

Tweed Coast Koala Study 2018

February 2019

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Cover: Male koala at Kings Forest. Photo by Marama Hopkins.

Executive Summary

The reassessment of the koala population on the Tweed Coast is a three-yearly action of the Tweed Coast Comprehensive Koala Plan of Management. The aim of this study is to determine current occupancy rates and assess changes in the distribution and levels of koala activity over time during the operation of the plan. This report details the second koala study since the Koala Habitat Study was prepared in 2011.

Surveys were carried out between August and December 2018 and involved resampling a large proportion of those sites surveyed during the 2011 Habitat Study, utilising identical methodology. Sixty-nine sites on Council owned and managed land, private land and Nature Reserve were surveyed. Records of koala sightings were collated from all available sources.

Koala activity remains widespread throughout the study area, and in contrast with the findings of the 2015 study, a number of encouraging observations arise from the results of the current study. The amount of available habitat that is currently occupied by permanent resident koala populations has shown a slight increase since 2015, however this is still well below that recorded in 2010. When areas of low and infrequent use are also included, overall, koalas are also using a larger proportion of the study area than was recorded in 2015 and 2010. Observations of breeding females also continue to be reported from the occupied areas.

Monitoring results indicate that the Pottsville Wetland population continues to remain stable, and koalas appear to have slightly increased their use of habitat in the Kings Forest and Round Mountain areas since the previous monitoring period. Infrequent use by koalas of areas between the main population centres may indicate some recovery beginning to occur. However, these results must be interpreted with caution recognising that recovery and sustaining of resident populations above and beyond the 2010 levels is required for long term koala population persistence.

The ongoing use by koalas of food tree plantings undertaken under the KPoM by is also encouraging. A significant increase in koala sightings reported by community members indicates that community engagement efforts by Council and partner agencies are being effective. Continued use by koalas of restored and newly-created koala habitat also confirms the success of these KPoM actions.

Until currently isolated koala populations are well connected and resident populations occupy a larger proportion of the available habitat, the Tweed Coast koala population remains at high risk of extinction. The results of this study suggests that the substantial ongoing decline observed between 2010 and 2015 has slowed, and thus provide support for the ongoing investment in implementation of the KPoM, as it works to support population recovery.

Introduction

One of the actions of the Tweed Coast Comprehensive Koala Plan of Management (KPoM) is the ongoing monitoring of koala activity (see Section 13 of the plan). As stated in the KPoM, ongoing monitoring is essential to:

- ensure that the plan remains relevant and that planning controls are implemented to achieve the vision and aims of the plan;
- determine the effectiveness of the plan in achieving the recovery of the Tweed Coast koala population; and
- update and respond to current knowledge on the status of the Tweed Coast koala population.

The Tweed Coast Koala Habitat Study (Phillips et al. 2011) provided a comprehensive overview of the status of the koala population on the Tweed Coast at that time. The resulting KPoM required an initial reassessment of koalas on the Tweed Coast to be done within 12 months of the plan's commencement, and ongoing monitoring events at three-yearly intervals thereafter. The initial reassessment was done in 2015, five years after the initial study (Tweed Coast Koala Study 2015, TSC, www.tweed.nsw.gov.au/koalas). The current study is the third assessment of koala activity in this long-term monitoring project.

This assessment focused on the Southern Tweed Coast KMA, located east of the Pacific Highway, between Cudgen and Billinudgel Nature Reserve. This area is where the majority of the koala population was recorded during the Habitat Study, and is therefore the focus of the KPoM's management actions.

Aims

1. To determine changes in the distribution and levels of koala activity within the Southern Tweed Coast Koala Management Area within the last eight years.
2. To assess changes in occupancy within the Southern Tweed Coast Koala Management Area.

Methods

Site selection

Field site selection was based on the field sites sampled in 2010 during the Tweed Coast Koala Habitat Study (Phillips et al. 2011). During the Habitat Study, sites were positioned using a 600 x 600 metre grid, where possible, to enable uniform and unbiased coverage of the study area.

In the 2015 study, sites were selected for sampling on the following basis:

- Active sites (sites where koala activity was recorded) sampled in 2010.
- Inactive sites (where no koala activity was recorded) sampled in 2010, adjacent to modelled population boundaries.

The current study attempted to resample as many of the 2015 and 2010 sites as possible. Sampling at these previously unoccupied locations was most likely to detect population expansion, or a shift in distribution should this have occurred. For the 2018 study, one new site was added within Nature Reserve (TC1507) and one was relocated on private land (TC057) in order to improve the completeness of data gathered from the central portion of the Round Mountain KAP. New and relocated sites were aligned as closely to the original sampling grid as possible.

As directed by the KPoM, an attempt was made to incorporate the majority of sites located within the Koala Activity (KAP) and Koala Linkage Precincts (KLP), whilst working within limitations of time and funding. Sites located within the Individual Koala Plan of Management (IKPoM) areas at Kings Forest, Koala Beach and Black Rocks were included in the study in order to provide complete coverage of the study area.

Landholder engagement

Where proposed sites occurred on privately-owned land, landholders were sent a letter requesting permission to carry out surveys on their property. Landholders were subsequently contacted by phone or email to confirm permission and access arrangements. Where permission was not granted or it was not possible to make contact with the landholder, surveys were not carried out on that property.

NSW National Parks and Wildlife Service consent was obtained for surveys within Nature Reserve.

Sampling

In most cases, the central point of each field site that had been sampled during the Habitat Study was readily identifiable (due to the centre of the site being marked with usually two flagging tapes in 2010 and/or 2015). For sites where the previously marked centre tree could not be found, a new centre tree was chosen and flagged as close as possible to the identified coordinates. Degraded flagging tape was replaced.

Field sites were sampled using the Spot Assessment Technique (SAT) methodology of Phillips and Callaghan (2011), the same protocol that was used during the Habitat Study. At each site, an area of one metre out from the base of each of 30 trees ($\geq 100\text{mm}$ diameter at breast height) were searched for two person-minutes for the presence of one or more koala faecal pellets. Each tree was scored for the presence or absence of a faecal pellet detected within the search time. Each tree was also identified to species, and its diameter recorded.

Field sampling was carried out between August and December 2018 by a two or three-person team of Council officers, all of whom were experienced in koala faecal pellet identification, koala survey and tree species identification.

Work was carried out under Scientific License 100540.

Data analysis

Koala activity

The koala ‘activity level’ at each site was determined by calculating the percentage of trees in a site that had a faecal pellet detected beneath them. Activity thresholds developed by Phillips and Callaghan (2011) were used to interpret the activity level at each site. The activity level at a site indicates how frequently it is used by koalas in the area, and therefore whether or not the site forms part of an area occupied by a resident koala population. The key measures are detailed below in Table 1.

Table 1 Summary of activity categories and their interpretation.

Activity category	Activity level	Interpretation
Significant activity	≥ 22.52%	Site is regularly used by one or more koalas as part of normal ranging behaviour. These areas are occupied by resident koalas, and support the majority of the koala population.
Low activity	> 0% - 22.51%	Occasional or transitory use of the site by (for example) dispersing animals not yet displaying established home ranging movement patterns.
Inactive	0%	Site infrequently used or not used at all by koalas.

The terms “significant activity”, “low activity” and “inactive” are used throughout this report to describe the above scenarios.

Comparisons of activity across the study area over time were done using the 56 sites that have been sampled during each of the three survey events. Trends in a) the presence of *any* koala activity, and b) the presence of *significant* activity were estimated. The first describes what proportion of available habitat is currently utilised by koalas in any way, and the second indicates what proportion of habitat is occupied by resident populations, which comprise the majority of the koala population.

Mapping habitat use by the koala population

Heat maps were produced using the koala activity level recorded at each field site. The heat maps provide a basic visualisation of how koalas are using the landscape across the study area, and ready identification of broad “hot spots” and “cold spots” of koala presence.

Heat maps were produced with ArcGIS Pro, using a radius of 30, and the activity levels at all of the sites sampled during each of the survey events. Note that the number of field sites is not constant from year to year.

Also note that the heat maps do not account for barriers such as fauna exclusion fencing and major waterways, and do not intend to accurately define the extent of koala presence at a fine scale.

Results

Field sites

Sixty-nine field sites were sampled across the Tweed Coast from north of Kings Forest to the Byron Shire border. Sites were located across all land tenures, and comprised 24 sites on privately-owned land, 25 sites on Council-owned or managed land and 20 sites within Nature Reserve (Table 2, Figure 1).

Table 2 Summary of land tenure associated with field sites.

Tenure	Sites
Private land	24
Council owned/managed	25
Nature Reserve	20
Total	69

Over the three monitoring events, 73 sites have now been sampled on at least two occasions, and 56 sites have been sampled during all three survey events.

Within the 69 sites surveyed during the current study, at least 2,070 trees were searched for the presence of koala faecal pellets.

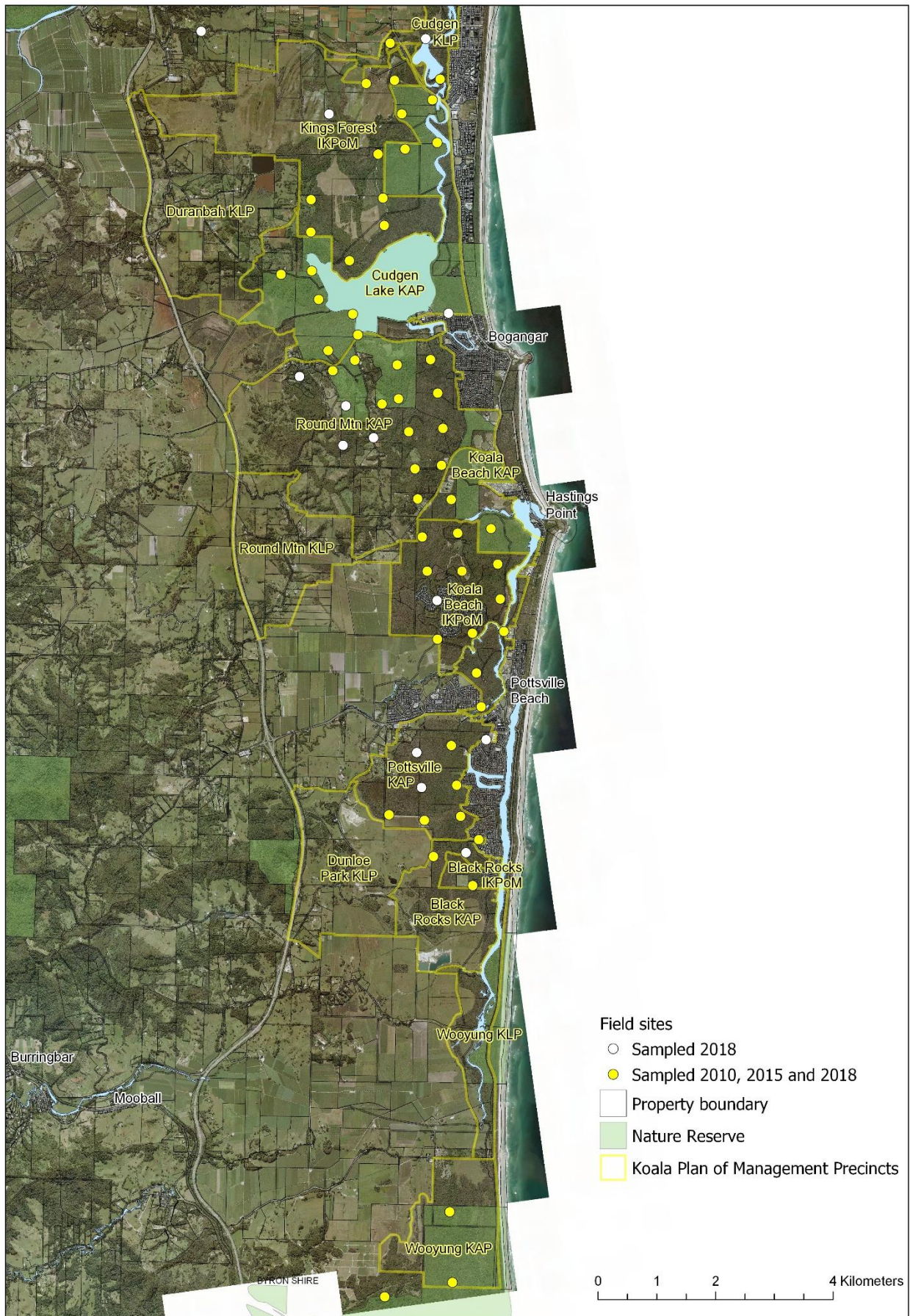


Figure 1 Distribution of field sites across the study area for the 2018 koala study. Koala Management Precinct boundaries, as defined in the Tweed Coast KPoM, are also shown.

Koala activity

This study

Koala activity was recorded from 75% (n=52) of the 69 field sites sampled during this study. Of the sites that contained koala activity, 24 sites indicated significantly high activity levels to indicate regular use by resident koalas (Figure 2). Figure 3 provides a comparison of koala activity at the 56 field sites that have been sampled on each of the three monitoring events.

Koala activity (at least one faecal pellet recorded beneath at least one tree) was recorded from within each of the Koala Activity Precincts, with the exception of Wooyung KAP. Evidence of koala activity was recorded from sites within all land tenures with 20 active sites on private land, 21 sites on Council-managed land and 11 sites in Nature Reserve.

Comparing 2010, 2015 and 2018

The 2015 study resampled 61 of the same field sites sampled in 2010, and reported a decrease in activity levels within these sites across the study area within that time. The number of sites returning any evidence of koala activity had decreased slightly, and the number of sites returning significant koala activity had decreased by approximately half.

Fifty-six (56) sites have now been sampled during each of the three monitoring events. When activity levels are again compared across years at sites that have been sampled on each occasion, the number of active sites has increased and is currently higher than that recorded in either 2015 or 2010. The majority of these sites are low use sites however (n=27). 17 sites returned significant activity; slightly higher than that recorded in 2015 but well below the 2010 level.

Table 3 provides a summary of activity/occupancy data at the 56 field sites sampled during each of the three monitoring events, and Figure 2 provides a graphical illustration of the same data.

Table 3 Comparison of activity levels at 56 field sites sampled during each of three monitoring events.

	2010	2015	2018
Active sites (any activity)	70%	62%	78%
Sites with significant activity (occupied by resident populations)	48%	25%	30%

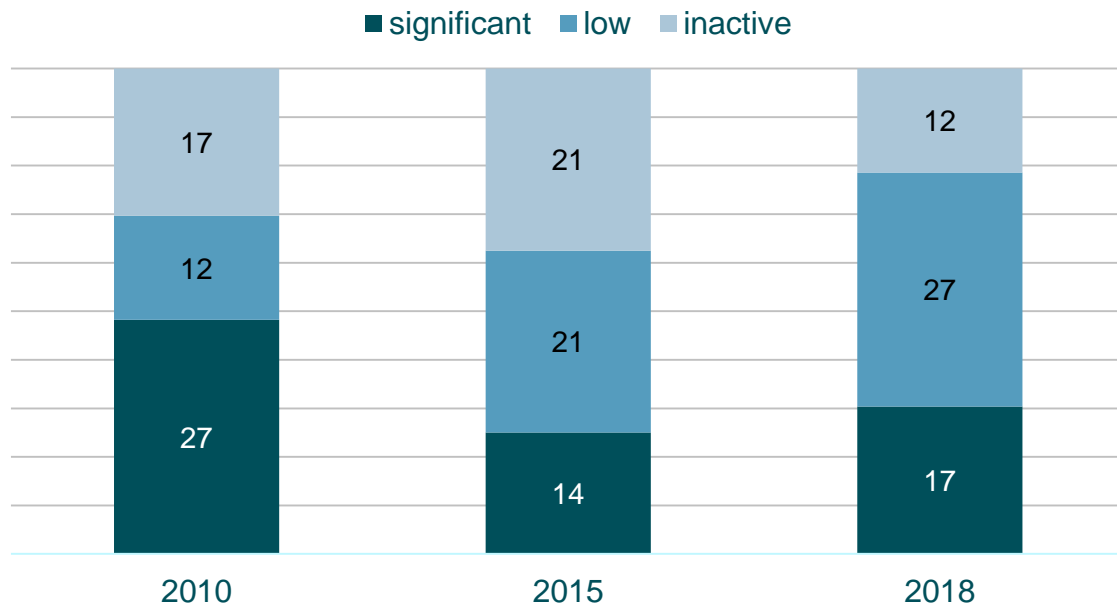


Figure 2 Comparison of koala activity levels at 56 sites sampled during all three survey events.

Whilst activity levels are expected to change over time, change at a particular site is ecologically meaningful if there is a shift from one activity category to another (eg. from above threshold (significant activity) to below (low activity or inactive), or *vice versa*.)

Between 2015 and 2018, meaningful positive change in activity levels has occurred at 28% (n=19) of the 66 sites sampled on both of those occasions; 12 sites that were previously not used by koalas are now active, and seven sites that were previously used infrequently or not at all are now occupied by resident koalas. Negative change (a shift from significant activity to low or no activity, or from low to zero activity) was recorded at 10% (n=7) of sites.

Conversely, the 2015 study saw activity levels at 28% (n=17) of sites decrease from significant to low or no use between then and 2010. Only 11% (n=7) of sites saw meaningful positive change in that time.

Koalas have maintained regular use of 15 sites between 2015 and 2018, and a further 14 sites maintained occasional use status. Eleven sites that were inactive during the previous study remained inactive during the current study.

A table of activity levels at each site sampled during the three monitoring events is provided at Appendix 1. These changes can also be seen in Figure 4.

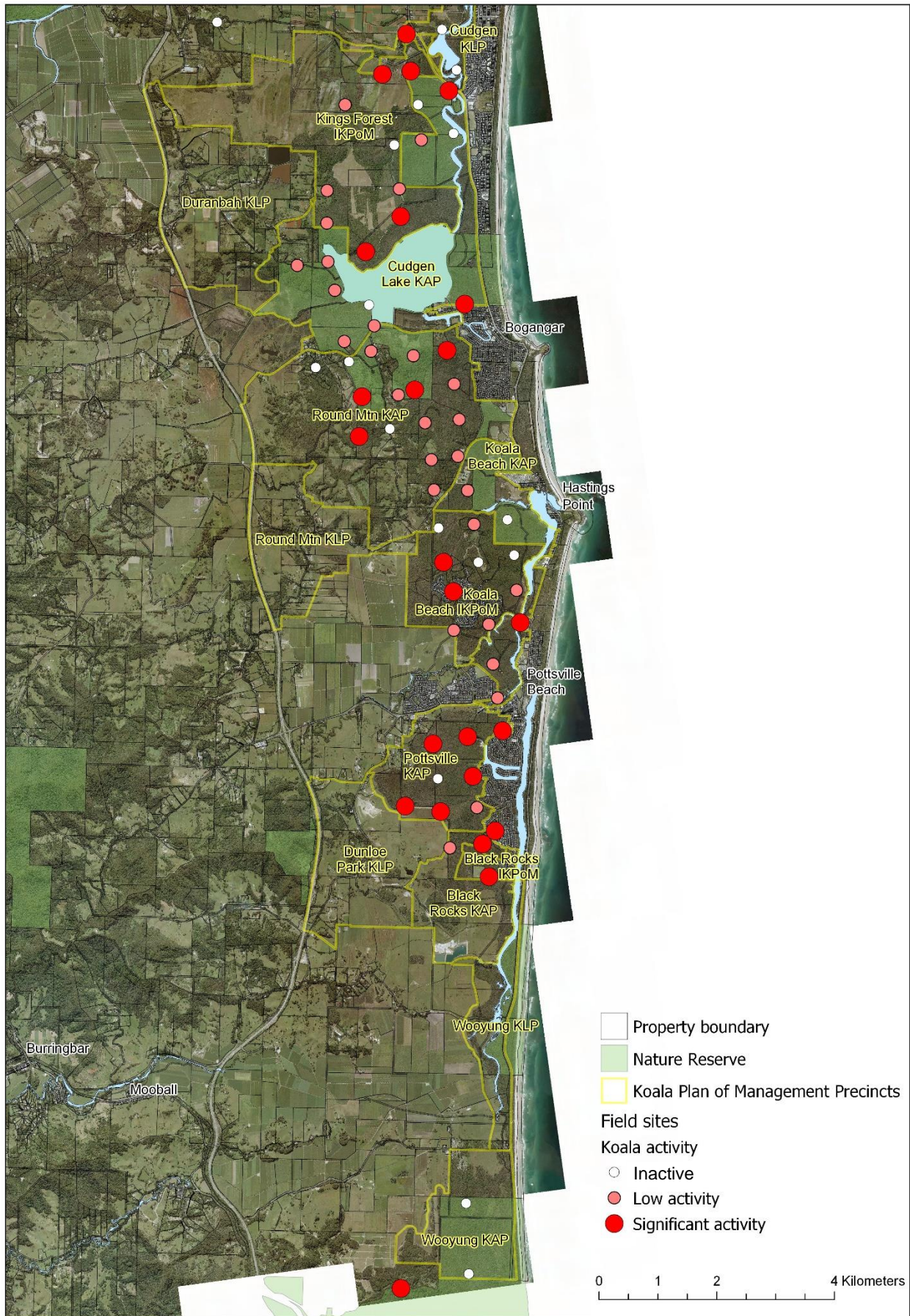


Figure 3 Distribution of koala activity at field sites sampled during the 2018 study.

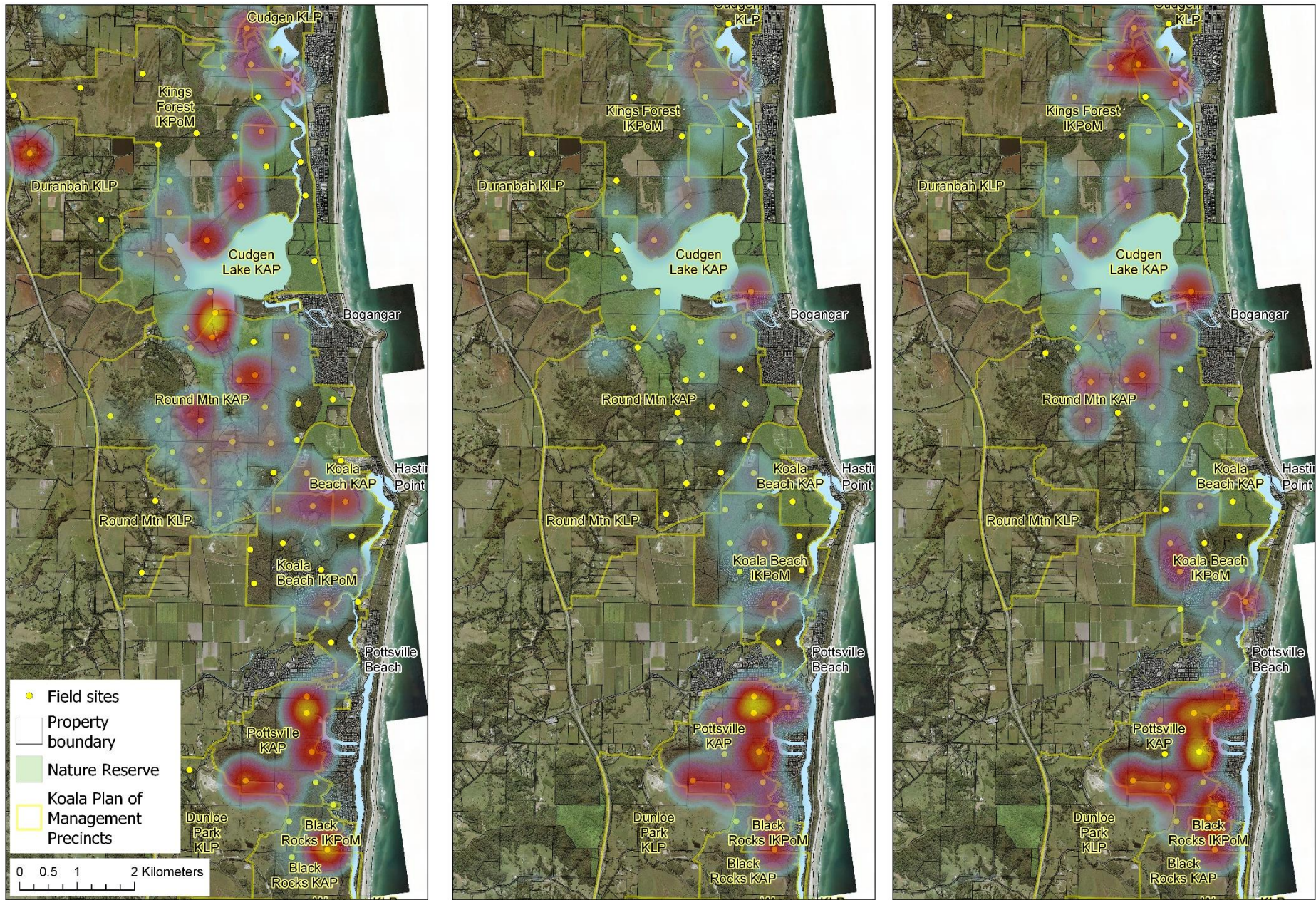


Figure 4 Heat maps representing the relative level of koala activity at each field site during each of the sampling events (left, 2010; centre, 2015; right, 2018). Hotter colour indicates higher activity.

Koala sightings

Within the study area, 472 records of koala sightings have been reported to or obtained by Council since the previous koala study (September 2015 – December 2018). This is a notable increase of more than 100%, from an average of approximately five sightings to approximately 12 per month; 322 sightings were reported in the almost six years previous. Records were obtained from a number of sources, including the public, Council officers, Atlas of Living Australia, NSW Office of Environment and Heritage's BioNet, Friends of the Koala Inc. and Council's remote monitoring cameras.

Records of koala sightings remain widely distributed throughout the study area, with clusters occurring at Kings Forest, along the eastern portion of Clothiers Creek Rd, throughout Koala Beach, Pottsville Environment Park, and Pottsville Wetlands (Figure 5).

At least twenty sightings of breeding females have been reported over the last three years. The majority of sightings of females with joeys have been reported from Pottsville, and one was sighted at Bogangar, during the reporting period.

The increased reporting rate is a phenomenon that has been noted also by Friends of the Koala Inc., across the region, and may be attributed to the increasing ease with which community members can report sightings online; Council's own reporting tool went live during this period, along with awareness raising activities by Council and wildlife groups. Ongoing Council engagement with landholders replanting and restoring koala habitat has also resulted in a greater number of sightings reported from private land and Koala Linkage Precinct areas.

Roads

Koalas continue to be recorded regularly using the fauna highway overpass at Pottsville, detected by Council's remote cameras. Eleven reports of vehicle strike have been reported since September 2015. The majority of reported vehicle collisions occurred on the Pacific Highway, with hot spots at Chinderah and Pottsville. Three vehicle strikes occurred on Clothiers Creek Rd in the period. Two vehicle strikes were also reported from urban areas within Pottsville Waters and Seabreeze estate. The rate of reported road strike is similar to that of the previous three years.

Dog attack

Three reports of dog attack have been made in the reporting period, at Pottsville, Kings Forest and Bogangar. This is slightly higher than for the previous reporting period, however it is well known that dog attacks go largely unreported and do not provide a good indication of the level of threat.

Rescues and sightings of diseased animals account for a further 21 koala records, with the majority of sightings being observations of healthy animals. It is important to note that sightings data is not systematically collected, inevitably contains multiple sightings of the same animals, and is biased towards more densely human-populated or frequented areas.



Figure 5 Koala sightings reported between September 2015 and December 2018.

Key outcomes & discussion

The results of this study suggest that the koala population on the Tweed Coast has not continued on the same trajectory of decline that was reported in the previous survey. In the three years since the 2015 koala study, some expansion of resident koala populations has been observed, along with a substantial increase in areas being used by koalas on an occasional basis, when compared to the previous study.

Koala population status

Two measures of “occupancy” are presented in the results of this report. “Occupancy” describes the proportion of a sampled area where the target species is present. The first is usage of habitat by koalas at *any level*, be it occasional or frequent. The second and more useful measure is occupancy by *resident koala populations*. Changes in occupancy by resident koalas in a population is the more meaningful as it describes the trend as it relates to the majority of the koala population at any given time.

The 56 field sites sampled during this and the previous studies provide good coverage of the available, well-connected habitat in the study area, are placed regularly throughout the landscape, and so provide a sound sample from which to examine trends over time.

One of the main outcomes from the 2011 Habitat Study was that there was a large proportion of habitat on the Tweed Coast that was suitable for koalas but was not regularly used (occupied) by resident koalas. It was concluded that the situation at the time was the result of a decline in the population that had been occurring for at least the preceding three koala generations (approx. 18 years).

The 2015 koala study reported a further dramatic decline in the area of habitat occupied by resident populations (that is, areas supporting the majority of the koala population; animals occupying stable home ranges and breeding females), at approximately half of that previously reported. The resulting prognosis was that the situation was severe for the Tweed Coast koalas, and that, with the exception of the koalas in the Pottsville Wetland area, the population was struggling to maintain itself in the face of ongoing threats.

The results of the current study suggest that the decline may have slowed and has not continued along its previous catastrophic trajectory. Within the comparison sites, the proportion of habitat occupied by resident koala populations currently sits between the 2015 and the 2010 levels. The areas supporting resident populations that were reported in the 2015 study, particularly those in the northern and central portions of the study area, appear to have undergone some recent minor expansion, while the majority of habitat in the southern portion of the study area remains occupied as it has done since 2010.

In terms of areas that are subject to *any* koala use (whether occasional or frequent), the occupancy rate within these sites of 78% is higher than the 2015 and 2010 rates of 62% and 70%, respectively. This means that koala activity, in its broadest sense, has returned to some of the areas that were vacated between 2010 and 2015, and that a similar, if not slightly higher, proportion of the habitat is being used on a transient or occasional basis as was being used in 2010.

The Habitat Study spoke broadly of the sub-optimal occupancy rate across the Tweed Coast. The results of the 2015 study subsequently suggested that the trend of decline had continued. The results of the current study suggest that some recovery may be occurring, however it may also be the case that this year's sampling has detected what might be short-term fluctuations in the population's distribution. Despite the above positive observations, koala population on the Tweed Coast remains unstable, small, fragmented, and at an occupancy rate that is well below sustainable. As a result, populations remain highly susceptible to well-known threats, particularly stochastic events such as high-intensity wildfire and ongoing vehicle and dog-related mortality.

Management precincts

Meaningful increases in koala activity have occurred throughout the study area. One field site in each of the Kings Forest, Round Mountain and Black Rocks KAPs and three sites in the Koala Beach area are currently occupied by resident koalas where previously these sites had been subject to low or no use. Areas that are now being used occasionally or by transient/dispersing koalas are now substantially more widespread than observed in 2015, but the most notable positive change in this activity has occurred within the northern precincts.

Meaningful declines were less common; represented by three field sites within Koala Beach IKPoM area, two sites in the Pottsville KAP and a single site in each of Cudgen Lake and Round Mountain KAPs.

Observations of current activity and changes over time are examined in more detail below.

Kings Forest IKPoM

Koala activity remains widespread throughout the eastern portion of the Kings Forest IKPoM area and adjacent Cudgen NR. An area of significant activity continues to persist in the Depot Rd area in the north, and has expanded to cover an additional site to the west, since the previous study. One site in an area of forest that was subject to fire in January 2018 is currently being used on an occasional basis, when no koala activity was recorded during the previous study. A male koala was observed at this site during field work. The small population occupying the area between Cudgen Paddock and Cudgen Lake (represented by three adjacent sites of significant activity) has persisted, however it remains more restricted and activity levels here remain lower than observed in 2010. As in 2015, active low use sites connect the northern and southern areas of significant activity where they were previously contiguous. The two south-western sites are receiving some use by koalas, showing slight improvement since 2015 but again not yet reaching 2010 levels.

Cudgen KLP

As for the previous study, no activity was recorded in within the southern portion of the Cudgen KLP. Only two field sites are located in this precinct, and suitable habitat is currently limited.

Cudgen Lake KAP

Cudgen Lake KAP encompasses Cudgen NR to the west of Cudgen Lake, wraps around the lake to the south and extends to the north to NR on the eastern boundary of Kings Forest. Eleven field sites are located within Cudgen Lake KAP. One site returned significant activity in the north, adjacent to Tweed Coast Rd and Cudgen Creek. The other three sites

in the north show low or no use, with a slightly lower level of use overall than in the previous study.

One site on the northern edge of Bogangar's urban area also contained significant activity, which has persisted since the previous study. A sighting of a breeding female koala within this population cell during both 2015 and 2018 field work reinforces the significance of habitat on this urban edge.

While the small population "cell" that was present in 2010 in the vicinity of Sliprails Rd to the south of the lake has not re-established, the area to the southwest of the lake is again showing evidence of some use by koalas where these sites were mostly unoccupied during the previous study. As discussed in previous studies, this area experienced habitat collapse following peat fires west of Cudgen Lake in 2009 and was assumed to be impeding dispersal. While it is not known whether this area is now fully functioning as connected habitat, an increase in use by koalas is encouraging, and indicates potential for the Round Mountain and Kings Forest/Duranbah populations to re-connect in the future.

Koala sightings continue to be reported from Clothiers Creek Rd and vicinity, confirming continued occupancy in this area.

Round Mountain (KAP, KLP)

The most notable improvement was observed within the Round Mountain KAP. The 2015 study noted that the substantial population that occupied much of the precinct during 2010 was largely then absent. The current study detected significant koala activity at four sites, where in 2015 it was restricted to one site in the far north east, indicating a return of resident koalas to a broader area. Low activity was recorded at a large proportion of sites that returned zero activity during 2015, and suggest that a reconnection between populations at Round Mountain and Koala Beach may be re-establishing.

The 2011 Habitat Study noted the irregular shape of the metapopulation boundary in 2011, suggesting that it was reflective of historical disturbance, including fragmentation of habitat and wildfire. It would appear that the influence of these impacts may be lessening over time since fire, habitat restoration efforts or that the population is highly dynamic and will continue to fluctuate in response to ongoing threats and their changes in intensity.

It should be noted that access to field sites on private land in the western portion of Round Mountain KAP remains unavailable, so the status of any koala populations in these areas remains unknown. The location of some sites in this area has been adjusted slightly to improve reliability of access over subsequent surveys.

Koala Beach KAP and IKPoM

Koala activity remains present within these management areas, and as reported in 2015, areas occupied by the main resident populations continue to shift over time. Koala activity at these field sites is slightly higher overall than that reported in 2015, with one additional site returning significant activity (adjacent Pottsville Beach Public School) and one additional low use site. Two adjacent sites indicate an area of significant activity adjacent to and north west of the urban area.

The results of the current study should be interpreted with regard to the results of more detailed survey work that is done within the Koala Beach IKPoM area on a regular basis. These surveys are currently underway.

Pottsville KAP, Black Rocks KAP, Black Rocks IKPoM

A large and contiguous resident population continues to persist in the Pottsville KAP, associated with habitat in the Pottsville Wetland. Two low-use sites within Pottsville Environment Park suggest that connectivity is likely to be present between the Pottsville Wetland and Pottsville Environment Park. One previously low-use site in the centre of the wetland showed no evidence of koala activity during this study however the majority of the sites in these southern precincts remain active. Activity has increased from occasional to frequent at two sites in the southern wetland. Resident koalas continue to occupy habitat adjacent to Pottsville Waters urban area, along the Kellehers Road reserve and adjacent to the Black Rocks sports field and appear to remain well connected to the northern wetland.

Records of koalas including breeding females continue to be reported to from the vicinity of the wetlands, rural properties to the west of the wetlands, Pottsville Waters residential area and habitat surrounding the Black Rocks sports field.

Dunloe Park KLP

No survey data is available for the majority of the southern portion of Black Rocks KAP and the Dunloe Park KLP. It is known that koalas occur within these areas, however the status of koalas in those management precincts thus remains largely unknown.

Wooyung KAP

No koala activity was recorded at either of the two field sites within the Wooyung KAP, however some evidence of koalas was detected approximately 350 m west of the southern-most site in the KAP. One site adjacent to and south west of the Wooyung KAP returned significant koala activity, where none had been recorded in the previous two studies. Occasional koala sightings are reported from the area.

Future prognosis

The results from this study are reason for cautious optimism for the future of the Tweed Coast koala population. Some expansion of resident populations in the northern portions of the study and the increased use of habitat between these populations may be an early indicator of recovery.

Evidence of breeding females throughout the study area, continued regular sightings of healthy koalas and the relative stability of the koala population in the Pottsville and Black Rocks area are all encouraging indicators of the population's potential for persistence and recovery. In the eight years since the Habitat Study, progress has continued on the restoration and creation of koala habitat, which aims to provide habitat of sufficient area and quality available for population expansion in the longer term. Monitoring of koala habitat plantings done under the KPoM have recorded koalas using at least two thirds of the new habitat, and that a substantial proportion is utilised to some degree by koalas within 2.5 years of planting. Evidence of koalas continuing to use older plantings suggests that in the long term populations will benefit from this new habitat where it is located appropriately.

Despite the above, there remains a real possibility that the Tweed Coast koala population will decline to extinction within the next few decades. The population remains small and fragmented, and subject to ongoing threats, and thus the situation remains severe. This study is only the third in the long-term monitoring program, and observation of ongoing positive change in distribution and activity over many monitoring events will be required to conclude with certainty that recovery is occurring.

Limitations

Access

Access to privately-owned land to carry out survey work was the largest limitation to data collection during this study. This will continue to be the case, and the sites to which access is granted will vary between sampling events. Whilst not ideal, this does not affect the overall interpretation of the results of the study, and its influence is limited to a small proportion of the study area. Nevertheless, knowledge gaps continue to exist in areas where access to privately owned land was not provided, thus it is not possible to determine the status of koala populations in the western portion of the Round Mountain KAP and parts of Black Rocks KAP and Dunloe Park KLP.

Population size

Whilst population size is a measure that is easily understood and communicated, for very small populations, the sample size and survey effort required to provide statistically robust data becomes prohibitively large and uneconomical on an ongoing basis. Rather than draw conclusions from insufficient data, or expend unnecessarily substantial resources this study has not attempted to provide an estimate of population size. The other measures described herein provide more detailed, statistically robust and site-specific detail on trends in the population.

Technology is emerging that is showing promise for determining population abundance estimates. As directed by the KPoM, Council is continuing to partner with research institutions to take advantage of any developments in this area that aim to improve the efficiency and accuracy of population surveys.

Recommendations

The Tweed Coast KPoM provides a comprehensive set of management actions for addressing the key threats and encouraging population recovery in the short- and long-term. It is not yet possible to determine which of these actions are demonstrating greatest effectiveness, and as stated in the plan, koala recovery will require a multi-disciplinary and long-term approach. In general, it is recommended that the implementation of the KPoM continues, and that it is acknowledged as appropriately responsive to the status of the population. The following specific recommendations are offered in conjunction with the ongoing implementation of the KPOM actions:

- It remains important that connectivity is improved within the Koala Linkage Precincts, with particular attention to ensuring that development outcomes in these areas meet the objectives of the Tweed Coast KPoM in order to provide for future individual movement and population expansion.
- In the short to medium term, it remains vital to continue implementing the key actions of the KPoM, working to reduce the key threats of vehicle strike, wildfire and dog attack on the population. It should be recognised that the success of these actions requires behavioural change from the broader community.

- Implement the Tweed Coast Koala Fire Management Plan to reduce the level of risk associated with high intensity wildfire through delivery of hazard reduction burns in accordance with the HR burn guidelines for koala habitat on the Tweed Coast.
- Work should continue on Council-managed and privately-owned land to maintain and build upon the success of ongoing habitat creation and restoration efforts to improve the quality and amount of suitable habitat that is available for expansion and eventual support of a viable population in the long term.
- In implementing the plan, Council should remain open to considering novel and emerging management approaches should they arise, including exploring the utility of new and emerging technologies for improving the efficiency and accuracy of population abundance estimates.
- It is recommended that monitoring of distribution and occupancy of koala populations continues, using methods consistent with those described in this report. The monitoring program should also respond to opportunities to obtain further insights including examination of available remote camera monitoring and fire history data.
- Continue and expand on existing work to collaborate at a regional scale and cross-border, where applicable, on education, engagement, research, conservation planning and regional population recovery actions.

Acknowledgements

Council would like to thank those Tweed Coast landholders who kindly provided access to their property for survey work, and National Parks and Wildlife Service for consent to work on Nature Reserve. Assistance with field work was also provided by Dave Norris and Adam McArthur.

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Appendix 1 – Location and koala activity at field sites

Site	Activity level			Location	
	2010	2015	2018	Easting	Northing
TC002	0	-	-	550771	6850008
TC003	0	0	33.3	551997	6849959
TC004	0	0	0	553180	6850031
TC005	0	-	-	549408	6851181
TC006	0	-	-	550922	6851114
TC008	0	0	0	553297	6851232
TC011	0	-	-	551965	6852451
TC018	0	-	-	554404	6853657
TC031	3.85	16.7	36.7	554652	6857428
TC032	0	-	-	552246	6858375
TC034	76.9	96.7	90.0	554392	6858397
TC038	23.3	70.0	-	554444	6859369
TC043	10.7	16.7	3.33	554412	6860912
TC044	0	10.0	43.3	555555	6860873
TC046	0	-	-	551892	6861895
TC048	0	10.0	30.0	554387	6862076
TC049	0	0	0	555607	6862027
TC051	0	-	-	552296	6863105
TC052	23.3	-	-	553169	6863328
TC053	0	0	6.67	554412	6863330
TC054	0	-	-	555591	6863358
TC056	3.57	-	-	551721	6864674
TC057	58.8	-	26.7	553269	6864386
TC058	23.3	0	13.3	554403	6864461
TC059	0	-	-	555598	6864435
TC062	0	0	0	553266	6865666
TC063	0	6.67	13.3	554373	6865619
TC067	16.7	3.33	16.7	553198	6866899
TC069	0	-	-	555607	6866866
TC071	0	-	-	552025	6868084
TC072	23.3	10.0	3.33	553241	6868029
TC073	47.6	23.3	23.3	554483	6867990
TC074	0	-	-	555609	6868019
TC075	86.7	0	-	550951	6869402
TC077	0	-	-	553191	6869250
TC078	0	0	0	554526	6869200
TC079	0	0	0	555558	6869270
TC080	0	-	-	550818	6870439
TC081	0	-	-	551980	6870413
TC082	0	-	-	553090	6870509
TC083	10.0	6.67	33.3	554509	6870428
TC084	0	0	0	555756	6870330

Site	Activity level			Location	
	2010	2015	2018	Easting	Northing
TC086	13.8	-	0	551833	6871681
TC094	0	-	-	555951	6873301
TC095	0	-	-	556723	6872818
TC106	0	-	-	554354	6875149
TC107	0	-	-	555473	6875453
TC110	3.85	-	-	548422	6876436
TC115	0	-	-	554413	6876332
TC116	0	-	-	555611	6876500
TC117	0	-	-	546035	6877605
TC118	0	-	-	547458	6877415
TC120	0	-	-	549661	6877418
TC121	0	-	-	550833	6877532
TC125	0	-	-	555362	6877664
TC129	0	-	-	548419	6878838
TC130	0	-	-	550774	6878748
TC134	0	-	-	555507	6878860
TC135	0	-	-	545993	6879979
TC136	0	-	-	547348	6880075
TC137	0	-	-	548877	6880339
TC139	0	-	-	550283	6879366
TC140	0	-	-	551975	6880047
TC142	0	-	-	554390	6880023
TC143	0	-	-	555603	6880090
TC144	0	-	-	545853	6881236
TC145	0	-	-	546978	6881286
TC146	0	-	-	548382	6881279
TC148	0	-	-	550705	6881131
TC149	0	-	-	551888	6881244
TC150	0	-	-	553178	6881237
TC151	20.0	-	-	554345	6881090
TC153	0	-	-	545990	6882616
TC155	0	-	-	548645	6882309
TC156	0	-	-	549665	6882094
TC157	0	-	-	550853	6882462
TC159	0	-	-	553110	6882275
TC160	0	-	-	554399	6882352
TC162	0	-	-	546014	6883638
TC163	0	-	-	547310	6883718
TC164	0	-	-	548468	6883953
TC165	3.57	-	-	549459	6883544
TC169	0	-	-	554374	6883581
TC171	0	-	-	547185	6884919
TC172	0	-	-	548383	6884813
TC201	50.0	63.3	66.7	553769	6857884
TC202	3.85	43.3	20.0	554391	6857864

Site	Activity level			Location	
	2010	2015	2018	Easting	Northing
TC204	90.9	80.0	76.7	554402	6859079
TC205	14.3	0	-	553376	6862730
TC206	11.1	0	-	553785	6863208
TC207	10.0	-	-	552705	6863907
TC208	23.3	-	-	553198	6863880
TC209	29.0	3.33	-	553775	6863936
TC210	27.6	3.33	6.67	554431	6863820
TC211	0	0	3.33	554883	6863820
TC212	11.1	-	-	552538	6864489
TC214	0	3.33	3.33	554989	6864439
TC216	25.0	0	13.3	554017	6864984
TC217	55.0	6.67	41.9	554308	6865054
TC218	17.2	0	3.33	554985	6865041
TC219	19.3	0	3.33	552623	6867406
TC220	23.3	0	6.66	553143	6867400
TC221	70.6	38.7	30.0	553806	6867478
TC223	9.68	0	10.0	553313	6868632
TC224	0	-	-	555002	6868615
TC225	48.0	20.0	20.0	554514	6868457
TC300	50.0	26.7	36.7	554996	6871038
TC301	40.7	33.3	58.6	554981	6870413
TC302	0	20.0	0	555018	6869832
TC303	45.8	40.0	43.3	555578	6869991
TC304	0	-	-	553875	6869353
TC305	50.0	13.3	10.0	554999	6869231
TC306	0	-	-	555603	6868613
TC307	0	0	0	553736	6866571
TC308	20.0	0	3.33	553236	6866030
TC309	91.7	10.0	16.6	553778	6866219
TC310	58.8	6.67	13.3	553663	6865792
TC311	26.6	30.0	33.3	554937	6865627
TC312	28.1	20.0	3.33	554976	6863223
TC313	26.7	13.3	0	554400	6862657
TC314	43.5	6.67	16.7	555002	6862638
TC315	58.3	0	0	555573	6862686
TC316	0	-	-	553815	6862039
TC317	7.40	33.3	0	554985	6861992
TC318	0	-	-	553801	6861444
TC319	0	-	-	554993	6861521
TC320	20.0	0	6.67	555568	6861427
TC321	27.6	36.7	13.3	555017	6860920
TC323	0	0	6.67	555001	6860248
TC324	22.6	10.0	16.7	554992	6859663
TC325	83.3	73.3	66.7	553188	6858049
TC326	7.40	10.0	19.3	553833	6857261

Site	Activity level			Location	
	2010	2015	2018	Easting	Northing
TC327	7.40	-	-	553806	6856627
TC328	100	70.0	46.7	554442	6856686
TC1501	-	0	0	555612	6871034
TC1502	-	0	20.0	553803	6869992
TC1503	-	0	0	551906	6869260
TC1505	-	13.3	0	552693	6865645
TC1508	-	0	0	553799	6864439
TC1509	-	6.67	36.7	554498	6861562
TC1510	-	43.3	33.3	553804	6859044
TC1511	-	53.3	66.7	554993	6859105
TC1512	-	20.0	0	553867	6858426
TC1514	-	36.7	50.0	554384	6857217
TC1517	-	61.3	56.7	555352	6866366
TC1507	-	0	40.0	553407	6865044

Note:

Datum: GDA.

- indicates site not sampled.