Tweed Shire Council

BLOSSOM BAT MONITORING REPORT, KOALA BEACH ESTATE, WINTER 2007

Report prepared by David Hannah and Ben Lewis for the Koala Beach Wildlife & Habitat Management Committee, August 2007

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BLOSSOM BAT MONITORING 2007

General Notes

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BLOSSOM BAT MONITORING 2007

TABLE OF CONTENTS

Figures

Tables

Plates

Executive Summary

In accordance with Koala Beach Common Blossom Bat Plan of Management (CBBPoM) monitoring for the Common Blossom Bat (*Syconycteris australis*) was undertaken over three nights in July 2007. Up to six mist nets of three sizes (9,12,18 m) were established in the Blossom Bat Reserve and operated between 1800-2345 hrs each evening totaling 586.5 mist-net metre hours. The condition of habitat within the Reserve was also assessed using aerial photographs dating from 1944 to 2007 along with plot based surveys (5 x 5 m) designed to measure the density of Coast Banksia in three age classes and to also assess the number of productive inflorescences at the time of survey.

A total of 19 blossom bats were captured comprising 14 individuals (nine males, five females) at a capture rate of 3.2 bats per 100 mist-net metre hours (nmh's). Five bats were recaptured and allowed a population estimate to be undertaken which estimated 16.33 (± 1.76) blossom bats occurred in the study area (~1.2 ha) or about 12.14 - 15.02 bats per hectare. Although similar numbers of bats were recorded on each night the number of bats per 100 nmh's declined markedly on the third night due to a substantial increase in survey effort.

Blossom bat activity reached its peak between 1900-2000 hrs before declining gradually until after 2200 hrs when few individuals were captured. Only one bat was recorded prior to 1900 hrs indicating that individuals probably roost some distance (>1 km) from the study area with this information broadly consistent with previous, albeit limited radio telemetry studies in the area.

The habitat assessment identified the vegetation community may be as little as 14 years old and coincided with the removal of livestock. Coast Banksia tended to have a patchy distribution over the site at densities of ~1500 stems per hectare with most (75%) of these being mature trees. Few juvenile trees were recorded and these were confined to the western extent of the study area indicating poor recruitment at the site. In light of this poor recruitment a review on the potential threats to Coast Banksia has been undertaken to foster a greater understanding about germination and recruitment suppression and the role which weeds and browsing animals may play. Despite the poor recruitment, an assessment on the productivity of Banksia resources at the time of survey resulted in an average of 6.4 (± 1.6) productive inflorescences per tree and an overall density estimate of 9555 inflorescences per hectare placing the site among other high value resource sites in coastal NSW. The results outlined above have been discussed in light of previous monitoring events and other studies of this species further a-field.

A review of performance indicators and monitoring methodology outlined within the CBBPoM has also been undertaken. In response to performance indicators, the current study found that the absence of fire and grazing may have a long term profound effect on the recruitment of Banksia, that bat activity levels remain high and substantiate earlier statements about the local and regional significance of the site, and that construction of earlier stages may have had negligible impacts on this species via effective mitigation and habitat preservation.

Synthesis of the results obtained during this monitoring event has enabled the distillation of several recommendations. Among them is a need to develop and implement a habitat management strategy, a need to continue monitoring blossom

bats at 3-4 year intervals with annual monitoring of habitat variables, a reduction in the number of nmh's from 1000 to ~500 nmh's per monitoring event, and for the Koala Beach Wildife and Habitat Management Committee to give consideration to commissioning a study to determine the availability and use of roost habitat in the area.

1.0 INTRODUCTION

The Common Blossom Bat (*Syconycteris australis)* (hereafter Blossom Bat) is a small nectar/pollen specialist (Law 1993) occurring throughout tropical New Guinea south along the coast of Queensland into temperate NSW to Hawks Nest on NSW mid north coast (Richards, 1983). In contrast to other Megachiropteran bat species such as the flying-foxes, the blossom bat appears to be solitary, selecting roosts within dense foliage of rainforest and swamp sclerophyll forests through much of its range (Richards 1983, Law 1993). In northern NSW, roosts are often within close proximity to exposed coastal heathlands (Law 1993; Phillips *et al* 1995; Richards, 2003) where bats are known to forage primarily on the flowers of Coast Banksia (*Banksia integrifolia*) (Law 1994 & 1996).

In NSW, the Common Blossom Bat is listed as Vulnerable under Schedule 2 of the NSW *Threatened Species Conservation* Act 1995. Its listing is primarily due to the suspected reduction in population and distribution, threatening processes such as clearing of critical winter food resources, and the specialist nature of the blossom bat's ecology (DECC, 2005).

The presence of the blossom bat within the Koala Beach Estate (formerly Searanch) was confirmed during initial surveys for the Fauna Impact Statement by Phillips et al., (1995). At that time, it was suggested that the Koala Beach Estate, while not supporting a resident population of the Blossom Bat, did constitute a regionally significant food resource for the Blossom Bat, particularly during winter months (Phillips et al., 1995). Subsequently, an area of Blossom Bat habitat consisting of about 1.2 hectares of Coast Banksia dominated forest was reserved as part of the final subdivision approval (referred to hereafter as the *Blossom Bat Reserve*).

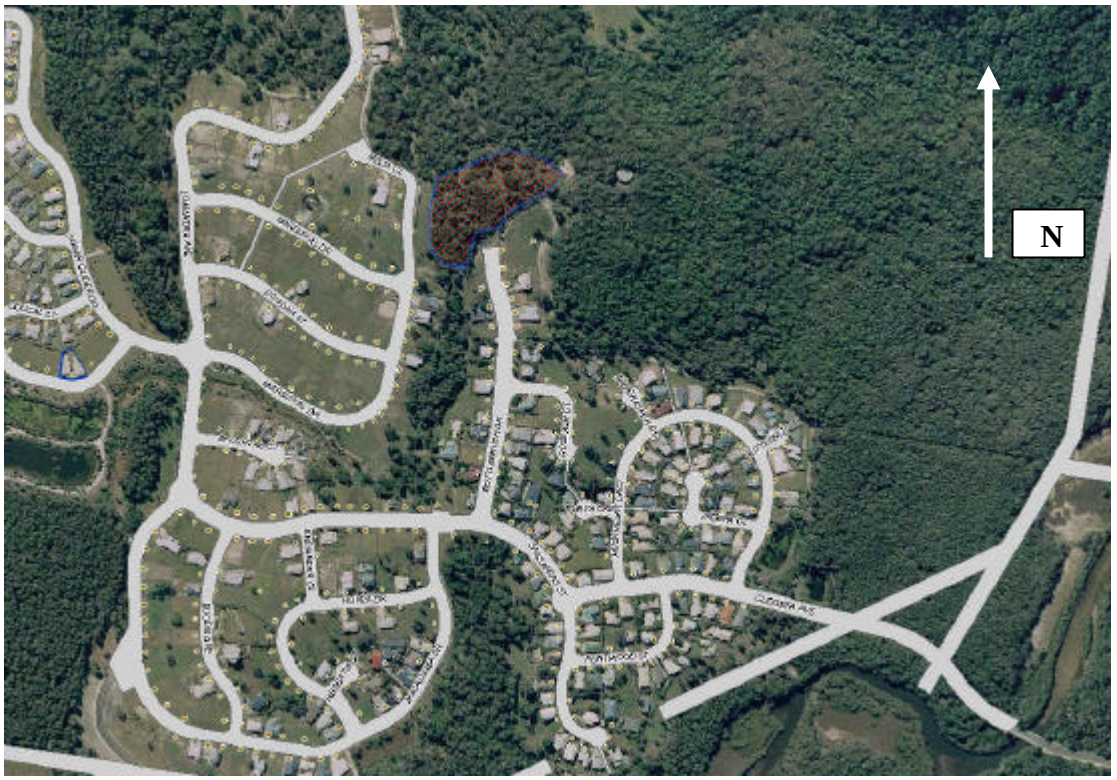
A Blossom Bat Plan of Management (BBPoM) was prepared and approved in 2000 and included recommendations for the management of the reserved Blossom Bat habitat area and for monitoring the use of this habitat by Blossom Bats (Coburn and Markus, 2000). The rationale for the monitoring was to establish whether the Blossom Bats are continuing to use the Coast Banksia food resources regardless of the proximity of housing developments and associated disturbance. The BBPoM was subsequently revised in 2004 as at the time of preparing the BBPoM, the final layout details of Stage 5, which adjoins the Blossom Bat Reserve habitat, was not known. It was recommended in the revised BBPoM that since the monitoring of impacts from the proximity of housing developments and associated disturbance to the Reserve were yet to be established, that the annual monitoring proceed from the date of completion of Stage 5 for at least the prescribed 3 years (AKF 2004a). The subdivision certificate for Stage 5 (A, B and C) of Koala Beach Estate was released December 2004.

In response to the monitoring requirements within the BBPoM, an intensive three day monitoring program was initiated within the Blossom Bat Reserve during July 2007. Monitoring methodology was based on that outlined within

the BBPoM (Coburn and Markus 2000) and the revised BBPoM (AKF 2004a). Up until this time, however, no monitoring of Blossom Bats based on the methods outlined within the BBPoM had been undertaken. Since the time of initial surveys for the FIS, only a 2 day monitoring episode, one day in June and one day in August 2001, had been undertaken at the site (Phillips 2004).

This report outlines the results of the 2007 monitoring event. Specifically, the report aims to:

- Present relative densities of Blossom Bats based on mist-netting results at the site and compare these results to past trapping studies both within Koala Beach and further a-field;
- Discuss population estimates for Blossom Bats within the Reserve;
- Provide information on the quality of the food resources at the site and compare this to other sites in northern NSW;
- Document methods for establishing permanent vegetation plots for monitoring ongoing habitat management within the site;
- Review monitoring methodology outlined within the approved Blossom Bat Plan of Management; and
- Provide recommendations for future management of the Reserve.



Blossom Bat Reserve shown in hashed section **Scale: 1:5000**

Blossom Bat Reserve shown in hashed section **Scale 1:2000**

Figure 1: Blossom Bat Reserve, Koala Beach Estate

2.0 STUDY AREA

The Blossom Bat Reserve comprises about 1.2 hectares of Coast Banksia dominated forest on southern facing slopes of a low ridge within the Koala Beach Estate. The site is bounded by Stages 4 and 5 in the south and west respectively and forested lands to the north and east (refer Figure 1). A Tweed Shire Council owned water reservoir is located directly to the east.

The geology is described as rolling hills on metamorphics of the Neranleigh-Fernvale Group (Morand 1996). Soils are generally erodible, strongly acid, hardsetting and dispersive of low fertility and localised shallowness and stoniness (Morand 1996).

Coast Banksia dominates the sub canopy with the occasional emergent Northern Grey Ironbark (*Eucalyptus siderophloia*) and Brushbox (*Lophostemon confertus)*. A large prominent fig is located within the site and was fruiting at the time of the field study. Regenerating Brushbox, Acacia species, and the occasional Tuckeroo (*Cupaniopsis anarcardioides)* were present in the mid to upper stratum. The ground layer is dominated by the introduced grass (*Setaria sphacelata)* especially along cleared edges. Native grasses including Kangaroo Grass (*Themeda australis*) and Bladey Grass (*Imperata cylindrica*) were co-dominant particularly in the south-west and south-east- sections of the site.

Adjacent vegetation to the north and east is generally described as sclerophyll open to closed forest dominated by Coastal Blackbutt (*Eucalyptus pilularis)*, Grey Ironbark, Pink Bloodwood (*Corymbia intermedia*), Small-fruited Grey Gum (*E. propinqua*) and Brushbox, with a subcanopy of Forest Oak (*Allocasuarina torulosa*). A patch of about 1.66 hectares of low Forest Oak dominated forest occurs directly to the north of the Blossom Bat Reserve and has been similarly reserved as habitat for the Glossy Black Cockatoo (*Calyptorhynchus lathami*) which are known to regularly feed at the site.

The Blossom Bat Reserve is presently zoned as 2 (c) Urban Expansion under the Tweed Local Environment Plan 2000 (TLEP 2000) although under the draft Tweed LEP 2007 zoning, the site will be re-zoned as 7(a) Environmental Protection (Significant Natural Habitat and Wildlife Value). Lands directly to the north and east are presently zoned 7(l) Environmental Protection under the TLEP 2000.

3.0 METHODS

3.1 Banksia flowering abundance and age class assessment

Density estimates of predictors of food abundance (following the methods outlined in Law (1994) were used to relate relative abundance of Blossom Bats to food abundance at the site. To achieve this, Coast Banksia inflorescences (flowers) were counted within 15, 5 m x 5 m plots. Plot dimensions were based on that employed by Law (1994), who undertook extensive studies into relationships between Blossom Bat abundance food resources in coastal northern NSW, thereby enabling comparative interpretation of results. Plots were randomly located along north - south running transect lines spaced 30 m apart (refer Figure 2). All transects were set out along a constructed timber fence which aligns with the southern boundary of the site. The first transect was located at the eastern extent of the timber boundary fence. Seven transects were established with all transects consisting of 2 plots except for the most western transect which comprised 3 plots due to the extended dimensions of the study area in this area. Plot locations and distances along respective transects are summarised in Table 1 below.

5 x 5 m vegetation monitoring plot locations along north running transects spaced at 30m intervals along southern boundary fence (See Table 1 for further detail on plot locations)

Source: Tweed Shire Council **Scale 1:1200**

Figure 2: Vegetation monitoring plot locations

The south-west corner of each plot was marked with a steel star picket and painted with yellow fluorescent line marking paint. The top of each star picket was used as a photo reference point with a single photo taken at a 45 degree angle across the plot (refer Appendix 1).

Within plots, only productive *B. integrifolia* flowers were counted. Productive inflorescences were those flowers considered to be producing nectar and pollen. Flowers in this stage are known to be highly correlated with the amount of nectar and pollen produced (Law 1994). Plate 1 shows the four stages of inflorescences observed at the site with only inflorescence stage B and C considered productive. The average number of productive inflorescences per tree was converted to an estimate of inflorescence density by multiplying by the number of Coast Banksia trees per hectare (after Law 1996).

The age class of Coast Banksia trees was also assessed within the 5 x 5 m plots to better understand the successional stage of the community. Banksia trees were separated into three age classes based on height and included juvenile trees < 1.5 m, immature trees 1.5 – 3.0 m, and mature trees > 3.0 m. Coast Banksia are known to flower after about 2 – 3 years depending on site conditions (R. James pers. comm., 11/8/07). No trees in the juvenile age class (i.e. to 1.5 m) had developed flowers. Stem diameters for trees beyond about 3 m tall were distinctly larger than those within the immature height class and were therefore considered mature (pers. obs.). Senescing or dead Coast Banksia trees were also recorded within plots to determine the influence of drought or other natural or stochastic events effecting the community.

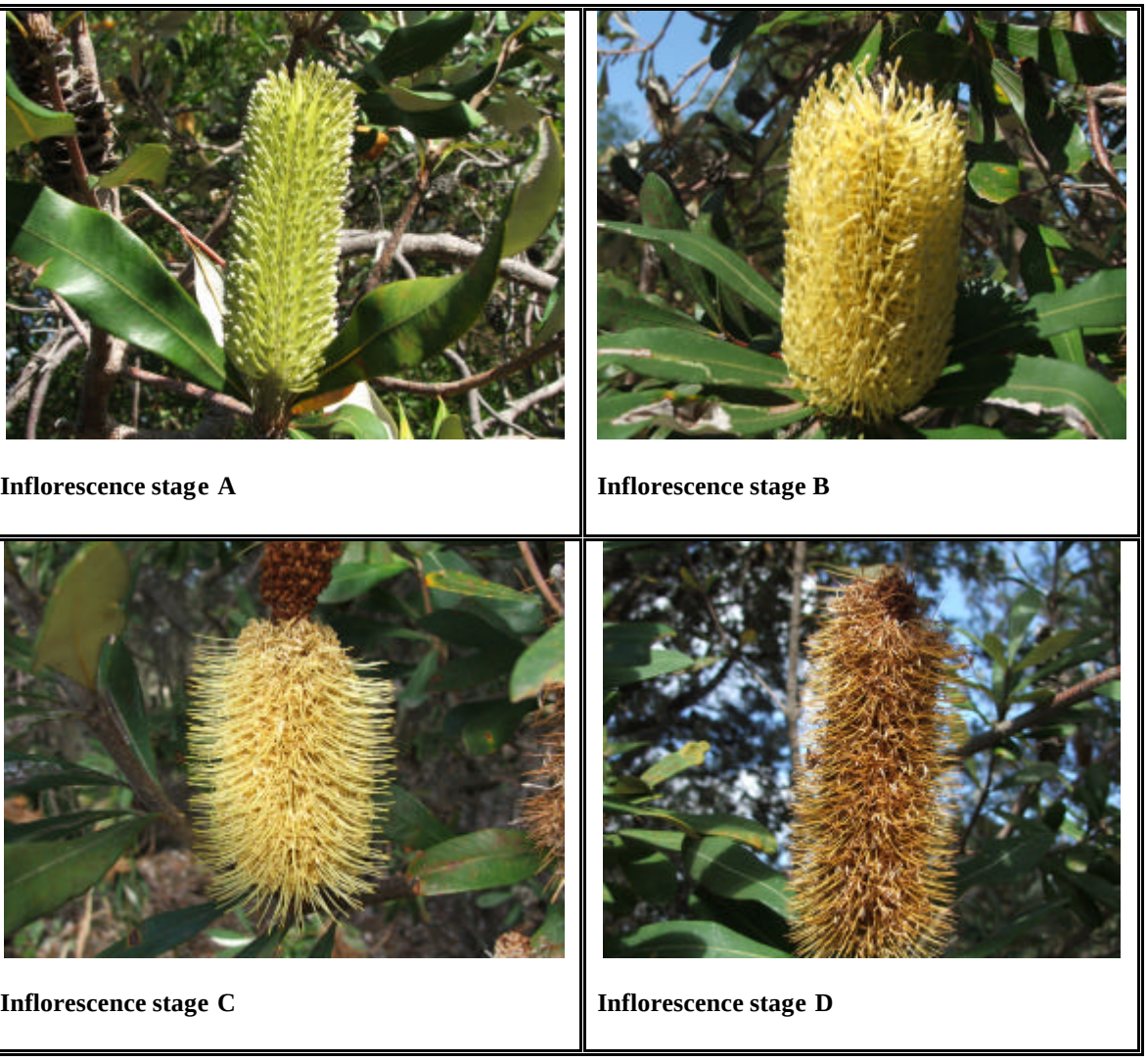
The age class assessment was also facilitated by undertaking a chronological approach to understanding the history of the Blossom Bat Reserve. This comprised a review of aerial photographs dating from 1944 to present. In particular, aerial photo runs from 1944, 1962, 1993, 1996 and 2007 were reviewed (refer Appendix 2). Aerial photography from

Table 1: Coast Banksia monitoring plot locations data

Transect Number	Plot distance along transect[1]	Zone	Easting	Northing
1	7	56	554988	6861644
1	36	56	554994	6861676
2	4	56	554964	6861635
2	18	56	554967	6861644
3	36	56	554943	6861644
3	63	56	554948	6861672
4	4	56	554912	6861615
4	24	56	554921	6861615
5	30	56	554897	6861612
5	50	56	554899	6861630
6	7	56	554885	6861556

Transect Number	Plot distance along transect[1]	Zone	Easting	Northing
6	48	56	554889	6861606
7	30	56	554863	6861578
7	72	56	554870	6861622
7	107	56	554879	6861654
Total transects = 7	Total Plots = 15			

[1] transects commenced at zero delineated by the eastern end of a wooden boundary fence



Inflorescence stage A

Inflorescence stage B

Inflorescence stage C

Inflorescence stage D

Plate 1: Four stages of Coast Banksia inflorescences
(Note: Only Coast Banksia in inflorescence stage B and C were considered productive (see text for further details)

3.2 Sampling Blossom Bats

Blossom Bats were sampled over three consecutive nights between the 14th and 17th of July 2007. Surveying aimed to coincide with the estimated peak flowering of Coast Banksia at the site (refer Plate 2). Weather conditions

during the survey period were taken from the nearest Bureau of Meteorological Station located at Coolangatta Airport and are summarised in Table 2 below.

Plate 2: General indication of density of Coast Banksia inflorescences at the time of monitoring

Table 2: Weather data during survey period

Date	Minimum overnight temperature (^{0}C)	Maximum daily temperature (^{0}C)	Wind direction (9.00 am – 3.00 pm)	Wind speed (9.00 am – 3.00 pm)	Cloud cover (8th)	Moon phase
14/7/2007	3.8	19.6	WSW – NNE	6 – 17	nil	new
15/7/2007	2.9	18.7	SSE - ENE	7 – 19	nil	new
16/7/2007	7.5	18.9	SSW – E	15	nil	new
17/7/2007	5.5	19.7	Calm - N	0 - 26	6	new

(Source: Bureau of Meteorology)

Bats were captured using 1 inch gauge monofilament mist-nets measuring 9, 12 and 18 metres in length. All nets consisted of 4 shelves, and were set between 2 and 5 metres above the ground. Nets were attended at all times by at least 2 experienced observers and furled during day light hours. The number of nets open at any one time varied between two and six nets depending on the level of flying-fox activity at the site. The site is located within about 1.7km of a Grey-headed Flying-fox (*Pteropus poliocephalus*)

camp consisting of about 3000 individuals (at the time of the survey). Flying-foxes were actively foraging at the site during all sampling times although tended to forage high in the Coast Banksia canopy during the early evening then moving lower into the canopy within the range of nets later in the evening (pers. obs.). The density of flying-foxes at the site appeared to be higher immediately following roost emergence. This activity, as suggested above, dictated to some extent the net array employed, and timing of their deployment and duration. In general however, mist-nets were open between 1815 and 2315 hrs and averaged in excess of about 100 mist-net metre hours (nmh) per evening (refer Table 3).

Mist-nets were distributed primarily along the top of the ridge and the southern facing mid-slopes as Banksias in this area appeared to contain more inflorescences. Mist-nets were either moved to a new location or re-orientated over the three nights and were never left in the same location for more than two nights to reduce the potential of net-avoidance by bats.

Captured Blossom Bats were sexed (and their reproductive condition noted), weighed (± 0.05 gm), and had their forearm lengths measured (± 0.1 mm). An index of condition was calculated by dividing body mass by forearm length (after Law 1996).

Blossom Bat abundance was calculated based on a catch per unit effort approach. That is, the number of bats captured per 100 and 1000 mist-net metre hours (nmh). This approach is consistent with the other studies in similar habitats in northern NSW (e.g. Law 1993, 1994, 1996; and Richards 2005) and would then lend itself to direct comparisons with those studies.

Table 3: Summary of Blossom Bat monitoring effort

Date	Net reference	Net length (m)	Time open	Time closed	Hours open	nmh/net[1]	nmh/ night
Night 1							
14/07/2007	12a	12	1945	2315	3.5	42	
	12b	12	1945	2315	3.5	42	
	18a	18	2015	2315	1.0	18	102
Night 2							
15/07/2007	9a	9	1900	2230	3.5	31.5	
	9b	9	1900	2245	3.75	33.75	
	12a	12	1915	2215	3.0	36	
	12b	12	1945	2230	2.75	33	134.25
Night 3							
16/07/2007	9a	9	1815	2230	4.25	38.25	
	9b	9	1830	2230	4.0	36	
	12c	12	1800	2245	4.75	57	
	12d	12	1800	2245	4.75	57	
	18a	18	1800	2230	4.5	81	
	18b	18	1800	2230	4.5	81	350.25

1: nmh = length of respective mist-net multiplied by the length of time each net was deployed for.

All Blossom Bats captured were marked with texta-paint on their dorsal fur with the location of marking differing between nights 1 (head) and night 2 (rump). This enabled a population estimate to be derived if one or more individuals were recaptured during the course of the field survey. The survey was designed to enable the Triple Catch population estimate (Donnelly and Guyer 1994) to be undertaken as this approach allows for survival gains and losses, however due to no recaptures between the first and second sampling events, this was not possible. As an alternative, the Chapman's modification of the Peterson Population Estimate (Donnelly and Guyer 1994) was used and is considered robust when using small datasets comprises <10 recaptures. The formula is:

$$\text{Population Size} = \frac{(r + 1)(n + 1)}{(m + 1)} - 1$$

where

r = number of animals caught during the first and second night sampling periods (236.25 mist-net metre hours of effort)

n = number of animals caught during the third night sampling period (350.25 mist-net metre hours of effort)

m = number of animals caught on third night and have been previously marked.

Standard error was performed on the population estimate data as defined by Seber (1970, 1982). The formula is:

$$SE = \frac{(r + 1)(n + 1)(r - m)(n - m)^{0.5}}{(m + 1)^2(m + 2)}$$

4.0 RESULTS

4.1 Relative abundance and morphology of captured Blossom Bats

In total, there were 19 captures of 14 individual Blossom Bats over a total of 586.5 nmh. Capture rates were similar over the first two nights (as an index of bats captured per 100 nmh; refer Figure 3 and Table 4), then declined on the final evening when effort was substantially increased. The number of nets opened increased from 3 nets (2x12m and 1x18m nets) on the first evening to 4 nets (2x9m, 2x12m nets) and finally to 6 nets (2x9m, 2x12m, and 2x18m nets) on the final evening.

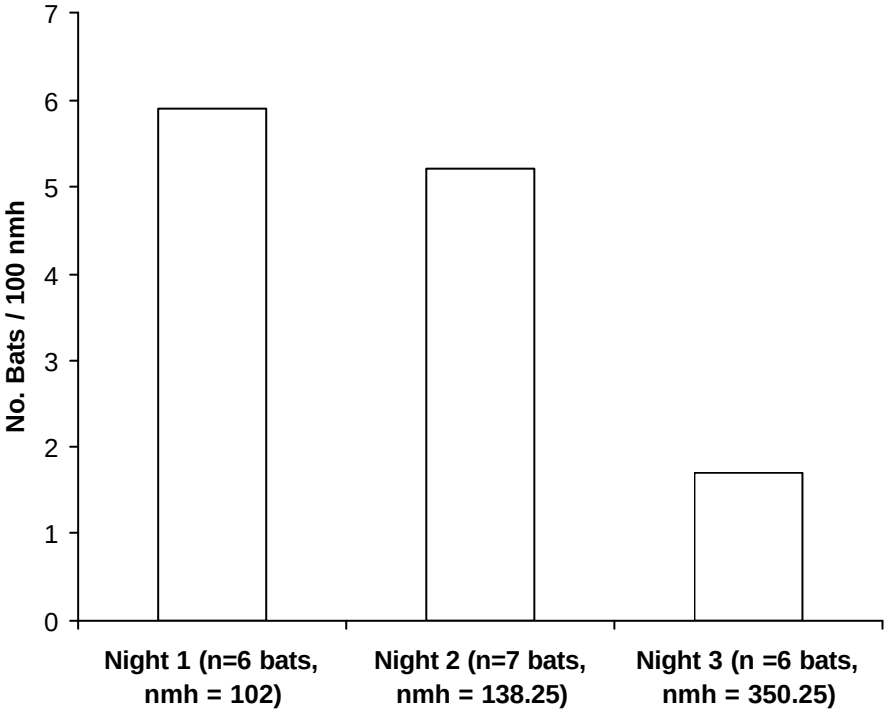


Figure 3: Capture results for Blossom Bats over 3 consecutive nights

All Blossom Bats captured were adults comprising 9 males and 5 females (Table 5). No pregnant or post breeding females were captured during the monitoring survey. The mean weight of captured bats was 16.2 ± 0.59 g, with females generally heavier (18.05 ± 0.56g, *n = 5*) than males (15.17 ± 0.64g, *n=9*). Forearm lengths averaged 40.64 ± 0.59 mm with female forearm lengths similarly larger (42.46 ± 0.39 mm; *n = 5*) than male forearm lengths (39.62 ± 0.7mm; *n = 9*). These trends were reflected in Blossom Bat condition

with females having a higher condition index (0.42 ± 0.01) than males (0.38 ± 0.02).

Table 4: Blossom Bat capture data expressed as numbers of captures and individuals per mist-net metre hours

Sampling event	nmh	No. bats captured	No. Recaptures	Bats / 100 mnh[1]	Bats / 1000 mnh[1]
Night 1	102	6	0	5.9	58.8
Night 2	138.25	7	0	5.2	52.1
			5 (1 from night 1 and 4 from night 2)		
Night 3	350.25	6		1.7	17.13
Total	586.5	19	5	3.2	32.4

1 – calculation is: (standardised nmh value / actual nmh) * number of bats captured)

Table 5: Biology and morphology of captured Blossom Bats

Sampling event[1]	Sex[2]	Weight (g)	Forearm length (mm)	Condition	Recaptures[3]
Night 1 (14/7/07)	Female	18.75	43.4	0.43	
	Male	15.75	39.3	0.40	
	Male	16.25	40.8	0.40	
	Female	16.5	42.1	0.39	
	Male	16.5	43.4	0.38	
	Male	15.5	40.8	0.38	
Night 2 (15/7/07)	Female	17.75	41.8	0.42	
	Male	15.5	38.7	0.40	
	Female	19.75	43.4	0.46	
	Male	16.5	40.6	0.41	
	Male	16.75	35.8	0.47	
	Male	12.25	38.6	0.32	
	Female	17.5	41.6	0.42	
Night 3 (16/7/07)	Male				n2
	Female				n1
	Male				n2
	Male	11.5	38.6	0.30	
	Male				n2
	Female				n2

1 – refer Table 3 for sampling effort; 2 - all bats captured were adults and no evidence of breeding recorded; 3 - n1 = night 1 recapture, n2 = night 2 recapture.

4.2 Blossom Bat activity periods

Blossom Bat activity, based on captures per mist-net metre hours, was highest between 1900 and 2200 hours (Figure 4). Activity peaked between 1900 and 2000 hours (n=7 captures; 6.1 bats/100nmh) then trailed off marginally between 2000 and 2100 hours (n= 6 captures, 4.3 bats/100nmh) and 2100 hours and 2200 hours (n=5 captures; 3.5 bats/100nmh). Only one Blossom Bat was captured before 1900 hours (i.e. 1845 hrs) and no Blossom Bats were captured after 2128 hours.

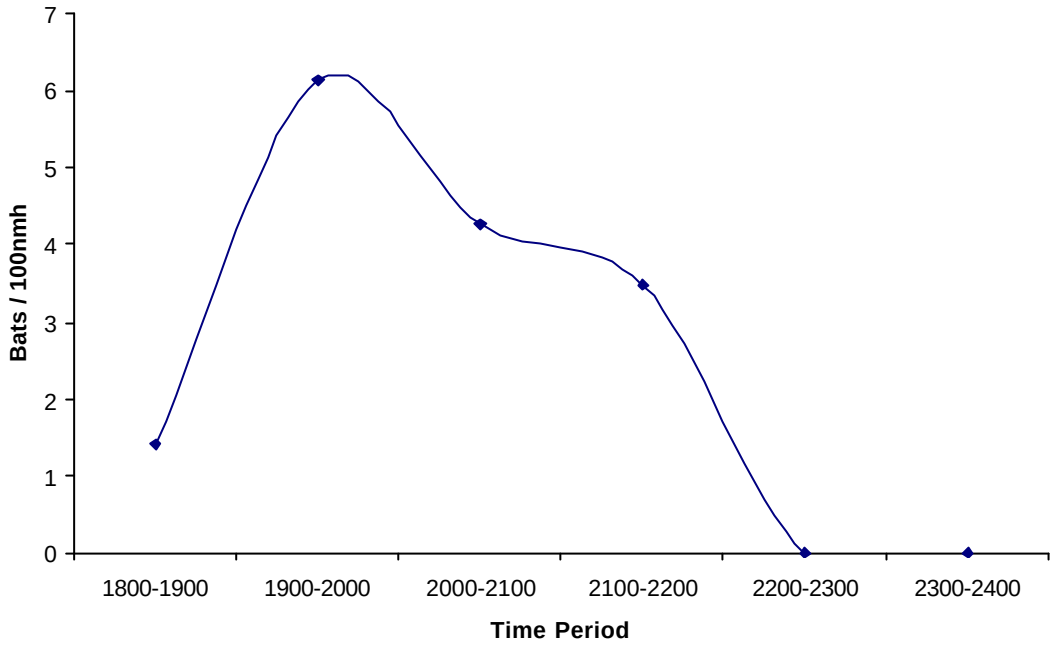


Figure 4: Capture times for Blossom Bats expressed as captures per mist-net metre hours

As mentioned, the only recaptured Blossom Bats occurred on night 3. Recaptured bats were captured between 1930 hours and 2128 hours and generally distributed throughout the trapping area. A summary of respective capture times for recaptured bats is presented in Table 6.

Table 6: Capture times for recaptured Blossom Bats

Trapping date	Net ID	Capture time	Night first captured
16/07/2007	18a	1930	Recapture from night 1
16/07/2007	9a	1935	Recapture from night 2
16/07/2007	12a	2030	Recapture from night 2
16/07/2007	9a	2110	Recapture from night 2
16/07/2007	18b	2128	Recapture from night 2

4.3 Banksia age structure and food availability

Plot data yielded 56 Coast Banksia trees from the 15 plots (375m^2) at an average of 3.73 trees per plot. Extrapolating the data to a more interpretable scale returned a value of 1493 trees per hectare. Of the trees counted, approximately 75 % were considered mature (i.e. > 3.0m tall), 18 % were immature (i.e. between 1.5 and 3.0m tall) and 7 % were immature (i.e. < 1.5m tall). The mean number of trees in respective age classes is presented in Figure 5. Photographic references of all plots are presented in Appendix 1.

Few juvenile trees were recorded with only four stems from 2 plots located along the most western transect. Immature trees were recorded from 6 plots totaling 10 stems with most of these recorded in the central part of the study area. Mature trees were recorded from 11 (or 73%) of plots and were notably clumped in some areas. For example, in the middle sections of the study area on the ridge line, one plot contained 15 mature trees. Two plots contained no trees at all demonstrating the patchy distribution of Banksia at the site. Dead trees were recorded from two plots totaling five dead stems.

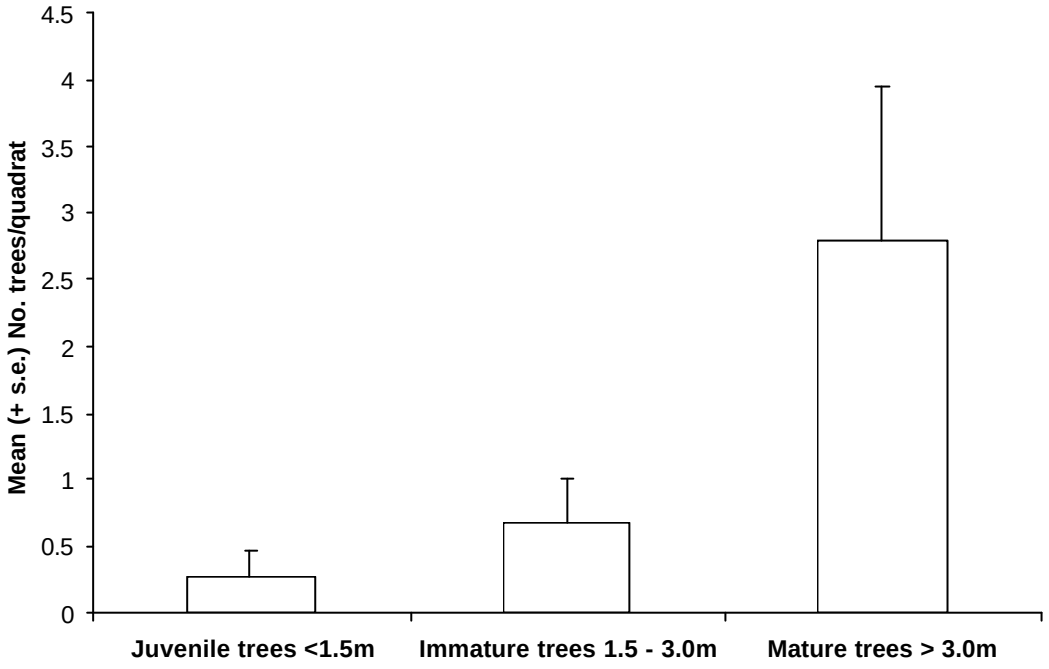


Figure 5: Banksia integrifolia age classes determine from plot based counts

Productive Banksia inflorescences were counted within plots to provide an estimate of inflorescence density and relative productivity of the site for Blossom Bats (Table 7). An average of 6.4 (± 1.6) productive inflorescences were counted per tree (n = 43 trees) with the greatest number of inflorescences counted on a tree totaling 56. Inflorescence density was estimated at 9555 inflorescences per hectare.

Table 7: Coast Banksia age class and productive inflorescence loads among plots

Transect Number	Plot number	Juvenile tree <1.5m	Immature tree 1.5 - 3.0m	Mature tree > 3.0m	Dead/senescing trees	Total Inflorescences
1	1	0	0	0	0	0
1	2	0	1	1	0	38
2	1	0	0	1	0	23
2	2	0	0	1	0	45
3	1	0	0	1	0	27
3	2	0	5	15	2	46
4	1	0	1	2	0	3
4	2	0	1	0	0	0
5	1	0	1	2	0	17
5	2	0	0	10	0	19
6	1	0	0	0	0	0
6	2	0	0	1	3	0
7	1	3	0	0	0	0
7	2	0	0	0	0	0
7	3	1	1	8	0	56
Total transects = 7	Total plots = 15	Total trees < 1.5m = 4	Total immature trees = 10	Total mature trees = 42	Total dead trees = 5	Total flowers = 274

4.4 Blossom Bat population estimates

The mark-recapture study estimated that 16.33 (± 1.76) Blossom Bats occurred in the study area (~1.2 ha) at the time of the survey which effectively equates to approximately 12.14 - 15.02 bats per hectare.

5.0 DISCUSSION

5.1 Population monitoring and activity

Monitoring of Blossom Bats revealed bat activity is relatively high within the Reserve. Results of the current study compare favourably with the original trapping episodes at the site by Phillips et al. (1995) as trends based on captures per unit effort have increased (refer Figure 6). For example, Phillips et al. (1995) when undertaking studies for the Fauna Impact Statement prior to approval of Koala Beach Estate, netted 11 Blossom Bats over 505 net-metre hours (or 2.2 bats per 100 nmh) within the Blossom Bat Reserve (their site M3). The present study returned 19 Blossom Bats over 586.5 net metre hours (or 3.2 bats per 100 nmh). The Blossom Bat Reserve habitat was also trapped on two occasions during June and August 2001 (AKF 2004b). Although no bats were recorded during the June session, 4 Blossom Bats were captured during the August session equating to a combined effort of 4 captures over 101.28 net-metre hours (or 3.9 bats per 100 nmh). Caution is warranted in interpreting the 2001 monitoring data as total survey effort during the Phillips' 2001 study (i.e. 2 evenings over 2 separate months) was substantially less than that employed during Phillips et al. (1994) and the current study.

The results suggest peak foraging activity for Blossom Bats occurred between 1900 hours and 2200 hours over the trapping period and then declined. No trapping was undertaken between 2400 hours and dawn such that it is unclear whether Blossom Bats undergo another peak in foraging activity during this time period. However, Law (1994) found that although other species of bats may reduce their activity as nightly temperatures drop (Richards 1989 *in* Law 1994), no correlation was found between minimum nightly temperatures and the number of Blossom Bats captured per site.

Increased capture rates of Blossom Bats are likely to coincide with the arrival of bats into the study area estimated here to be about an hour after civil twilight. This suggests two important components associated with the present study. Firstly, that roosting sites may occur some distance from the study area and may be in the order of 1-3 km and secondly, it is important that future monitoring episodes incorporate this time period into their monitoring schedule.

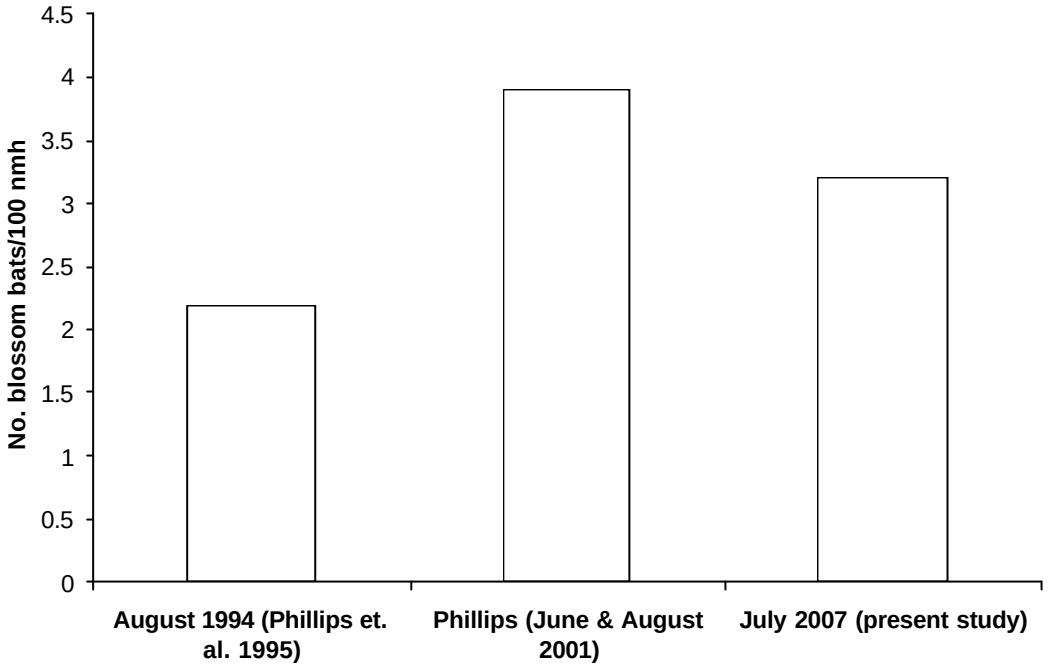


Figure 6: Comparison of Blossom Bat numbers from present and past surveys within the Blossom Bat Reserve, Koala Beach Estate

5.2 Blossom Bat density comparisons to other sites and regions

Richards (2005) provides the only other recent study in the Tweed Shire which looks at relative densities of Blossom Bats in relation to foraging resources. Richards (2005), who investigated Blossom Bat usage of Coast Banksia compensation areas for the SALT development about 10 km's north of Koala Beach, captured 12 Blossom Bats from two separate sites during winter surveys in 2003, and 14 Blossom Bats from the same two sites in winter 2004. Interestingly, no Blossom Bats were captured at their monitoring sites in 2005; the latter result attributed to competition with Black Flying-foxes (*P. alecto*) during sampling (Richards 2005).

There was insufficient detail provided in Richards (2005) to calculate catch per unit effort. However, based on their effective net area of 2 ha, highest densities of captured bats was 5 bats per hectare at one of their sites in 2004. If considering that the array of nets set within the present study was effectively sampling bats from the entire Coast Banksia patch at the Koala Beach Reserve habitat (i.e. an effective net area of 1.2 ha), then the present study captured 15.8 bats per hectare. Mark recapture analysis puts this figure at between 12.14 and 15.02 bats per hectare. This is significant as Law (1994) who investigated Blossom Bat abundance and food sources at nine Coast Banksia dominated sites from Taree north to the Qld/NSW border, recorded similarly high capture densities at only one site (17.5 bats per hectare) with the remaining eight sites recording 10.5 or less Blossom Bats per hectare. In

the context of these other studies across the region (and not accounting for temporal variations in the respective studies), the densities of bats captured at the koala beach Blossom Bat Reserve is comparatively high, and has remained high since at least 2001.

5.3 Food resource availability and site carrying capacity

During the past Blossom Bat monitoring events at Koala Beach, no data has been presented on the availability of inflorescences at the time of sampling except to say that sampling was undertaken during 'peak' flowering. This study attempted to establish baseline data to better understand relationships with Blossom Bat densities and food resources at the time of sampling.

The abundance of productive inflorescences was estimated at 9555 inflorescences per hectare which clearly suggests the Koala Beach Blossom Bat Reserve is a 'high-food' site (after Law 1996). Other 'high food' Coast Banksia sites investigated in northern NSW averaged between about 6500 to 10000 productive inflorescences per hectare during peak winter flowering periods (Law, 1996).

Richards (2005) investigated potential Blossom Bat carrying capacity per hectare at SALT based on relationships between Blossom Bat energy requirements (in KJ/hectare) and inflorescences per hectare. At their sites, inflorescences per hectare varied between 3000 and about 6000 per hectare over three consecutive years. Potential Blossom Bat carrying capacity at their sites ranged between about 26 and 41 bats per hectare (Richards 2005).

Similar carrying capacity calculations undertaken for the Koala Beach Blossom Bat Reserve suggests about 65 bats per hectare. However, factors such as competition effects among Blossom Bats, and with other nectarivores, would likely reduce this estimate significantly. For example, numerous nectivorous birds (i.e. Little Wattlebird, White-checked Honeyeater), the Sugar Glider (*Petaurus brevipes*) and the Grey-headed Flying-fox were recorded during the sampling period.

5.4 Roosting potential within and adjacent Koala Beach Estate

The only information on roosting habitats for Blossom Bats at Koala Beach comes from studies by Phillips during the initial fauna surveys for the Fauna Impact Statement (Phillips et al., 1995). During that study they radio tracked four individuals (3 males and 1 female) to three separate roosts; a *Syzygium oleosum* in swamp oak about 300 m south-east of the Blossom Bat Reserve, a banana plantation and adjacent wet sclerophyll/rainforest vegetation about 2.5 km to the north west of the site, and wet sclerophyll/rainforest vegetation about 5.5 km south south-west from the site. The latter of these roosts is well beyond the foraging ranges for Blossom Bats reported in other studies in

northern NSW (e.g. Law 1993 and Richards 2003) although Law (1993) notes that commuting distances are likely to be more extensive where feeding and roosting habitats are separated by a greater distances.

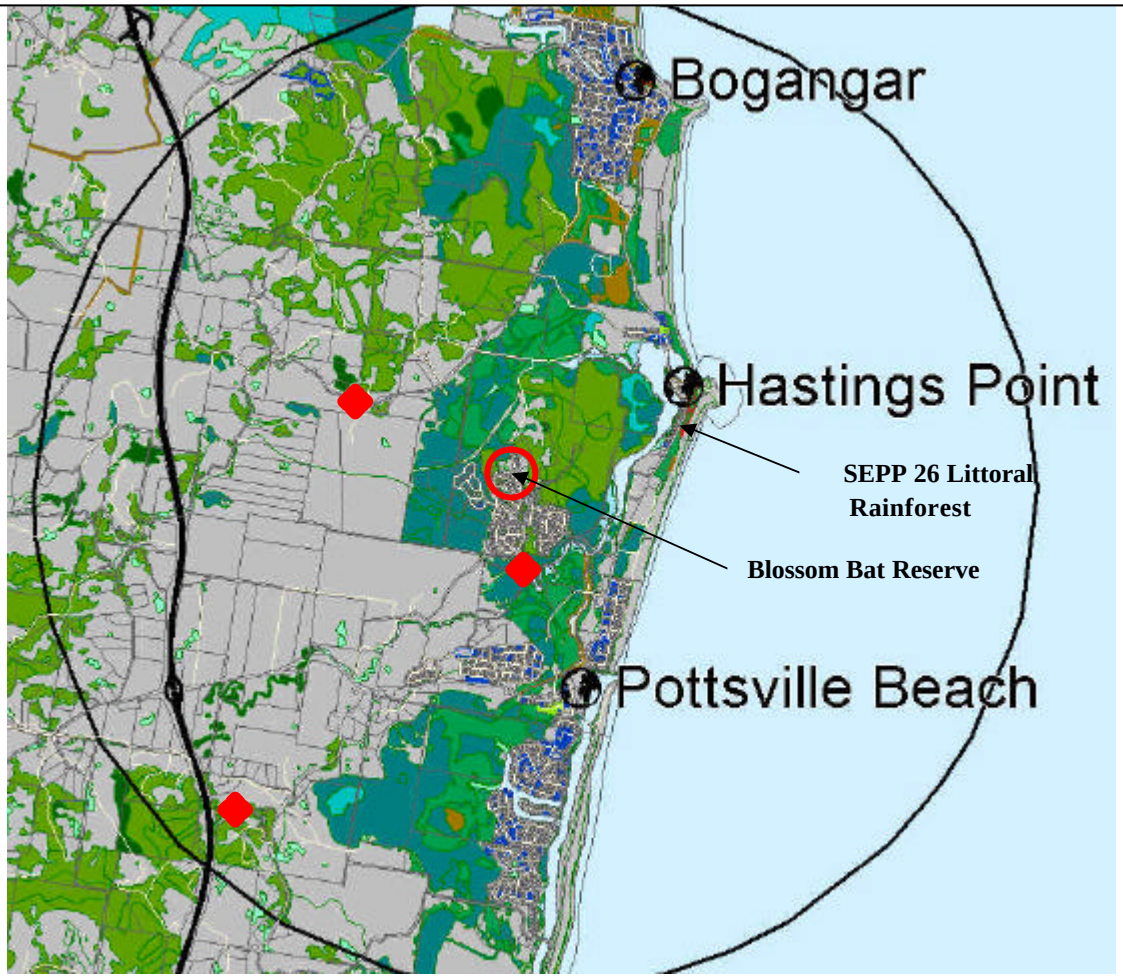
Law (1993), who investigated roosting habitat for Blossom Bats from two sites in northern NSW, found that roosts were almost entirely from littoral rainforest habitats. Where a roost was found in other habitats (e.g. Melaleuca swamps and Banksia littoral zones), Blossom Bats were always within rainforest trees (Law 1993). The closest mapped littoral rainforest to the Reserve is about 650 m to the north east at Hastings Point. Beyond this, the nearest patches are about 5 km at Cudgen Nature Reserve, and about 5 km to the south towards Wooyung (refer Figure 7). Mapped polygons of rainforest/riparian forests are similarly limited in the area (refer Figure 8).

Based on distances to roosts recorded by Phillips et al. (1995), it was highlighted in the BBPoM that the substantial commuting distances recorded for these bats indicate that the Blossom Bat Reserve is likely to represent a locally and regionally significant food resource for the species (Markus and Coburn 2000). Phillips et al (1995) also suggested that, based on the results obtained from the fauna survey, coupled with the limited perspective on roosting and foraging activity obtained from radio tracking, the Koala Beach site, while providing temporary roosting sites at specific times through the year, does not support a resident population of Blossom Bats. This assumption is partly supported based on capture times of Blossom Bats in the present study with the earliest capture occurring about 45 minutes after civil twilight. That is, no foraging activity was recorded directly after dusk suggesting bats were not roosting at or close to the site but rather commuting to the site to forage. Nonetheless, retained vegetation within the broader area is considered to have changed since the time of the initial surveys in 1994 through removal of cattle grazing, an absence of fire, ongoing weed management and supplementary planting. This in turn has influenced vegetation structure and composition and ultimately, the potential for transition from drier forest to moist forest. Further radio-tracking proposed within the BBPoM may confirm whether parts of Koala Beach are supporting a resident population of the Blossom Bat.

Note: Littoral rainforest patches shown in red hatching
(Source: Tweed Shire Council)

Scale 1:100,000

Figure 7: Littoral Rainforest mapping



Approximate location of Blossom Bat roosts recorded by Phillips et al (1995).

Vegetation community codes

- Vegetation
  - Estuarine Complexes
  - Foredune Complex
  - Heathlands
  - Highly Modified / Disturbed
  - Melaleuca and Swamp She-oak Forests
  - Miscellaneous Map Units
  - Rainforest and Riparian Communities
  - Sclerophyll Forests / Woodlands on Sand Substrates and Alluvium
  - Sclerophyll Open Forests on Bedrock Substrates
  - Sedgelands and Related Communities

Figure 8: Vegetation community mapping within a 5km boundary of the Blossom Bat Reserve, Koala Beach Estate

5.5 Banksia age class and habitat management

A review of aerial photography dating back to 1944 found that the Blossom Bat Reserve was totally cleared from at least this time through to about 1993 when only scattered trees were present (refer Appendix 2). Subsequently, the vegetation community at the site is considered to be about 14 years old. During this 14 year time period, Coast Banksia has become dominant in the canopy.

An assessment of the age class of Coast Banksia within the Reserve area found a lack of recruitment of juvenile trees. Seventy five percent of trees counted were considered to be in the mature age (i.e. >3 metres tall). Away from plots, very few juvenile plants were observed suggesting that the random plot design to assess Coast Banksia age class (and food resources) was reliably sampling the heterogeneity of the Coast Banksia habitat at the site. In a review of threats on Blossom Bats and habitats, it has been suggested that many areas of *Banksia integrifolia* healthland are in senescence due to germination and recruitment suppression by weed infestations (Dodkin and Gilmore 1985, Law 1992; cited in AKF 1995). Although senescing and dead Coast Banksia trees was not considered a significant feature of the site, infestations of exotic pasture grasses such as *Setaria sphacelata* was particularly evident within the understorey and cleared edges throughout most of the Reserve (refer Plate 3).

Plate 3: Colonisation by exotic grasses (*Setaria sphacelata*) along cleared edges within the Blossom Bat Reserve

The removal of cattle in conjunction with the absence of fire may be limiting the recruitment of Coast Banksia seedlings into immature and mature age classes. Unlike most Banksia species, Coast Banksia does not require fire to trigger the release of seed. Rather seed is released spontaneously on reaching maturity in late summer. The species' non reliance on fire for seed dispersal suggests that the exclusion of fire would not affect plant populations, but a number of studies have found the opposite to be true (Bennett and Attiwill, 1996; Price and Morgan, 2003). For example, in areas where fire had been excluded for many years, populations have declined substantially (Price and Morgan 2003). Causal factors included high seedling mortality rates due to grazing by herbivores and intense competition for soil moisture during summer (Price and Morgan 2003), and the absence of fire creating unsuitable soil conditions (Bennett and Attiwill, 1996). In a review of threats on Blossom Bats and habitats, it has been suggested that many areas of *Banksia integrifolia* healthland are in senescence due to germination and recruitment suppression by weed infestations (Dodkin and Gilmore, 1985, Law 1992; cited in AKF 1995). Exotic pasture grasses such as *Setaria sphacelata* is a feature of the site (refer Plate 3) and in addition to potentially impacting on recruitment, is contributing to fire fuel loads at the site.

Herbivory by the Swamp Wallaby (*Wallabia bicolor*) is suggested as another compounding affect on Coast Banksia recruitment at the site. Indeed, during all visits to the site, Swamp Wallaby was observed sheltering in rank grasses. Any proposal to encourage seedling development, either through assisted natural generation or supplementary planting, would need to consider physical protection of seedlings.

Fire management to both limit fuel loads and generate appropriate requirements for Coast Banksia recruitment may be an appropriate and viable management option for the site. Optimum fire frequency proposed for heathlands and coastal sclerophyll forest can range between about 8 to 15 years although variably, management of coastal heath generally adopts a fire frequency of about 8-12 years (Watson 2006). The aim of a burn at the site would be to provide a cool patchy spring burn to remove the exotic weed cover and fine litter layer thereby providing suitable soil conditions and open cover for seedling growth. Timing of a burn would need to consider the importance of the foraging resource for Blossom Bats and be implemented prior to summer seed setting of Coast Banksia at the site.

When considering fire as an ecological management tool, it is important to consider other species which may be impacted. One such species, the Coastal Planigale (*Planigale maculate),* is a threatened species in NSW and known from dense blady grass habitats in fringing forests at Koala Beach. Past surveys at Koala Beach suggest that Planigale prefer low lying sections of the site, together with forested lower slopes and fringing grasslands (AKF 2004). A review of capture locations within Callaghan et al. (2005) did not reveal any records for Coastal Planigale at the Blossom Bat Reserve.

5.6 Common Blossom Bat Plan of Management - review of performance indicators and monitoring methodology

The main objective of the management of the Blossom Bat at Koala Beach Estate is to facilitate the continued use of the site by the species for the purposes of both roosting and foraging. To facilitate this, the BBPoM proposed three key objectives:

1. To maintain and enhance the available resources for this species within and outside the identified significant habitat (i.e. the Blossom Bat Reserve) to ensure that the regional importance of the site as a food resource is not lost as a result of development.

2. To monitor the Blossom Bat population on the Koala Beach site at intervals throughout the development period to assess whether the primary objective, i.e. that the site continues to be used by this species, has been achieved.

3. To collect baseline information about the Blossom Bat population using the Koala Beach site, i.e. approximate numbers, sex ratios, demographics, distribution of roost sites etc. for future comparative purposes.

Management measures proposed within the BBPoM included weed management to limit degradation and habitat quality, community involvement and education, fire management (to reduce fire hazard impacting on Banksia recruitment), and site enhancement strategies such as supplementary planting and restricted access. In addition, the BBPoM proposes that management objectives also be undertaken externally to the Reserve through enhancement plantings around the estate, monitoring of large isolated Coast Banksia trees for Blossom Bat activity, and actively managing other potential roosting areas on the site.

Performance indicators were established to gauge the success of the BBPoM through establishing whether the Blossom Bats are continuing to use the site and the likely size of the population utilising the site from year to year. These measures are as follows (Coburn and Markus 2000):

- Successful maintenance and regeneration of Coast Banksia stands within and beyond the area of significant habitat;
- Maintenance of the area of significant habitat in its current undeveloped state; and
- Comparison of the number of captures of Blossom Bats per metre/hour between years.

5.6.1 Response to performance indicators

In response to the performance indicators within the BBPoM, the 2007 monitoring event found that:

- Assisted regeneration of the Reserve through weed management has been successful in maintaining the site as a high food or critical winter foraging resource for Blossom Bats in the area.

- Fencing of the site boundary to the south and a locked access gate across the track leading up to the site has deterred vehicle access to the site and resultant vegetation disturbance.

- The absence of fire and grazing and the resultant colonisation of invasive exotic grasses may, in the longer term, have a profound effect on the recruitment of Coast Banksia at the site.

- Comparison of baseline (1994) and monitoring data (2001 and 2007) suggests that the Reserve continues to be a critical winter food resource for Blossom Bats and that the site continues to be locally and regionally significant for Blossom Bats.

- Construction activities have not impacted significantly on the site as a foraging resource for Blossom Bats as revealed from current monitoring results compared to the original baseline information for the site (note: housing construction for Stage 5 is still only in the very early stages).

- Blossom Bats are known to display high site fidelity at certain sites and that this strong site attachment would increase the vulnerability of this species to the effects of disturbance (Law 1996). Fire hazard management is now seen as an important management measure due to the increasing fuel loads associated with exotic weed growth.

- Little information still remains about roost site usage within the estate and whether Koala Beach supports a resident population of Blossom Bats.

5.6.2 Comments on the Blossom Bat monitoring methodology

The BBPoM prepared by Coburn and Markus (2000) and revised by AKF (2004a) outlined a marking and monitoring methodology to assess the continuing presence of Blossom Bats at the site (refer Appendix 3). Comments on aspects of the methodology are provided as essentially, the present study is the first attempt to follow the approved methods. Comments are provided on two aspects of the monitoring methods:

1. A minimum effort of 1000 metre / hours over a minimum of three nights will be employed during each sampling period.

Comment: We found during this monitoring event that a minimum effort of 1000 mist-net metre hours was unachievable in three days of monitoring. This was primarily due to the density of flying-foxes foraging at the site

affecting the amount of nets that could be ethically operated. To increase effort, you would either need to increase the number of experienced zoologists and/or increase the number of trapping nights. Either option would also increase the costs of the program.

The BBPoM notes that the minimum trapping effort requirement is the approximate effort required to capture 10 individuals, as calculated from the results of the FIS (Coburn and Markus 2000). This study found that indeed, much less effort is required to capture 10 individuals and subsequently, a minimum of 500 mist-net metre hours over three nights is a more realistic approach to sampling Blossom Bats at the site during any future monitoring events.

2. Sampling should occur annually for at least three years. The first two samples should focus on the significant habitat site to identify and mark the maximum number of individuals likely to be using the site in any one season. Subsequent samples should also target other parts of the Koala Beach site and adjacent areas in order to establish the location of alternative foraging sites

Comment: The only monitoring of Blossom Bats at the Reserve prior to the present study was by Phillips during 2001 (AKF 2001) although effort was less than the present study and that proposed in the BBPoM. The frequency of sampling should reflect the ongoing development associated with the surrounding stages and also any changes to the Blossom Bat Reserve in regards to habitat management. As such, monitoring would more likely need to occur every 3 or 4 years rather than annually. In contrast, monitoring every 6 or so years, which has been the case to date, is considered too coarse a time frame to notice any fluctuation in site usage and/or population size.

Monitoring away from the Reserve area of large isolated Coast Banksia trees was not undertaken during the present study due primarily to the added costs, as these surveys would need to be undertaken on separate nights. Nonetheless, monitoring of isolated trees, where conditions were appropriate (i.e. out of the public view, away from busy roads etc), is supported and would provide valuable information on whether Blossom Bats are foraging on isolated trees or in remnants only, and foraging generally through the urban environment.

6.0 Recommendations

The following recommendations are proposed to achieve the stated aim of the BBPoM which is to *facilitate the continued use of the site by the Blossom Bat for the purposes of both roosting and foraging*. Recommendations are explained as follows:

Blossom Bat monitoring recommendations

- Monitoring for Blossom Bats within the Reserve habitat should continue ever 3-4 years with the frequency revised after each monitoring event. This level of Blossom Bat monitoring is proposed to assess the effectiveness of habitat management measures to be implemented at the site (discussed below) and considering that only limited housing development has occurred adjacent to the site (especially in Stage 5).

- Monitoring of the Blossom Bat resource including age-class assessment and abundance of inflorescences should be undertaken annually to provide a measure of habitat management success and resource availability for Blossom Bats at the Reserve.

- The identification and subsequent development of a proposal to monitor a selection of isolated Coast Banksia trees should be investigated in earnest and provided to the Koala Beach Wildlife and Habitat Management Committee for consideration if feasible.

- Consideration should be given to implementing a radio tracking study in conjunction with a Blossom Bat monitoring event to better understand whether a resident population of Blossom Bats occurs within the estate. Only limited information exists on the roosting habits of Blossom Bats in and around Koala Beach (Phillips et al., 1995). Radio tracking could be undertaken as part of University program to help limit the costs of such as program.

Habitat management recommendations

- Disturbance trials (including a burn option) should be undertaken at the Reserve to determine the suitable methods to encourage Coast Banksia seedling growth. Detailed vegetation structure and composition, and soil surface conditions should be recorded prior to any trials and utilise the established monitoring plots. Timing of a prescribed burn, should this be incorporated into trials, should coincide with the decline in Coast Banksia food resource and prior to trees setting seed (e.g. late September – early October). A proposal should be developed and presented to the Koala Beach Wildlife and Habitat Management Committee prior to implementation.

- Slashing of two existing tracks within the Reserve should be implemented as a matter of urgency at the site. These existing tracks

are becoming overgrown with Setaria grass and would provide at least some fire protection for the site.

- Weed management has been particularly successful throughout much of the site in controlling woody herbaceous weeds. Ongoing weed management is encouraged at the site as a key habitat management measure.

- Supplementary planting adjacent the site, and throughout the broader area, be facilitated though protection and translocation of seedlings growing adjacent to the Reserve area. A number of small seedlings were observed growing in slashed asset protection zones APZ's) on the western side of the Reserve. These seedlings should be protected with temporary bollards and used as a source of retained trees within the APZ or translocated if possible to other areas. The location of retained trees in the APZ would need to consider APZ requirements such as crown separation distances, and provision of adequate access and turnarounds areas for fire fighting vehicles and equipment

References

AKF (1995). Fauna Impact Statement for the proposed Searanch residential development. Report prepared for RDC Pty Ltd by the Australian Koala Foundation, January 1995.

AKF (2004a). Revised Blossom Bat Plan of Management, In Koala Beach

AKF (2004b). Koala Beach, Koala Plan of Management, Report prepared for the Ray Group Pty. Ltd., February 2004.

Bennett, L.T. and P.M. Attiwill (1996). The Nutritional and Status of Healthy and Declining stands of Banksia integrifolia on the Yanakie Isthmus, Victoria. Australian journal of Botany 45: 15-30.

Callaghan, J., Fitzgerald, M., Lloyd, G., Rhodes, J., de Jong, C. and James, R. (2005). Koala Beach Estate Common Planigale Plan of Management; report prepared on behalf of the Australian Koala Foundation for the Ray Group Pty Ltd, January 2005.

Coburn and Markus, (2004). Plan of Management for the Queensland Blossom Bat *Syconycteris australis* on the Koala Beach Residential Estate; prepared in accordance with conditions relating to the NSW National Parks and Wildlife Service License No. TS0092 on behalf of the Australian Koala Foundation,

Department of Environment and Climate Change (2005). Common Blossom Bat *Syconycteris australis*, Species Profile. Department of Environment and Climate Change Threatened Species Website.

Donnelly, M.A. and Guyer, C. (1994). Estimating Population Size. Pp 183-205 in Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Ed by W. R. Heyer, M.A. Donnelly, R.W. McDiarmid, L-A.C. Hayek and M.S. Foster. Smithsonian Institution Press, Washington.

Fitzgerald, M., (2005). Glossy Black-cockatoo *Calyptorhynchus lathami* Koala Beach Monitoring Report, December 2005. Report prepared for the Australian Koala Foundation.

Law, B.S. (1993). Roosting and foraging ecology of the Queensland Blossom Bat (*Syconycteris australis*) in north-eastern New South Wales: Flexibility in response to seasonal variation. Wildlife Research, 20: 419-431

Law, B.S. (1994). Banksia nectar and pollen: Dietary items affecting the abundance of the Queensland Blossom Bat *Syconycteris australis* in southern Australia. Australian Journal of Ecology, 19:425-434

Law B.S (1996). Residency and site fidelity of marked populations of the common blossom bat *Syconycteris australis* in relation to the availability of Banksia inflorescences in New South Wales, Australia. Oikos, 77: 447-458

Morand, D.T. (1996) Soil Landscapes of the Murwillumbah – Tweed Heads, 1:100 000 Sheet. Department of Land and Water Conservation.

Phillips, S. 2004. Koala Beach Stage 1 Initial Koala Monitoring Program Results for Koala Beach Community Koala Management Committee; *in* AKF 2004, Eight Part Tests for Significance, Sports Fields and Access Road, Koala Beach Estate, Pottsville

Phillips, A. Parnaby, H, and Fitzgerald, M. (1995). Fauna survey of lands associated with the proposed Searanch residential development, Tweed Shire, New South Wales. Consultants report to RDC Pty. Ltd.

Price, J.N. and J.W. Morgan (2003). Mechanisms controlling establishment of the non-bradysporous Banksia integrifolia (Coast Banksia) in an unburnt coastal woodland. Austral Ecology 28: 82-92.

Richards, G.C. (1983). The Queensland Blossom Bat, In The Complete Book of Australian Mammals. Ed R. Strahan. Angus and Robertson: Sydney.

Seber, G.A.F. (1970). The effects of trap response on tag-recapture estimates. Biometrics, 26:13-22.

Seber, G.A.F. (1982). The Estimation Of Animal Abundance and Related Parameters. 2nd Edition Macmillian, New York.

Watson, P. (2006). Fire Frequency Guidelines and the Vegetation of the Northern Rivers Region, Draft 2. Report prepared for the Hotspots Fire Project.

Appendix 1: Photo reference sheet

Transect Number: 1
Plot Distance: 7 m
Plot Number: 1
GPS Reference: Z56, E554988, N6861644

Transect Number: 2
Plot Distance: 36 m
Plot Number: 2
GPS Reference: Z56, E554994, N6861676

Transect Number: 2
Plot Distance: 4 m
Plot Number: 1
GPS Reference: Z56, E554964, N6861635

Transect Number: 2
Plot Distance: 18 m
Plot Number: 2
GPS Reference: Z56, E554967, N6861644

Transect Number: 3
Plot Distance: 36 m
Plot Number: 1
GPS Reference: Z56, E554943, N6861644

Transect Number: 3
Plot Distance: 63 m
Plot Number: 2
GPS Reference: Z56, E554948, N6861672

Transect Number: 4
Plot Distance: 4 m
Plot Number: 1
GPS Reference: Z56, E554912, N6861615

Transect Number: 4
Plot Distance: 24 m
Plot Number: 2
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Plot Number: 1
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Plot Number: 2
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Transect Number: 6
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Plot Distance: 30 m
Plot Number: 1
GPS Reference: Z56, E554863, N6861578

Transect Number: 7
Plot Distance: 72 m
Plot Number: 2
GPS Reference: Z56, E554870, N6861622

Transect Number: 7
Plot Distance: 107 m
Plot Number: 3
GPS Reference: Z56, E554879, N6861654

Notes:

Angle of photo: Horizontal plane at 45^0 compass bearing
Camera height: Camera placed on top of star picket
Camera setting: wide angle

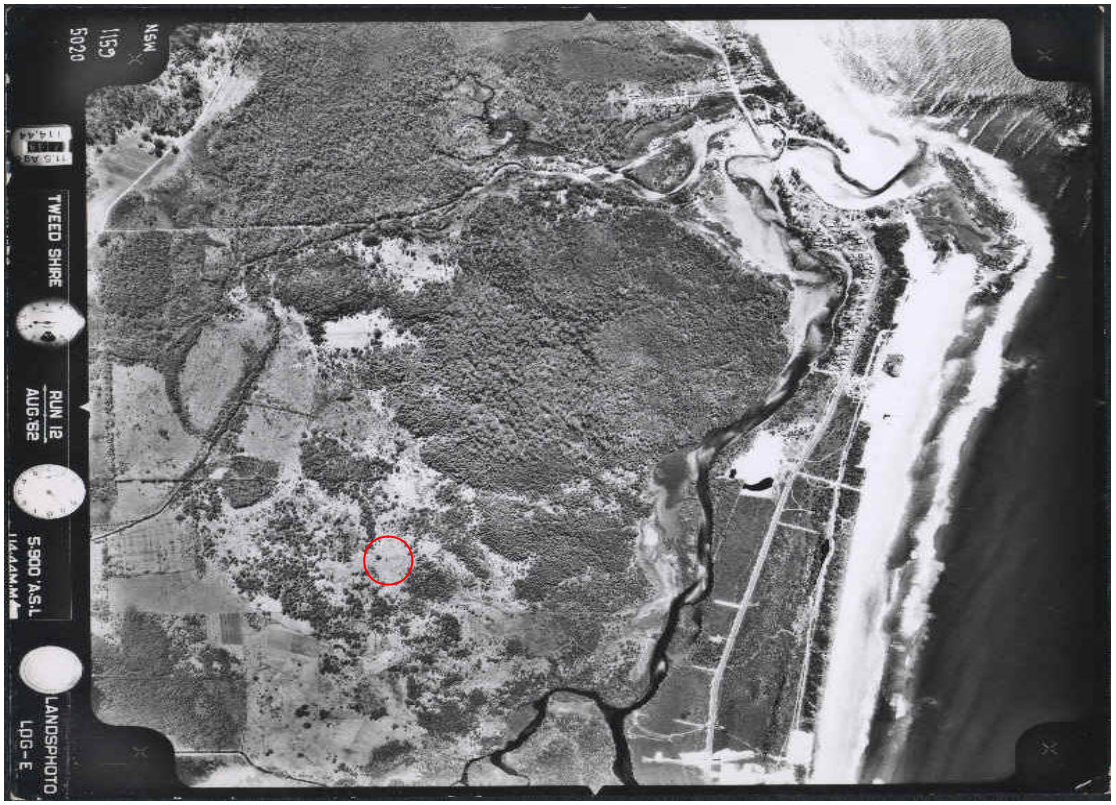
Source: David Hannah

Appendix 2: Comparison of historical aerial photography

Aerial photography dated 1944 - Blossom Bat Reserve is circled

Close up view of 1944 aerial photography

Aerial photography dated 1962 - Blossom Bat Reserve is circled



Close up view of 1962 aerial photography

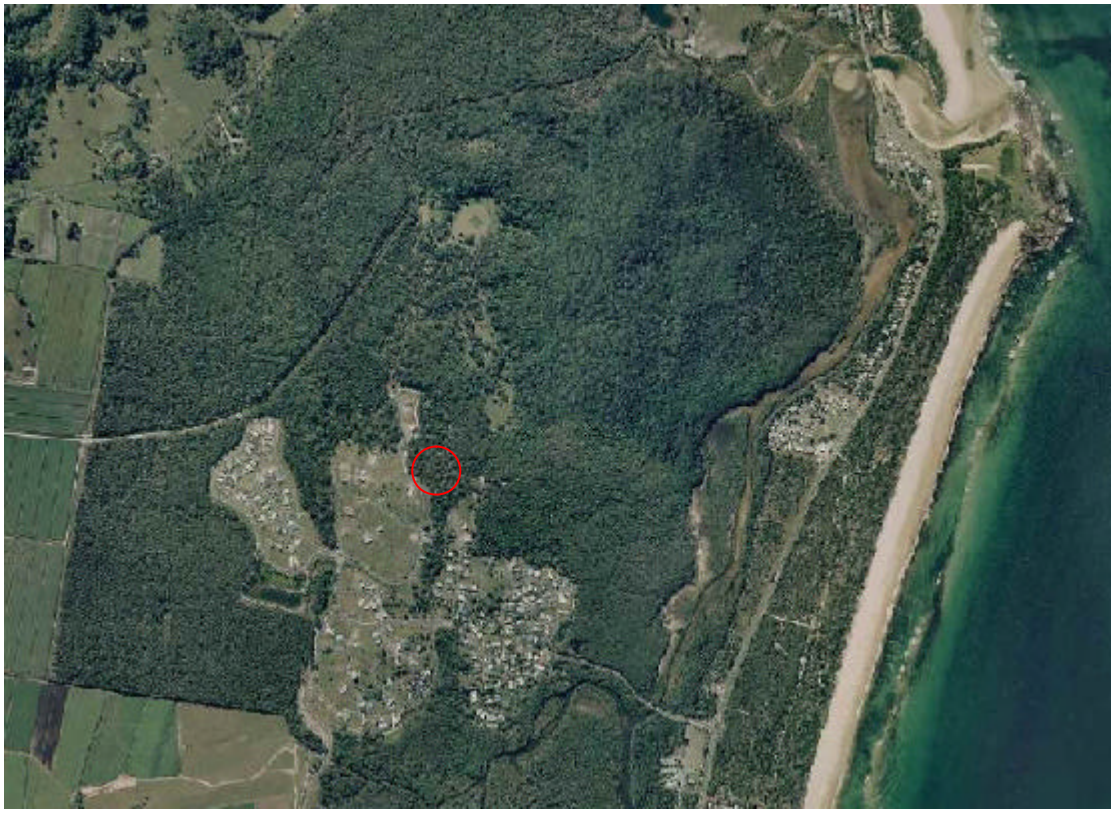
Aerial photography dated 1993 - Blossom Bat Reserve is circled

Close up view of 1993 aerial photography

Aerial photography dated 1996 - Blossom Bat Reserve is circled

Close up view of 1996 aerial photography

Aerial photography dated 2007 - Blossom Bat Reserve is circled



Close up view of 1996 aerial photography

Appendix 3: Blossom Bat monitoring methodology outlined within the Blossom Bat Plan of Management

Monitoring is to be undertaken in accordance with the current adopted Blossom Bat Plan of Management and is described as follows:

1 (a) Monitor use of the reserved Blossom Bat habitat area and additional Coast Banksia (*Banksia integrifolia*) habitat over one survey period between July and September. The timing of monitoring should coincide as far as possible with peak flowering of Coast Banksia on the site.

1(b) Monitoring includes mist-netting for Blossom Bats in the Blossom Bat habitat area and should comprise a minimum of 1000 net metre/hours over 3 consecutive nights.

1(c) Record the sex, weight, reproductive status, any signs of illness or injury, and forearm length for each captured individual.

1(d) Temporarily mark captured individuals by application of nail polish or similar non-harmful marking to the claws on the feet of individual bats to identify return visits.

1(e) It is recommended in the Plan of Management that existing large Coast Banksias within the residential development at the Koala Beach Estate which may also serve as food resources for the Blossom Bat be the subject of monitoring. Identification of suitable trees and co-operation of landholders should be investigated in the first round of monitoring.

2. Assess the condition of the Blossom Bat habitat area and provide information including but not restricted to: general tree health and any tree death; recruitment of Coast Banksia (*Banksia integrifolia*); and disturbance (e.g. tree removal, branch lopping, dumping of garden wastes, fire, and weed development). Report on condition of plantings, if any.

3. Provide a report of monitoring results and recommend revision to the Blossom Bat Plan of Management if deemed necessary.

3(a) The report should be provided on disk as a Word document, and as a printed hard copy.

3(b) Copies of the report are to be provided to:
Koala Beach Wildlife and Habitat Management Committee;
Department of Environment and Conservation (Threatened Species Unit in Coffs Harbour).