Fauna sensitive infrastructure investment opportunities on the Nebo to Eton stretch of the Peak Downs Highway, Central Queensland.

A report to the Queensland Department of Transport and Main Roads

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Koala Research CQ

This report was prepared as part of a larger study; *Managing the Clarke-Connors Range koala population*, funded by the Queensland Department of Transport and Main Roads.

Queensland Government

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Contents

Introduction

The Queensland Department of Transport and Main Roads (TMR) is currently constructing the Eton Range on the Peak Downs Highway approximately 40 km west of Mackay. The Federal Department of the Environment and Energy (DEE) declared the Eton Range Realignment Project a controlled action under the *Environment Protection and Biodiversity Conservation Act* 1999 due to the potential for significant impacts on koalas or koala habitat. The DEE required residual impacts, after TMR's impact mitigation, to be offset through two years of research relating to koala ecology and conservation management around the Eton to Nebo stretch of the Peak Downs Highway, and following the study, koala sensitive infrastructure to be placed at strategic locations along this portion of the Peak Downs Highway. This report is an account of a survey to identify opportunities for the placement of koala sensitive infrastructure.

Methods

Interpreting the pattern of koala road kill records

The distribution of 69 recorded koala road kills (September 2014 to August 2017) was mapped along the stretch of Peak Downs Highway from Nebo Junction to Hazledean. This was projected onto *Google Earth* to facilitate a tablet-based road survey (Figure 1). Groups of sightings (three or more) were considered a cluster that was then given a name based on a prominent local feature or property. Ten clusters were identified (Table 1). The area between clusters was designated an inter-cluster. With one exception, inter-clusters were free of koala road kills during the sample timeframe.

Broad vegetation descriptions, from field inspections, were made of each cluster and inter-cluster (Table 1). Discrete attributes were derived from the vegetation and landscape description. These included prominent tree species and land form elements (Table 2).

Analysis of the resulting multivariate data set was undertaken using the multivariate analytical software package *Community Analysis Package* (Pisces Conservation Ltd, www.pisces-conservation.com). Data were investigated using agglomerative cluster analysis (Ward's – Euclidian distance) for the existence of natural grouping in the data. The significance of apparent clusters was tested by an analysis of similarity (ANOSIM). Our examination of the field clusters and inter-clusters suggested that the koala records may occur across an environmental gradient. Consequently, the clusters and associated attributes were examined using detrended correspondence analysis (Hill and Gauch 1980) (DECORANA). This method maps the relationship between sites and attributes, and is considered particularly useful when data are derived along environmental gradients.

Potential for infrastructure investment

Clusters were investigated by road and on foot. Within each cluster, notes were taken of infrastructure and terrain opportunities for investment in protective infrastructure or for the retrofitting of existing infrastructure. The coordinates of the linear extent along the highway of each cluster was recorded.

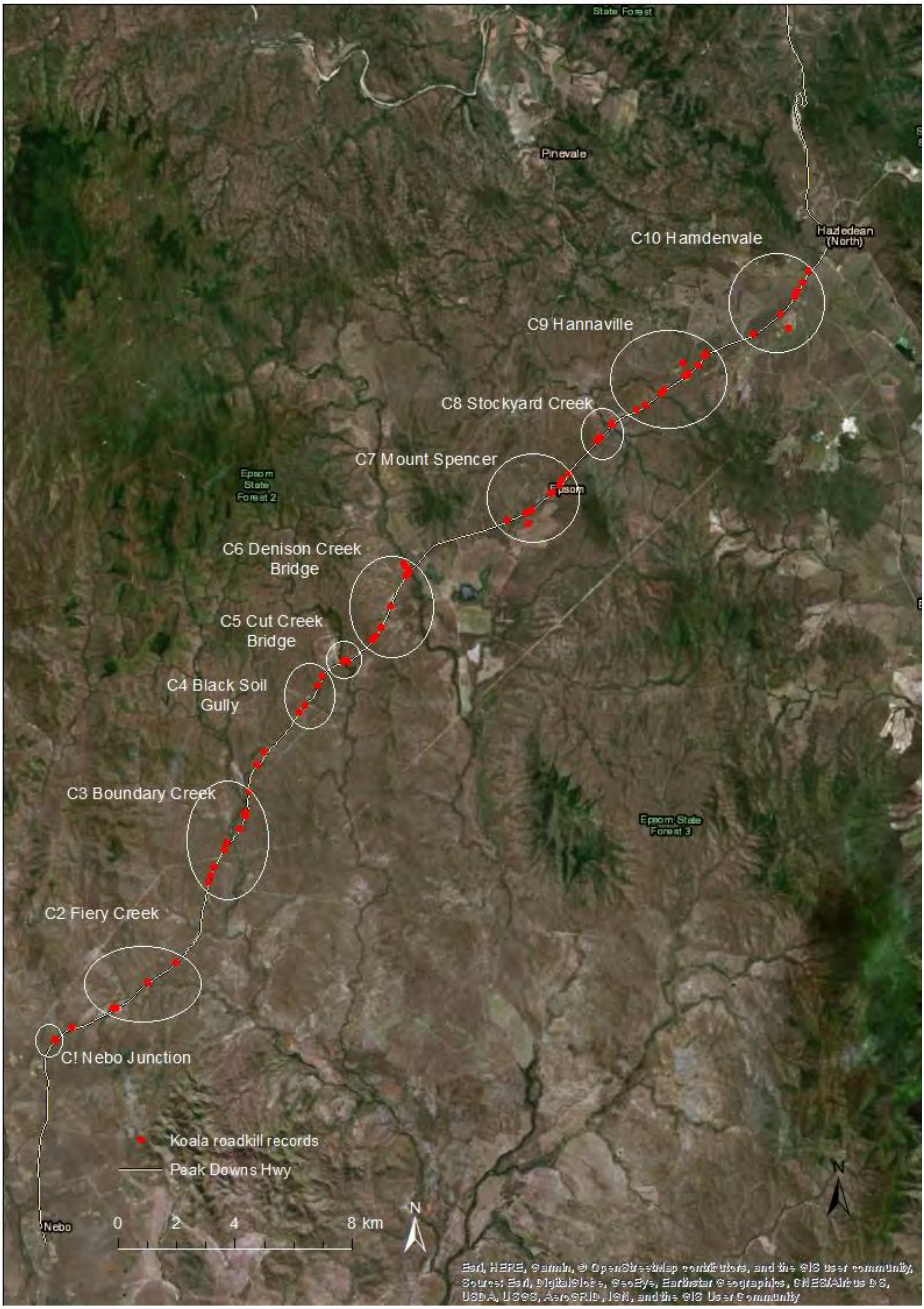

Figure 1. Distribution of koala road kills (September 2014 – August 2017) between Nebo Junction and Hazledean on the Peak Downs Highway, Central Queensland. The koala records are shown as red points. The records were unevenly distributed and grouped into 10 clusters with three or more records (white ovals).

Table 1. Description of clusters of 69 recorded koala kill records (September 2014 to August 2017) between Eton and Nebo on the Peak Downs Highway and adjacent inter-clusters.

Cluster name	Cluster Code	Koala Records	Chainage (km) Start	Chainage (km) End	Vegetation and land form description	Notes
Nebo Junction	C1	30, 89, 106, 107	6.56	7.46	*Eucalyptus tereticornis*, *E. platyphylla* alluvial flat.	Rises to *E. drepanophylla* woodland on ridges.
Inter-cluster	IC1	0			*Eucalyptus drepanophylla* open forest on ridge crests	
Fiery Creek	C2	83, 145, 88, 102	9.16	12.43	*Eucalyptus platyphylla* woodland with occasional *E. tereticornis* on alluvial flat. *E. drepanophylla* open forest to woodland on adjacent ridges and hills, with *E. tereticornis* and *Melaleuca* sp. open woodland in minor drainage lines and gullies.	
Inter-cluster	IC2	0			*Eucalyptus drepanophylla, Corymbia dallachyana*, *C. erythrophloia* on ridge crests and hills adjacent to stream fringing forest including isolated to very isolated *E. tereticornis*.	At *Strathdee* and including Lonely Creek Bridge
Boundary Creek	C3	77, 104, 248, 78, 27, 96, 244, 103, 60	14.95	18.79	*Eucalyptus tereticornis*, *E. platyphylla* tall open woodland on alluvia. *E. drepanophylla*, *E. platyphylla* +/- *E. tereticornis*, *Corymbia tessellaris* open forest to woodland on adjacent lower ridge slopes. Tall *Melaleuca* fluviatilias and *Corymbia tessellaris* emergent from a forest of rainforest elements fringing the creek.	
Inter-cluster	IC3	239, 76			*Eucalyptus drepanophylla* open forest or woodland on ridges and hill tops; including one broad alluvial flat supporting *E. tereticornis*, *E. platyphylla* woodland	The two isolated records were associated with the alluvial flats.
Black Soil Gully	C4	58, 129, 242, 243,	21.63	23.70	*Eucalyptus tereticornis*, *Corymbia tessellaris*, *E. drepanophylla* woodland on an undulating clay flat or depression.	Depression between *E. drepanphylla* woodland on low hills.
Cut Creek Bridge	C5	39, 68, 245	23.79	24.98	*Eucalyptus tereticornis* emergent from stream fringing forest; *E. platyphylla*, *E. tereticornis* tall woodland on adjacent western alluvial flat, and *E. drepanophylla* woodland on the adjacent eastern ridge.	
Inter-cluster	IC4	0			*Eucalyptus drepanophylla* open forest on ridge crests and hills with isolated *E. platyphylla* and *E. tereticornis* in low pockets.	
Denison Creek Bridge	C6	8, 31, 54, 64, 69, 92, 98, 105, 131, 238	25.24	28.60	*Corymbia tessellaris*, *Eucalyptus raveretiana*, *Melaleuca* sp. and rainforest elements in a stream fringing forest. Adjacent broad alluvial flat supporting a tall open woodland of *E. tereticornis*, *E. platyphylla*, *C. tessellaris* and *C. dallachyana*. Open forest of *E. platyphylla*, *E. tereticornis*, *E. drepanophylla*, *C. tessellaris* on adjacent undulating low rises, lower slopes and associated low ridges.	
Inter-cluster	IC5	0			*Corymbia tessellaris*, *E. platyphylla* +/- *E. drepanophylla*, *E. tereticornis*, *Melaleuca viridiflora* open forest or woodland on low hills and undulating flats.	Abuts extensive clearing down to Lake Epson.
Mt Spencer	C7	42, 51, 82, 90, 108, 132, 205, 216, 247,	31.71	34.94	*Eucalyptus drepanophylla* +/- *E. tereticornis* woodland or open forest on ridges and hills dissected by ephemeral drainage lines supporting *E. tereticornis* open woodland. Ridges slope to the west to *E. tereticornis*, *E. platyphylla* woodland on undulating flats.	
Inter-cluster	IC6	0			*Eucalyptus drepanophylla* open forest to woodland on hills and ridge crests.	Minor drainage lines were absent.
Stockyard Creek	C8	3, 74, 85, 130, 133, 141	35.90	37.46	Stream fringing rainforest community with *Corymbia tessellaris*. *Eucalyptus tereticornis*, *E. drepanophylla* open forest on adjacent low hills.	
Inter-cluster	IC7	0			No data	

Hannaville	C9	1, 29, 62, 73, 86, 87, 100, 101, 112, 146	37.76	41.50	*Eucalyptus drepanophylla* woodland on hills dissected by ephemeral creeks supporting well-developed *E. tereticornis* open forest and *E. tereticornis* on adjacent alluvia.	Alluvial flats are broad in places. *E. tereticornis* may reach 25-30m.
Inter-cluster	IC8	0			*Eucalyptus drepanophylla* tall woodland on hills and ridges.	Minor drainage lines were absent.
Hamdenvale cluster	C10	28, 53, 91, 99, 109, 249, 252	42.57	45.99	Grassland with emergent *Eucalyptus tereticornis*, *Eucalyptus tereticornis* grassy open woodland	Regrowth and relic *E. tereticornis* in pasture. High value koala habitat.

Table 2. Environmental attributes attributed to clusters and inter-clusters.

Attributes	Definition	Code
Koalas	Number of records within each cluster or inter-cluster	
Vegetation Attributes	Presence or absence of characteristic tree species	
	Eucalyptus tereticornis	BG
	Eucalyptus platyphylla	PG
	Eucalyptus drepanophylla	BLIB
	Eucalyptus raveretiana	BIW
	Corymbia tessellaris	MBA
	Corymbia dallachyana	GG
	Corymbia erythrophloia	VBBW
	Melaleuca fluviatilias	PP1
	Melaleuca viridiflora	PP2
Land Form Elements	Stream bank	
	Alluvial flat	
	Minor drainage lines	
	Lower slopes	
	Ridge crest/upper slopes	
	Hills	

Results

Interpreting the pattern of koala road kills

The 69 koala kill records had an uneven distribution along the Peak Downs Highway from Nebo Junction to Hezledean. Sixty-seven occurred in 10 clusters, with koala records ranging from three to 10 per cluster. Two occurred as individual isolates within one of the eight inter-clusters. Descriptions of the clusters and inter-clusters are shown in Table 1. The association of vegetation and land form attributes with clusters and inter-clusters is shown in Table 3. The koala clusters and inter-clusters appeared to fall into four groups (Figure 2). The dendrogram exhibited two major divisions and four significant groups. The first level division appeared to relate to a landform gradient with groups 3 and 4 being characterised by ridge crests or upper slopes or hills. In contrast, groups 1, 2 and 3 were, with one exception, characterised by lower ridge slopes, alluvial flats and stream banks. The division of groups 3 and 4 appears associated with the presence (Group 3) or absence (Group 4) of alluvial and lower slope tree species (*E. tereticornis* and *E. platyphylla*). The distinction between groups 1 and 2 appears to rest on the predominance of alluvial flats in Group 1 and lower ridge slopes combined with the presence of *Corymbia tessellaris* in Group 2. There was a significant difference amongst these groups (ANOSIM 0.769, P = 0.001).

The DECORA ordination arranged the clusters and attributes into a generally horizontal pattern (Figure 3) reflecting a gradient from lowland landform elements and associated tree species (left) to highland elements and tree species (right). The ordination clearly resolved the four groups evident in the dendrogram (Figure 2). Groups 1 and 2 are at the lowest end of the gradient. Group 4 is at the upper end of the gradient. Group 3 is intermediate. Groups 1, 2 and 3 are associated with koala road kills. There are no kills in Group 4. The highest kill records were associated with groups 1 and 2, with lesser counts for Group 3 (Table 4).

Discussion

Koala kills were associated with:

(1) streams and associated alluvia where the dominant vegetation included *E. tereticornis* and *E. platyphylla*;

(2) ridges supporting *E. drepanophylla* open forest/woodland, where the ridge immediately abutted the stream or alluvia; as well as

(3) mid-lower slopes dominated by *E. drepanophylla*, where the slopes were dissected by minor drainage lines fringed by *E. tereticornis* +/- *E. platyphylla* on banks or adjacent minor alluvium.

Koala kill records were absent from *E. drepanophylla* open forest/woodland on the upper slope or crest of ridges and on hills.

The results largely support the initial classification of koala sighting clusters and inter-clusters. The analysis identified two anomalies in the initial cluster classification. Inter-cluster IC5 was included within group 2. Inter-cluster IC3 was included within group 3. No koala kills were recorded within IC5. However, the analysis and the associated vegetation suggests that potential road kills would be expected there. Further investigation is required to ascertain koala usage of that area, and in the absence of koalas, what additional attributes could explain why this inter-cluster has a low koala kill frequency. IC3 contained two isolated koala records. The field inspection revealed that these two records were associated with a minor drainage line fringed by *E. tereticornis* +/- *E. platyphylla.* The analysis suggests that this system should have been classified as a koala kill cluster with IC3 being reclassified as two smaller inter-clusters separated by a new sighting cluster.

The discussion above describes an association, not causation. The analysis did not take account of the engineered structural characteristics of the broader road verge associated with the topographical features of the road reserve.

Road verges on ridge crests and upper slopes are more likely to be characterised by larger/steeper cuttings through the ridges and batters over gullies. On the lower slopes, broader valleys and flats these engineered features are most likely to be lower, shorter, and perhaps, less steeply inclined.

It is possible to speculate that koalas may be more willing to approach a road where the engineered structures provide the least impediment to movement, and conversely are less inclined to approach a road across a long steeply inclined cutting or batter. More work on koala distribution across the entire landscape, and on koala behaviour around batters and cuttings is required to address this.

Despite these anomalies, the results provide a basis for on-ground classification of where koala-road interactions are most likely, and hence, provide a guide as to where to focus potential investment in protective infrastructure. There is also a strong accord between the clusters and the hot spots modelled by Schlagloth (2018) (Figure 4).

Table 3. Summary of attributes (road kill records & presence/absence of vegetation & landscape features) collected for koala clusters and inter-clusters.

Cluster name	Cluster Code	Koalas	BG	PG	BLIB	BIW	MBA	GG	VBBW	PB1	PB2	Stream bank	Alluvial flat	Minor Drainage	Low slopes	Ridge crests/upper slopes	Hill
Nebo Junction	C1	4	+	+	-	-	-	-	-	-	-	+	+	-	-	-	-
Fiery Creek	C2	4	+	+	+	-	-	-	-	+	-	-	+	+	-	+	+
Boundary Creek	C3	9	+	+	+	-	+	-	-	+	-	+	+	-	+	-	-
Black Soil Gully	C4	4	+	-	+	-	+	-	-	-	-	-	+	-	-	-	-
Cut Creek Bridge	C5	3	+	+	+	-	-	-	-	-	-	+	+	-	+	-	-
Denison Creek Bridge	C6	10	+	+	+	+	+	+	-	+	-	+	+	-	+	-	-
Mt Spencer	C7	9	+	+	+	-	-	-	-	-	-	-	+	+	-	+	+
Stockyard Creek	C8	7	+	-	+	-	+	-	-	-	-	+	-	-	+	-	-
Hannaville	C9	10	+	-	+	-	-	-	-	-	-	-	+	+	-	-	+
Hamdenvale	C10	7	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Inter-cluster	IC1	0	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-
Inter-cluster	IC2	0	+	-	+	-	-	+	+	-	-	+	-	-	-	+	+
Inter-cluster	IC3	2	+	+	+	-	-	-	-	-	-	-	+	-	-	+	+
Inter-cluster	IC4	0	-	-	+	-	-	-	-	-	-	-	-	-	-	+	+
Inter-cluster	IC5	0	1	1	1	-	+	-	-	-	+	-	-	-	+	-	-
Inter-cluster	IC6	0	-	-	1	-	-	-	-	-	-	-	-	-	-	+	+
Inter-cluster	IC7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Inter-cluster	IC8	0	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-

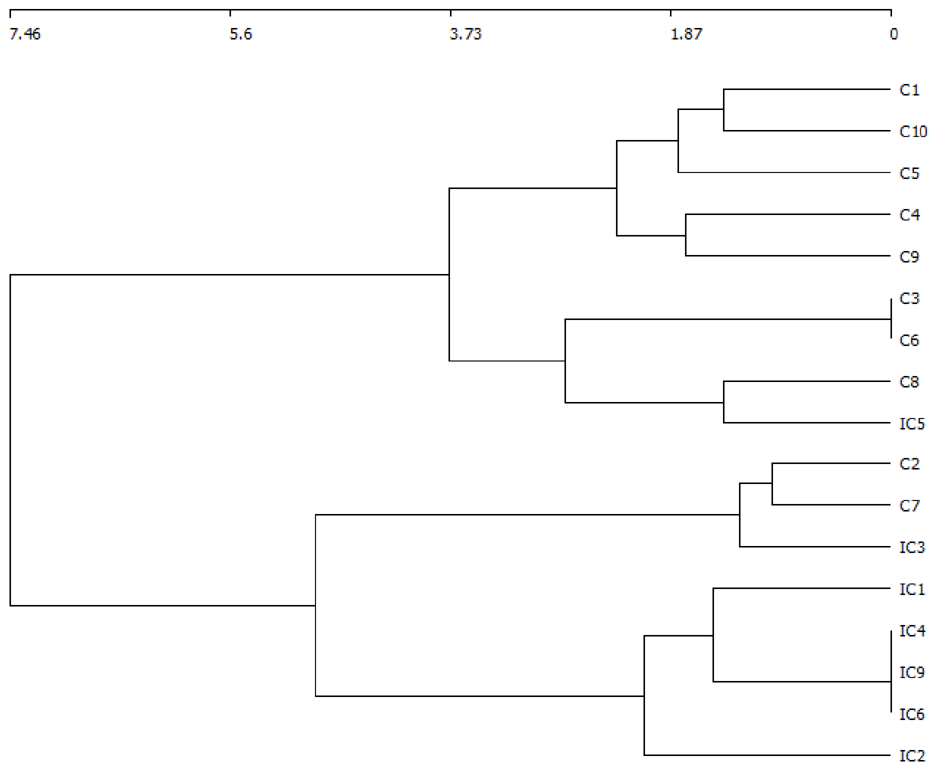

Figure 2. Grouping of clusters and inter-clusters derived from an agglomerative cluster analysis using Ward's method and Euclidean distance. Rare data have been removed. There are two major divisions and four significant groups. **Group 1**: C1, C10, C5, C4, C9; **Group 2**: C3, C6, C8, IC5; **Group 3**: C2, C7, IC3; **Group 4**: IC1, IC4, IC9, IC6, IC2. Groups 1, 2 and 3 are associated with koala sightings. There were no koala sightings in Group 4. The X axis represents the distance between the clusters at the time they were analysed.

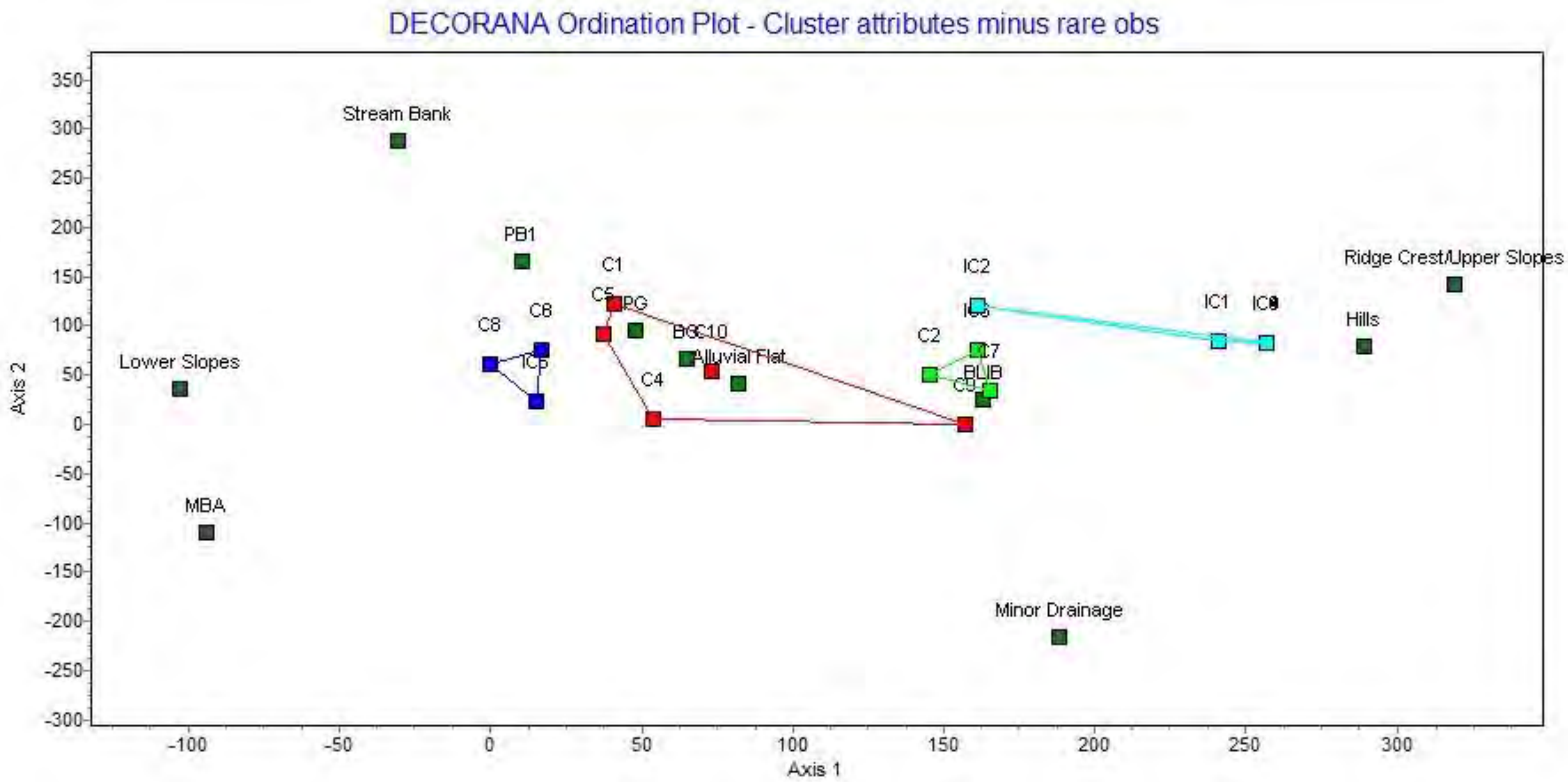

Figure 3. DECORANA ordination of cluster and inter-cluster attributes. Axis 1 follows a landform gradient from stream bank and lower slopes (left) to upper slopes, ridge crests and hills (right). The group boundaries, identified in Figure 2, are shown and are arranged, left to right, group 2, group 1, group 3 and group 4. Koala records are associated with groups 1, 2 and 3. There are no records for group 4.

Table 4. Koala records associated with koala road kill groups.

(Clusters and inter-clusters by groups - Group 1: C1, C10, C5, C4, C9; **Group 2**: C3, C6, C8, IC5; **Group 3**: C2, C7, IC3; **Group 4**: IC1, IC4, IC9, IC6, IC2.)

	G1	G2	G3	G4
	4	9	4	0
	7	10	9	0
	3	7	2	0
	4	0		0
	10			0
N	5	4	3	5
Sum	28	26	15	0
Mean	5.6	6.5	5	NA
SD	2.9	4.5	3.6	NA

Figure 4. Relationship between the koala clusters and road kill hotspots identified by Schlagloth (2018)

Potential for infrastructure investment

A summary of infrastructure investment opportunities by cluster is provided in Table 5. The association of bridges and culverts with the clusters is shown in Figure 5.

Bridges

Existing bridges provide the best opportunity for wildlife underpasses – especially the most recently upgraded infrastructure. These bridges have sufficient span to provide clear lines of vision, and usually include some lower terrace features that would allow koalas and other wildlife to traverse the underpass during periods of low flow. Low, or no flows constitute the usual condition for these streams. No retrofitting would be required for koalas. Periodic maintenance to ensure that these are clear of flood debris following wet season flows may be required. Wildlife fences need to be installed to make these bridges fully functional as wildlife underpasses. Such fences would also require routine maintenance.

Culverts

Some larger culverts (1.6 m – 2 m diameter) provide opportunities for conversion to wildlife underpasses. They provide a wide entrance, and light is visible along the length of the culvert. However, they are somewhat enclosed spaces, and the length may deter some fauna. Installation of barrier fences is required to direct wildlife to the mouth of these features. Maintenance would be required to keep the approaches free from overgrowth, and debris, so as not to deter wildlife movement. In addition, given the age of the road, the majority of culverts are constructed of corrugated steel pipe. These pipes have a circular cross section, and restricted cross sectional area of the corrugated steel pipes. This is likely to make them less effective as a faunal underpass as the contemporary square concrete culverts (T. Dalton pers. com.).

Smaller dimension culverts (1.2 m diameter) provide some opportunity for faunal access. However, their dimensions are not likely to be favourable to koala utilisation.

Barrier fences

The distribution of koala sightings across the majority of the Eton to Nebo extent of the Peak Downs Highway precludes the extensive investment in major engineered structures such as additional bridges, underpasses and overpasses. Further, the terrain provides limited, yet well defined opportunities for the locating of such facilities. The protective infrastructure with the most utility over distances, and through variable terrain, is appropriately designed barrier fencing. Such fencing has been installed as part of the Eton Range Realignment Project mitigation works (Figure 6).

Barrier fencing is required to direct fauna to the existing bridges and larger culverts so that these facilities can act as effective fauna underpasses. Where the opportunity to direct fauna to an underpass does not exist, the fences would deter animals from entering the road reserve, and from attempting to cross the highway. However, the location and subsequent maintenance of the fences requires some thought. The highway is already fenced to prevent stock access to the carriageway. Efficiencies may be possible by co-locating the stock fences and the wildlife barrier fences by:

- making use of an existing fence alignment and associated track, and
- shared monitoring and maintenance between TMR and property managers.

Given the road reserve is largely forested, the fate of koalas resident within the reserve (if any) requires some management.

Prioritisation

Given the engineering and financial constraints on the construction of fauna sensitive infrastructure along such an extensive stretch of highway and in complex terrain, a meeting was held (16th November) to prioritise initial infrastructure investment. The meeting involved TMR officers and CQUniversity researchers. It was acknowledged that the existing bridges provide the best opportunity for safe animal movement beneath the highway as they were:

- associated with more significant drainage features that generally have a larger cross sectional area;
- more likely to allow for animal movement in the wet season;
- easier to tie into to ensure complete animal exclusion from the road.

In contrast many culverts were:

- narrow in profile, and long with little visibility along the culvert, and had a low probability of use by koalas and larger fauna;
- pipe shaped, precluding wet season crossing by fauna;
- often located in situations where the installation of barrier fencing was technically difficult or proscribed for road safety reasons.

It was decided:

1. initially, to focus on the installation of koala barrier fences 100m either side of targeted bridge locations;
2. TMR would inspect proposed culverts to determine whether installation of fauna exclusion fencing was practical; and
3. that future culvert replacements or upgrades may be required to ensure the culvert aperture width is sufficient for animal movement.

Table 5. Investment opportunities

Cluster name	Cluster Code	Culverts & bridges (dimension)	Chainage (km)	Investment notes	Recommendation
Nebo Junction	C1	None		This is a tight cluster around a minor drainage line leading to a nearby stream and associated alluvia.	Install protective fences on both sides[1] to deter koalas crossing from the alluvial habitat to the adjacent low ridges.
Fiery Creek	C2	Bridge (not provided)	9.958	Culverts provide a number of opportunities for faunal underpasses. Koala signs were present near the mouth of at least one culvert. The Fiery Creek bridge provides a suitable underpass without retrofitting.	Install protective fences to guide wildlife[2] towards the culverts and to the bridge.
		Culvert (1 pipe /1650mm diam)	11.966		
		Culvert (1 pipe/2300mm diam)	11.28		
		Culvert (1 pipe/1200 diam)	11.221		
		Culvert (3 pipes/1800mm diam)	10.777		
		Culvert (4 channel/2130 X 1800mm)	9.124		
Boundary Creek	C3	Culvert (1 pipe/3500mm diam)	17.88	Culverts offer some opportunity for fauna underpasses. Boundary Creek bridge requires no retrofitting and is suitable as a fauna underpass.	Fence to culverts and to the Boundary Creek bridge. As the highway directly abuts and follows habitat on alluvia and stream banks for some distance, the protective fences should span those areas where possible.
		Bridge (not provided)	16.75		
Black Soil Gully	C4	Culvert (4 channel/2100 X 1800mm)	22.93	The existing culverts to the east and west of the Black Soil Gully culvert provide some potential as wildlife underpasses. The main gully culvert is not suitable. Plan to upgrade to a larger box culvert as a fauna underpass at some stage.	Install protective fences leading to the eastern and western pipe culverts. Plan to upgrade the main box culvert to a wildlife standard when feasible.
Cut Creek Bridge	C5	Bridge (not provided)	24.174	This is a small cluster adjacent to Cut Creek. The bridge provides a suitable underpass environment without retrofitting.	Install protective fences at least 200 m each side of Cut Creek to direct wildlife to the bridge underpass.
Denison Creek Bridge	C6	Bridge (not provided) Culvert (5 channel/2400 X 1800mm)	28.081	It is not clear why this cluster does not extend to the east of Denison Creek. Review habitat to ascertain the need to include fences on both sides of the creek.	Install protective fences from the bridge west to the entrance of the rest area. Extend fencing west to the limit of the cluster. Fence the eastern side of the bridge.
Mt Spencer	C7	Culvert (1 pipe/2550mm diam)	34.437	2 m diameter culvert in this cluster. Koala activity was evident around the mouth of the culvert.	Install fences directing wildlife to culverts. Maintain entry of culvert clear of grass and debris. When the opportunity arises, replace with a larger scale box culverts.
		Culvert (1 pipe/1950mm diam)	34.257		
		Culvert (1 pipe/1650mm diam)	34.115		

		Culvert (2 channel/2100 X 1500mm)	31.858		
Stockyard Creek	C8	Bridge (not provided)	36.822	Fence to culvert on the creek & fence to bridge mouth	Install protective fencing. There is no need to retrofit the bridge.
Hannaville	C9	Culvert (not provided)	38.788	Road cuts through *Eucalyptus tereticornis* flats. Culverts are mostly too small to be used by koalas.	Install protective fencing. Construct underpasses or install larger culverts when appropriate.
Hamdenvale	C10	Culvert** (2 pipe/2440mm diam)	42.46	** This culvert is just outside the cluster.	Install protective fencing. Consider the feasibility of running barrier fences from the cluster to the nearby culvert.

[1] **The length of koala fencing installed depends on the extent and nature of the feature being fenced. In the case of a road abutting high vale koala habitat (stream fringing vegetation or alluvial flats) fencing the entire extent would be ideal. Logistic and economic realities may constrain this.**

[2] **The extent of the guide fencing should be to the maximum feasible given logistical and economic constraints. More work research is required to ascertain koala behaviour in relation to guide fences, and especially to the length of end-of-fence returns.**

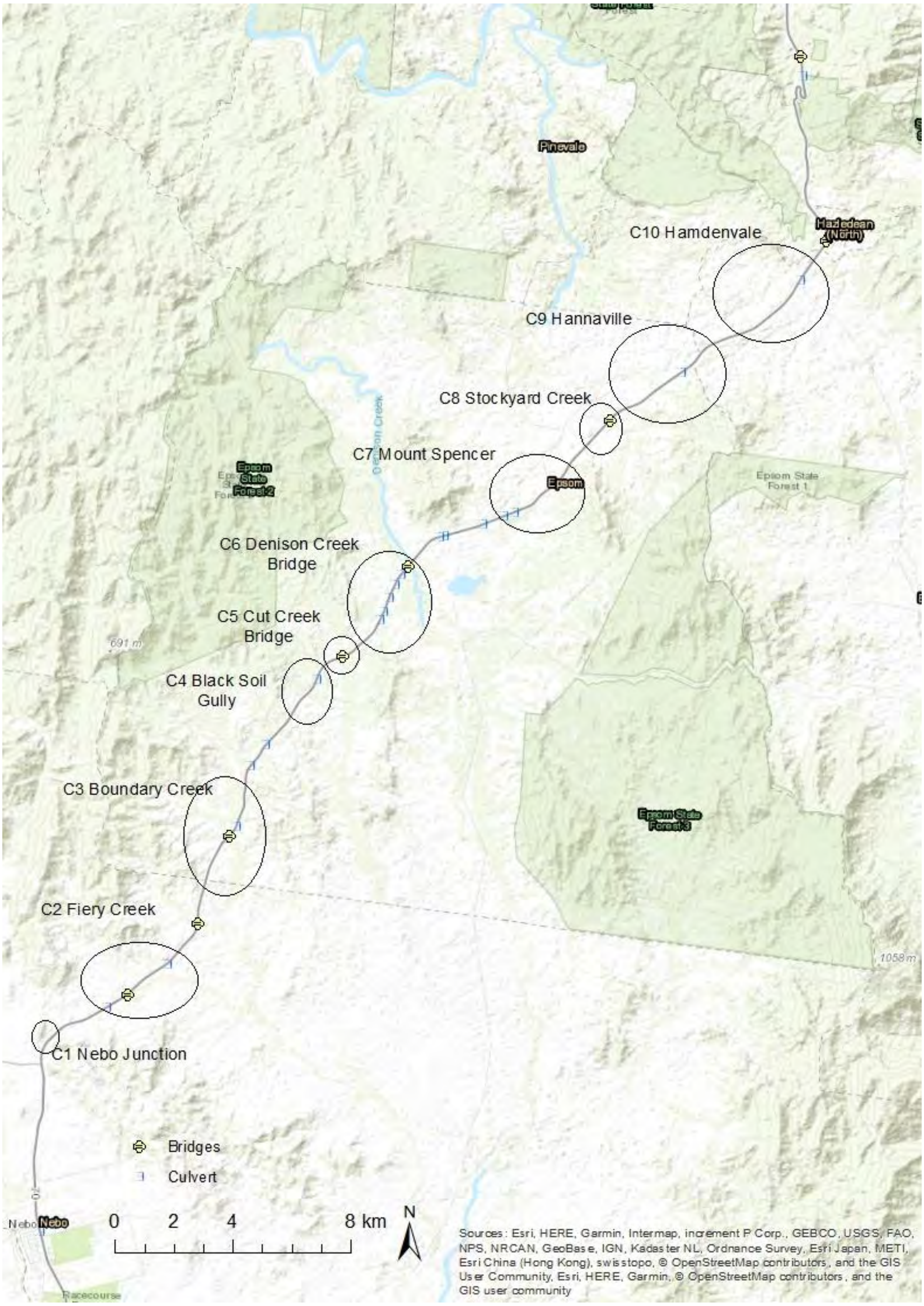

Figure 5. Association of koala clusters with bridge and culvert infrastructure on the Peak Downs Highway. Clusters are denoted by black ovals. Bridges by yellow squares. Culverts by blue lines.

Figure 6. Koala barrier fencing erected in association with the upgraded Eton Range upgrade of the Peak Downs Highway.

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