TWEED SHIRE COUNCIL

Common Planigale *(Planigale maculata)* monitoring at Koala Beach Estate from 2005 to 2015

November 2016

TWEED SHIRE COUNCIL | TOGETHER FORWARD

Revision History

Rev. No.	Date	Comments	Prepared by	Reviewed by	Approved by
1	15/11/2016	Draft for review	David Hannah & Greg Lollback	Marama Hopkins	Marama Hopkins

Acknowledgements

Thanks to Marama Hopkins for input into the project and comments on a draft version of the report. Thanks also to the many Council staff that helped in the field during surveys. All surveys (except for 2005) were conducted under the Principal Investigator's NSW NPWS Scientific License Number S12045 and the Director General's NSW DPI Ethics Approval. The initial 2005 monitoring survey was conducted on behalf of the Ray Group Pty Ltd under a separate authority.

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EXECUTIVE SUMMARY

Planigale records at Koala Beach go back to 1981. Development of Koala Beach Estate (KBE) started in 1996, with the commencement of subdivision works. In 2005, the Planigale Plan of Management (PPoM) was written: a period when staged development at KBE was continuing. The PPoM suggested that Planigale (*Planigale maculata*) numbers should be monitored from 2005 for at least 10 years. Hence, the Tweed Shire Council sampled for Planigales at KBE from 2007 to 2015. Twelve different pitfall sites were used during this period to monitor Planigales in Spring. The numbers of Planigales caught over the period varied from 1-12 individuals per session. Occupancy analysis showed that the proportion of sites occupied varied from ~0.1 – 0.7 and the probability of capturing a Planigale that was on the site varied from ~0.2-0.4. The fluctuating site occupancy and detectability of the species was probably not due to short-term climatic conditions, but was most likely due to the species behaviour, reproductive potential and realised reproductive rates associated with environmental conditions. Consequently, developing a monitoring program to detect a decline in population numbers would be difficult and would need many pitfall sites. It is recommended that monitoring of Planigales at KBE be scaled back to 5-yearly or occur in a more intensive manner when different management practices that potentially influence Planigales are introduced.

The results of the monitoring program suggest that while Planigale numbers likely fluctuate, the population at KBE is sustainable. Indeed, capture rates during the study are higher than any other study in literature that documented Common Planigale captures using pitfall traps. If current management practices continue, it is likely that the Common Planigale will continue to exist at sustainable population levels.

1.0 INTRODUCTION

1.1 Background to the study

Monitoring surveys for the Common or Coastal Planigale (*Planigale maculata)* at the Koala Beach Estate (KBE) commenced in 2005 following the preparation of the Planigale Plan of Management (PPoM) (Callaghan *et al.* 2005). The PPoM outlined management actions including an ongoing monitoring program with the stated objective being to maintain and monitor the status of the Planigale population within the KBE over the next 10 years and beyond (Callaghan *et al.* 2005). Consequently, ten monitoring stations were established in spring 2005 targeting known and representative habitats adjacent to development at Koala Beach. Since 2005, there has been an additional five monitoring events; the last being Spring 2015.

1.2 General ecology

The Common Planigale occurs in coastal and sub coastal Queensland from Cape York extending southward along the coastal fringe to near Newcastle (Redhead 1995; NPWS 2000; Menkhorst and Knight 2001). In northern NSW, it has been suggested that the distribution of the Planigale often corresponds with the low-lying flat and undulating areas of the coastal plains that often occur near intensively settled areas (Gilmore and Parnaby 1994).

The Common Planigale has a wide distribution (Figure 1) and occurs in a wide range of habitats (Australian Living Atlas; van Dyck and Strahan 2008). Preferred habitats range from rainforest, eucalypt forest, heathland, marshland, grassland and rocky areas (Van Dyck 1979; Andrew and Settle 1982; Menkhorst and Knight 2001). A common feature among habitat types includes a preference for dense ground covers, a close association with water, and areas of ecotonal forest (Denny 1982; NPWS 2000; Menkhorst and Knight 2001).

The Common Planigale is an unspecialised predator that forages mainly on insects, other invertebrates, small vertebrates, and occasionally nectar (Callaghan *et al.* 2005 and references therein). This species is generally most active from slightly before dusk to before sunrise, interspersed with rest periods and periods of high activity, and is capable of eating the equivalent of its own body weight in food daily (Van Dyck 1979). It has the ability to enter torpor in response to food deprivation (Van Dyck 1979) or cold weather (Morton and Lee 1978). Introduced predators of the Common Planigale include cats (Redhead 1995), dogs (Fleay 1981) and foxes (Glen *et al.* 2006). There is limited movement data available for Common Planigales although other members of this genus are widely recognised as having a shifting home range in response to local climatic conditions and food resources (Denny 1982; Read 1982; Read 1988; Miller 1998).

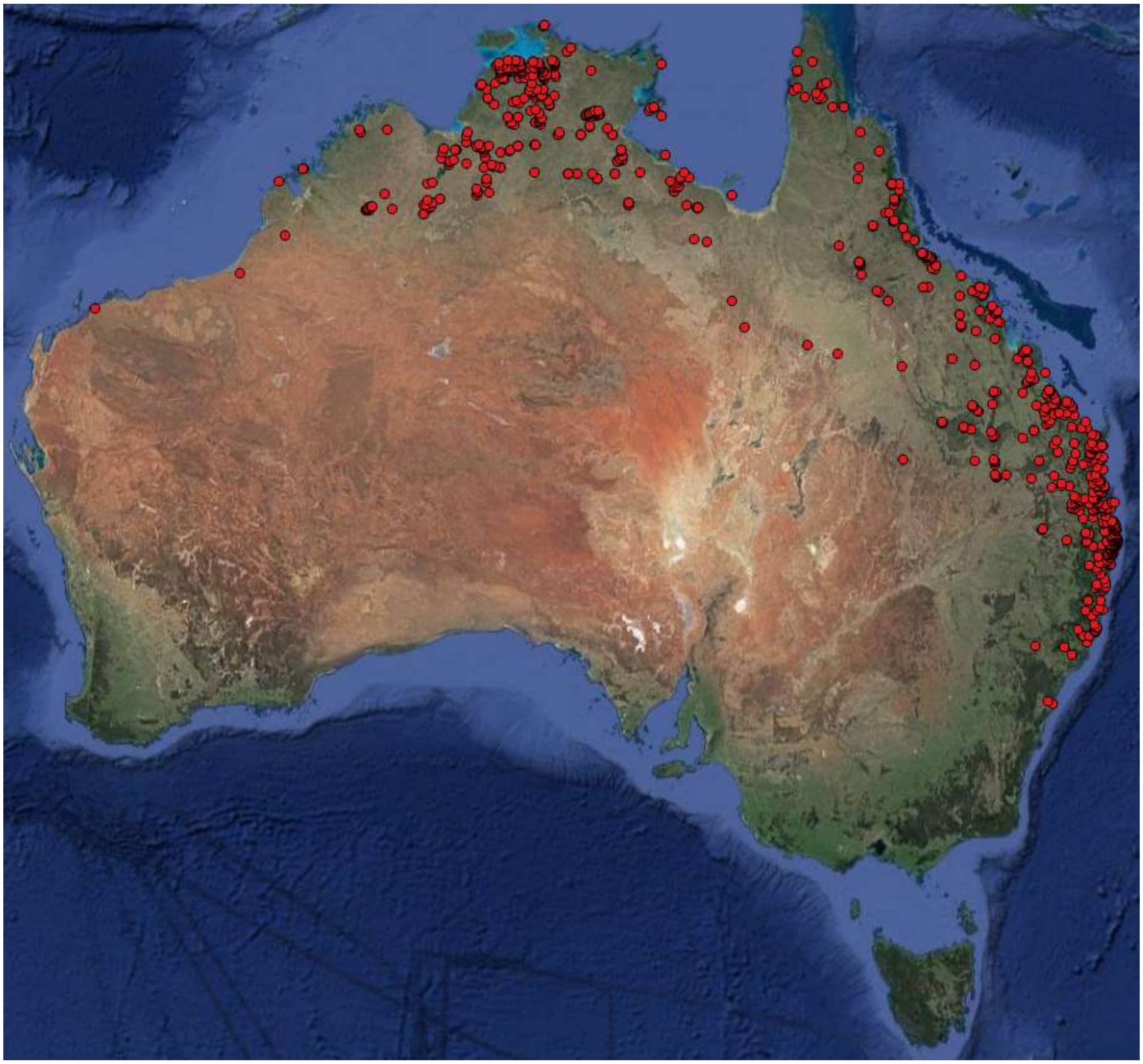

Figure 1. Atlas of Living Australia Common Planigale records (red circles), showing the species' broad distribution.

1.3 Current status

The Common Planigale is currently listed as 'Vulnerable' on Schedule 2 of the NSW *Threatened Species Conservation Act 1995*. This elevated conservation ranking is based on the following: "Population and distribution suspected to be reduced; poor recovery potential; threatening processes moderate; ecological specialist". Principally, these threats arise from land use practices which reduce the extent of understorey vegetation and fallen log cover, particularly those adjoining water (NPWS 1998).

The Common Planigale is not listed nationally under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999.

1.4 The Koala Beach Planigale Plan of Management

The Common Planigale was recorded during a number of surveys for the KBE both prior to and during various stages of the development. Survey results indicated that the local Planigale population is focused in fringing forest areas with dense grass cover or with tall, dense grass stands nearby (mostly dominated by introduced *Setaria sphacelata* which has not been grazed by cattle since 1994) (Callaghan *et al.* 2005).

The Common Planigale Plan of Management (PPoM) was developed in 2005 with the overall objective of maintaining and monitoring the status of the Planigale population within the KBE over the next 10 years and beyond. A number of management actions and associated performance criteria were developed (refer to Appendix 2). In response to the PPoM, surveys targeting Planigale have occurred within the KBE from 2007-2015. The PPoM performance measures were assessed following the 2012 monitoring event and corrective actions proposed where required. In summary, most performance measures were either being addressed or were ongoing with the exception of:

a. the frequency of monitoring – which was nominated as annual monitoring of 6 stations and
b. the installation and subsequent monitoring of 20 fixed monitoring shelters.

A total of 10 monitoring stations (pitfall trapping lines consisting of 5 pitfall traps intersected by drift fence and left open for 4 nights) were established in 2005 (Figure 2). These sites were again monitored in 2007 and then in 2012; two sites were dropped during the 2012 monitoring event due to issues with site access. The 2012 monitoring report recognised that the annual monitoring frequency was not being achieved stating that annual monitoring for Planigale was proposed within the PPoM to identify changes or trends in the distribution and status of the local population over time. However, the frequency of monitoring up until 2012 has not allowed for these trends to develop. It was subsequently recommended that to allow more confidence in discussing whether the distribution and status of the Planigale within the Estate has not changed significantly despite ongoing development in the area, monitoring of pitfall stations every year (or every two years) was proposed for at least three consecutive events. As a consequence, monitoring was undertaken annually with three subsequent monitoring events up until 2015.

It was also noted in the 2012 monitoring report that the installation of the 20 monitoring shelters was never implemented effectively. That is, most shelters could not be located and it was unclear whether they were placed and removed or the trial was never initiated.

1.6 Scope of this report

This report aims to summarise the results of Planigale monitoring to date including an assessment of monitoring results against Key Performance Indicators outlined within the PPoM and propose future directions for the management of Planigales at Koala Beach Estate.

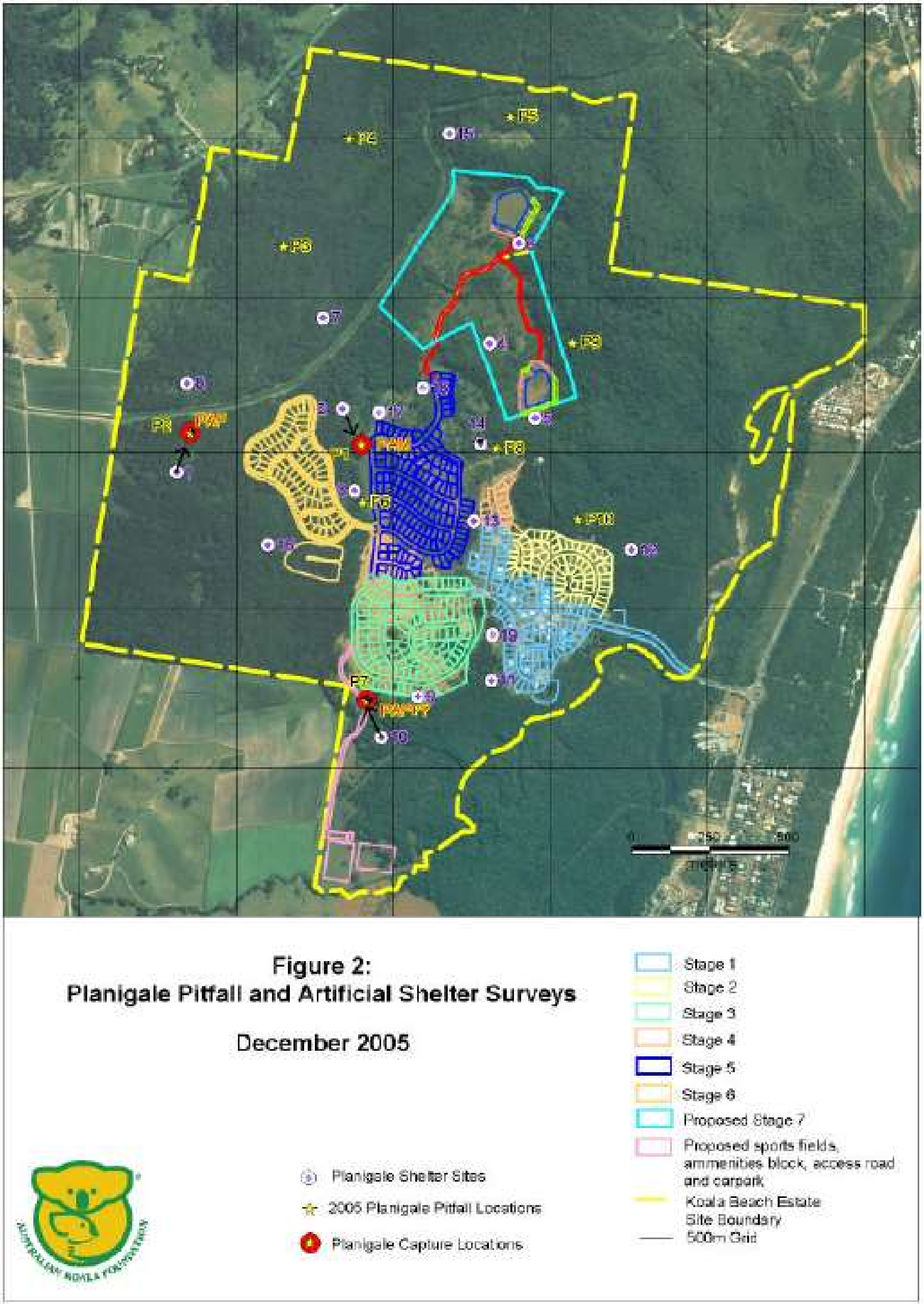

Figure 2: Koala Beach Subdivision Stages and Baseline Pitfall and Shelter Site locations (Source: Callaghan *et al.* 2005)

2.0 STUDY AREA

Monitoring of pitfall stations occurred within the KBE, a residential subdivision located on the Tweed Coast north of Pottsville in the Tweed Local Government Area (Figure 3). Ecological studies for the KBE were first commenced in 1994 prior to planning approval. The Estate now consists of six residential stages, all of which are complete, covering an area of approximately 64 ha, with about 300 ha set aside as environmental zoned land (Figure 2). A seventh stage consisting of a large lot subdivision is located to the north of Stage 5 and except for access road development, has not had any further infrastructure development.

The topography of the study area consists of a combination of undulating hills and alluvial plains, the latter of which are seasonally inundated. The area drains to Cudgera Creek or to constructed (cane) drains which in turn drain to Cudgera Creek. Geology is primarily metamorphics on hills supporting cleared and regenerating wet sclerophyll forests or Pleistocene sand sheets overlying peat and alluvium on plains dominated by swamp sclerophyll forests.

A review of historical aerial photography for the area suggests that land clearing for grazing had occurred, particularly within the areas currently developed for subdivision and low-lying areas to the west of the estate, prior to 1944 (the earliest photo accessible). Christies Creek had undergone some conversion to channel to the west of the subject site. By 1962, low-lying areas to the north and west of Stage 6 to the boundary of Christies Creek remained cleared; whilst the remaining low hills associated with other current stages of the subdivision also remained patchily cleared. By 1993, all areas associated with stages 1 to 7 of the KBE was generally cleared land for grazing whilst those areas norther and west of Stage 6 had regenerated. This regeneration was primarily *Casuarina glauca* with a grassy understorey dominated by Broad-leaved Paspalum and Setaria spp. Subdivision works for Stages 1 and 2 had commenced by 1996.

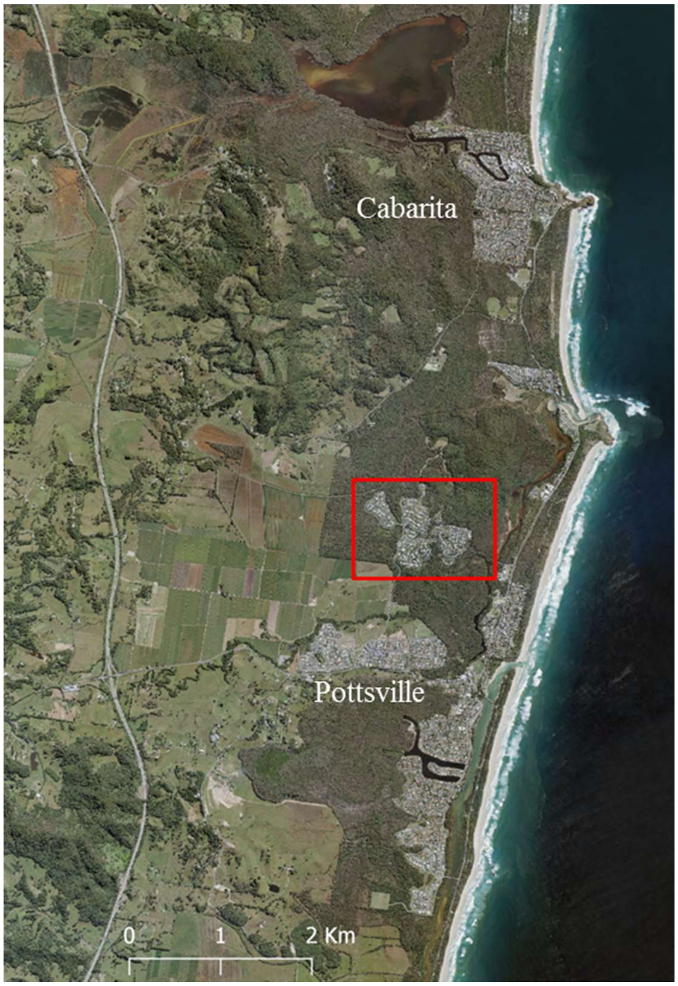

Figure 3. The locality of the Koala Beach Estate within the Tweed Shire. The estate is shown within the red box.

3.0 METHODS

3.1 Survey Design

The Planigale pitfall monitoring sites were first established by others in 2005. At that time, ten pitfall trapping stations were established. Limited information could be obtained regarding the Planigale monitoring in 2005 other than the surveys were undertaken during a period of heavy rainfall in Spring 2005 and that no Planigales were captured (pers. comm. R. James, 2007).

The ten survey sites were monitored again in 2007 and in 2012. Two of the original survey sites were excluded during the 2012 survey due to access constraints (refer to the 2012 monitoring survey report for further discussion). Two new sites were included in the 2013 monitoring survey; a site within Stage 7 and a site at Lower Greg Gum Gully. Both sites aimed to sample fringing habitat to development; Lower Grey Gum Gully has also been subject to assisted bush regeneration activities. These new sites in addition to the existing 8 original sites were surveyed annually from 2013 to 2015 resulting in a total of 6 monitoring events between 2005 and 2015 (Table 1). Site locations are shown in Figure 4.

Habitat data was initially collected for sites in 2007 and again in 2012. A comparison of the data between the two sampling years did not show any marked change in vegetation structure. All trapping sites generally contained an upper stratum, lower stratum and ground cover layer. Based on height and cover assessments, sites are consistent with the open forest formations described by Specht *et al.* (1974). Proportions of microhabitat variables were also compared with all sites characterised by high proportions of vegetative ground cover and litter; the exception being site 2 which was dominated by Paspalum in the understorey with limited fine and coarse litter. The two new sites sampled in 2012 were similarly fringing forest and similar to the existing range of monitoring sites in terms of forest structure and microhabitat. All sites were also subject to limited disturbance such as fire and other anthropogenic disturbances and are all regenerating. Many of the sites were also subject to assisted bush regeneration (i.e. targeted weed removal). Consequently, given the similarity in vegetation structure, floristics and micro habitat variables among sites, ongoing measurement and analyses of these variables has not been undertaken.

Pitfall trapping was always conducted in spring and undertaken over a four-night period. Each pitfall line comprised between four (2005 and 2007 surveys) and five (2012 and all subsequent surveys) 20 litre plastic buckets measuring 28 cm in diameter and 40 cm deep. Buckets were buried into the ground, spaced at 4-5 m intervals and interconnected with a 40 cm high polythene drift fence. As noted, the number of pit traps per site was increased from 4 buckets per site in 2007 to 5 buckets per site in 2012 and thereafter. The additional pitfall bucket was added to the end of each established pit line. A summary of pit trapping effort per site and sites monitored during respective years is presented in Table 2.

At the completion of each trapping event, pitfall buckets were cleaned of all debris, sealed with a tight-fitting lid, weighed down with rocks and soil, and left *in-situ*; the exception being for low-lying sites where buckets were removed due to the risk of flooding. Pitfall buckets were individually marked using high visibility flagging tape so they could be located during subsequent trapping events.

Pitfall traps were checked early on each morning of the survey with all fauna identified to species level using standard nomenclature and released approximately 10 m from the capture point. Traps were revisited each afternoon to release any diurnally active species captured. Fine and coarse litter was placed within pitfall buckets to provide shade and shelter for captured individuals. All pitfall traps were dry (i.e. no preservative added).

Planigales captured during the survey were processed to record their age class, sex and weight. Fur was clipped from their rump to determine if successive captures were recaptured individuals.

Read (1988) noted that abiotic variables can influence indices of trap response in small dasyurid fauna. Subsequently, weather data including air temperature and rainfall was obtained from the closest Bureau of Meteorology weather station to facilitate interpretation of results (refer to Appendix 1).

Table 1. Planigale monitoring periods between 2007 and 2015

Trapping year	Trapping date
2007	25 - 30 November
2012	6 – 11 October
2013	24 – 29 November
2014	29 October – 3 November
2015	23 – 27 November

Table 2. Summary of Planigale pitfall trapping monitoring effort (PTN) between 2005 and 2015, Koala Beach Estate. – denotes no trapping at site. PTN = Pitfall trapping nights calculated as the number of pitfall buckets per site: 2007 survey = 4 pits per site x 10 trapping sites x 4 trapping nights = 160 PTN; 2012 survey = 5 pits x 8 trapping sites x 4 trapping nights = 160 PTN.

Site Number	2005	2007	2012	2013	2014	2015	Total effort per site
1	16	16	20	20	20	20	112
2	16	16	20	20	20	20	112
3	16	16	20	20	20	20	112
4	16	16	20	20	20	20	112
5	16	16	-	-	-	-	32
6	16	16	20	20	20	20	112
7	16	16	20	20	20	20	112
8	16	16	20	20	20	20	112
9	16	16	-	-	-	-	32
10	16	16	20	20	20	20	112
11(Stg 7)	-	-	-	20	20	20	60
12(LGGG)	-	-	-	20	20	20	60
Total effort	**160**	**160**	**160**	**200**	**200**	**200**	**1080**

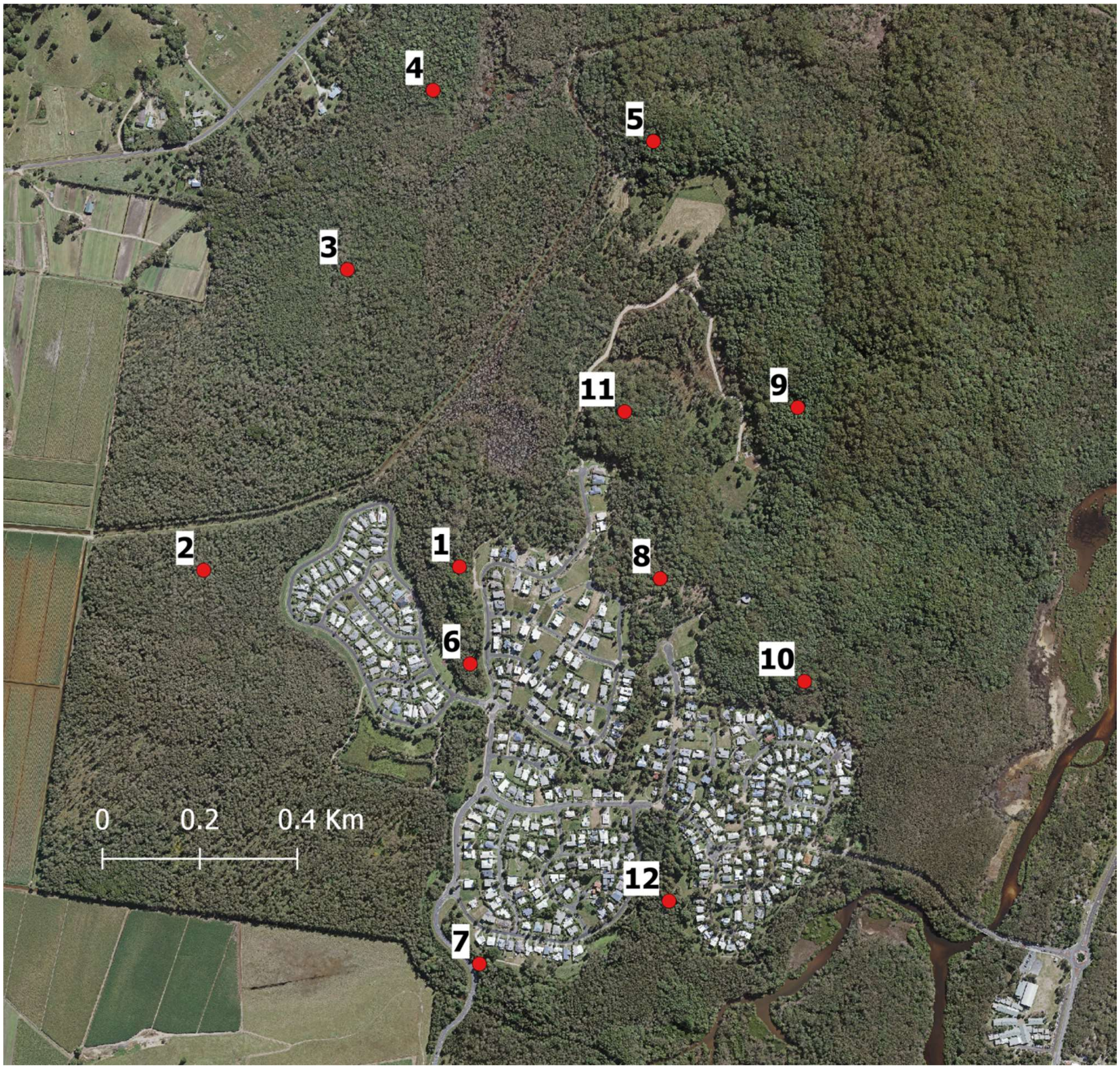

Figure 4. Planigale pitfall monitoring stations, Koala Beach Estate. Sites 1-10 = Pitfall trapping site numbers & corresponding locations. Sites 5 and 9 were not surveyed in 2012 (*Imagery Source: Tweed Shire Council*)

3.2 Analysis

Occupancy modelling was performed on capture data (presence/absence) collected in 2007-2015. Data collected in 2005 was excluded because capture history was unknown for this sampling period. The estimates were then used to determine sample size needed to reliably estimate occupancy rates of the Planigale. Studies have used species abundance in the past to estimate required sample size (Thomas 1997; Clarke *et al.* 2003), however, this is difficult with Planigale because of the low capture rate. Additionally, studies have shown that there is a correlation with abundance and occupancy (Gaston *et al.* 2000; Freckleton *et al.* 2006). Analyses were therefore based on occupancy estimation.

The aim of occupancy modelling is to determine the proportion of sites that are occupied by the species/community of interest. Detection rate is also estimated because it can influence an estimate of occupancy through the recording of false negatives. Occupancy (Ψ) and detectability (p) are estimated using probabilistic arguments coupled with maximum likelihood (MacKenzie *et al.* 2005). The influence of covariates on occupancy and detectability are modelled using logistic regression. Because sampling was undertaken over five seasons, with a short intra-season sampling period (four days), there is potential to use a multi-seasonal analysis that estimates colonisation (γ) and extinction (ε) in addition to occupancy and detectability. However, capture rates in this study were too low to use a multi-season analysis, so several single-season analyses were run instead. Distance from closest forest edge was used as a covariate to estimate occupancy because this could indicate if the KBE development affected occupancy of current sites. Akaike's Information Criterion (AIC) was used for the selection of the model that fitted the data 'best'(Burnham and Anderson 2002). The model with the lowest AIC value was considered to be the most parsimonious model. Any models that differed from the model with the lowest AIC score by a value >2 (i.e. Δ_i>2) were considered far from being parsimonious. Akaike weights (w_i) provide a relative weight of evidence for each model as part of the model assessment process. For further explanation of the AIC equations, see Burnham and Anderson (2002).

It is possible to estimate the number of sites needed given a level of Ψ, p and standard error (MacKenzie and Royle 2005). The level of precision changes the number of surveys needed and a value of 0.1 was used here. Setting the standard error to 0.1 can be considered realistic in that estimates of such precision are useful when making management decisions.

4.0 RESULTS

4.1 Summary of results

The number of Planigale captures among sites has been highly variable over the monitoring period (Table 3). No Planigales were captured during the initial 2005 monitoring event. In 2007, ten animals were captured. There were very low numbers captured in subsequent years until 2015, where 12 animals were captured.

Table 3: Capture frequency of sites over the duration of the project. – denotes periods where a site was not surveyed.

Sites	2007	2012	2013	2014	2015	Total captures
1 (Dunghir Reserve)	6	0	0	0	1	**7**
2 (Swamp Oak Stg 6)	2	0	0	0	0	**2**
3 (Control West)	1	0	0	0	1	**2**
4 (Control East)	0	0	0	0	0	**0**
5 (Barrage)	1	0	-	-	-	**1**
6 (Stage 5/6 Gully)	0	3	0	1	0	**4**
7 (Link Road)	0	0	0	0	0	**0**
8 (GBC)	0	0	2	0	3	**5**
9 (Stage 7 Rainforest)	0	0	-	-	-	**0**
10 (Blackbutt)	0	0	1	0	1	**2**
11 (Lower GGG)	-	-	0	0	5	**5**
12 ((Stage 7 new)	-	-	2	0	1	**3**
Total captures	**10**	**3**	**5**	**1**	**12**	**31**

The majority of Planigales caught were adult males, with a range of 1-8 males caught each year (Figure 5). The range of females caught per year was 0-3 and 2015 was the only year when juveniles were caught.

Neither temperature (average daily maximum), or the amount of daily rainfall appeared to influence the capture rate (numbers of captures divided by PTN). See Appendix 1 for figures.

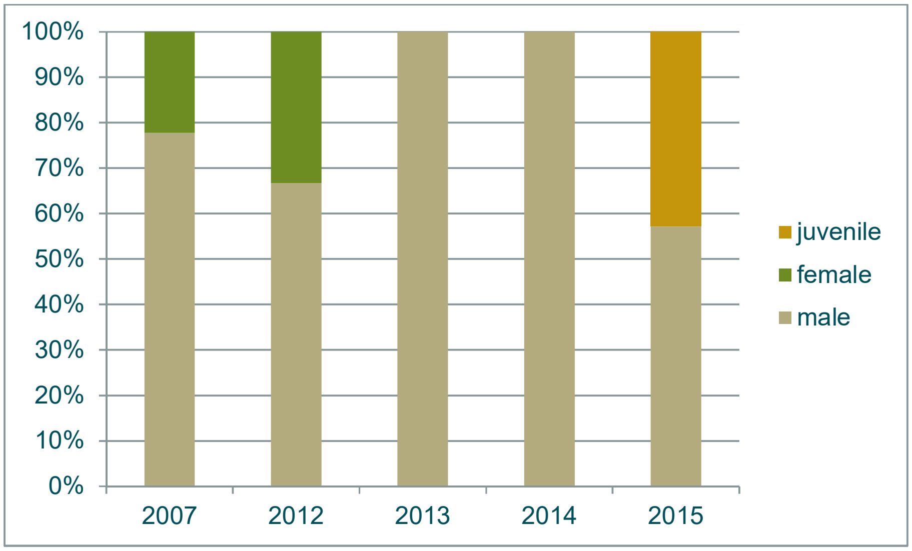

Figure 5. The cumulative proportion of males, females and juveniles caught during each trapping period.

4.1 Occupancy analysis

Because of the lack of captures in some years, occupancy modelling was only run for the 2007, 2013 and 2015 survey periods. Estimates for occupancy and detectability varied (Table 4). Variation around each estimate is wide because of the low capture rate. Model performance was similar between the model with constant occupancy and detectability and the model with varying occupancy with distance from edge and constant detectability (Table 4). Hence, there is little evidence that occupancy of a site varies with distance from forest edge. For the sake of parsimony and estimate confidence, occupancy and detectability estimates for the further analysis were taken from the model with constant occupancy and detectability.

Table 4. Occupancy models, their relative performance and the estimates from the preferred model. Δ_i AIC = is the AIC difference; w_i =is the relative weight; Ψ = is the estimated site occupancy; and p = estimated detectability. The standard error for each estimate is shown in brackets.

Year	Model	Δ_i AIC	w_i	Ψ	*p*
2007	Ψ(.) *p*(.)	0	0.42	0.373 (0.203)	0.335 (0.171)
	Ψ(dist) *p*(.)	0.28	0.37		
	Ψ(.) *p*(survey)	1.53	0.20		
2013	Ψ(.) *p*(.)	0.53	0.42	0.528 (0.404)	0.190 (0.158)
	Ψ(dist) *p*(.)	0	0.55		
	Ψ(.) *p*(survey)	6.53	0.02		
2015	Ψ(.) *p*(.)	0	0.53	0.691 (0.197)	0.398 (0.120)
	Ψ(dist) *p*(.)	0.42	0.43		
	Ψ(.) *p*(survey)	5.43	0.03		

Although variation was large in the estimates, the results show that occupancy and detectability varied quite noticeably between the years. It is likely that site occupancy could drop as low as 0.3 and climb to 0.75. Likewise, detectability could plausibly be as low as 0.15 and be as high as 0.45. Detection rates of 0.45, 0.3 and 0.1 were chosen to model the number of surveys needed with varying levels of occupancy (Figure 6). Given the occupancy rates estimated in this study, somewhere between 26-960 pitfall sites (4 visits per site) are needed, depending on occupancy and detection rates.

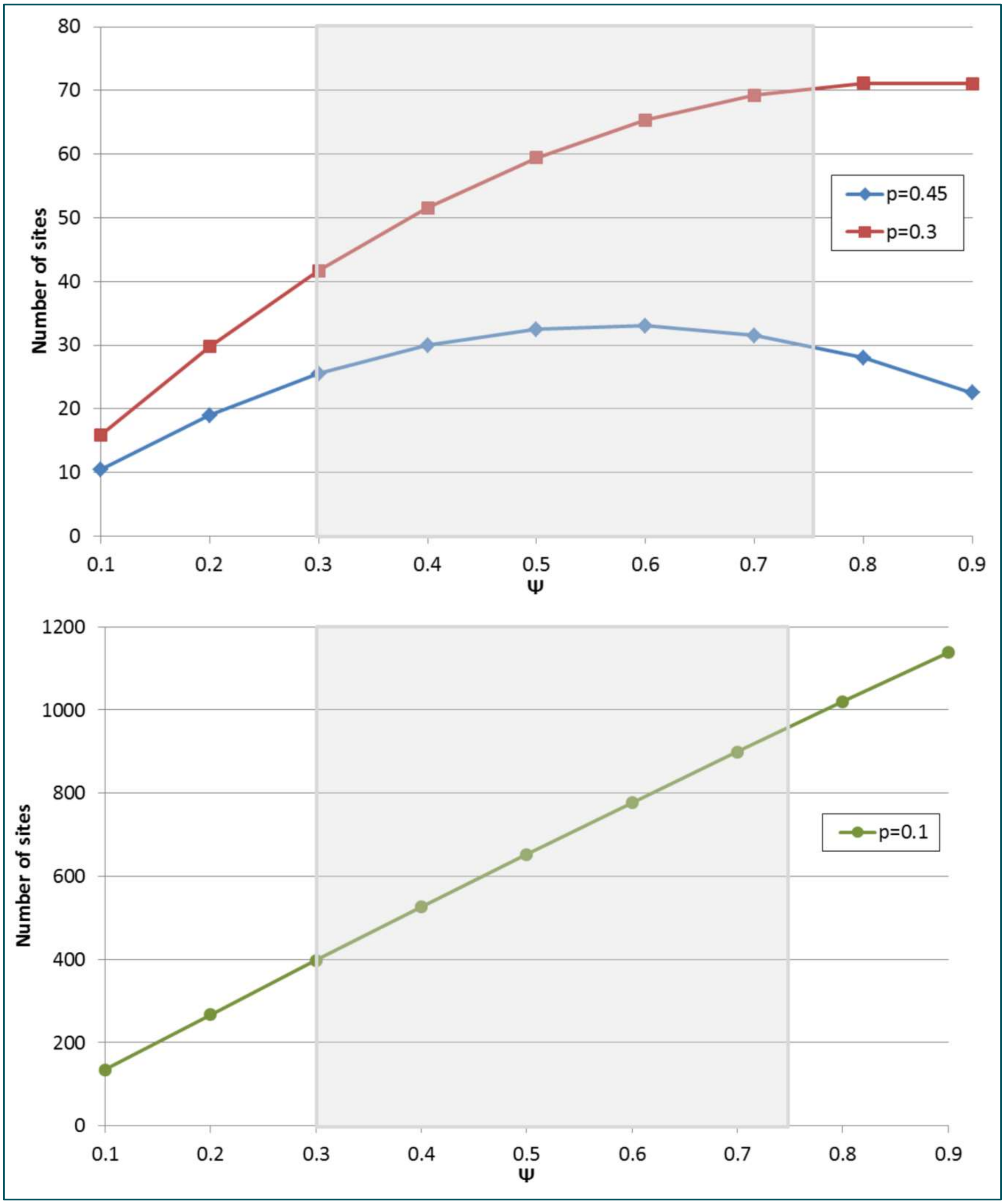

Figure 6. The number of sites needed to estimate varying levels of occupancy with a standard error of 0.1 are shown. It is assumed that there are four visits to each site. Ψ = occupancy estimate. The top figure shows the relationship between the number of sites and occupancy if detectability equals 0.45 or 0.3. The bottom figure shows the same relationship if detectability equals 0.1. Chosen detection rates were based upon the 2007-2015 survey data. The grey shaded areas represent a plausible occupancy estimate, which was based upon the survey data.

5.0 DISCUSSION

Monitoring the KBE for Planigales was a management action recommended by the PPoM (Appendix 2). Monitoring detailed in this report shows that the Common Planigale has persisted from 2007-2015 within the KBE. Within this period, captures were patchy, with some sites only detecting animals in one sampling period for the extent of the project. Furthermore, total numbers caught for each sampling period fluctuated over the life of the project (Table 1). With a high proportion of juveniles caught and a relatively high number of Planigales caught overall in 2015, data suggests that the Planigale population is at least as abundant as was the case since monitoring began.

Past studies have reflected the low capture rates found in this study. Garden *et al.* (2007) caught only two Planigales from 1650 PTN (59 sites) and Catling *et al.* (1997) caught two Planigales from 1652 PTN (51 sites) in the Murwillumbah area. Another study within the region caught three Planigales from 600 PTN (Lewis 2004). A northern Australian study caught 56 Common Planigales over 3528 PTN (≤147 sites). While the capture rate at the KBE is higher than those studies, the common theme is that the species is clearly not easy to detect. It is likely that the inconsistent numbers of Planigales caught within and between sites is a reflection of the species' ecology. Planigales go into torpor and body temperature is known to be influenced by ambient temperature (Morton and Lee 1978), suggesting that ambient temperature will influence availability for capture. Additionally, Planigales are small, have a high metabolic rate and have a short lifespan (>2 years maximum in captivity (Aslin 1975), but most likely less in the wild) that suggests rapid turnover of individuals. The species seems to have a reasonable capacity for large reproductive output in good conditions (Aslin 1975). Other small insectivorous mammal species have shown a higher reproductive output with favourable environmental conditions (Dickman *et al.* 2001). A combination of low survival and high reproductive potential would conform to the differing capture rates experienced in this study.

Literature on capture rates of Common Planigales are scarce. However, Table 5 indicates that the capture rate (combined years) in this study clearly exceeds any other study listed here. Two of the cited studies have occurred within the Tweed Shire, while Milledge (1991) was conducted close by, from Ocean Shores to Byron Bay. While study design, season and long-term weather may influence capture rate, the data suggests that the Planigale population has been sustainable for the extent of the survey period population and is not currently at risk of becoming extinct. This is especially the case if management practices within the estate do not change, with current management practices leaning towards conserving the Planigale habitat. The risks that could cause rapid extinction are broad-scale habitat change, e.g. fire, a rapid increase of predators or land clearing, which goes specifically against management practices listed in the management guidelines listed for the Estate (Bushland

Restoration Services 2009). The species appears somewhat robust to habitat change, with Planigale records within the KBE forest patch going back to 1981 (ALA records), indicating the occupancy of the forest patch by the species survived the clearing and development of the estate. Considering grazing within the forest patch occurred before 1984 (see PPoM), the Planigale population at Koala Beach has survived various land management practices.

Table 5. Details of studies that captured the Common Planigale. All animals were caught in pitfall traps. Capture rate = number of Planigales caught/PTN. PTN = Pitfall trap nights = number of sites x number of pitfall traps per site x number of nights surveyed. * = studies conducted within or close to the Tweed Shire.

Study	Number of sites	No. of pitfall traps per site	PTN	No. Planigales captured	Capture rate
This study*	10-12	4-5	920	31	0.03
Catling *et al*. 1997*	51	8	1652	2	0.003
Lewis 2005*	15	5	600	3	0.005
Milledge 1991*	15	34	2040	7	0.003
Garden *et al*. 2007	59	5	1650	2	0.001
Legge *et al*. 2010	≤147	8	3528	56	0.01

4.1 Review of the Planigale Plan of Management Key Performance Indicators

Key Performance Indicator (KPI) 8 and 10 of the PPoM (see Appendix 2) recommend annual monitoring for 10 years and beyond. However, the above data and analysis show that a large number of sites are needed to keep variation of the estimate low. A low coefficient of variation (cv) gives confidence in an occupancy estimate and would allow a decline in occupancy to be revealed in the data. For example, the cv of the occupancy estimate in 2015 – a year of many captures – was 29%. If occupancy and detectability did not vary from the 2015 data, it would take 39 sites with four visits to each site to obtain a standard error of 0.1 (cv = 7%). If there was an occupancy (and maybe population decline) of half, only 31 sites would be needed to estimate this decline with a standard error of 0.1 – a variance tight enough to pick up the decline from one season to the next.

However, it is unlikely that 30 pitfall sites will be ever used to monitor Planigales at KBE. The resource cost in terms of survey time and budget would be too high. As discussed, and is evident in the data, it is likely that the species goes through local colonisation and extinctions throughout years. It is most likely not worth the effort to try and detect population trends because of: the dynamic nature of the population; the continual subsistence of the population, sometimes seemingly at relatively healthy numbers (assuming capture rate reflects abundance); and the lack of evidence of edge effects on occupancy.

Consequently, a number of recommended monitoring options are proposed based on the assumption that long term monitoring is a consideration for this species at KBE:

Option 1: It is recommended that the frequency of pitfall monitoring be less intensive than it was during the 2007-2015 period. A better return from effort invested would be to monitor the population every five years utilising the same number of sites, knowing that the causes of an extinction event would be discovered retrospectively. Knowing that an extinction has occurred, actions such as reintroduction could occur relatively soon after the event of extinction.

Option 2: To detect a potential decline in Planigales, when surveys are conducted, >30 sites should be used every 2-3 years; noting that this level of effort is not considered cost effective.

Option 3: To detect an effect of management, it is recommended that monitoring occur using an experimental design in the spring before and after the implementation of differing management practices. However, for the monitoring scheme to be successful, the intensity of monitoring needs to increase from 10 sites annually to >30 sites.

During any subsequent surveys, it is recommended that monitoring shelters be used simultaneously with the pitfall traps at each site to determine which monitoring method is best. Figure 6 shows that detectability can markedly influence the ability to estimate occupancy and the PPoM shows that the encounter rate of Planigales using monitoring shelters was greater than the encounter rate when using pitfall traps. If the monitoring shelters greatly deteriorate between pitfall monitoring events and/or do not produce substantially greater encounter rates than the pitfall traps, the monitoring shelters should not subsequently be used.

5.0 CONCLUSION

The monitoring of Planigales within KBE from 2007-2013 has been successful, given the nature of the species. Monitoring has shown that the Planigale population has continued from 2005-2015, with signs of good numbers and recruitment rate in 2015. There is little evidence to suggest that the current management practices and KBE housing will cause the extinction of the local population of Planigale, especially considering the population has survived different land management practices over the last 35 years and beyond. Because increasing spatial or temporal survey effort would not solidify Planigale occupancy rates or allow us to estimate abundance, it is recommended that surveying occur every 5 years, with the aim of detecting a local extinction. The next surveying event should use pitfall trapping and monitoring shelters, for the purpose of evaluating which method has higher detectability of Planigales.

6.0 REFERENCES

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APPENDIX 1

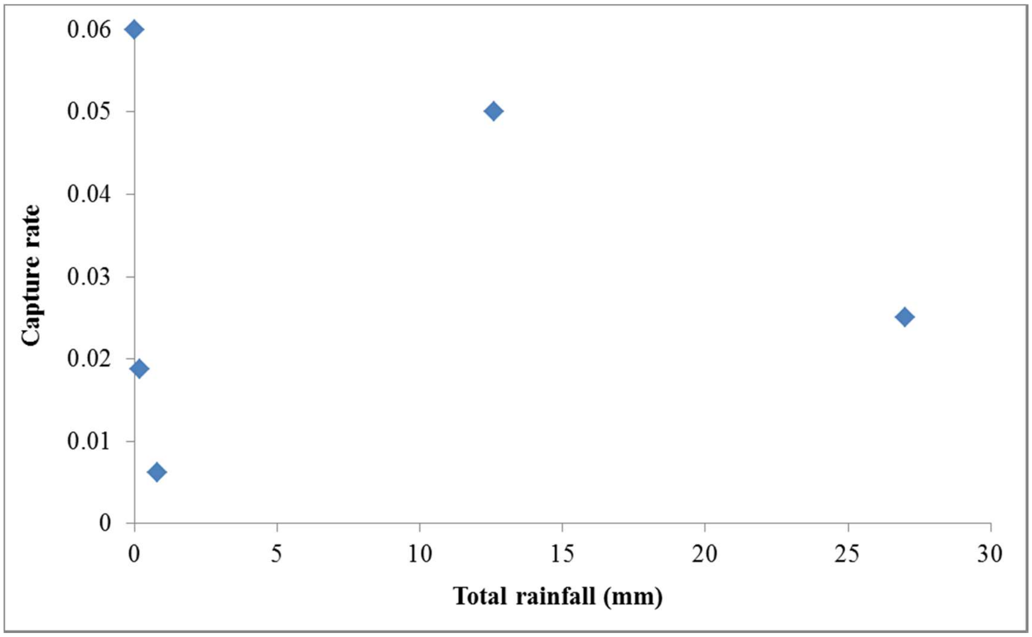

Figure A1. Varying capture rate (captures per number of trap nights) versus total rainfall during the trapping period. Rainfall data was taken from the Coolangatta weather station.

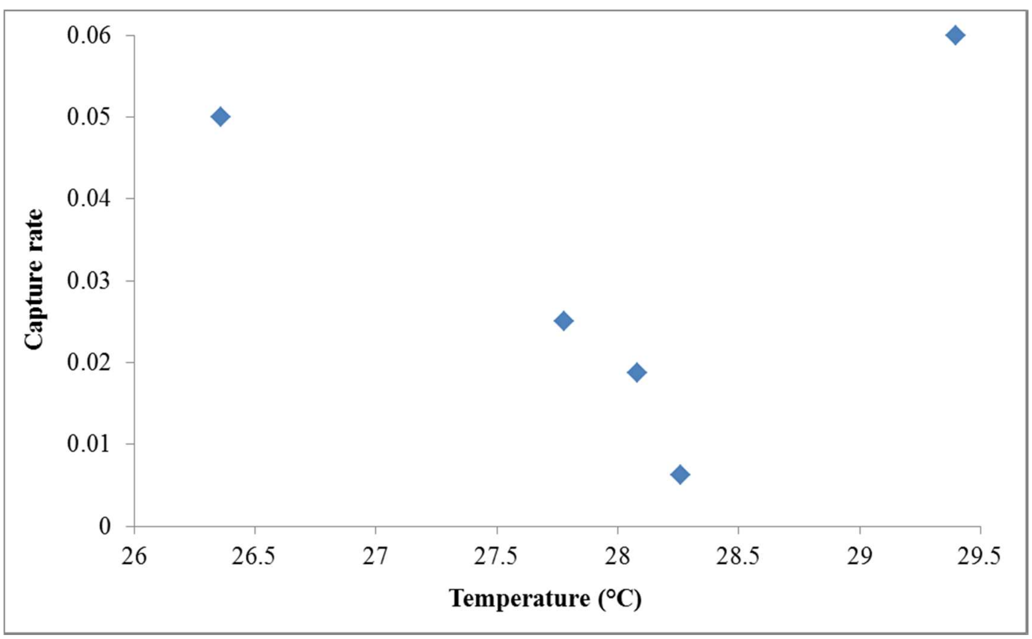

Figure A2. Varying capture rate (captures per number of trap nights) versus average maximum temperature during the trapping period. Temperature data was taken from the Coolangatta weather station.

APPENDIX 2

Management actions and performance criteria, Planigale Plan of Management (Callaghan *et al*., 2005).

Management Action	Performance Criteria
1. Any soil disturbance, slashing or clearing should commence at one location and proceed on one front.	All disturbance undertaken systematically on one front.
2. Ensure construction activities and associated impacts are fully constrained to a clearly marked construction site.	No impacts from construction activities beyond the designated construction site.
3. Avoid risks of bushfire during construction.	No bushfires resulting from construction activity.
4. Ensure a gradual or staged replacement of exotic grasses with native ground covers in conjunction with habitat restoration activities	Gradual or staged replacement of exotic grasses with structurally similar ground-layer vegetation.
5. Incorporate outcomes from the ongoing monitoring into annual planning for habitat restoration.	Planigales recorded within areas subject to habitat restoration work.
6. Undertake appropriate management actions to control foxes, feral cats and roaming dogs.	Foxes, feral cats and roaming dogs successfully controlled on site.
7. Install and clearly mark (with a central brightly-painted star picket) a total of 20 fixed monitoring shelters.	20 monitoring shelters successfully installed and clearly marked.
8. Inspect all 20 monitoring shelters annually over 5 consecutive days between September and November.	20 monitoring shelters successfully inspected and recorded.
9. Annually install 6 monitoring stations (each consisting of 4 pitfall traps with drift-net fencing) in fixed areas of higher quality habitat adjoining developed sections of the Estate. Two stations should be in areas subject to habitat restoration.	6 monitoring stations successfully installed annually.
10. Survey all 6 monitoring stations annually over 4 consecutive trap nights between September and November.	6 monitoring stations successfully surveyed and recorded.

11. Provide an annual report describing the results from the monitoring program to Koala Beach Wildlife and Habitat Management Committee (KBWHMC).	Annual report (electronic and hard copy) provided to the KBWHMC by March.

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