	8	–
Collared Sparrowhawk <i>Accipiter cirrocephalus</i>	8	150, 150, 500, 750
Wedge-tailed Eagle <i>Aquila audax</i>	1	–
Little Eagle <i>Hieraaetus morphnoides</i>	9	120, 300
Brown Falcon <i>Falco berigora</i>	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)	<i>Eucalyptus camaldulensis</i>	1	1
	<i>E. leucoxylon</i>	3	3
	<i>E. melliodora</i>	2	4
	<i>E. microcarpa</i>	1	10
	<i>E. tricarpa</i>	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).

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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.