University of the Sunshine Coast Eastern grey kangaroo investigation
Summary of findings and management recommendations

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Executive Summary

This report provides a summary of research conducted into the conservation status of the Eastern grey kangaroo (*Macropus giganteus*) population at the University of the Sunshine Coast’s (USC) Sippy Downs campus. Repeat transect-based census since 2010 demonstrate that the kangaroo population inhabiting the USC campus are consistently with pouch young and/or joeys at heel, and that the population is in good health. At the same time, the population has declined from an estimated 90 kangaroos in 2010 to 27 adult kangaroos at the beginning of the study period in July 2014. This represents an average decline of 24% per year over the four-year period prior to this research commencing.

During the study period (July 2014 – October 2015) this decline has continued to the present; over the past 16 months we have witnessed a further decline of 30% and the population is now at 19 adult kangaroos as at 1st November 2015. Over this same period, there have been 15 reported deaths from within this population; vehicle strikes represent 10 of the 15 fatalities and wild dogs account for one. It is likely that those kangaroos which were reported as ‘drowned’ and other unaccounted mortality of joeys, was a result of dog activity; however this was not substantiated during the study. Fifty percent of road-based fatalities occurred on roads on the USC campus.

Given that many kangaroo deaths are not reported, it is evident that currently mortality rates are unsustainably high and outstrip maximum possible birth rates. This is supported by the steep decline observed in the past five years. If we are unable to manage the sources of kangaroo mortality and the death rate continues at its current rate, the extirpation of the Sippy Downs kangaroos is likely within 5 years.

Analysis of kangaroo habitat use and movement patterns on the USC campus has revealed areas of greatest risk to kangaroos. This potentially allows us to mitigate those risks on and off campus. Risk mitigation strategies include;

- installation of vehicle speed mitigation measures,
- kangaroo habitat retention and active habitat management,
- fencing assessment and modification,
- external stakeholder engagement,
- implementation of a targeted public awareness campaign.

There are many factors to be considered to ensure long-term persistence of kangaroos on the USC campus however if the rates of death are not significantly reduced in the short-term, long-term planning measures will have no meaning. Reducing rates of road kill on and off campus has been identified as the immediate priority for a sustainable kangaroo management strategy. Protection and maintenance of kangaroo habitat on campus should also be a priority. It is likely that a strategic plan with multiple risk mitigation measures involving multiple stakeholders will be needed in order to secure the USC kangaroo population for the future.
Introduction

This report has been prepared to summarise the findings of a research study conducted in 2014 and 2015 in response to concerns about the conservation status of the Eastern grey kangaroo (*Macropus giganteus*) population on the University of the Sunshine Coast’s (USC) Sippy Downs campus. The USC campus and surrounding areas have undergone significant development and growth in the previous decade (ABS 2015). This development has led to an increase in vehicle traffic and built infrastructure and a decrease in potential kangaroo habitat on and off campus. Research to date has incorporated GPS collaring, on foot monitoring, incidental kangaroo behavioural and occurrence observations and collation of records of kangaroo occurrence, injuries and mortalities. This allowed for a comprehensive assessment of the spatial ecology, habitat requirements, and conservation status and risk exposure of the kangaroo population at the USC campus.

Key threatening processes and potential management strategies to mitigate these risks have been identified and are presented in this report. The knowledge of habitat use and movement through the urban landscape gained from this research has allowed for the development of site-specific mitigation strategies with an aim to achieving recovery and future conservation of the kangaroo population on the campus.

This research was conducted by as part of a Master of Science project and the results of this investigation are outlined in this report. This research is ongoing on the USC kangaroo population as well as other Eastern grey kangaroo populations forming the basis of a Doctor of Philosophy. It is anticipated that the ongoing research on patterns of decline and abundance and stress levels in urban kangaroos throughout South East Queensland (SEQ) and the Australian Capital Territory (ACT) will provide further insight into appropriate conservation strategies for at risk urban macropod populations, in particular the kangaroo populations on the USC Sippy Down’s campus.
Methods

In August 2014, five kangaroos on the USC campus were fitted with GPS collars programmed to take fixes every two hours over a period of sixty days. Kangaroo locations were overlayed on a digitised map of habitat types on the USC campus and surrounds using ARC GIS (ESRI 2013). Home range estimates were calculated for each collared kangaroo and these data were analysed for habitat selection using a Goodness of fit test using SPSS (version 22.0) statistics package. All analyses were run for individual kangaroos and at both a second and third order of habitat selection (Johnson 1980). To analyse second order selection, the number of fixes in each digitised habitat category was compared to the expected number of fixes with respect to the proportion of each habitat type over the whole study site. All kangaroos were assumed to have the same amount and proportion of habitat available to them at this level of selection. To analyse third order selection, the expected number of fixes was calculated as the proportion of each habitat category within the home range of each kangaroo multiplied by the total number of fixes for that kangaroo. Only habitat categories that were included in the kangaroo’s home range were included in these analyses. The home ranges for each kangaroo were estimated using a 95 and 100 % Minimum Convex Polygon using R Adehabitat HR (Calenge 2006). The 100%MCP was used for analysis of habitat selection. GPS data were also analysed for exposure to risks, including roads and built-up areas.

To augment the GPS collaring data, on foot surveys of kangaroo numbers and distribution were undertaken on the USC Sippy Downs campus, to count and identify gender, reproductive condition and habitat context of all kangaroos seen. These surveys were undertaken with the same methodology used in annual population surveys that have been part of USC undergraduate teaching courses since 2010. This involved groups of volunteers walking three transects over the entire university and study area west to east between 5:30am and 7:30am. These surveys were undertaken at six to eight week intervals for thirty-eight survey days.

Incidental data on kangaroo movements and exposure to risks on the campus have been collected opportunistically throughout the study. Known deaths and injuries of kangaroos in and around the study area have been documented and cause of death recorded. These records were collected from a number of sources including Australia Zoo Wildlife Hospital records, USC security logs, staff and community reports, and personal sightings. A photographic identification guide was developed for twelve of the kangaroos on campus and this guide is now being updated with the aim to encompass all of the resident kangaroos.
Results

The total number of adult kangaroos on campus during annual population monitoring decreased by 77% since 2010 (Figure 1). Regular surveys conducted during the study period between July 2014 and November 2015 showed a continued decline. Between August 2014 and January 2015, adult kangaroo numbers decreased to 13, with a slow increase to the current adult count of 19 on 1st November 2015 (Figures 2 & 3). This recent increase coincided with both the mating season and the clearing of remnant eucalypt forest on Sippy Downs drive that was known to be habitat for at least one other mob of kangaroos as well the population that is present in Sienna College.

The population currently hosts 13 breeding aged females, each with the maximum capacity, under favourable environmental conditions with no mortality nor variable age structured fecundity, to have 1 or 2 joeys recruited into the population each year (Caughley et al. 1984, Dawson 2012). The observed joey survival rate at Sippy Downs is no more than 50% however, the exact rate and causes of death were not able to be determined during the study.

Fifteen deaths of kangaroos were documented on campus and the surrounding roads during the study period, with the majority of deaths being caused by kangaroo-vehicle collisions (Figure 4). Three of the five kangaroos that were collared are now deceased. Photo identification of individual kangaroos on campus has demonstrated little evidence of significant immigration into the population aside from the instance of major clearing on Sippy Downs drive in September 2015. Assessment of the available habitat surrounding the campus shows that there is only one significant vegetation corridor that links with the campus (Mooloolah River National Park) and planned construction and infrastructure development around the university will further limit connectivity.
Figure 1. Maximum counts of adult kangaroos observed in annual population monitoring at USC campus from 2010 to 2015.

Figure 2. Number of adult kangaroos present during population monitoring surveys at USC from August 2014 to November 2015.
Figure 3. Maximum counts for each reproductive category for kangaroos present at population monitoring at USC from August 2014 to November 2015.

Figure 4. Proportions of causes of kangaroo mortality documented from July 2014 to November 2015.
Habitat use and requirements

The kangaroos observed are members of three mobs that utilise the campus and surrounding areas in different ways:

- **Mob 1** is the resident mob present on campus most of the time. These animals are located in the areas adjacent to campus buildings and across to the Sports stadium and Chancellor College, also utilising remaining habitat across Sippy Downs drive.
- **Mob 2** is a mob that is resident primarily on the Sienna and Chancellor Primary school grounds, but which also forages on the southwestern edge of the USC campus and travel across Sippy Downs drive into areas that are currently being cleared for housing development.
- **Mob 3** is a mob that utilise the eastern edge of the campus around the sporting fields and areas around the Sippy Downs police station and into the national park and who use the wildlife underpass and cross Claymore Road and Sippy Downs drive regularly.

There are also up to four transient males that pass through the campus but are not consistently present. The sole male kangaroo that we collared who is now deceased (a member of Mob 1) roamed over an area of 125.7 ha (95% MCP) and appeared to travel between Mob 1 and Mob 2 as well as venturing further afield. His home range did not significantly overlap with Mob 3. In contrast the home ranges of the three collared females belonging to Mob 1 and 2 were much smaller 15.75ha, 27.78ha, 28.26ha respectively (95%MCP). Figure 5 shows the locations of kangaroos across the USC campus and surrounding areas that were determined from GPS logs and visual surveys.

Habitat selection

All kangaroos showed significant habitat selection at the second and third order (Table 1) (Chi square goodness of fit, p < .001) however, no kangaroos selected for habitat in exactly the same way. Three kangaroos showed a strong preference for watered, fertilised and mowed lawn areas within the university and school grounds. Two of the four tracked kangaroos showed a preference for areas of open eucalypt forest across the study site, while two showed a preference for Melaleuca woodlands. Three kangaroos showed a preference against or no preference for or against any of the USC sporting ovals. Kangaroo 1 showed a strong preference for the Sienna sports oval but no preference for or against lawns. Most kangaroos exhibited either preference against or no preference either way for grass areas that were not maintained, with the exception of the male kangaroo which showed a preference for areas of dry grass that were not maintained.
All kangaroos showed strong selection against grass that was mown but unwatered, heathland (including the translocated areas), roads and areas of anthropogenic disturbance such as construction areas.

Table 1. Habitat preferences at the third order of selection (within their home range) for four collared kangaroos. (+ indicates strong selection, 0 indicates no significant selection, - indicates selection against habitat type).

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>Kangaroo 1</th>
<th>Kangaroo 2</th>
<th>Kangaroo 3</th>
<th>Kangaroo 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banksia Woodland</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>-</td>
</tr>
<tr>
<td>Carpark</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Disturbed Anthro</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Drainage Line</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Garden</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Grass lawn, watered</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Grass maintained (mowed only)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Grass, not maintained, dry</td>
<td>na</td>
<td>0</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Grass, not maintained, wet</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Heathland</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Melaleuca Swamp</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>New planting</td>
<td>na</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Open Eucalypt</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Paved</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Road</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>Sports Oval</td>
<td>+</td>
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</tbody>
</table>
Figure 5. Aerial map of USC Sippy Downs campus and surrounds showing recorded kangaroo locations from August 2014 to November 2015.
Risk exposure

Roads
GPS track-logs and opportunistic observations reveal that kangaroos cross Sippy Downs Drive and Claymore Road at all times of day. This tracking also shows that forest and grassland across from USC on Sippy Downs Drive formed an important part of the kangaroo’s habitat during the collaring period. The majority of this habitat is now unavailable due to construction or due to be cleared in the near future. This is a historical movement corridor (Boosamra 2007) for the kangaroos that would have integrated with Buderim populations via this route before the recent housing and infrastructure developments. It may take some time for the kangaroos to adapt and discontinue crossing the road. While there continues to be habitat available, it is likely that the kangaroos will still attempt to access it, even at increasing risk of injury or death.

During the study period, 50% of road kills recorded have occurred on campus, 30% on the Sunshine Motorway on and off ramps and 20% on Sippy Downs Drive, with no kangaroos reported killed on Claymore Road. In previous periods (between 2010 and 2013), there were higher rates of kangaroo-vehicle collisions on Sippy Downs Drive. GPS collaring and on foot monitoring data suggest there are some crossing “hotspots” i.e. areas where kangaroos are known to cross the road regularly and/or where kangaroos have been hit by cars on and off campus (Figure 6).

Dogs
The presence of dogs on campus is also a risk for the kangaroos, in particular joeys, and this is mostly evident on the eastern side of the campus around the sports field and lakes. There is evidence of dingos and wild dogs on campus however, the presence of domestic dogs is more prevalent and therefore may pose more of a risk for the kangaroos. This information has been gleaned from reports of domestic dogs chasing down and injuring kangaroos and from observations of dogs being walked on campus on a regular basis, particularly on weekends. On one afternoon, four separate incidents of dogs being walked on campus were noted. Dogs pose a risk both from a predation point of view but also as potential stressor for kangaroos who may seek to avoid areas where there is evidence of predators such as dogs. This may be one of the reasons that all of the collared kangaroos avoided the southeastern corner of the campus where both wild and domestic dogs frequent.
Ongoing and future research focus

In order to explore broader patterns of decline in urban Eastern grey kangaroo populations, historic occurrence and injury records have been collected to map the distribution of Eastern grey kangaroos in SEQ. These records have been sourced from wildlife rescue organisations, government agencies, online wildlife databases and community groups. Citizens have been engaged via an online survey, which was designed to supplement the insufficient amount of historical and current occurrence data available on Eastern grey kangaroos. The survey and the research project have been widely advertised through local government, natural resource and wildlife networks and local media via the project website and Facebook page.

Funding has been secured from Sunshine Coast Council to explore stress as a potential cause of decline in urban kangaroo populations. This will involve comparing mean faecal cortisol levels across twenty-four sites in SEQ and ACT, including the Sippy Downs population. This work will also allow for comparison of successful urban populations in ACT to less secure populations SEQ. It is expected that further insights will be gained to apply to urban kangaroo conservation and management in SEQ, and more specifically, on the USC campus at Sippy Downs.

As kangaroo populations become more reliant on urban landscapes there is growing need for research to examine kangaroo interactions with urban environments and the threats that these populations face. This research will provide much needed baseline data to allow for conservation planning for kangaroos in urban landscapes across SEQ and may act as a model for urban species conservation. As is often the case for species with large historical geographical ranges e.g. koala and emu, while local populations may be threatened there is little official recognition of a threat to the species. Despite being iconic, there is currently insufficient data on Eastern grey kangaroo distribution and conservation status in SEQ.
Implications for management

Research to date indicates that in order to conserve the USC kangaroo population risk mitigation strategies need to be considered and implemented with haste. While current and future research will provide further insight into strategies for ensuring the long-term persistence of kangaroos in the region, the long-term success of the population is dependent upon effective short-term risk mitigation. It is likely that a strategic plan with multiple risk mitigation measures and future conservation strategies will be needed in order to secure the USC kangaroo population.

The suggested objectives for kangaroo management on campus are outlined below:

Short-term management objectives (2016):
1. Reduce and minimise the rates of car related deaths on Sippy Downs Drive, Claymore Road and USC campus by at least 50%.
2. Reduce the presence of unauthorised dogs on campus.
3. Reduce the impact of construction for the Sippy Downs town centre on kangaroo habitats and kangaroo road crossing capability.

Long-term management objectives (2016-2026):
1. Maintain and increase optimal kangaroo habitat on campus with appropriate shelter and offset loss of kangaroo habitat.
2. Maintain corridors on campus for kangaroo movement.
3. Minimise impacts of university activities on kangaroo habitat and populations.
4. Minimise impacts of future development on campus on kangaroo habitat and populations.
5. Minimise impacts of future development on Sippy Downs Drive on kangaroo habitat and populations.
6. Minimise impacts of increased traffic that will occur along Claymore Road because of the future Palmview development.
Short-term Management Options

Short-term management recommendations are outlined in Table 2 (See Appendix) and are discussed in detail below.

Objective 1.

Reduce and minimise the rates of car related deaths on Sippy Downs drive and Claymore Rd and USC campus by 50%.

Road mitigation considerations for macropods

There is a growing field of literature on the impacts of roads on macropods in Australia and these impacts may vary from the obvious, such as a reduction in survival and population growth, as seen in Tammar wallaby populations (Chambers and Bencini 2010), to the less intuitive such as changes in population demography of Eastern grey kangaroos due to male biased road fatalities (Coulson 1997). The impact of roads can also act as a compounding factor on already stressed populations and may lead to localised extinctions (Ben-Ami et al. 2006). Recent research into interactions between macropods and roads suggests that most macropods are critically affected by roads (Bond and Jones 2014). The potential impact of roads on macropod abundance and population demography is supported by research on Eastern grey kangaroos in a suburban landscape in Victoria (Coulson et al. 2014).

There is a small pool of literature addressing the efficacy of road kill mitigation strategies for macropods in Australia. Studies on odour (Ramp et al. 2005) and sound deterrents (Bender 2003, Sarah et al. 2006) and wildlife warning reflectors (Ramp and Croft 2006) have to date shown them to be ineffective however much more research and development in this area is needed before the effectiveness of these methods can be properly assessed.

The most commonly used method of road kill mitigation is wildlife warning signs however their effectiveness often comes under question and is likely to be site and species specific. Some studies have shown a significant reduction in large mammal vehicle collisions while others have found no observed benefit from introduction of signs (Huijser et al. 2015). It is widely accepted that warning signs on their own may be limited in their efficacy in reducing wildlife vehicle collisions and are best used in conjunction with other collision mitigation methods (Glista et al. 2009).

The development and implementation of vehicle and animal detection systems have proven to be effective in mitigating road kill of large mammals across the world (Huijser et al. 2015). It is doubtful however that these types of systems would be worthwhile implementing in Sippy Downs. The majority of key areas where kangaroos are moving are also spaces where pedestrians, bicycles or other vehicles travel and this is likely to lead to many false signals being triggered. Many studies have shown that a large number of false alarms will significantly reduce the effectiveness of the device (Bond and Jones 2013, Huijser et al. 2015). A detection system that could differentiate between kangaroo and human or vehicle motion would be ideal however these are not currently available. The use of wildlife
underpasses or overpasses combined with wildlife exclusion fencing are an effective way of reducing and avoiding kangaroo-vehicle collisions however the scope to implement these further at the Sippy Downs site is also limited.

Road kill mitigation considerations for USC

The broad aim of management should be to keep kangaroos off roads where possible to limit the risk of kangaroo-vehicle collisions. This should be done while allowing for permeability of the habitat to allow for kangaroo movement and genetic exchange with other kangaroo populations. The characteristics of the USC site present some constraints on ideal road kill mitigation. Development around the university is set to increase in the coming years so consideration needs to be given to future infrastructure around the university. Both the period of construction as well as the characteristics of the completed developments will affect the habitat and movements of kangaroo populations in Sippy Downs. It would be highly beneficial for USC to work with Sunshine Coast Council planning and development staff to identify the key elements of all proposed developments adjacent to the university. This will allow for assessment of the likely nature of impacts on wildlife in Sippy Downs and will enhance the effectiveness of any mitigation. The future growth of the university, particularly future infrastructure and increased traffic, will also affect kangaroo populations. Mitigation strategies will need to be implemented in alignment with the university’s strategic plan.

Road crossing hot spots identified from this research (Figure 6) represent key areas to focus risk mitigation strategies. The development of the nearby Sippy Downs town centre and Palmview estate will result in increased traffic volumes posing a higher risk of kangaroo-vehicle collisions (Kloeden et al 1997). Incomplete fencing along the national park and non-maintenance of one underpass under Claymore road are also contributing factors to the risk of kangaroo death or injury. Injury on roads is the biggest off-site risk to the kangaroo population and the best short-term option would be to target mitigation at these “hot spots”. Similar targeted mitigation has proved to be effective for deer (Found and Boyce 2011) in urban areas.

On campus roads

Since 50% of kangaroo deaths have occurred on campus, one potential strategy would be to adopt a “No kangaroo-vehicle collisions at USC” policy, as USC has a direct influence to implement risk mitigation on campus. Reduction of vehicle speed dramatically decreases the risk of wildlife vehicle collisions (Kloeden et al 1997). There are several key areas on campus where kangaroos are regularly crossing roads (Figure 6, Appendix). Speed signs were installed on the western side of the ring road in mid-2015 however, cars and buses continue to exceed the 25 km/hr speed limit. It is recommended that a form of traffic calming device be put in one location as indicated in Figure 7 (Appendix). As the road is
frequented by buses and other heavy vehicles, is it likely that a speed bump may be the most effective type of device.

The introduction of kangaroo road signage on campus is essential, particularly as student and visitor numbers are expected to increase annually in the coming decade. Entrance signs could be placed at each vehicle entry to the university that could be multi-purpose by reinforcing the speed limit and kangaroo road awareness and the rules of no domestic animals, not approaching animals, etc. They could also serve to advertise USC’s commitment to being a sustainable campus and a wildlife refuge. The ideal locations of these signs are indicated on Figure 7 (Appendix).

Smaller signs adjacent to the crossing areas could be simpler with the primary aim to raise driver awareness of kangaroos crossing in identified “hot spot” areas (Figure 7). While many standard wildlife warning signs exist, research has shown that interactive signs are likely to be more effective (Huijser et al. 2015). In addition, signs that are location or time specific are also known to be more effective, as are signs that report the number of animals killed or identify the area as a high-risk area (Bond and Jones 2013). By placing targeted road crossing, signs to at known kangaroo crossing “hotspots” drivers are more likely to drive appropriately in those areas. Signs that are informed by our knowledge of kangaroo’s on campus and the attitudes of those that frequent campus are likely to be effective in reducing kangaroo-vehicle collisions on campus. Some examples of potential signs for use are shown in the Appendix (Figures 8-13).

Community Awareness

Community awareness can also play a role in reducing road kill by increasing the effectiveness of other speed mitigation measures using a targeted community awareness campaign (Huijser et al. 2015). This is considered a favourable option for the university as it serves the dual purpose of reducing road kill of kangaroos as well as advertising the university’s commitment to sustainability and increasing engagement with the wider community. A broader discussion of potential community awareness strategies appears below (Page12).

Off campus roads

There is potential to reduce kangaroo-vehicle collisions around USC by making fewer areas where kangaroos are able to cross the roads and making these crossing areas safer. A reduction in collisions could be achieved by using strategic fencing combined with interactive warning signs and traffic calming based on the current knowledge of kangaroo movements identified from GPS and observational data and the current available habitat. This type of risk mitigation would require multiple stakeholder participation, including Sunshine Coast Council and the Queensland Department of Parks and Wildlife and potentially local developers. Consideration would need to be given to future development
surrounding the university and it is likely that the placement of warning signs may need to be reviewed upon completion of the Sippy Downs Town Centre.

**Objective 2. Reduce the presence of unauthorised dogs on campus.**

The Sippy Down’s campus is currently listed as a Wildlife Refuge and therefore no dogs, other than service dogs, are permitted on site. The persistence of dogs on campus despite these rules suggests that management of this risk should focus on education within USC and in the broader community along with enforcement of these rules. As there is no evidence of persistent and habitual hunting of kangaroos by dingoes or wild dogs, strategies that focus on ensuring no domestic dogs are on campus are likely to significantly reduce this risk.

**Education**

Signage can once again form an important part of education, particularly for those outside of the university community, who are unlikely to be aware of the restrictions imposed on domestic animals on campus. As the presence of domestic dogs on campus is a common occurrence there is potential to use the entrance signs discussed above to reinforce the ‘no dog’ rule. However, the placement of dog specific signage at pedestrian entrance points on the southern and eastern sides of the campus is also necessary to educate and discourage members of the public from using the campus as a dog exercise area as this is more commonly how they are accessing the site (Figure 7).

**Security Patrols**

It has been noted that the incidences of dogs on campus increases outside of working hours, particularly on weekends, when there is less of a presence of staff on campus. The extension of security patrols to include the sporting fields and lakes would allow security officers to reinforce this policy.

**Canine Detection dogs**

It should be noted that there are plans to house canine detection dogs on campus and this has the potential to negatively affect the kangaroo population. The proposed location for this facility is adjacent to a significant movement corridor for kangaroos on the campus. All care should be taken to ensure that dog enclosures are well screened and that kangaroos do not avoid using this corridor and move onto the road instead due to the presence of predators. Any exercising or training of dogs on site is not recommended as this may cause kangaroos to avoid preferred habitat and corridors. As the dogs are well trained, the risk of injury may be lower than for other domestic dogs however, there is still a risk of flight causing injury, increased stress and displacement from habitat. It is also essential that the dogs are always wearing their jackets that identify them as service dogs as there is potential
for the presence of unidentified canine detection dogs to cause confusion about the University’s “No Dog” policy that may serve to undo any efforts of public education.

**Objective 3. Reduce the impact of construction on Sippy Downs drive.**

Kangaroo movements will be affected by construction in two significant ways: loss of habitat and obstruction of movement paths. The increase in heavy vehicle and trade vehicle traffic is also likely to increase risk of kangaroo-vehicle collisions however, this risk is addressed in the discussion of Objective 1 above. As kangaroos are displaced from habitat, they are more likely to travel further and more often in search of new habitat, meaning they are more likely to come into conflict with vehicles. Construction fencing that does not allow for kangaroo movement forces kangaroos to travel much longer distances along roads and roadsides, increasing the risk of vehicle animal collisions, which is a danger for both the kangaroos and for drivers.

There is potential to liaise with property developers to allow for kangaroo movement on the edges of and between construction sites. Sunshine Coast Council planning staff have indicated that they are able to facilitate discussions with developers and construction companies. The site that is to be the future headquarters for YOUI insurance company is currently an important movement corridor for the kangaroos. There is significant potential to work with YOUI to design kangaroo movement corridors between the Chancellor State College, the YOUI site and the university campus to retain a refuge and exit point from the road onto campus.

**Community education and engagement**

USC is in a unique position of having kangaroos as an icon for the university. The presence of kangaroos is a drawcard for international students and visitors from the community and there is significant support in the community for their conservation. As a result of this research, over fifty people have volunteered to help with kangaroo surveys and the status of the Sippy Downs kangaroos has been publicised through local and national media outlets with a strong response from the community.

This community support indicates that a well-designed community awareness campaign could play a key role in altering driver behaviour on campus and surrounding roads. It would also serve the dual purpose of advertising USC’s commitment as a sustainable university and maintaining and strengthening ties with the community. To date, discussions have been held with the Sippy Downs Community District Association, local councillor Christian Dickson and representatives from planning and environmental sections of the Sunshine Coast Council and Queensland Parks and Wildlife. The outcomes from these meetings indicate
that USC has support for conservation efforts in the Sippy Downs area from a variety of external sources.

The USC media team have designed a logo (Figure 15 in Appendix) which could be used as part of a targeted community awareness campaign to be implemented first within the university and in the community as well. It is recommended that a communication education program be implemented alongside other road kill mitigation methods. If the rate of road kill can be reduced and maintained by half of the current rate, there is a chance of short-term recovery of the kangaroo populations. If short-term outcomes are achieved, then the implementation of a long-term kangaroo management plan at USC will be well founded.

Long term management considerations

On campus management

Habitat Management

Broad long-term management objectives have been identified as a result of this research, however long term strategies will be better informed upon completion of the research project in 2017. The timing of this research however provides an opportunity to incorporate kangaroo habitat retention and management into the next Campus Master Plan. It is paramount that important habitat and movement corridors are protected and managed if kangaroos are to persist on the campus. The projected growth rate of the university will mean a further increase in infrastructure and vehicular traffic on campus. There is significant potential to retain and improve kangaroo habitat on campus alongside the projected growth but this will require official recognition of essential habitat in the university’s future strategic planning.

The analysis of habitat use on campus highlights key information to inform campus habitat management. It is evident that areas of grass that are well maintained and watered are optimal grazing for kangaroos. It also highlights the need for risk mitigation in areas where lawns are surrounded by roads i.e. front quadrangle of campus. Open Eucalypt forest is a significant source of this shelter, approximately 22% of which has now been cleared from the study area since the GPS study was carried out, with another 24% more expected to be cleared in the near future. The clearing of this forest is a loss of significant habitat for the kangaroos and the remaining stands of forest are likely to be of increasing importance to the population. Strategic plantings on campus may serve to offset some of this habitat loss.

Studies on habitat utilisation suggest that a mosaic of many types of habitat are optimum for eastern grey kangaroos and that they prefer edge habitats, with good quality forage nearby to patches of woodland for shelter (Hill 1981, McAlpine et al. 1999, Moore et al. 2002, Dawson 2012). In urban areas, these requirements are likely to hold true and at USC kangaroos have shown a preference for areas that are fertilised, watered and mowed with adjacent shelter. There is potential to develop designated ‘kangaroo habitat areas’ to
encourage kangaroos to areas where they are less likely to be at risk i.e. further away from roads. This would involve managing and maintaining lawn areas through waterering and fertilising as well as targeted revegetation and management of patches of appropriate shade trees and shelter throughout the campus. Good forage and shelter has been shown to be effective in encouraging kangaroos to use wildlife overpasses and underpasses and movement corridors (Bond and Jones 2008) and Eastern grey kangaroos have been documented as consistently choosing habitat with higher pasture quality (Taylor 1984). Several potential sites for ‘kangaroo habitat areas’ are indicated on Figure 14 in green (Appendix). These areas have been selected based on current kangaroo presence and movement patterns, distance to roads and from built areas however are not currently the areas most frequented by most of the kangaroos on campus. Consideration also needs to be given also to habitual movement patterns and to mob interactions. Several areas would need to be maintained at some distance from one another to allow them to be utilised by all of the mobs present. It is likely that Mobs 1 and 2 would continue to utilise their current habitats until these ‘kangaroo habitat areas’ were developed and there is no way of knowing how quickly kangaroos would adapt to the new available habitat, if at all. The mowing of areas adjacent to the Eastern Lake and growth of a previous planting has seen some kangaroos from Mob 3 utilising this area more in the last six months. This demonstrates that kangaroo habitat use on campus is adaptive to current conditions and this is supported by previous studies that suggest that habitat use is effected by habitat structure and pasture quality (Hill 1981, McAlpine et al. 1999, Moore et al. 2002). Figure 14 also illustrates the current major movement corridors on campus (shaded in red). The area highlighted in blue is an area of significant habitat for Mob 1, as demonstrated by the high use shown in Figure 5, and is classified as a campus wildlife reserve.

Translocated vegetation

All kangaroos were seen to actively avoid areas of heathland and the translocated habitat areas provide no significant habitat for kangaroos. Some kangaroos are seen to graze on the mowed fire breaks between translocated plots but none were seen to spend significant time in this area. The only time kangaroos have been seen to utilise these sites is following a prescribed burn.

It is noted that there is a proposal to place more translocated heath on the eastern side of the campus. For the kangaroos, this would represent a significant loss of habitat in the form of grassland and this area is also a movement corridor for the kangaroos at present and connects the campus to the Mooloolah National park via an underpass. The planned educational centre to be placed in this location is likely to affect kangaroos in the construction phase however it is likely that once the building was completed the kangaroos could again utilise this area. Any impediment of kangaroo movement through this area during the construction period would need to be actively managed. There is an opportunity to create a ‘kangaroo habitat area’ nearby this centre, which could be a key feature of the educational facility. The plantings associated with this would be more in line with the pre clearing ecosystem type in the area, which is currently listed as “Of concern”. Appropriate
canopy species to be planted would include *Eucalyptus latisinensis, Corymbia intermedia, Eucalyptus robusta, Lophostemon confertus, Corymbia intermedia, Corymbia gummifera, Eucalyptus latisinensis, Eucalyptus tindaliae* and *Melaleuca quinquenervia* (Queensland Herbarium 2015). There is significant conservation value in the reestablishment of the preclearing habitat type and this would serve not only to improve habitat for kangaroos but for other wildlife as well.

**USC as a Wildlife Refuge**

At present, one of the greatest risks to kangaroos is during their movements between the campus and adjacent habitat; however this risk is likely to decrease in the future if all or most of the potential habitat in the area is restricted to the campus or Mooloolah National Park. While the kangaroo’s behaviour and movement patterns are habitual it is anticipated that if all of the areas across Sippy Downs drive are replaced with residential and commercial buildings then the rates of movement across this road will decrease in the coming years. This outlines the importance of maintaining and developing optimal kangaroo habitat on campus to encourage kangaroos to use the campus as a complete habitat.

The current risks however are likely to remain until such a time that the planned developments are completed and will need to be managed until such time. In the future, the USC campus is likely to be the only area of significant habitat available to the kangaroos and therefore the habitats on campus are of conservation significance. The adjacent area of Mooloolah National park will act as the main source of potential genetic exchange with other populations in Palmview, Birtinya Wetlands and the eastern side of the National Park. Maintaining these connections is an integral step in sustaining healthy kangaroo populations in this area into the future.

**Off campus management**

Minimising the impacts of future development and increased traffic is likely to be best achieved by engaging external stakeholders including Sunshine Coast Council, developers and local schools to address kangaroo management issues. There is potential for significant stakeholder engagement on developing risk management strategies such as habitat retention, kangaroo movement corridors, strategic fencing and safer road crossings as part of a holistic kangaroo road mitigation plan for the Palmview and Sippy Downs areas. It is noted that a similar strategy was suggested in the Eastern grey kangaroo report prepared as part of the 2010-2016 campus master plan (Boosamra 2007).
Conclusions

The Eastern grey kangaroo population at USC’s Sippy Downs campus and in the broader Sippy Downs area is at risk of undergoing local extinction within five years. There is potential for recovery and conservation of the population if kangaroo-vehicle collisions on and around the university are significantly reduced.

While there are other risks and pressures on the kangaroos, including habitat loss, there are management strategies that can be employed to manage these risks and allow for recovery of the kangaroo population. If the road mortality rate is significantly reduced in the immediate future, it will allow for short-term kangaroo population recovery. Road kill mitigation strategies are required both on and off campus and should be implemented with haste.

The Sippy Downs campus currently has sufficient habitat and infrastructure to support a recovering kangaroo population and ensure the kangaroos continued presence on campus as an icon for the university and Sippy Downs community. Steps should be taken to secure this important habitat for future years as part of USC’s strategic plan. The USC campus will become increasingly important as a refuge for wildlife in an increasingly urbanised area. If strategically managed, it is possible that the kangaroo population at USC may continue to be both a drawcard for the university and a population of conservation significance that may allow kangaroos to persist in the wider region.
### Appendix

Table 2. Summary of Short-term management considerations showing the relationship between objectives, performance criteria, actions and potential contributors.

<table>
<thead>
<tr>
<th>Specific objective</th>
<th>Performance criteria</th>
<th>Action</th>
<th>Potential contributors</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short term</strong></td>
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<tr>
<td>1. To reduce and minimise the rates of car related deaths on Sippy Downs Drive, Claymore Road and USC campus by 50%.</td>
<td>1. Kangaroos are kept off roads where possible without populations being genetically isolated. No kangaroo-vehicle collisions on campus with low or no incidence rates occurring at crossing points off campus.</td>
<td>1. Traffic calming device (speed bumps would be most effective) installed at key kangaroo crossing points to stop vehicles exceeding 25km/hr speed limit.</td>
<td>USC</td>
<td>High</td>
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<td></td>
<td></td>
<td>2. Increase kangaroo road signage on campus at road entrances to the campus.</td>
<td>USC</td>
<td>High</td>
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<td></td>
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<td>3. Increase community awareness</td>
<td>USC, Sunshine Coast Council</td>
<td>Medium</td>
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<td></td>
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<td>4. Use strategic fencing combined with interactive warning signs to make fewer off campus roads available for kangaroos to cross.</td>
<td>Sunshine Coast Council, Queensland Department of Parks and Wildlife, local developers, USC</td>
<td>Medium</td>
</tr>
<tr>
<td>2. To reduce the presence of unauthorised dogs on campus.</td>
<td>2. No domestic dogs present on campus at any time.</td>
<td>1. Increase signage for the community, particularly dog specific signage a pedestrian entrance points on southern and eastern sides of the campus</td>
<td>USC</td>
<td>Medium</td>
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<td></td>
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<td>2. Extend security patrols to include sports fields and lakes, particularly at weekends</td>
<td>USC</td>
<td>Medium</td>
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<td>3. Canine detection dogs to always wear jackets to identify them as service dogs. Avoid onsite training or exercise of dogs.</td>
<td>USC</td>
<td>Low</td>
</tr>
<tr>
<td>Specific objective</td>
<td>Performance criteria</td>
<td>Action</td>
<td>Potential contributors</td>
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<td>3. To reduce the impact of construction for the Sippy Downs town centre on kangaroo habitats and kangaroo road-crossing capability.</td>
<td>3. No loss of movement to the kangaroos after construction has occurred.</td>
<td>1. Allow kangaroo movement on the edges of and between construction sites particularly in a known movement corridor where the YOUI insurance company headquarters are to be constructed.</td>
<td>YOUI, Sunshine Coast council, USC</td>
<td>Low</td>
</tr>
<tr>
<td>4. Increase community education and engagement</td>
<td>4. The recovery program has high level of community awareness</td>
<td>1. A targeted community awareness campaign to alter driver behaviour on campus and surrounding roads, promoting USC as a wildlife refuge.</td>
<td>Sippy Downs Community District Association, local councillor Christian Dickson, Sunshine Coast Council, Queensland Parks and Wildlife, USC</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Use of media (a logo has been developed) for the campaign to encourage community awareness</td>
<td>USC</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Figure 6. Aerial map of USC campus and surrounds showing identified kangaroo road-crossing “hot spots”.
Figure 7. Aerial map of USC campus showing recommended locations for risk mitigation signage. Major entry sign locations are indicated by blue points, smaller road crossing signs by green points, No dog signs by pink points and speed bump location by an orange point.
Figure 8. Static sign identifying high risk collision area

Figure 9. Static warning sign

Figure 10. Vehicle activated sign. The first sign flashes when it detects a vehicle, the second sign flashes once a slower speed is detected.

Figure 11. Static sign for crossing hot spots

Figure 12. Static sign for use on campus roads

Figure 13. Alternative static sign for use on campus roads

Image Sources: Figures 8,9,10 - Department of Transport and Main Roads 2012 in Bond and Jones 2013, Figures 11,12,13 – Elizabeth Brunton.
Figure 14. Aerial map of USC campus highlighting potential future sites for “kangaroo habitat areas” (Green), current key movement corridors (Red) and current recognised kangaroo refuge areas (Blue).
Figure 15. – USC Community awareness Logo
References

Department of Transport and Main Roads. 2012 Manual of Uniform Traffic Control Devices (MUTCD), Fourth Issue; Department of Transport and Main Roads: Brisbane, Australia.
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Queensland Herbarium 2015 Regional Ecosystem Description Database (REDD). Version 9.0, April 2015, Queensland Department of Science, Information Technology and Innovation: Brisbane.

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