# Removing a threatened apex predator from an oceanic World Heritage island: the Masked Owls of Lord Howe Island

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ABSTRACT

The Masked Owl *Tyto novaehollandiae* was introduced to Lord Howe Island in the 1920s to control an irruption of the Black Rat *Rattus rattus*. The owl is a threatened species in New South Wales but is regarded as a pest on the island due to the perceived risk it poses to endemic land birds and breeding seabirds. However, its main diet there comprises *Rattus rattus* and House Mice *Mus musculus* and because it is proposed to eradicate these rodents from the island in 2019, the owls are also scheduled for removal then due to the likelihood of their switching their prey base to endemic land birds and breeding seabirds. Simultaneous point surveys and radio-tracking of two female owls over 14 months in 2009-2010 indicated that owls occupied small overlapping home ranges with smaller discrete home range cores. The population of *Tyto novaehollandiae* on the island was estimated at between 20 and 30 pairs, almost ten times the density that the species occurs at in its natural range. Roost sites were mainly in the dense crowns of canopy trees and in hollows and crevices of large trees. Analysis of regurgitated pellets and pellet remains showed that owl diets were predominantly comprised of *Rattus rattus* (in 72% of intact pellets) and *Mus musculus* (in 28% of intact pellets) with the remainder mostly seabird species (in 21% of intact pellets). It is suggested that the introduction of *Tyto novaehollandiae* in the 1920s may have slowed the extinction rate of endemic terrestrial birds on the island, with the species now functioning as the top apex predator there and possibly limiting population numbers of *Rattus rattus*. If *Tyto novaehollandiae* is exerting mesopredator control, this cautions the removal of its population, as required to prevent it switching its prey base once rodents are removed. Removal of owls prior to the removal of rats could lead to mesopredator release, with further highly detrimental effects on the island's biodiversity, emphasising that owls should be removed concurrently with rodents.

**Key words:** owls, rats, oceanic island, apex predator, territorial overlap, mesopredator control

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## Introduction

Lord Howe Island is a mountainous, subtropical, oceanic island of volcanic origin lying 570 km east of Port Macquarie on the Australian mainland at latitude 31$^0$ 33' south. The island is approximately 11 km long and up to 2.8 km wide along its north-south and east-west axes respectively, with an area of approximately 1,500 ha and reaching an elevation of 880 m asl at Mt Gower in the south (Figure 1, Hutton 1991, DECC 2007, DECCW 2010).

Lord Howe Island was settled in 1834 but only approximately 11% of the island has been cleared of vegetation, mainly about the settlement in the north (Figures 1 and 2), with the remainder currently dominated by oceanic rainforest (Keith 2004). The Lord Howe Island Group of islands, comprising the main island and small outliers, was listed on the UNESCO World Heritage Register in 1982 (DECC 2007).

**Figure 1.** Lord Howe Island, looking south from the northern hills and showing part of the cleared area around the settlement and 880 m Mt Gower at the southern end. Photograph D. Milledge

In June 1918 the supply ship "Mokambo" went aground on rocks in the north of the island and was run onto Ned's Beach for repairs, which appears to have been the source of a Black Rat *Rattus rattus* invasion (Hindwood 1940, Hutton 1991). The rats quickly colonised the island, establishing a population that had irrupted by 1920 and was threatening the settlers' food resources and their main source of income, the palm seed industry (McCulloch 1921). As a result, the Lord Howe Island Board (LHIB) attempted a number of control measures that included introducing about 100 owls of five species between 1922 and 1930 (Hindwood 1940, Hutton 1991, data from this study).

Unfortunately Sydney's Taronga Zoo, which sourced the owls and organized shipments did not keep complete records of these transfers, although an examination of the Zoo's files (Animal arrival and departure book 1917-1928; data obtained June 2010 per S. Brice, Registrar, Taronga Zoo) showed that at least 25 Southern Boobooks *Ninox novaeseelandiae*, 29 Masked Owls *Tyto novaehollandiae*, 12 Australian Barn Owls *T. alba delicatula* and 10 American Barn Owls *T. alba furcata* were included in this total.

An examination of the minutes and correspondence from LHIB files indicated that 80 owls had been introduced by 1928, with one American Great Horned Owl *Bubo virginianus* included in a shipment in 1923 (Lord Howe Island Board of Control report 1923, per H. Bower).

However, *Tyto novaehollandiae* was the only species that successfully established and it currently occurs in all habitats on the island, from sea level to the summit of Mt Gower (McAllan *et al.* 2004) and is often heard calling around the area of the settlement (data from this study). Its rainforest and coastal heath habitats on the island (Figures 3 and 4) are very different from the drier, more open forests and woodlands mainly occupied by the species in its natural range throughout south eastern mainland Australia and Tasmania (Higgins 1999).

Until recently Lord Howe owls were considered to be descended from birds obtained from the Tasmanian population (Hindwood 1940, McKean and Hindwood 1965, Hutton 1991, McAllan *et al.* 2004). The Tasmanian *Tyto novaehollandiae* population is generally larger and darker than the south-eastern mainland Australian population and is recognised as a separate subspecies *T. n. castanops* (Higgins 1999). However, because of the range of size and colour variation exhibited by Lord Howe *Tyto novaehollandiae*, it had been speculated that some individuals from the south-eastern mainland population had also been included in the introductions (McAllan *et al.* 2004). Recent genetic analysis has confirmed this, demonstrating that at least one female from the south-eastern mainland had successfully bred on the island and indicating that the Lord Howe owls represent a hybrid population (Hogan *et al.* 2013).

**Figure 2.** Lord Howe Island, looking north from the summit of Mt Gower with Mt Lidgbird in the foreground and showing the cleared area around the settlement in the distance. Photograph D. Milledge

**Figure 3.** The slopes of Mt Lidgbird from Mt Gower showing the dense oceanic rainforest comprising the primary habitat for the Masked Owl *Tyto novaehollandiae* on Lord Howe Island. Photograph D. Milledge

**Figure 4.** Coastal heath and shrubland on Lord Howe Island's northern hills, used by the Masked Owl *Tyto novaehollandiae* as hunting and breeding habitat. Photograph D. Milledge

In 2007, in accordance with its World Heritage listing, the LHIB approved the Island's Biodiversity Management Plan (DECC 2007). This suggested investigating the threat posed to biodiversity by introduced fauna species that included *Tyto novaehollandiae* and, if necessary, implementing appropriate controls or eradication. The subsequent Rodent Eradication Plan (LHIB 2009) proposes to eradicate the *Tyto novaehollandiae* population simultaneously with rodents, on the basis of the owl's predation of breeding seabirds and some endemic land birds. This necessitated an owl eradication plan, which required information on the species' status, population size, habitat use, movements and other aspects of its ecology on the island. As a result, the LHIB, supported by the Commonwealth Government's Caring for Country Program, initiated a research project that was undertaken over 14 months between June 2009 and July 2010.

## Methods

Field investigations for the project were undertaken during seven trips to the island of two to three weeks duration each, covering all seasons and comprising a total of 147 days. The methods used to obtain the required information comprised:

1. community consultation with island residents experienced in owl occurrence and habits;
2. simultaneous point surveys to estimate owl numbers;
3. call playback at selected locations to assess territorial, seasonal and other responses;
4. trapping using a drop net with radio-tracking of individuals to provide data on movements, home ranges and roost and nest sites; and
5. searches for regurgitated pellets and other prey remains at roost and kill sites to determine diet.

***Community consultation*** Community consultation included contacting a number of long-term island residents who had encountered owls over past years. Liaison with local naturalists Ian Hutton (long term resident and flora and fauna authority), Dean Hiscox (LHIB ranger for 16 years) and Jack Shick (5th generation islander) provided particularly relevant and useful information, relating to owl occurrences over the previous three decades.

***Simultaneous point surveys*** Simultaneous point surveys were undertaken by multiple observers listening at dusk from elevated vantage points surrounding two areas of known *Tyto novaehollandiae* habitat. Surveys were conducted in the southern mountains and the northern hills (Figures 5, 6 and 7) on the nights of 1 November 2009 and 2 June 2010 respectively. Two observers per point listened for owl calls and looked for owls for a

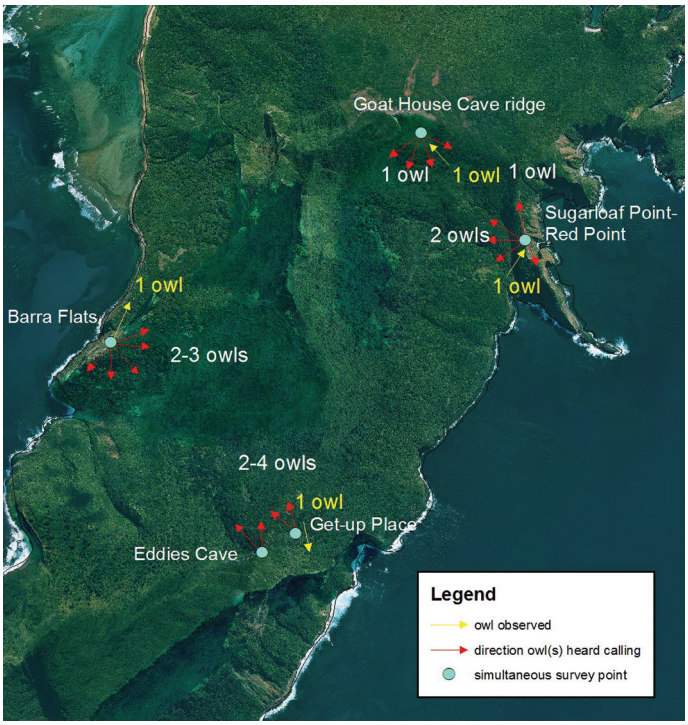


**Figure 5.** The area of the southern mountains centred on Erskine Valley where a simultaneous point count was undertaken by multiple observers in November 2009. The red arrows indicate directions from where owls were heard calling and the yellow arrows where owls were seen. The number of owls present was estimated by pooling results from each point and discarding apparent replicate records.

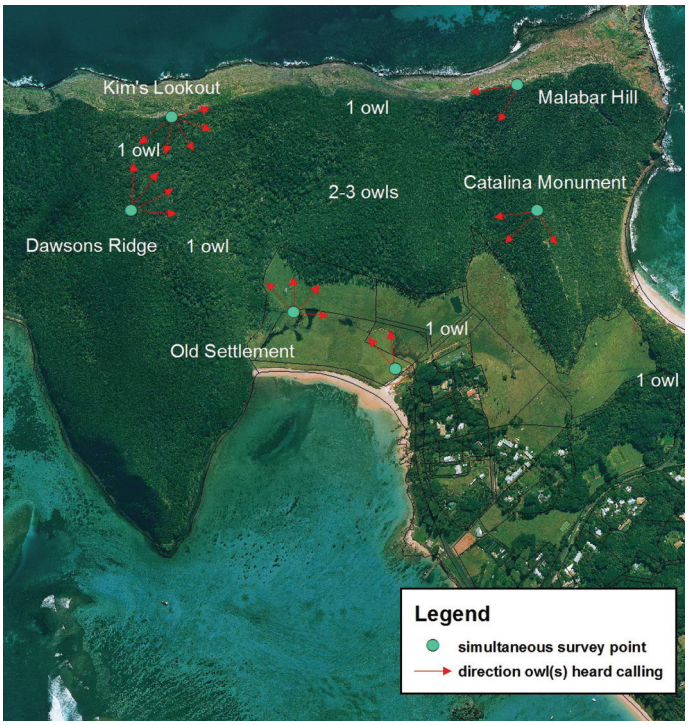


**Figure 6.** The area of the northern hills where a simultaneous point count was undertaken by multiple observers in June 2010. The red arrows indicate directions from where owls were heard calling and the number of owls present was estimated by pooling results from each point and discarding apparent replicate records.

synchronised 45 min period from dusk, estimating the direction and distance of calls and noting the time. This was followed by a 3 min period of call playback and a 5 min period of listening and observing (aided by a 50 w 12 v spotlight, as detailed below), with the call playback and listening and observing sequence then repeated.

The numbers of owls present in the survey area were estimated by pooling results from each point and discarding records that appeared to involve replicate records.

***Call playback*** Playback of *Tyto novaehollandiae* calls was undertaken opportunistically throughout the study period and across the island wherever access allowed. Equipment used comprised a Sony Walkman CD player coupled to a Toa transistorised horn speaker which broadcast sound audible to the human ear to approximately 1 km distant. Initially, recorded calls of mainland owls were used but because it was found that Lord Howe owls often responded poorly to these calls (data from this study), recorded calls of local owls were used for most of the study. Responses to the playing of recorded calls were most vigorous and sustained in winter and spring and less so in summer and autumn (data from this study). Where individual owls had been over-exposed to playback, responses were usually muted and of short duration.

Following call playback, a 50 w 12 v hand-held spotlight was used to confirm the presence and number of owls that had responded.

***Trapping and radio-tracking*** Trapping of owls was carried out with a 10 m high x 12 m long drop-net (Dho-Gaza type) using alternating call playback between horn speakers placed either side of the net. The net was suspended on carabiners between two trees in a gap in the forest or at the forest edge (Figure 8) and dropped once an owl had hit the mesh when flying low between the speakers. Decoy mounted owls were placed near the net during some trapping sessions in an attempt to increase capture success.

The method required three operators, with two stationed at either end to drop the net once an owl had hit, and another stationed about 10 m away to switch the playback between speakers.

Fifteen sites were trapped during the study (Figure 9) with several trapped a number of times, amounting to a total of 28 trap nights. Captured owls were banded with numbered metal leg bands supplied by the Australian Bird and Bat Banding Scheme and fitted with a Titley Scientific GP1-16MS2 radio transmitter package with a 250 mm long aerial (Figure 10). The transmitter included a "mortality" switch that doubled the signal rate if it remained stationary for more than 12 hrs and was attached using a light cord harness (Figure 10) modified from the design of Karl and Clout (1987). This included a three-strand cotton "weak link" intended to break if snagged, and eventually perish to shed the transmitter once its 12-month battery life had expired. The harness was fastened with small cable ties sealed with supaglue and a sheepskin pad was attached to the underside of the transmitter to prevent abrasion of the owl's feathers and skin. Total weight of the package and harness was 26 g, representing approximately 4% of the average weight of Lord Howe owls (data from this study).

Tracking of owl movements was undertaken using a three-element Sirtrack Yagi aerial and a Communications

**Figure 7.** The view from a point located near Eddies Cave overlooking the Erskine Valley in the southern mountains where owls were recorded during a simultaneous point count in November 2009. Photograph D. Milledge

**Figure 8.** The drop-net used to trap owls for fitting radio transmitters being suspended between trees on the edge of rainforest in the north of the island. Playback of owl calls from speakers placed either side of the net was used to lure owls into the net. The sheeting placed under the net during erection, to prevent it becoming entangled in vegetation and debris, was removed once the net was set. Photograph D. Milledge

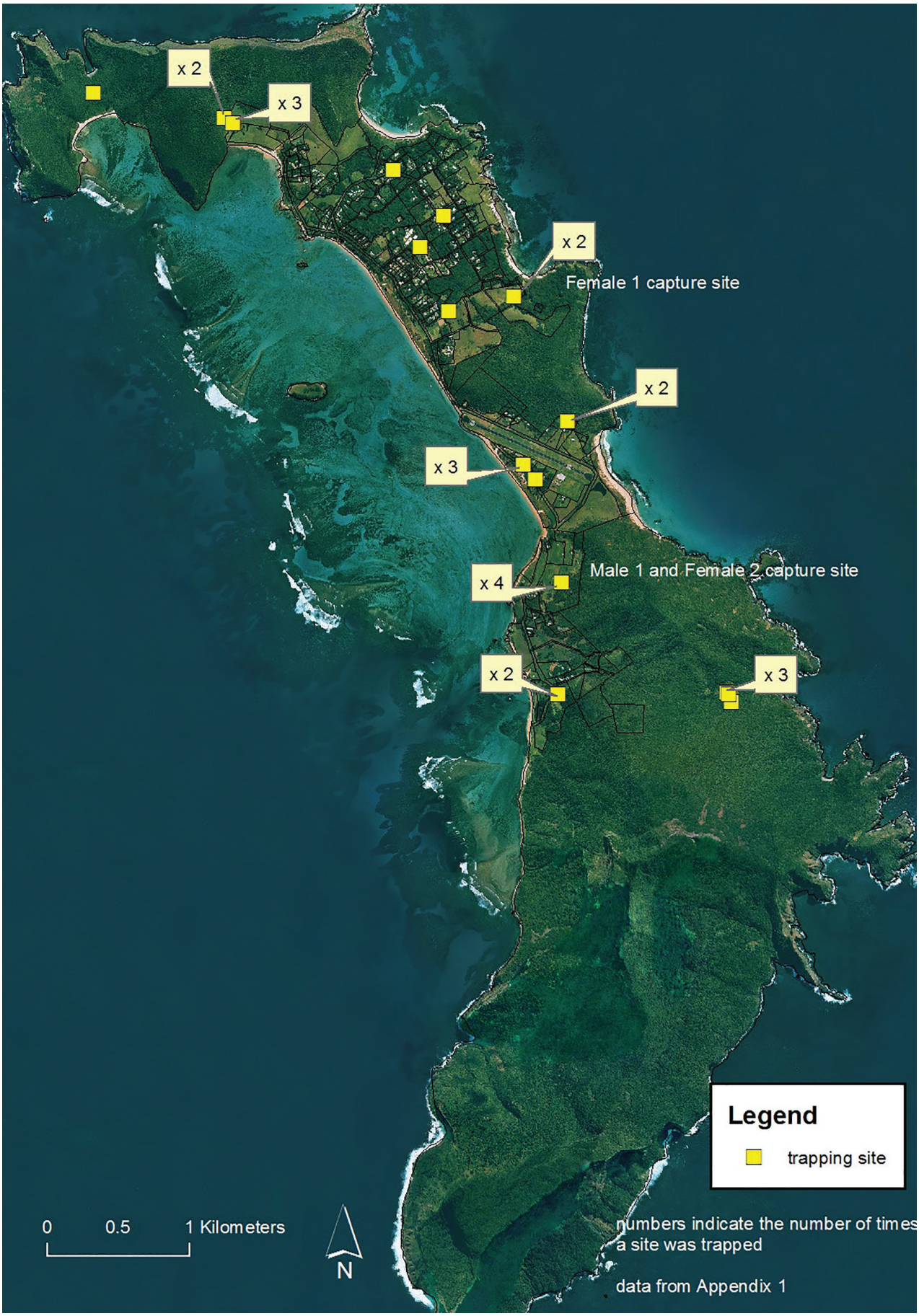


**Figure 9.** The 15 sites used in attempts to trap owls for fitting radio transmitters in the centre and north of the island. Owls were trapped successfully at one site in the north and another in the centre of the island. Photograph D. Milledge

**Figure 10.** Fitting a 26 g transmitter with a 250 mm aerial and "weak link" harness to Female 1. A sheepskin pad to prevent abrasion of the owl's feathers and skin can be seen attached to the underside of the transmitter. Photograph G. James

Specialists R1000 telemetry receiver. During the day, tracking was initially carried out from a vehicle along the island's road system to establish the general location of a tagged owl, which was then tracked down on foot to the roost site. At night, tracking was limited to use of the road system, but triangulation was used to provide a more accurate estimation of the location.

***Pellet and prey remains searches*** Searches for regurgitated food pellets focused around the roost sites of tracked owls. Other searches were undertaken by methodically covering the ground in areas where owls had been heard calling at dusk. This was a time when pellets were frequently disgorged as owls left their roosts. Searches were also carried out under mature trees with dense canopies that typically provided roost sites and under Lord Howe Banyans *Ficus macrophylla columnaris* with large horizontal limbs that were frequently used as perches by owls leaving roost sites.

## Results

***Community consultation*** Community consultation produced anecdotal records and one photographic record of *Tyto novaehollandiae* taking a Lord Howe Woodhen *Hypotaenidia sylvestris*, as well as multiple anecdotal accounts of predation of breeding seabirds, particularly the Black-winged Petrel *Pterodroma nigripennis* and White Tern *Gygis alba*.

The predation of seabirds had previously prompted opportunistic culling of owls, principally around the area of the settlement, and details of this were provided by Dean Hiscox, who had undertaken the shooting while a ranger with the LHIB. Sporadic culling was initiated in the 1970's but became more frequent during the 11 years from 1988 to 1998 and then became sporadic again up until 2007. An unpublished log maintained by Dean Hiscox covering the period from 1988 to 2007 showed that during the first 11 years a total of 95 owls were shot, with the highest number 15 in 1997 (Figure 11). Juveniles averaged one third of annual totals over this period.

***Simultaneous point surveys*** The results from the two simultaneous point surveys conducted in the southern mountains and northern hills (Figures 5 and 6) indicated that these areas supported four and three pairs of owls respectively (based on a conservative estimate of 8 and 6 owls in each area). When extrapolated to remaining habitat across the island and informed by data obtained from radio-tracking and the location of roost sites (below), this suggested that the population comprised between 20 and 30 pairs, with potentially an additional number of immature owls occupying sub-optimum habitat.

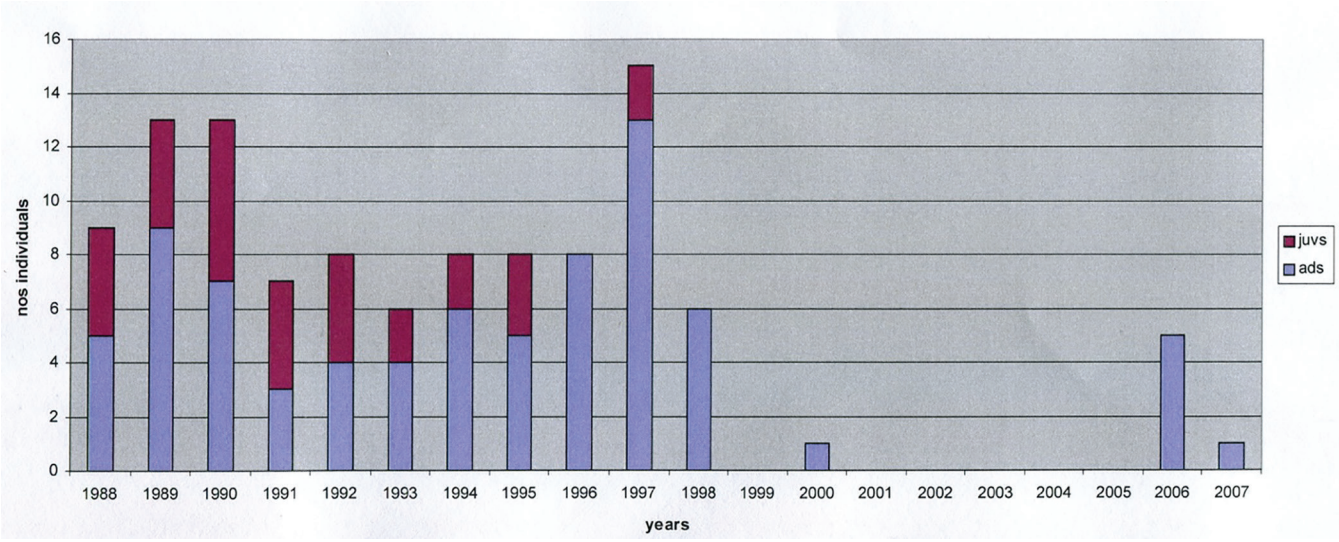


**Figure 11.** The numbers of Masked Owls *Tyto novaehollandiae* culled annually between 1988 and 2007, showing the proportions of adults and juveniles. A total of 95 owls was shot between 1988 and 1998, with 15 the highest number taken in 1997 (data per D. Hiscox).

This density is unprecedented in the natural range of *Tyto novaehollandiae* in south-eastern mainland Australia and Tasmania where territory sizes have been estimated at 1,000 to 3,000 ha (Kavanagh and Murray 1996, McNabb *et al.* 2003, Young 2006, Kavanagh *et al.* 2009) and an area the size of Lord Howe Island would only support one to two pairs.

***Call playback*** Call playback, particularly when using locally recorded calls (as noted above) proved to be an effective method for detecting owls, with responses obtained from more than 90% of playbacks (data from this study). These responses always included vocalisation, mostly at the beginning of playback from an owl flying in and perching overhead, but occasionally after playback had finished. The latter cases usually involved an owl flying in low to investigate playback and then retreating to a high perch 20-30 m away before beginning to vocalise.

However, the intensity of response (strength, duration, proximity to playback operator) was diminished by repeated exposure of individual owls to playback. Owls that had been subjected to playback at sites more than five or six times usually did not approach closer than 30 m, gave only a short call or series of calls and left the site within 5 min.

***Trapping and radio-tracking*** One female *Tyto novaehollandiae* (Female 1), and a male and second female (Female 2) were trapped at two sites in the northern and central sections of the island in August and September 2009 respectively (Figure 9, Table 1) and fitted with transmitter packages (Figures 10 and 12). On each occasion pairs of owls responded to call playback, with the males flying into the net first, followed by the females. The male of the pair that responded in August escaped, but both the male and female were trapped in September. Both females appeared to have bred, based on the transverse shape of the cloaca opening (following Serventy 1956).

Attempts to trap additional owls at these and other sites during August, September, October and November 2009 and March, May and July 2010 were unsuccessful due to various factors including owls not flying sufficiently low to strike the net, owls striking the net but escaping and wariness learnt from such escapes, repeated exposure to the trapping method and persistent adverse weather conditions, particularly strong wind.

Unfortunately, the male's transmitter appeared to fail a week after fitting as it could not be detected subsequently, but Females 1 and 2 were tracked over 12 and 11 months respectively up until the end of the study. The tracking demonstrated markedly different patterns of movement and home range size between the two females (Figures 13, 14 and 15) and although representing a very limited sample, together with the results from the simultaneous point surveys this suggested that territoriality was relaxed in the island population. Nevertheless, some territoriality was obviously maintained due to the vigorous responses to call playback (above) and was probably concentrated in individual home range cores (below).

**Figure 12.** Fitting a transmitter package to the male Masked Owl captured together with Female 2 in the centre of the island. This owl was not able to be tracked due to the apparent failure of the transmitter soon after it was released. Photograph I. Hutton

**Table 1.** Details of Masked Owls *Tyto novaehollandiae* trapped and fitted with transmitter packages on Lord Howe Island in August and September 2009.

| date | age/sex | weight (g) | trapping location | easting (GDA94) | northing (GDA94) | notes |
|---|---|---|---|---|---|---|
| 27.8.'09 | adult female (Female 1) | 810 | north-eastern forest edge at Middle Beach Common | 507117 | 6511787 | one of a pair that responded together to call playback, captured after the male had escaped from the net |
| 10.9.'09 | adult male | 552 | western forest edge at southern end of golf course | 507445 | 6509778 | one of a pair that responded together to call playback, captured first |
| 10.9.'09 | adult female (Female 2) | 820 | western forest edge at southern end of golf course | 507445 | 6509778 | one of a pair that responded together to call playback, captured after the male had been removed from the net |


**Figure 13.** Tracked movements of 0.5 km or greater by Female 1 between roost and foraging sites in the one night between September 2009 and July 2010. Movements were mainly confined to the centre of the island between Transit and Intermediate Hills but extended into the southern mountains.

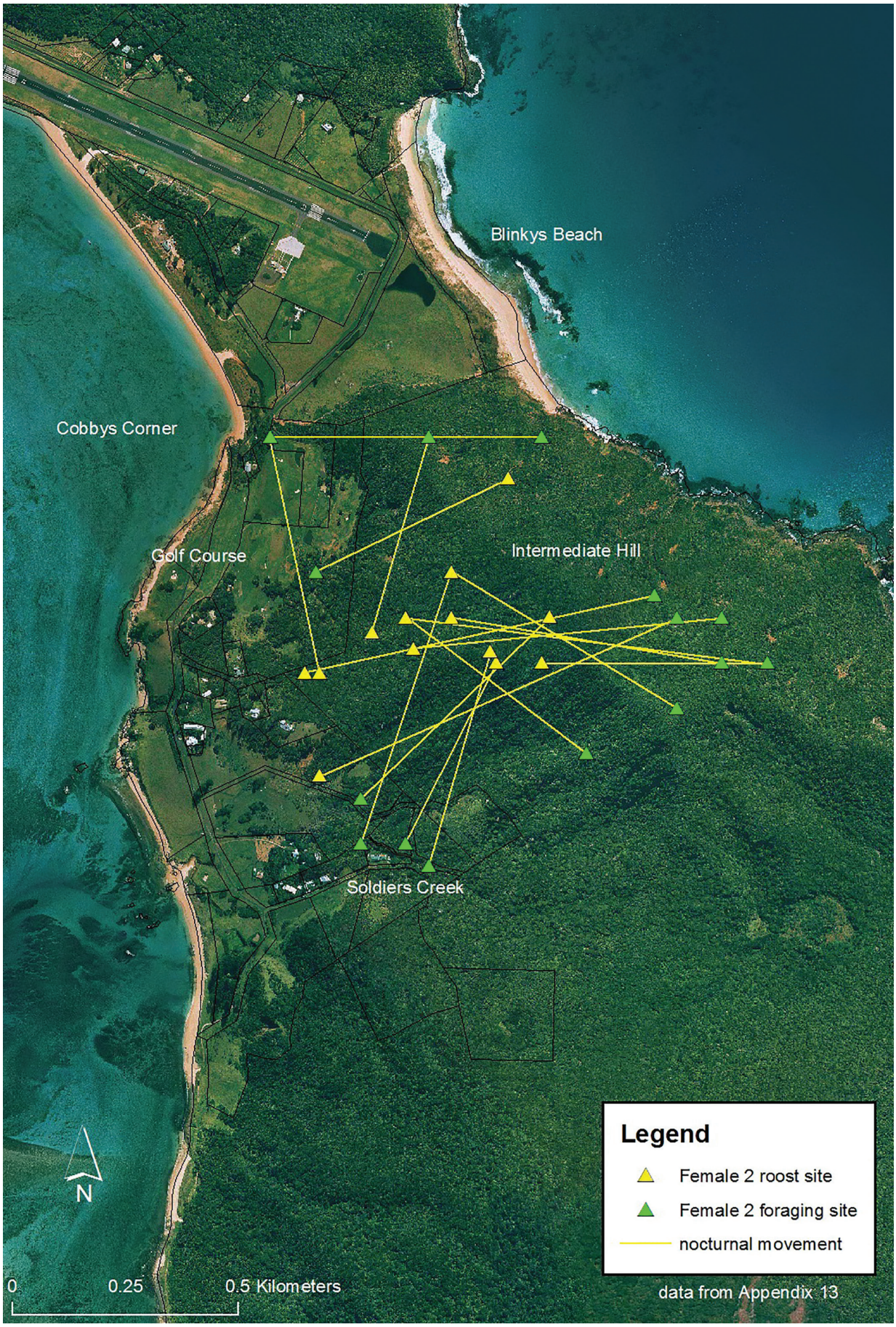


**Figure 14.** Tracked movements of 0.5 km or greater by Female 2 between roost and foraging sites in the one night between September 2009 and July 2010. Movements were entirely confined to the area about Intermediate Hill.

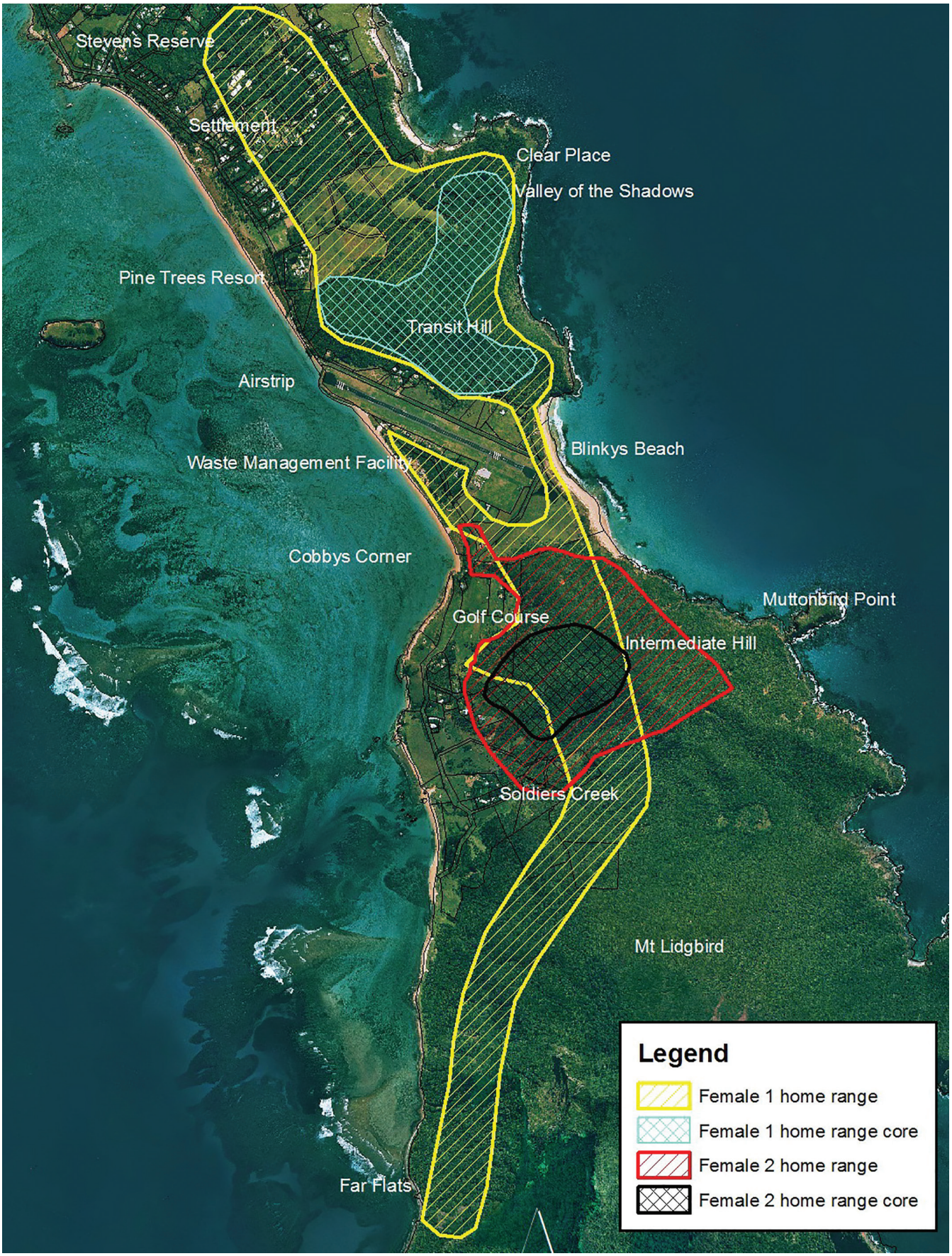


**Figure 15.** Estimated home ranges and home range cores of Females 1 and 2 tracked between August 2009 and July 2010. Female 1 occupied a home range of 230 ha with a home range core of 39 ha whereas Female 2 occupied a home range of 75 ha and a home range core of 20 ha. The home range of Female 1 overlapped that of Female 2 including its home range core, although their home range cores were discrete.

Female 1 was found in a distressed state in a paddock adjoining the settlement on 21 December 2009, exhibiting secondary poisoning symptoms apparently after consuming rats or mice poisoned by an anticoagulant rodenticide (H. Bower unpubl. data). The owl recovered following injections of Vitamin K and feeding with rodents injected with Vitamin K during a short period of care and apparently suffered no adverse effects, being tracked for a further 7 months to the end of the study.

Female 1 was considerably more mobile than Female 2 over the study period, undertaking 27 tracked movements equal or greater than 0.5 km (with a maximum of 4.1 km) between successive roost sites, whereas Female 2 undertook only 10 tracked movements equal or greater than 0.5 km between successive roost sites (with a maximum of 0.6 km).

Construction of minimum convex polygons from the tracking data (modified to exclude unsuitable habitat such as cleared areas) showed that Female 1 occupied an estimated home range of approximately 230 ha while Female 2 occupied a much smaller estimated home range of approximately 75 ha (Figure 15). However, both females spent most time in smaller home range cores (defined by movements of less than 0.5 km, not shown in Figures 13 and 14), Female 1 in an area of about 39 ha and Female 2 in an area of about 20 ha (Figure 15).

During the first two months of the study period Female 1 spent most time outside its home range core in the vicinity of the home range of Female 2. During this period and occasionally throughout the remainder of the study period, Female 1 foraged and roosted within and closely adjacent to the home range core of Female 2.

This behaviour suggested that Female 1 had not established a permanent home range core, although it appeared to have bred at least once (above) and overlapping home ranges appear necessary to accommodate the Island's high density population. Notably, however, Female 2 never ventured into the home range core of Female 1 (Figure 15).

The roost sites of both females, as revealed by tracking, were mostly in dense tree canopies and tree hollows although crevices in *Ficus macrophylla columnaris* were used on occasions (Figure 16, Table 2). Tree hollow roosts were mainly in large Scalybarks *Syzygium fullagarii* and canopy roosts in slender Greybarks *Drypetes deplanchei* and Scalybarks (Table 2, Figures 17 and 18). Roost sites were mostly changed on a nightly basis with a number of favoured sites within the home range cores used on numerous occasions.

Neither female bred during the study period and no nests of other owls were found, although at the end of July 2010 a nest containing three eggs was located

**Figure 16.** A roost site of Female 1 in a crevice in a Lord Howe Banyan *Ficus macrophylla columnaris* in the Valley of Shadows in the north of the island. Photograph D. Milledge

**Figure 17.** One of Female 2's regular roost sites in a hollow in the trunk of a large Scalybark *Syzygium fullagarii* on the slopes of Intermediate Hill in the centre of the island. Photograph D. Milledge

**Figure 18.** A roost site of Female 1 in the dense crown of a Greybark *Drypetes deplanchei* near Blinky's Beach in the centre of the island. Photograph D. Milledge

**Table 2** Details of roost sites used by Masked Owl *Tyto novaehollandiae* Females 1 and 2 on Lord Howe Island between August 2009 and July 2010.

| | tree species | dbh* range/ mean# cm | roost height above ground range/ mean# m | number of roosts | | | |
|---|---|---|---|---|---|---|---|
| | | | | tree canopy | under-storey | trunk crevice | trunk/ branch/ epiphyte hollow |
| Female 1 | Greybark | 17-71/ 44 | 2-16/ 9 | 11 | | | |
| | Elkhorn clump in Greybark | 23-39/ 31 | 14-15/ 15 | | | | 2 |
| | dead fallen Greybark | - | - | | 1 | | |
| | Lord Howe Banyan | 290+ | 14-20/ 17 | 2 | | | |
| | Lord Howe Banyan | 300+ | 15/ 15 | | | 7 | |
| | Scalybark | 73-149/ 106 | 8-14/ 10 | | | | 4 |
| | dead Scalybark | 98 | 12 | | | | 1 |
| | Maulwood | 79 | 13 | 3 | | | |
| | **canopy/ understorey roosts** | | | **17 (55%)** | | | |
| | **hollow roosts (including crevices)** | | | **14 (45%)** | | | |
| | **total roosts** | | | **31** | | | |
| | | | | | | | |
| Female 2 | Greybark | 25-60/ 39 | 10-18/ 15 | 10 | | | |
| | Greybark | 58 | 12 | | | | 1 |
| | Scalybark | 31-74/ 45 | 11-18/ 14 | 5 | | | |
| | Scalybark | 99-148/ 116 | 8-12/ 10 | | | | 10 |
| | Blackbutt | 35 | 17 | 1 | | | |
| | **canopy roosts** | | | **16 (59%)** | | | |
| | **hollow roosts** | | | **11 (41%)** | | | |
| | **total roosts** | | | **27** | | | |

* dbh – trunk diameter at breast height, # includes repeated use of same roosts tree and epiphyte species: Blackbutt *Cryptocarya triplinervis*, Greybark *Drypetes deplanchei*, Lord Howe Banyan *Ficus macrophylla columnaris*, Maulwood *Olea paniculata*, Elkhorn *Platycerium bifurcatum*, Scalybark *Syzygium fullagarii*

in the area of the northern hills (D. O'Dwyer pers. comm.). This was situated on the ground in a recess in a rocky outcrop in coastal heath and screened by an epiphyte clump.

***Pellet and prey remains searches*** Analysis of the diets of both females from intact regurgitated pellets recovered from under their roosts (Figures 19 and 20), together with analysis of intact pellets from under other owl roosts showed that 72% contained the remains of *Rattus rattus*, 28% contained the remains of House Mice *Mus musculus* and 23% contained the remains of birds (21% seabirds, Table 3). Bird species taken were mainly seabirds, consisting of *Pterodroma nigripennis*, Little Shearwater *Puffinus assimilis*, Sooty Tern *Onychoprion fuscatus* and *Gygis alba*, together with *Hypotaenidia sylvestris*. Examinations of broken pellet remains from under the roosts of both females and other owls showed that the Flesh-footed Shearwater *Ardenna carneipes*, Buff-banded Rail *Hypotaenidia philippensis* and Lord Howe Currawong *Strepera graculina crissalis* were also included in owl diets (Table 3).

**Figure 19.** A collection of pellets and pellet remains, representing several weeks of hunting, recovered from under a roost regularly used by Female 1 on Transit Hill. The skulls, leg and other bones are mainly of the Black Rat *Rattus rattus*. Photograph D. Milledge

**Figure 20.** The prey items from Figure 19 arranged to show the dominance of the Black Rat *Rattus rattus* in the owl's diet. Photograph D. Milledge

**Table 3** Occurrence of prey species remains in intact* regurgitated Masked Owl *Tyto novaehollandiae* pellets collected on Lord Howe Island between July 2009 and July 2010.

| | numbers of pellets containing prey species remains | | | | |
|---|---|---|---|---|---|
| prey species | female 1 | female 2 | unknown owls# | total pellets | % total pellets |
| Little Shearwater *Puffinus assimilis* | 2 | | | 2 | (all bird species) 23 |
| Black-Winged Petrel *Pterodroma nigripennis* | 3 | | | 3 | (seabird species) |
| Lord Howe Woodhen *Hypotaenidia sylvestris* | | 1 | | 1 | 21 |
| White Tern *Gygis alba* | 1 | | | 1 | |
| Sooty Tern *Onychoprion fuscatus* | 1 | 1 | | 2 | |
| unknown bird | 1 | | | 1 | |
| House Mouse *Mus musculus* | 5 | 3 | 4 | 12 | 28 |
| Black Rat *Rattus rattus* | 8 | 2 | 21 | 31 | 72 |
| **total pellets** | **18** | **3** | **22** | **43** | |

*remains of broken pellets from under roosts included Flesh-footed Shearwater *Ardenna carneipes*, Buff-banded Rail *Hypotaenidia philippensis* and Lord Howe Currawong *Strepera graculina crissalis*

#from two adjoining pellet regurgitation sites adjacent to Boat Harbour track

## Discussion

*Tyto novaehollandiae* is listed as a threatened species in its natural range in New South Wales (*Biodiversity Conservation Act 2016*) yet on Lord Howe Island it is regarded as a pest species because of its predation of endemic land birds and breeding seabirds. It has successfully established as the top predator in the island's closed forests, very different habitat from the drier open forests it favours on mainland Australia and in Tasmania. It maintains a very high population density, ten times or more than that of the mainland and Tasmanian populations, with apparently overlapping home ranges. The latter is unusual as most terrestrial vertebrate apex predators are highly density dependent (Terborgh *et al.* 2010), but the opposite is the case on Lord Howe Island, probably due to the stable and abundant food supply provided by *Rattus rattus*.

***Impacts on Lord Howe Island biodiversity*** On Lord Howe Island *Tyto novaehollandiae* is known to prey on endemic land birds, including *Hypotaenidia sylvestris* and *Strepera graculina crissalis* (Table 3, N. Carlile unpubl. data), and breeding seabirds, particularly *Pterodroma nigripennis*, *Onychoprion fuscatus* and *Gygis alba* (Table 3) and also *Puffinus assimilis*, *Ardenna carneipes* (Table 3) and the Providence Petrel *Pterodroma solandri* (Bester *et al.* 2007), although these species appear to represent a minor component of the diet. Notably, evidence suggests that populations of *Hypotaenidia sylvestris* and some seabird species have increased over the past decade (LHIB unpubl. data, Priddel *et al.* 2003, Carlile and Priddel 2015).

It has been suggested that *Tyto novaehollandiae* was responsible for the extinction of the Lord Howe Boobook *Ninox novaeseelandiae albaria* in the 1950s through competition for food and nest sites and possibly predation (Hutton 1991, McAllan *et al.* 2004), although no evidence exists to support this contention. *Tyto novaehollandiae* may have preyed on boobook fledglings, including those of boobooks introduced from the mainland in the 1920s (above), which could explain the species' disappearance in the 1950s as remaining adults died out.

However, the species presently functions as the top predator on the island and may be contributing to maintaining some balance in limiting the *Rattus rattus* population through predation and also fear-mediated effects (Berger 2010). Support for this hypothesis is difficult to demonstrate, although some evidence may be provided by the extinction chronology of endemic land bird species and subspecies on Lord Howe Island following the *Rattus rattus* irruption in 1918-19 (Figure 21).

Before establishment of the *Tyto novaehollandiae* population in the 1920s, three endemic land bird species

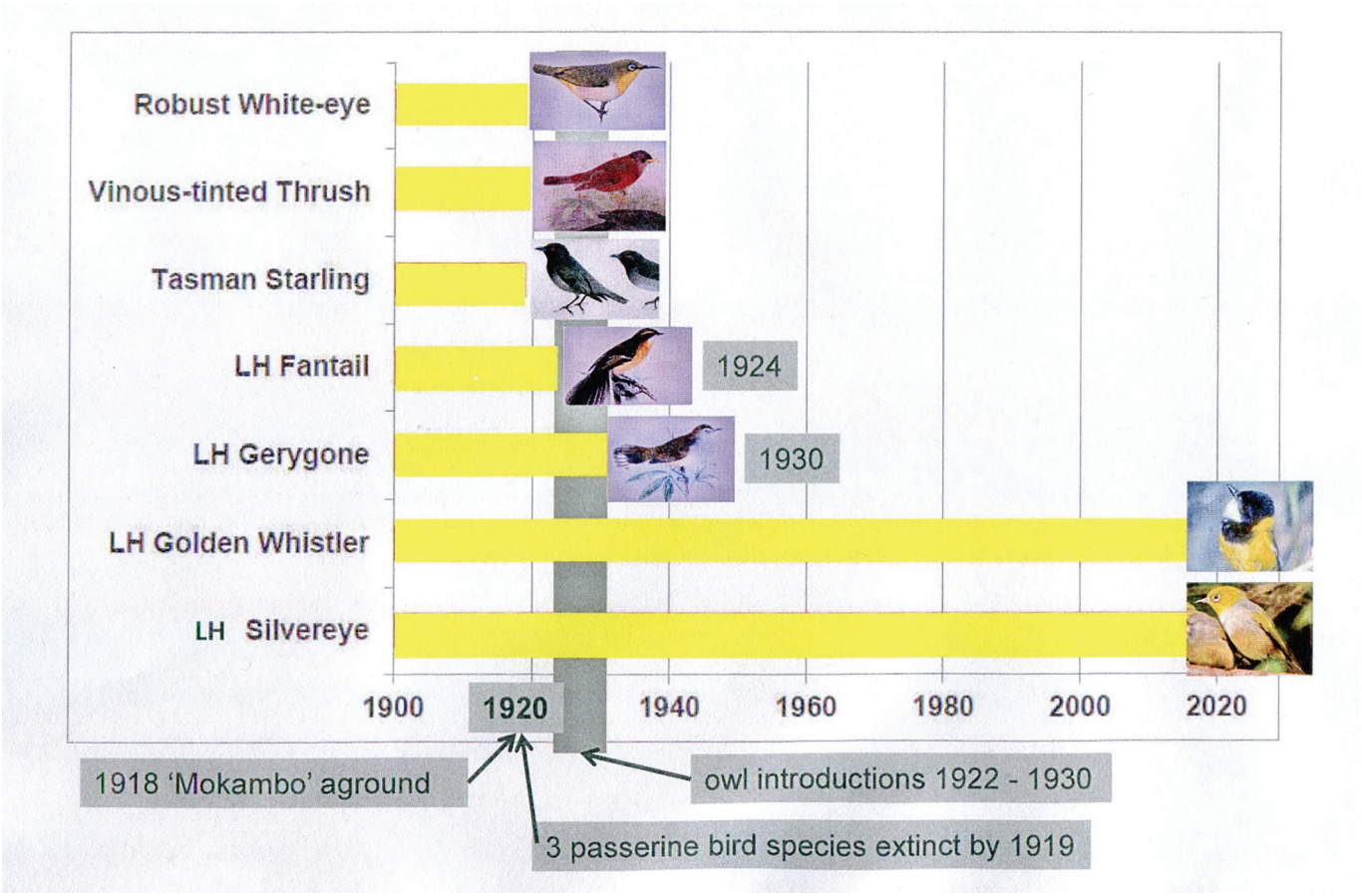


**Figure 21.** The extinction chronology of Lord Howe Island's endemic land birds, showing how establishment of the Masked Owl *Tyto novaehollandiae* in the 1920s may have assisted in slowing the extinction rate and possibly enabled the survival of the Lord Howe Golden Whistler *Pachycephala pectoralis contempta* and the Lord Howe Silvereye *Zosterops lateralis tephropleurus*. Vignettes and photographs I. Hutton

and subspecies, the Robust White-eye *Zosterops strenuus*, Island Thrush *Turdus poliocephalus vinitinctus* and Lord Howe Starling *Aplonis fusca hulliana* were reported to have succumbed to *Rattus rattus* (Figure 21, Hindwood 1940, Hutton 1991). Another endemic subspecies, the Lord Howe Fantail *Rhipidura fuliginosa cervina* became extinct about 1924 and the endemic Lord Howe Gerygone *Gerygone insularis* survived a little longer, up until approximately 1930 (Figure 21, Hindwood 1940, Hutton 1991). It is possible that the owls began to exert some control of the rat population in the 1920s, slowing the extinction rate of the latter two species and perhaps preventing the extinction of two other endemic subspecies (Figure 21), the Lord Howe Golden Whistler *Pachycephala pectoralis contempta* and Lord Howe Silvereye *Zosterops lateralis tephropleurus* that are presently widespread across the island (Hutton 1991, McAllan *et al.* 2004).

***Masked Owl eradication*** The Lord Howe Island Biodiversity Management Plan recommended control or eradication of *Tyto novaehollandiae* from the island (above, DECC 2007) and a decision has been made to eradicate the population concurrent with implementation of a rodent eradication plan (above, LHIB 2009, O'Dwyer and Carlile 2016), proposed to be initiated in mid-2019 (LHIB 2016).

The primary reason for achieving concurrent eradication of owls with rodents is the likely switching of the owl's prey base from predominantly *Rattus rattus* to endemic land birds and breeding seabirds once rats are eradicated or substantially reduced. However, the risk of mesopredator release (Brashares *et al.* 2010) if owls were to be removed prior to the removal of rats, freeing the rat population from owl predation, is also a potential risk. This could threaten the survival of endemic species and subspecies such as the Lord Howe Placostylus *Placostylus bivaricosus*, *Pachycephala pectoralis contempta* and *Zosterops lateralis tephropleurus* as well as having a major adverse impact on biodiversity generally.

Another reason for eradicating *Tyto novaehollandiae* is the proposed reintroduction of extinct Lord Howe Island species such as the Red-fronted Parrakeet *Cyanoramphus novaezelandiae* and Southern Boobook *Ninox novaeseelandiae* to the island (DECC 2007), which is considered likely to be hampered or even prevented by the presence of an introduced apex predator.

It is assumed that many owls will perish during the rodent baiting program due to secondary poisoning from eating dead or dying rodents. Evidence for this is provided by periodic records of sick or dying owls

exhibiting secondary poisoning symptoms consistent with eating rodents poisoned by brodifacoum-based rodenticide baits (similar to those proposed for use in the baiting program) laid around palm seed collection areas and tourist resorts in the settlement (data from this study, H. Bower unpubl. data).

However, as not all owls can be expected to succumb to secondary poisoning (data from this study, O'Dwyer and Carlile 2016), the remaining population is proposed to be removed in accessible areas by targeted shooting using call playback, and in remote areas by trapping with goshawk-type traps. The former method will only be employed during and after rodent baiting to ensure that owls do not become habituated and consequently unresponsive to call playback before the baiting program commences (O'Dywer and Carlile 2016).

Regular monitoring for remaining owl presence, using call playback or acoustic recorders followed by appropriate removal techniques will be used to ensure complete eradication of *Tyto novaehollandiae* from the island (O'Dywer and Carlile 2016).

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