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Greater Sydney Branch
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Office of Environment and Heritage

Thursday, 28 June 2018

Dear Ms Schaeper

RE: Review of Office of Environment and Heritage (OEH) Project “Temporary fencing on Appin Road - Analysis of costs and benefits for koalas”

Executive Summary

1. On a section of Appin Road, between St Helens Park and the Beulah BioBank site, there have been a relatively high number of koala road deaths. There have been 8 records of roadkill along Appin Road in 2018 so far.
2. OEH is examining the potential impacts of building a 2.2km temporary fence on the on the eastern side of Appin Road to stop koala road deaths until there is a more permanent solution.
3. There are very few recent records of koalas on the western side of Appin Road (5 records) in the Beulah biobank site near the roadkill hotspot (probably only 3 koalas), while the numbers are much higher on the eastern side of Appin Road (>100 koala records).
4. There is much more continuous koala habitat on the eastern side of Appin Road; habitat on the western side is small and fragmented.
5. Hence, a “floppy-top” fence on the eastern side of Appin Road would protect most koalas from dying on the road.



6. The increasing number of road deaths could be detrimental to the local koala population, so a fence should be built as soon as possible. Road mortality is having such a detrimental impact on the koalas that a fence would not likely affect gene flow in the koala population any more than road traffic
7. Koalas on the western side of the Appin Road roadkill hotspot in the Beulah BioBank site should be translocated to the east so they do not die due to road traffic. However, careful monitoring is required on the eastern side of Appin Road to make sure these koalas do not displace, or are displaced by resident koalas.
8. As there is some koala habitat on the western side of Appin Road, a long-term strategy for the koala population would be to fence both sides of the road, and provide an underpass for koalas to cross.
9. Long-term fencing could be expanded to 6km long to protect the koalas north of the roadkill hotspot in Rosemeadow, and south of the hotspot near Appin. This would be need to be combined with an underpass for koalas to cross.
10. Longer-term fencing and underpasses will, however, depend on local terrain and future development in the Greater Macarthur region.

Report

I have been commissioned by OEHL to review provide a scientific review and analysis of Temporary fencing on Appin Road-Analysis of costs and benefits for koalas relating to the following two project objectives:

1. To provide clear advice on the pros and cons for koalas of 2.2 km of temporary fencing being constructed along the east side of Appin Road between St Helens Park and Beulah BioBank site, and
2. To provide recommendations for practical measures to support the long-term survival of the local koala population in the event of fencing along Appin Road

The scope of the work is a report on the anticipated pros and cons for koalas of 2.2 km of temporary fencing being installed along the east side of Appin Road between St Helens Park and Beulah BioBank site. The advice will be developed from expert opinion, BioNet koala record data, and supported by the literature. The advice includes analysis of:



- The likelihood of a 2.2 km temporary fence on the east side of Appin Road reducing vehicle strike for the Campbelltown koala population
- The potential long and short-term impact on the koala population of having no temporary fence on the east of Appin Road,
- The potential impact on the koala population of having a fence on the east of Appin Road, with no fence on the west of Appin Road,
- The potential impact of koalas not being able to access habitats on both sides of Appin Road.
- Whether a 2.2 km fence would cause a barrier to geneflow in the Campbelltown population, and if so, how long might it be until an effect is felt?
- Whether a 6 km fence from St Helens Park to Appin would cause a barrier to gene flow in the Campbelltown population? And if so, how long might it be until an effect is felt?

The report provides recommendations for practical measures that will support the long-term survival of koalas in the event of fencing along the east Appin Road

I have been provided by OEH with a copy of “Conserving Koalas in Campbelltown and Wilton LGAs”, which I have previously reviewed, and a map of the proposed fence along Appin Road (Figure 1).

I will first outline my experience and qualifications with koala research, comment on the documents provided and provide my recommendations.

I am an Associate Professor in wildlife ecology and evolution in the School of Life and Environmental Sciences at the University of Sydney. I have researched on koalas in NSW since 2006, including publishing over 10 scientific papers on koalas. I have two papers on the koalas of the Campbelltown region and have advised on projects concerning koalas in the local region. I have also contributed to koala management by contributing to the NSW Koala Recovery Plan, and am a current expert advisory member on the NSW Save Our Species Koala Panel. I have a history of reviewing documents concerning koala management.

I will address each individual question below, using analysis of the records and GIS layers, the scientific literature, consultation with OEH staff and from my own expert experience.

The likelihood of a 2.2 km temporary fence on the east side of Appin Road reducing vehicle strike for the Campbelltown koala population

Roads are considered one of the major factors leading to decline in koala populations (Rhodes *et al.* 2014; Rhodes *et al.* 2011). Hence areas where there is



heavy vehicle traffic and rising human population growth, like in the Campbelltown City Local Government Area, mitigation measures for road effects are essential for koala population persistence (Lunney *et al.* 2010).

Fencing is probably the only way to reduce koala roadkill, where koalas live near busy roads (Polak *et al.* 2014). In fact, there is a linear relationship in population size persistence and fencing costs for koalas, meaning the more that is spent on fencing (Polak *et al.* 2014), the greater the koala population size. Fencing has the capability to reduced mortality in the population (Clevenger *et al.* 2001), increase population persistence (Fahrig and Rytwinski 2009), and when combined with under or over passes, facilitate movement and gene flow (Roger *et al.* 2011). Fencing must have a “floppy top”, to prevent koalas from climbing over the fence (Lassau *et al.* 2008; Taylor and Goldingay 2003). Although slowing down traffic speed could also reduce koala road mortality, there is little evidence that signage can achieve this positive benefit for koalas (Dique *et al.* 2003b; OEH 2018).

The area being examined is an area of high recent koala road kill. Through records on BioNet (<http://www.bionet.nsw.gov.au>, see Figure 2), and consultation with OEH staff, there have been 8 records of koala roadkill along Appin Road in 2018 so far. This compares with 6 koala roadkills in 2017 and 3 in 2016, again along Appin Road. Hence, the increasing rate of roadkill is certainly not only a cause for public concern, but also a potential impact on the local population.

The main consideration of how much of an impact the temporary fence will have on the local population is how many koalas there are and in which locations. The eastern side of the Appin Road has many koala records in BioNet (see Figure 2) and as documented in OEH (2018), especially in the vegetation adjacent to the Georges River. In contrast, there are much fewer records of koalas on the western side of Appin Road (8 koala records in the Beulah Biobank site, including 3 from 2018). Although it is impossible ascertaining accurate estimates of koala numbers in the area without systematic surveys, including spotlighting surveys (Wilmott *et al.* 2018), there appear to be very few koalas on the western side of Appin Road. These koala records seem to be restricted to a small area of vegetation adjacent to Appin Road in the Beulah BioBank site (Figure 2). My estimates based on BioNet records, consultation with OEH staff and amount of available habitat would be that there are only around 3-5 koalas in the Beulah BioBank site on the western side of Appin Road, while there would be over 100 koalas on the eastern side of Appin Road.

Another consideration whether a fence on the eastern side of the road would be beneficial is information on the movement of koalas on each side of the road. If



koalas are moving from east to west, a fence on the eastern side would certainly reduce roadkill. However, if the koalas are moving from west to east, they have the potential to be caught on the road, and almost certainly suffer road mortality. This information can only be gathered from the study of koala movements through GPS tracking, such as the K-Trackers (<http://www.trackkoalas.com.au>) being used in the Wollondilly LGA by OEH. These trackers allow real-time assessment of koala locations, which can enable quick mitigation measures if required.

Variation in koala home range sizes reflect habitat quality, whereby a sparsely distributed or lower quality food resource dictates a requirement for larger home ranges (Phillips and Callaghan 2000). Koala home range sizes vary throughout their range and can be between 1 ha to 300 ha (Ellis *et al.* 2002; Ellis *et al.* 2009; Hindell and Lee 1988; Kavanagh *et al.* 2007; Martin and Handasyde 1999; Matthews *et al.* 2016; White 1999). Regular movements through the night and day reflect koalas needing access to different trees for food and shelter, including balancing the need for nutrients while dealing with toxins within the *Eucalyptus* leaves (Crowther *et al.* 2014; Moore and Foley 2005). Hence, some koalas on either side of Appin Road could regularly cross the road to satisfy both food and shelter requirements.

Koalas can move large distances of over 20km within a few months (Dique *et al.* 2003a; Matthews *et al.* 2016). Larger scale movements are generally made by younger male koalas (20-36 months of age) for dispersing, but can be made by all sexes of all ages (Dique *et al.* 2003a), particularly after a major disturbance such as a fire (Matthews *et al.* 2016). BioNet records indicate koalas of all sexes and ages on both sides of Appin Road, including a recent female with a joey on the western side. Koalas are capable of finding passages to cross roads (Dexter *et al.* 2016; Lassau *et al.* 2008), hence the koalas either side of Appin Road will be able to walk around the fence to cross the road. This could lead to more koala road deaths at the ends of the fence, and hence must be monitored, using remote cameras and GPS-tracking after fence construction.

Without movement data and accurate koala numbers, it is very difficult to assess the true benefit of having a temporary fence on the eastern side of Appin Road. However, due to the extent of habitat on the east, the much larger population of koalas on the eastern side of the road (as indicated by the vastly higher number of records) and the high roadkill rate, a fence should have an overall beneficial impact on the koala population through the reduction of roadkill. Some koalas will follow the fence and cross further up the road. However, to reduce the mortality of koalas on the western side of Appin Road, more information is required. If koalas are moving from the west to the east, the few koalas on the

western side of the road in the Beulah BioBank site should be translocated until a more permanent solution for road crossings can be made. Consideration must be taken of moving koalas into other koalas' territories, as they have the potential to displace or be displaced by resident koalas. Hence a detailed survey on the eastern side of Appin Road should be undertaken before releasing koalas into that area.

The potential long and short-term impact on the koala population of having no temporary fence on the east of Appin Road

The short-term impact of having no temporary fence on the east of Appin Road will be more roadkill koalas. The rate of roadkill appears to be increasing, although this could be the result of an increasing koala population (Close *et al.* 2017). The koala population is apparently chlamydia-free (Close *et al.* 2017), hence the capacity for a growing population. Whatever the overall koala population is doing, the koala roadkill will increase in the short-term.

If koalas on the western side need to access to eastern side of Appin Road, they will certainly die-out within the short-term without any mitigation actions. This information will only be gathered by a tracking study. There will more losses of koalas from the eastern side of Appin Road without mitigation measures such as fencing.

The long-term impact on the koala population of not having a temporary fence is less certain without accurate movement and population estimate data. However, in studies of other koala populations threatened by road mortality in south-eastern Queensland, the "Do Nothing" approach was the worst for koala abundance (Polak *et al.* 2014). Some of the koala records are females, and essential for the population growth and maintenance. Hence, it is likely that not having any form of mitigation could have a detrimental long-term impact on the koala population, particularly with increased human population and traffic in the area.

The potential impact on the koala population of having a fence on the east of Appin Road, with no fence on the west of Appin Road

Again, this question is hard to address without accurate movement and population estimate data. However, the temporary fence would likely have a positive impact of the overall population. Most of the koalas and koala habitat is



on the eastern side of Appin Road; hence the fence will stop these koalas crossing, at least in the area of high road mortality to the western side.

A fence on just the eastern side of the road would most likely accelerate the deaths of the koalas on the western side of Appin Road. Koalas trying to cross would be caught on the road and hence killed by on-coming traffic. The best option would be to construct fences on both sides of the road, with an underpass for long-term koala survival, however the timeframe is too long to prevent the deaths of these koalas. If a temporary fence was to be constructed only on the eastern side of the road, efforts must be made to stop the deaths of the koalas from the western side of the road. This may include translocation of the koalas from the western side to a safe place on the eastern side of Appin Road. This needs to be done without causing disruption to koala territories on the eastern side of Appin Road.

The potential impact of koalas not being able to access habitats on both sides of Appin Road.

Habitat on the western side of Appin Road appears very limited (Figure 2). It is mostly fragmented, and the section with all the koala records is the small area adjacent to Appin Road. Although this habitat should be preserved for a later time when fencing on both sides of the road and an underpass can be completed, it may not be essential for the koalas' long-term survival in the area. The Beulah BioBank site is under 50 hectares and so probably would only support 2-3 koalas at most. Hence, koalas on the western side of the road will need to cross to the eastern side of the road, or find areas further afield in the west. There is a small amount of Eucalypt woodland on shale-derived substrate on the western side of Appin Road, considered core koala habitat in the region (Lunney *et al.* 2010; OEH 2018; Phillips and Callaghan 2000).

Koalas on the western side of Appin Road need to access the much larger expanse of habitat along the George's River on the eastern side of Appin Road. As mentioned above, the main section of habitat for koalas on the western side of Appin Road (Beulah BioBank site) is less than 50ha, hence could not address the needs of koalas in the longer term. If a temporary fence is to be built, koalas on the western side of Appin Road need to be located and translocated to suitable sites on the eastern side of Appin Road. If koalas were to be translocated, this would be an excellent time to collect health information on these koalas by veterinarians from the Koala Health Hub at the University of Sydney to aid the NSW Government Save Our Species koala strategy.



Whether a 2.2 km fence would cause a barrier to geneflow in the Campbelltown population, and if so, how long might it be until an effect is felt?

Roads have reduced gene flow within populations of koalas in south-eastern Queensland (Dudaniec *et al.* 2013; Lee *et al.* 2010a), which has occurred within the last 100 years, and probably more recently due to road widening. These barriers were a larger block to gene flow than urbanisation. A fence will be a block to gene flow on either side of the fence; however, with the small population size on the western side and the high mortality rate on Appin Road, it is likely that the gene flow is already broken. There is likely to be no detectable breaks in gene flow in the short-term. Genetic variation is relatively low in the Campbelltown population, possibly due to a bottleneck (Lee *et al.* 2010b), further complicating the detection of recent gene flow breaks.

As mentioned previously, koalas can move large distances over 20km (Dique *et al.* 2003a; Matthews *et al.* 2016), and are capable of finding passages to cross roads (Dexter *et al.* 2016; Lassau *et al.* 2008). Hence, they would be able to move around fences to cross the road. The issue is more that koalas from the west will be caught on the road where there is traffic. Hence, the fence will only negatively affect breaks in gene flow by reducing the movements of koalas from the western side of Appin Road to the east. This can be alleviated by translocating the few koalas from the western side of Appin Road to the eastern side.

Whether a 6 km fence from St Helens Park to Appin would cause a barrier to gene flow in the Campbelltown population? And if so, how long might it be until an effect is felt?

Analysis of the roadkill records from BioNet indicates that there are recent roadkill records north of the stretch of Appin Road where the 2.2 km temporary fence is proposed, near St Helens Park (Figure 2). There are also more koala records on both sides of the road, plus a section of vegetation on the western side of Appin Road (Noorumba Reserve, Rosemeadow; Figure 2). The fence would cut off the koalas in Noorumba Reserve, but give more protection to the koalas on the eastern side of Appin Road. A sensible long-term strategy would be to fence both sides of the road and supply underpasses so the koalas of Noorumba Reserve and those further south of the Beulah BioBank site, would be protected. Underpasses, however, are not only expensive, but sites can be limited due to terrain and development. For the short-term strategy of protecting koalas north of the roadkill hotspot, more information is needed on



the movements of koalas at Noorumba Reserve as well as accurate estimates of koala numbers in that area.

There are also a number of koala records south of the proposed 2.2 km temporary fence near the town of Appin (Figure 2) on both sides of Appin Road. There are a two recent roadkill records from this regions as well. There are not many koala records in patches of vegetation on the western side of Appin Road in this area, although there a quite are few in the actual town of Appin. More information is needed about koala densities on the western side of Appin Road in this region, but since the native vegetation is very patchy in this section, it is unlikely a fence would have a negative impact on the koalas in this region.

As is the case for the 2.2km long temporary fence, the road itself is as likely to be the major restrictor for gene flow, due to road mortality, rather than a fence. As mentioned above, the Campbelltown population has relatively low genetic diversity (Lee *et al.* 2010b) and the effects of a barrier on gene flow will be difficult to detect. However, it would be advisable in the short-term to move koalas from the western side of Appin Road to the eastern side for the duration of any temporary fencing. In the longer-term, gene flow will be maintained by “floppy-top” fencing on both sides of the road with an underpass.

In conclusion, while more information is needed on koala densities either side of Appin Road, and movement data of koalas near Appin Road, a temporary fence along the eastern side of Appin Road would be beneficial for the local Campbelltown koala population. In fact, the roadkill levels are so high, and apparently increasing, that a fence in the short-term is critically needed for the local koala population. Koalas on the western side of Appin Road will likely have to be translocated to the eastern side of Appin Road if the temporary fencing is constructed. Any effects on the gene flow in the local koala population from the temporary fence are likely to be minimal due to the rising mortality levels on Appin Road restricting koala movement.

To maintain long-term survival of koalas in the region, including maintaining gene-flow, both sides of Appin Road should be fenced for the 6km distance with an underpass provided to enable koalas to access habitat on both sides of the road. Although an expensive option, costs and koala abundance show a linear relationship in areas where roads are threatening their population (Polak *et al.* 2014). However, underpasses cannot be built in many areas, due to terrain and development in the Greater Macarthur region, hence longer-term planning must recognise these limitations.



Figure 1: Potential location of 2.2 km fence along Appin Road (in blue) from St Helens to Beulah BioBank site. Map supplied by OEH.

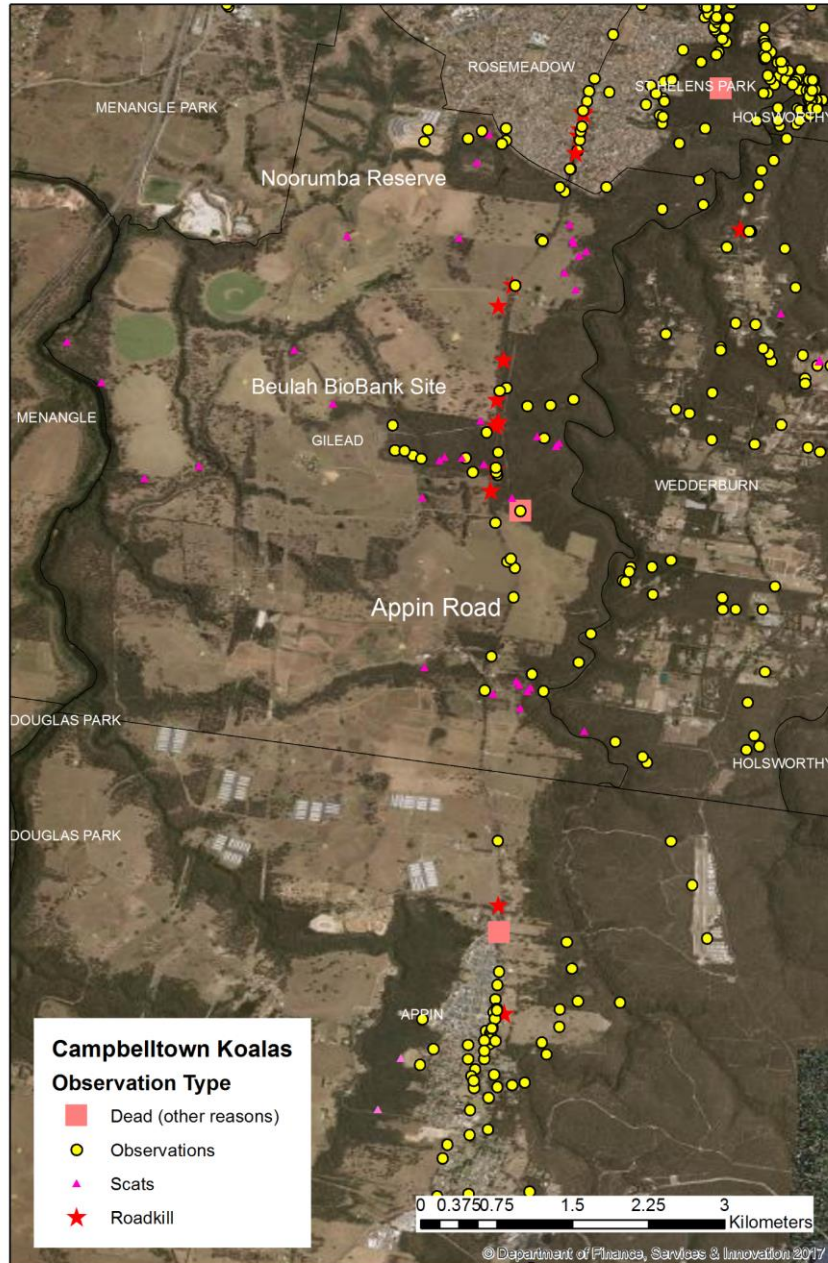


Figure 2: Koala records along Appin Road and surrounding area from BioNet (<http://www.bionet.nsw.gov.au>). The location of the Roadkill koalas (red stars) are along Appin Road. Records go back as far as 1986, although the vast majority of records are since 2000 (95% of records). All records west of the roadkill hotspot are since 2016.



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THE UNIVERSITY OF
SYDNEY

Sincerely,

A handwritten signature in black ink, appearing to read 'M Crowther', with a long horizontal flourish extending to the right.

Associate Professor Mathew Crowther

DISCLAIMER This report was prepared by Associate Professor Mathew Crowther, School of Life and Environmental Sciences, University of Sydney, in good faith exercising all due care and attention, but no representation or warranty, express or implied, is made as to the relevance, accuracy, completeness or fitness for purpose of this document in respect of any particular user's circumstances. Users of this document should satisfy themselves concerning its application to, and where necessary seek expert advice in respect of, their situation. The views expressed within are not necessarily the views of the Office of Environment and Heritage (OEH) and may not represent OEH policy.
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