



Observations of the Powerful Owl *Ninox strenua* in the Illawarra and Shoalhaven Regions of New South Wales

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Summary

Data on the diet, habitat, breeding biology and general ecology of the Powerful Owl *Ninox strenua* were analysed from eleven locations in the Illawarra and Shoalhaven regions of the southern central coast of New South Wales. These data show that Common Ringtail Possum *Pseudocheirus peregrinus* comprised 36%, Sugar Glider *Petaurus breviceps* 31% and birds 13% of the regional diet by number, based on a combination of regurgitated pellet analysis from four sites and cumulative observations of apprehended prey from ten sites. Quantified pellet analysis is presented from two locations, Bass Point and Culburra. At the former site Common Ringtail Possum comprised 45% of the local diet and at the latter site Sugar Glider comprised 73% of the recorded diet. A total of ten mammal species, including two Feral Cats *Felis catus*, eleven avian species and two coleopteran genera were contained in the regional diet. Habitat from which the owl is recorded includes moist and dry open forest from an elevated plateau, littoral closed forest, coastal open forest and riparian closed forest. Breeding is reported from three sites falling within the known breeding season, however the mean height of the nest hollows (9.3 m) is below the previously recorded minima. A nocturnal attack by a Powerful Owl on a Tawny Frogmouth *Podargus strigoides* is also described.

Introduction

Data on the behaviour, ecology and biology of the Powerful Owl *Ninox strenua* have been most recently reviewed by Schodde & Mason (1980), and augmented in subsequent studies (Tilley 1982, Wilson 1982, Ross 1986, Olsen 1987, Kavanagh 1988, Gibbons 1989, Hollands 1991, Pavey in press, Traill in press). Most of these studies have been conducted in Victoria, and may have resulted in a biased view of the species' ecology, particularly with respect to diet and habitat requirements. This paper reports the partial results of a long-term study of the ecological and biological requirements of the Powerful Owl from 1980 to 1990, concentrating on the diet and habitat utilisation of Powerful Owls in the Illawarra and Shoalhaven regions of New South Wales.

Study area and methods

Between 1982 and 1990 data on the Powerful Owl were collected from 11 sites in the Illawarra and Shoalhaven regions of New South Wales, a coastal strip 145 km long from Port Hacking on the southern outskirts of Sydney to Jervis Bay in the south and 65 km inland at the most western site, Bullio (Figure 1). Physiographically, this area consists of a relatively flat coastal plain varying from 0 to 20 km in width terminated by a steep escarpment, westward of which is an elevated plateau 300-800 m above sea level (a.s.l.) gently dipping to the west and characterised by numerous deeply eroded sandstone gorges. The coastal plain north of Nowra is heavily settled, with urban, industrial and agricultural development, whereas much of the plateau is contained in water catchment reserves, state forests and national parks, though farming activities also prevail. Natural vegetation on the coastal plain north of Nowra is generally restricted to forest remnants, a few nature reserves and two national parks which retain examples of coastal heathland, littoral closed forest, open forest and tall open forest. South of Nowra natural vegetation is better represented in several nature reserves and a number of state forests, which mainly contain open forest. Urban development is restricted to Nowra and several smaller villages. The entire escarpment

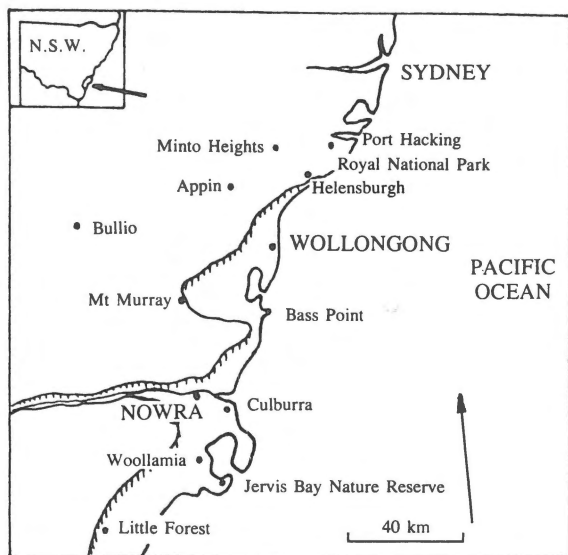


Figure 1.
Map showing site locations for records of Powerful Owl recorded in this study from the Illawarra and Shoalhaven regions of New South Wales.

slope is clothed in a mixture of tall open forest, closed forest and some tall closed forest. The plateau is largely dominated by open forest, though some remnants of closed forest and tall open forest exist in gullies and on volcanic outcrops (Pidgeon 1937, Mills 1988, Gibson 1989).

Owl data were collected from seven locations by the author and from four locations by interviews with observers known to the author. All locations were physically visited by the author to ascertain habitat structure. At four sites (Bass Point, Culburra, Royal National Park and Helensburgh), regurgitated pellets were collected for dietary analysis. No attempt was made to estimate the total number of pellets collected as they were mostly in a disintegrated condition when found. Pellets from two sites (Bass Point and Culburra) were collected over a long enough period (seven years and six months respectively) to allow the results to be pooled on a monthly basis per site, and an estimate of the minimum number of prey species per site made on the basis of identifiable cranial remains and/or the observation of apprehended prey in the birds' talons or dropped under the roost tree. Pellets were soaked in water to assist in their mechanical breakdown, and bones, feathers and insect exoskeletons were manually removed from the softened pellets similar to the method described by Dodson & Wexlar (1979). The resulting remains were compared with reference material.

A casual observation of this species near Young, N.S.W., which included foraging behaviour, was made in 1982. Although outside the study area, it is included here because there is little information published on the foraging behaviour of this species.

Results

The location of each study site is given in Figure 1. Vegetation structure for habitats is based on nomenclature from Specht (1981). Altitude is an approximation of the height above sea level for the respective observation sites based on information from 1:100 000 topographic maps. Habitats described generally refer to the vicinity of the observation site, and area estimates are given for isolated environments. Locations are reported in chronological sequence of an owl's first occurrence at that site.

Woollamia 35°01'S, 150°39'E

Altitude 50 m a.s.l. Habitat: open forest dominated by *Eucalyptus* and *Casuarina* species with scattered Turpentine *Syncarpia glomulifera*.

In July 1980 Margaret Parkinson located a Powerful Owl on a property at Woollamia. Both she and the property owners, Keith and Wendy Garbutt, were subsequently able to observe the owls on over forty occasions between 1980 and 1984. In October 1981 a nest tree — a 20 m Blackbutt *Eucalyptus pilularis* — was located on the property, with the entrance hollow being 9 m above the ground. The adults were observed perching with two juveniles near the nest site in December 1981, January 1982 and again in January 1983. At other times of the year the owls were most often observed roosting in Turpentines, with occasional sightings in casuarinas. Although pellets were collected by the observers and given to a local naturalist, no formal identification of them was made other than that they contained mammal remains. Prey items observed being held by the owls at roost sites included Greater Glider *Petauroides volans* (2), Sugar Glider *Petaurus breviceps* (1), Common Ringtail Possum *Pseudocheirus peregrinus* (3) and Australian Magpie *Gymnorhina tibicen* (1). In addition to this, they were once observed taking a Glossy Black-Cockatoo *Calyptorhynchus lathami* from the ground to a perch during the evening. Two additional dead cockatoos were found on the ground, and it is assumed that these were also killed by the owls. On another occasion a young owl was observed flying through the forest with a Common Ringtail Possum in its talons, before landing in a tree and partially devouring the anterior portion of the possum.

Young 34°00'S, 148°07'E

Altitude 320 m a.s.l. Habitat: open forest dominated by *Callitris* sp., with scattered eucalypts.

On 23 October 1982 my wife and I were travelling towards the Weddin Mountains State Forest on the South-West Slopes of New South Wales. At approximately 2130 h, some 40 km north of Young on the Henry Lawson Way, a Tawny Frogmouth *Podargus strigoides* was noticed perched on a roadside fence-post. The car was parked on the road verge with headlights shining on the bird, and after a few minutes a portable spotlight replaced the headlights. The Frogmouth was totally disinterested in our presence, its focus riveted to a spot on the ground. Suddenly a huge bird appeared from behind and to the left of the Frogmouth. It went straight for the Frogmouth, its huge talons wrapping around the bird's head. We were so startled by the owl's appearance that several exclamations were made. This appeared to affect the owl's behaviour because it dropped the Frogmouth, veered to the left and silently flew off into the adjacent forest, still illuminated by our spotlight. Although only lasting several seconds, the observation was long enough to identify the attacker as a Powerful Owl (viz. huge yellowish talons and uniform, broad brown and cream barring on the upper surface). The Frogmouth fluttered about on the ground for several seconds, obviously dazed by the attack, and then flew up to perch on top of a telegraph pole in a squat, disgruntled posture. We searched the surrounding bush for 15 minutes but failed to relocate the owl.

Bullio 34°21'S, 150°15'E

Altitude 760 m a.s.l. Habitat: open forest on ridge tops dominated by eucalypts with scattered casuarina and Turpentine. Occasional pure stands of *Casuarina* sp. Tall open forest in numerous gullies.

In November 1983 Ms Badgery of 'Wangendary', Bullio, reported locating a Powerful Owl on her property. It was roosting in a Turpentine with the remains of a Crimson Rosella *Platycercus elegans* in its talons. In September 1990 Ms Badgery again located a Powerful Owl on her property. This time it was perched in an unidentified eucalypt, holding a dead Glossy Black-Cockatoo.

Jervis Bay Nature Reserve 35°09'S, 150°44'E

Altitude 10-80 m a.s.l. Habitat: (a) 'Greenpatch', open forest dominated by eucalypts, Blackbutt, Bangalay *E. botryooides*, and banksia *Banksia serrata*, (b) Stony Creek Road, large tracts of heathland, wet and dry open forest with many Turpentines and 150 ha pine *Pinus radiata* forest.

At 'Greenpatch' camping area within the reserve the Powerful Owl has been recorded preying on Greater Glider and Common Ringtail Possum, both of which are relatively common there (R. Imisides pers. comm.). While spotlighting on 10 June 1984, I located a Powerful Owl in the pine forest along Stony Creek Road. Although no prey were recorded, Common Ringtail Possum, Sugar Glider and Yellow-bellied Glider *Petaurus australis* were recorded in adjacent open forest.

Bass Point Reserve (71 ha) 34°33'S, 150°54'E

Altitude 20 m a.s.l. Habitat: open forest dominated by banksias *Banksia integrifolia* and *B. serrata* and Coast Tea-tree *Leptospermum laevigatum* with scattered Bangalay. Also, centrally within the reserve, a discontinuous low closed forest of approximately 5 ha (Smith & Chaffer 1987).

In August 1984 I encountered an immature Powerful Owl within the low closed forest section of the reserve. Since then approximately 85 visits to the reserve have been made by me and several other local observers specifically looking for the owl, with 31 observations being recorded to December 1990. When possible pellets were collected and notes taken of prey in the owl's grasp (Table 1). It is assumed that the same individual owl was recorded on all occasions (see below).

Before this owl was located, casual spotlighting visits to the reserve had established the Common Ringtail Possum as being relatively common and possum dreys were frequently detected on diurnal visits. Approximately 18 months after the discovery of the owl, it was no longer possible to locate any dreys within the reserve sections regularly visited by observers, and it is assumed that the owl contributed to this population reduction. This opinion was also reached independently by a local mammalogist (Robinson 1988), and is supported by pellet analysis, which shows the continuous, though slight, downward trend in the frequency component of Common Ringtail Possum in the pellets. A spotlighting survey of the reserve (March 1990) produced only one possum, in a section of banksias where possums had previously been most abundant. Similar population reductions of principal dietary species have been inferred elsewhere (see Kavanagh 1988, Traill in press).

Following the reduction of the possum population, it was felt that the owl would move elsewhere and this has apparently occurred to an extent. Since 1985 no observations of the owl in the reserve have been obtained between December and April, and it is assumed that it moves out of the reserve during this period. Based on physical evidence of the owl's occurrence in the reserve i.e. sightings, pellet recoveries or detection of owl faeces at known roosting locations, it appears that the owl is now only an infrequent visitor to the reserve. It returns in autumn/winter when fruiting trees within the closed forest attract small numbers of Grey-headed Flying Fox *Pteropus poliocephalus*, and on two occasions the owl has been observed holding

Table 1

Prey items taken by the Powerful Owl at Bass Point N.S.W., August 1984-December 1990, and Culburra N.S.W., June-December 1989. Observations of captured prey in talons or under roost tree and cranial remains found in disorged pellets.

Species	Observations (n)	Cranial remains (n)	Estimated minimum number of prey individuals
BASS POINT			
Common Ringtail Possum			
<i>Pseudocheirus peregrinus</i>	13	10	23
Sugar Glider <i>Petaurus breviceps</i>		9	9
Grey-headed Flying Fox <i>Pteropus</i> <i>poliocephalus</i>	2	1	3
Feral Cat <i>Felis catus</i>	2		2
Bush Rat <i>Rattus fuscipes</i>		1	1
Black Rat <i>Rattus rattus</i>		7	7
Rabbit <i>Oryctolagus cuniculus</i>		1	1
Australian Raven <i>Corvus coronoides</i>	2		2
Insecta: Coleoptera (beetles)			8 ^a
Total	19	29	56
CULBURRA			
Common Ringtail Possum			
<i>Pseudocheirus peregrinus</i>	3	7	10
Sugar Glider <i>Petaurus breviceps</i>	3	34	37
Pied Currawong <i>Strepera graculina</i>	1		1
Pacific Black Duck <i>Anas superciliosa</i>	1		1
Unidentified bird feet		(2) ^b	2
Total	8	43	51

^atwo pellets with approximately 8 beetles (5 Cerambycidae and 3 Scarabaeidae).

^btwo species, both belonging to the Meliphagidae (see text).

the remains of this species at one of its diurnal roost sites. It has also been observed twice holding the rear portions of Feral Cats *Felis catus*; both cats were all black. The only other reference to cats being taken appears in Fleay (1968). Other prey species taken here include Sugar Glider, Black Rat *Rattus rattus*, Bush Rat *Rattus fuscipes*, Rabbit *Oryctolagus cuniculus* and Australian Raven *Corvus coronoides*, and in December 1990 two pellets contained numerous coleopteran (beetle) remains. In September 1989 the destroyed nest of an Eastern Yellow Robin *Eopsaltria australis* was found under a regular diurnal roost site. This nest had contained four chicks and had been constructed under the roost site, approximately 1.2 m above the ground. The presence of copious excreta and pellet remains on the nest suggested that the owl may have taken the chicks, although no avian remains could be identified from the pellets. This was the second occasion that I had found a destroyed Yellow Robin nest under an owl roost site; the first instance was considered coincidence and no precise data were recorded.

The owl has been located roosting in the reserve only within the closed forest section. The principal roost trees are various Plum Pine *Podocarpus elatus* with occasional records from Small-leaved Fig *Ficus obliqua*.

The nearest forested area to the reserve is at Minnamurra Spit (see Smith & Chaffer 1987), from where the owl could conceivably travel along riparian woodland to a disjunct 500 ha mature open forest farther west and north along the Minnamurra River.

It should be noted that Bass Point Reserve is surrounded on three sides by marine environments and directly on its western boundary by a large, actively mined stone quarry. West of this are open paddocks, swamp and a large lagoon. To get to Minnamurra Spit, or alternatively the township of Shellharbour, the owl would need to fly directly for 5 km over this open environment, a behaviour not previously reported for this species. As Powerful Owl feathers have been collected from Minnamurra Spit we can only assume this is what it does, at least two times per year, and possibly more frequently based on large gaps in recorded observations. Even if the owl were now resident at Bass Point (and I consider this highly unlikely), it would have had to make the flight in order to arrive at the reserve initially. There are no suitable nesting locations within the reserve.

Little Forest 35°17'S, 150°22'E

Altitude 80 m a.s.l. Habitat: mature open forest dominated by eucalypts, with numerous Turpentines. Closed forest along Little Forest Creek.

In October 1985, during a field outing of the Illawarra Bird Observers Club (IBOC) to Little Forest Creek near Milton, an adult Powerful Owl roosting low down in an unidentified rainforest tree was observed.

Minto Heights 34°02'S, 150°53'E

Altitude 100 m a.s.l. Habitat: semi-urban/disturbed open forest along upper Georges River, mostly eucalypts, casuarina and numerous Turpentines along the deep river gully.

In February 1986 the author located a Powerful Owl on a private property at Minto Heights. Although it held no prey, spotlighting here had revealed that both Common Ringtail Possum and Sugar Glider were present in the vicinity of the sighting.

Mount Murray 34°33'S, 150°38'E

Altitude 600 m a.s.l. Habitat: mature open and tall open forest dominated by various *Eucalyptus* species and 4.8 ha *Pinus radiata* forest.

In March 1986, during a field outing of the IBOC, an adult Powerful Owl was located just outside the pine forest at Mount Murray. It was perched in a large eucalypt and was being mobbed by a pair of Pied Currawongs *Strepera graculina*. It was holding the rear portion of a Common Ringtail Possum. Shortly after being located, the owl dropped the possum and flew off pursued by the Currawongs. Spotlighting has shown that Common Ringtail Possums and Greater Gliders are numerous in this area.

Appin 34°11'S, 150°45'E

Altitude 120 m a.s.l. Habitat: disturbed and undisturbed open forest along deeply eroding watercourses, dominated by various *Eucalyptus* species with scattered *Casuarina* and *Melaleuca* species, bordering rural paddocks.

In June 1986 Ian Rowles located a pair of Powerful Owls on a property near Appin. They subsequently nested in a 22 m Grey Gum *Eucalyptus punctata*. The entrance hollow was some 9.7 m from the ground and the base of the nest was only 450 mm below the bottom lip of the hollow (Olsen 1987). Two young were produced and they joined the parents outside the hollow on 30 August, roosting in a Grey Ironbark



Powerful Owl *Ninox strenua*. Adult male (left), photographed in central Victoria, and recently fledged juvenile (right), Eden, N.S.W.

Plate 45

Photos: David Hollands

Eucalyptus paniculata. On 21 August Ian climbed the nest tree for photographic purposes. The female, which had earlier left the nest, attacked him, swooping to within less than a metre, landed in an adjacent tree and continued glaring at him as he completed his photography, but did not repeat the attack. Nest defence has previously been regarded as not occurring in this species (Fleay 1968, Schodde & Mason 1980) but several recent reports of aggressive nest defence have been reported from Victoria (McNabb 1987, Gibbons 1989, Hollands 1991), indicating that the species may be more pugnacious than previously noted.

In June 1987, Ian again located the pair roosting together in a streamside paperbark *Melaleuca styphelioides* but no further breeding was recorded from the above-mentioned site. The owls were observed on at least 15 occasions from 1986 to 1989, with roosting also being noted in *Casuarina* sp. and *Acacia* sp. Prey items recorded at the diurnal roosts included Common Ringtail Possum (2) and remains of one bird, either Australian Magpie or Pied Currawong.

Royal National Park 34°05'S, 150°03'E

Altitude 20-80 m a.s.l. Habitat: mature open forest, tall open forest and patches of riparian closed forest along the middle portion of the Hacking River.

In December 1986 I led a field outing of the IBOC to the Audley area of the Royal National Park. Along a track on the western side of the Hacking River our attention was drawn towards a group of large Turpentines by what were obviously loud begging calls. As we watched, an adult Powerful Owl moved out of the dense foliage to perch on an exposed bare branch, clutching the rear portion of a Common Ringtail Possum. As the group of about 30 observers gathered around for an unobstructed view of the bird, a large juvenile owl came out of the foliage and perched next to the adult. The

time was 1645 h (Eastern Daylight Saving Time, about three hours before dusk) and both birds appeared to be totally unconcerned by our presence.

As the group watched, a second juvenile emerged from the brush and perched on the other side of the adult. Both juveniles began to bob up and down in an increasing tempo and began trilling excitedly. The staccato sound produced was very similar to that used by Southern Boobooks *Ninox novaeseelandiae* at the nest. This behaviour stirred the adult into action and, after what I can only describe as a yawn, it began to dismember the carcass. Holding the remains of the possum firmly on the tree limb, it tore strips off the carcass and passed them to the owlets, showing a distinct preference for the first juvenile which was obviously the bigger of the two youngsters. At one stage, a whole leg was offered and, after a bit of juggling, swallowed by the young owl. Eventually the second owlet moved around to perch next to its sibling and it then began to receive a better share of the meal, including the tail, which took several seconds to swallow. Trilling and bobbing by the bird that was not being fed were continuous throughout the meal. Feeding concluded at 1702 h, the adult flying off to perch in a nearby Turpentine, and all three settled down to roost. Diurnal activity has been recorded previously (Diggles 1877, Robinson 1968) and this appears to be the first recorded instance of diurnal feeding behaviour between adult and juveniles.

The owls at this location are well known to Sydney bird-watchers and several roost sites are known along the northern end of Lady Carrington Drive. A second pair of owls inhabits the southern end of Lady Carrington Drive (approximately 10 km separates roost areas), but this pair is more difficult to observe. A wide variety of food items has been recorded by several observers, including Superb Lyrebird *Menura novaehollandiae* (1), Purple Swamphen *Porphyrio porphyrio* (1), Dusky Moorhen *Gallinula tenebrosa* (1), Sulphur-crested Cockatoo *Cacactua galerita* (2), Australian Magpie (2), and Common Ringtail Possum (4) (A.R. McGill, J. Francis, D. Andrew and L.E. Smith pers. comm.). The only pellets that I have examined from this location were collected in December 1984 by J. Gibson and D. Turner and lodged in the Australian Museum; I identified the remains of two Common Ringtail Possums.

Curiously, along southern Lady Carrington Drive, the Greater Glider, which spotlighting has shown to be as abundant as the Common Ringtail Possum, has not yet been detected as a prey item in the National Park.

Culburra 34°56'S, 150°43'E

Altitude 30 m a.s.l. Habitat: open forest dominated by mature pure stands of *Casuarina* sp. with scattered eucalypt and Turpentine groves.

During the combined bird clubs of New South Wales camp at Culburra in June 1989, a Powerful Owl was heard calling each night at dusk although we were unable to locate it. On 25 June I searched the area with Diana Wright and eventually we located the adult bird roosting in a 15 m Turpentine, holding the posterior portion of a Sugar Glider, the tail casually draped over the branch. The area was subsequently visited on 11 occasions to December 1989, with the owl being located on 9 occasions at one of three different roost trees (all Turpentes), within 50 m of a 25 m Scribbly Gum *Eucalyptus sclerophylla* which was suspected as being a nest tree. The tree had a well-used large hollow 9.5 m from the ground. As well as observing the owl with prey items, we were able to collect a large quantity of disintegrated pellets on a fortnightly basis (total 350 g dry weight). Sugar Glider was by far the most abundant species (76%) recorded from the prey analysis (Table 1), which was interesting as spotlighting in the area had revealed Common Ringtail Possum and Greater Glider to be the most frequently detected arboreal marsupials, and on four two-hour nocturnal

surveys only one Sugar Glider had been observed or heard calling. Robinson (1984) found the Sugar Glider to be the most numerous arboreal mammal in this area during an environmental survey in early 1983 but no Powerful Owls were recorded, though he was familiar with the bird's habits (J. Robinson pers. comm.). One may speculate that the recent arrival of a pair of owls at this site resulted in a population reduction as has occurred elsewhere (cf. Bass Point observations). Common Ringtail Possum and several bird species constituted the remaining identifiable remains. A population of Greater Gliders was located approximately 300 m from the nest tree but this species never featured in any of the pellets. Two avian legs of different sizes (tibiotarsus, tarsometatarsus and phalanges) recovered from October pellets were identified at the Australian Museum as those of two larger species of the family Meliphagidae (W.E. Boles pers. comm.).

On 28 September Diana Wright took a group of Sydney bird-watchers to the site and found that a pair of juveniles had joined the parent bird. As illustrated by Fleay (1968) and as observed at Appin and Audley (see pp. 294-5), one juvenile was distinctly larger than the other. All three birds were subsequently observed in the same 25 m Turpentine until their dispersal in late November.

In the November pellets we did not find any cranial or forelimb remains and therefore assume that only rear portions of animals are fed to juvenile owls, as was observed at Audley. This is probable as the adults habitually feed on the head and foreparts first (Schodde & Mason 1980).

Helensburgh 34°10'S, 151°00'E

Altitude 300 m a.s.l. Habitat: mature tall open forest, mainly eucalypts.

In November 1989 Richard Jordan located a nest site of a Powerful Owl near the south-western corner of the Royal National Park at Helensburgh. A juvenile owl had been sighted in the area, and hollows were checked for possible nest sites. Situated near a creek, the nest hollow was in a 35 m unidentified eucalypt, the entrance being 29 m from the ground. The nest site was physically examined, and collected material was sent to the CSIRO Division of Wildlife and Ecology for identification: Brown Antechinus *Antechinus stuartii*, Greater Glider, Long-nosed Bandicoot *Perameles nasuta* and probably Common Ringtail Possum were identified by John Calaby, Gill Pfitzer and Ian Mason in the deposit of fur and bones.

Discussion

The data presented illustrate that the Powerful Owl is found in a variety of habitats in the Illawarra and Shoalhaven regions of New South Wales. Along the coastal plain it is found in low closed forest and open forest, and on the elevated plateau it is found in open forest, tall open forest and closed forest. The structural composition of each of these habitats is quite varied and the owl appears to inhabit drier sites such as Culburra and Appin equally as much as wetter sites such as Royal National Park and Mount Murray. The main criteria for inhabiting a site appear to be the availability of a sustainable food supply and suitable roosting and breeding sites.

In the study area Common Ringtail Possum and Sugar Glider were the principal dietary component by number, comprising 57% of the Bass Point total (Table 1), 92% of the Culburra total (Table 1) and 68% of the total for all sites combined (Table 2). At the two main sites, Bass Point and Culburra, birds were only a minor component of the diet (6%), but overall birds represented 13.3% of the recorded diet. A total of ten mammal species, at least 11 bird species and two coleopteran genera were

Table 2

Minimum totals of prey items taken by the Powerful Owl at nine sites in the Illawarra and Shoalhaven regions of New South Wales 1980-1990. Results combined from observations of captured prey and cranial remains from disgorged pellets as described in text.

<i>Species</i>		<i>Minimum totals (n)</i>	<i>% of diet</i>
Long-nosed Bandicoot	<i>Perameles nasuta</i>	1	0.7
Brown Antechinus	<i>Antechinus stuartii</i>	1	0.7
Common Ringtail Possum	<i>Pseudocheirus peregrinus</i>	55	36.4
Greater Glider	<i>Petauroides volans</i>	5	3.3
Sugar Glider	<i>Petaurus breviceps</i>	47	31.1
Grey-headed Flying Fox	<i>Pteropus poliocephalus</i>	3	2.0
Bush Rat	<i>Rattus fuscipes</i>	1	0.7
Black Rat	<i>Rattus rattus</i>	7	4.6
Rabbit	<i>Oryctolagus cuniculus</i>	1	0.7
Feral Cat	<i>Felis catus</i>	2	1.3
Total Mammals		123	81.5
Pacific Black Duck	<i>Anas superciliosa</i>	1	0.7
Dusky Moorhen	<i>Gallinula tenebrosa</i>	1	0.7
Purple Swamphen	<i>Porphyrio porphyrio</i>	1	0.7
Glossy Black-Cockatoo	<i>Calyptrorhynchus lathamii</i>	4	2.6
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	2	1.3
Crimson Rosella	<i>Platycercus elegans</i>	1	0.7
Superb Lyrebird	<i>Menura novaehollandiae</i>	1	0.7
Australian Magpie	<i>Gymnorhina tibicen</i>	2	1.3
Pied Currawong	<i>Strepera graculina</i>	2	1.3
Australian Raven	<i>Corvus coronoides</i>	2	1.3
Magpie/currawong	<i>Gymnorhina/Strepera</i> sp.	1	0.7
Unidentified bird	Meliphagidae	2	1.3
Total Birds		20	13.3
Insecta: Coleoptera	Cerambycidae	5	3.3
	Scarabaeidae	3	2.0
Total Beetles		8	5.3
Total individuals		151	100.0

recorded in the owls' diet throughout the study area. Although Common Ringtail Possum and Sugar Glider contributed the highest observed percentage of the diet, the inclusion of at least 19 other organisms in the diet illustrates the opportunistic nature of the Powerful Owl to utilise whatever prey it can find within its foraging range.

These results are comparable with dietary analyses conducted elsewhere (Gould 1848, Seebeck 1976, Van Dyck & Gibbons 1980, Tilley 1982, Hollands 1991, Traill in press, C. Pavey pers. comm.) and show that the Greater Glider, long considered the staple diet of the species in many areas (e.g. Fleay 1968, Schodde & Mason 1980, Calaby 1986), is not a major prey species through much of the owl's distribution (see Tilley 1982 and Hollands 1991 for additional comment). Although the Greater Glider is often taken in some locations (e.g. James 1980, Kavanagh 1988, Fletcher & Reckord 1989), its overall distribution is patchy and disjunct (R. Kavanagh pers. comm.) and only James (1980) provided any quantified measure illustrating Greater Glider as a major component of the owl's diet based on pellet analysis. Even Fleay

(1944, 1968), who consistently mentioned Greater Glider as a major dietary component, presented quantified data only for prey items brought to a brooding female at night (17 Common Ringtail Possums, 5 Greater Gliders and several birds).

In the study area Greater Glider populations are known to exist in six of the study sites, but the glider only featured in the owl's diet at three sites and does not appear to be a major component at any site within the study area.

Insects have not previously been recorded as a prey item of the Powerful Owl in New South Wales, though they have from several locations in Victoria (Seebeck 1976, Tilley 1982, Hollands 1991, Traill in press). The beetles (5 of family Cerambycidae and 3 of family Scarabaeidae) were contained in two pellets (the remains of which also contained an Australian Raven) taken in December, a period when the beetles are most numerous. This represented 14% of the local diet and 5% of the regional diet, supporting the view that the Powerful Owl is opportunistic in regard to prey selection.

Although the four breeding records reported herein (Woollamia, Appin, Audley, Culburra) all fell within parameters previously defined (Schodde & Mason 1980), the height of the entrance hollow from the ground at the three observed nest sites (Woollamia, Appin, Culburra) was consistently below that previously quoted [12-40 m (Schodde & Mason 1980, Calaby 1986) and 10-40 m (Pizzey 1980)]. The three heights in this study were 9 m, 9.2 m and 9.7 m (mean 9.3 m, s.d. \pm 0.36 m).

Although much work is currently being conducted on the biology and ecology of the Powerful Owl (R. Kavanagh and S.J. Debus pers. comm.), there is still a need for further work on dietary requirements and habitat utilisation. These two factors are fundamental in understanding the species' ecological requirements and are necessary for adequate strategies to be devised for consideration in forest management.

There is also the obvious need to justify statements that the Greater Glider is a principal component of the Powerful Owl's diet. Quantified dietary studies from regurgitated pellet analysis as well as observations of captured prey are required from those areas where the Greater Glider is relatively common.

The owl obviously utilises a much wider range of environments than has previously been stated (e.g. Schodde & Mason 1980, Calaby 1986), as indicated by this study, and by Victorian (Tilley 1982, Hollands 1991, Traill in press) and Queensland (Pavey in press) data.

Much of the general literature dealing with the Powerful Owl is based on a few detailed studies and a reliance on the work of Fleay (1968), who restricted his studies to tall open forests and did not publish any quantified results. This has led to a generally biased view of the ecological and biological requirements of the Powerful Owl. Much further work on the species is required, particularly pertaining to its diet, habitat requirements and status. This last point can be exemplified by the paucity of previously published dietary studies in New South Wales and Queensland, the recent spate of new localities in New South Wales where the Powerful Owl was previously unknown (e.g. O'Brien 1990, Sansom 1991, and Unusual Records reports by Morris & Chafer in N.S.W. Field Ornithologists Club newsletters since 1988) and the fact that before this study, only four site locations were known for the Powerful Owl in the Illawarra and Shoalhaven regions of New South Wales (Gibson 1977).

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References

- Calaby, J. (1986), 'Powerful Owl', in *Complete Book of Australian Birds*, Reader's Digest Services, Sydney.
- Diggles, S. (1877), *Companion to Gould's Handbook; or Synopsis of the Birds of Australia*, vol. 1, 15, Thorne & Greenwell, Brisbane.
- Dodson, P. & Wexlar, D. (1979), 'Taphonomic investigations of owl pellets', *Paleobiology* 5, 275-284.
- Fletcher, D. & Reckord, N. (1989), 'Powerful Owl at Tidbinbilla Nature Reserve', *Canberra Bird Notes* 14, 21-24.
- Fleay, D. (1944), 'Watching the Powerful Owl', *Emu* 44, 97-112.
- (1968), *Nightwatchmen of Bush and Plain*, Jacaranda Press, Brisbane.
- Gibbons, D. (1989), 'Nest defence by Powerful Owl', *Aust. Bird Watcher* 13, 58-59.
- Gibson, J.D. (1977), 'The birds of the County of Camden (including the Illawarra district)', *Aust. Birds* 11, 42-80.
- (1989), *Birds of the County of Camden (including the Illawarra Region)*, 2nd edn, Illawarra Bird Observers Club, Wollongong.
- Gould, J. (1848), *The Birds of Australia*, vol. 5, pl. 35 & 36, The Author, London.
- Hollands, D. (1991), *Birds of the Night: Owls, Frogmouths and Nightjars of Australia*, Reed, Sydney.
- James, J.W. (1980), 'Food of the Powerful Owl *Ninox strenua* in south-eastern Queensland', *Emu* 80, 34-35.
- Kavanagh, R.P. (1988), 'The impact of predation by the Powerful Owl *Ninox strenua* on a population of Greater Glider *Petauroides volans*', *Aust. J. Ecology* 13, 445-450.
- McNabb, E. (1987), 'An attempt to rehabilitate an "orphaned" Powerful Owl', *Aust. Bird Watcher* 12, 22-24.
- Mills, K. (1988), 'The clearing of the Illawarra rainforests: problems in reconstructing pre-European vegetation patterns', *Aust. Geogr.* 19, 230-240.
- O'Brien, D. (1990), 'Owls and nightjars on the Central Coast', *Aust. Birds* 24, 9-19.
- Olsen, J. (1987), 'Description of another Powerful Owl nest', *Canberra Bird Notes* 12, 24.
- Pavey, C. (in press), 'The distribution and conservation status of the Powerful Owl in Queensland', in Olsen, P.D. & Olsen, J. (Eds), Proc. Australasian Raptor Assoc. 10th Anniv. Conference, Canberra 1989.
- Pizzey, G. (1980), *A Field Guide to the Birds of Australia*, Collins, Sydney.
- Pidgeon, I.M. (1937), 'The ecology of the central coastal area of New South Wales; 1. The environment and general features of the vegetation', *Proc. Linn. Soc. N.S.W.* 62, 315-340.
- Robinson, L. (1968), 'Daylight hunting of the Powerful Owl', *Aust. Bird Watcher* 3, 107-108.
- Robinson, N. (1984), 'Faunal survey of land near Culburra', in *Culburra Village Extension. Draft Environmental Study*, Shoalhaven City Council, Nowra.
- (1988), *The Impact of European Man on the Status of Mammals in the Illawarra Region*, M.Sc. thesis, University of Wollongong, N.S.W.
- Ross, T. (1986), 'A breeding attempt by Powerful Owls in the ACT', *Canberra Bird Notes* 11, 121-122.
- Sansom, C. (1991), 'Observations of Powerful Owls at Pennant Hills', *Aust. Birds* 25, 18-21.
- Schodde, R. & Mason, I.J. (1980), *Nocturnal Birds of Australia*, Lansdowne, Melbourne.
- Seebeck, J.H. (1976), 'Diet of the Powerful Owl *Ninox strenua* in western Victoria', *Emu* 76, 167-169.
- Smith, L.E. & Chafer, C.J. (1987), 'The avifauna of Bass Point, N.S.W.', *Aust. Birds* 21, 1-18.
- Specht, R.L. (1981), 'Major vegetation formations in Australia', in A. Keast (Ed.), *Ecological Biogeography of Australia*, W. Junk, The Hague, pp. 165-297.
- Tilley, S. (1982), 'The diet of the Powerful Owl in Victoria', *Aust. Wildlife Research* 9, 157-175.
- Trill, B.J. (in press), 'The diet and movements of a pair of Powerful Owls *Ninox strenua* (Strigidae: Strigiformes) in dry forest', in Olsen, P.D. & Olsen, J. (Eds), Proc. Australasian Raptor Assoc. 10th Anniv. Conference, Canberra, 1989.
- Van Dyck, S. & Gibbons, D. (1980), 'Tuan predation by Powerful Owl' *Vic. Naturalist* 97, 58-63.
- Wilson, G.W. (1982), 'A record of adult and downy young Powerful Owl *Ninox strenua* from the Coranderrk Bushland of Sir Colin Mackenzie Fauna Park, Healesville, Victoria', *Aust. Bird Watcher* 9, 224-226.

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