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27 November 2018

Peter Bennett
B & J Catalano Pty Ltd
South West Highway
Brunswick Junction, WA 6224

Dear Peter,

Plantecology Consulting was commissioned by B & J Catalano to undertake a detailed investigation within of Lot 4 Ludlow Rd, Myalup (the site), in the Shire of Harvey (Figure 1). The purpose of the survey was to inform the proposed expansion of an active quarry and this letter outlines the results of that survey.

1 Introduction

The site is located on a limestone ridge between the active quarry and Lake Preston. The Department of Water and Environmental Regulation (DWER) advised that three priority taxa could potentially occur within such a habitat in this location:

- *Pterostylis frenchii* (P2). This species occurs in tuart and peppermint coastal woodland over limestone (Brundrett 2014);
- *Alyogyne* sp. Rockingham (P2). This taxon is a perennial shrub of the coastal region south of Perth, mainly occurring on soils with limestone nodules; and
- *Hibbertia spicata* subsp. *leptotheca* (P3). This taxon is a perennial shrub and occurs in sand on near-coastal limestone ridges and cliffs.

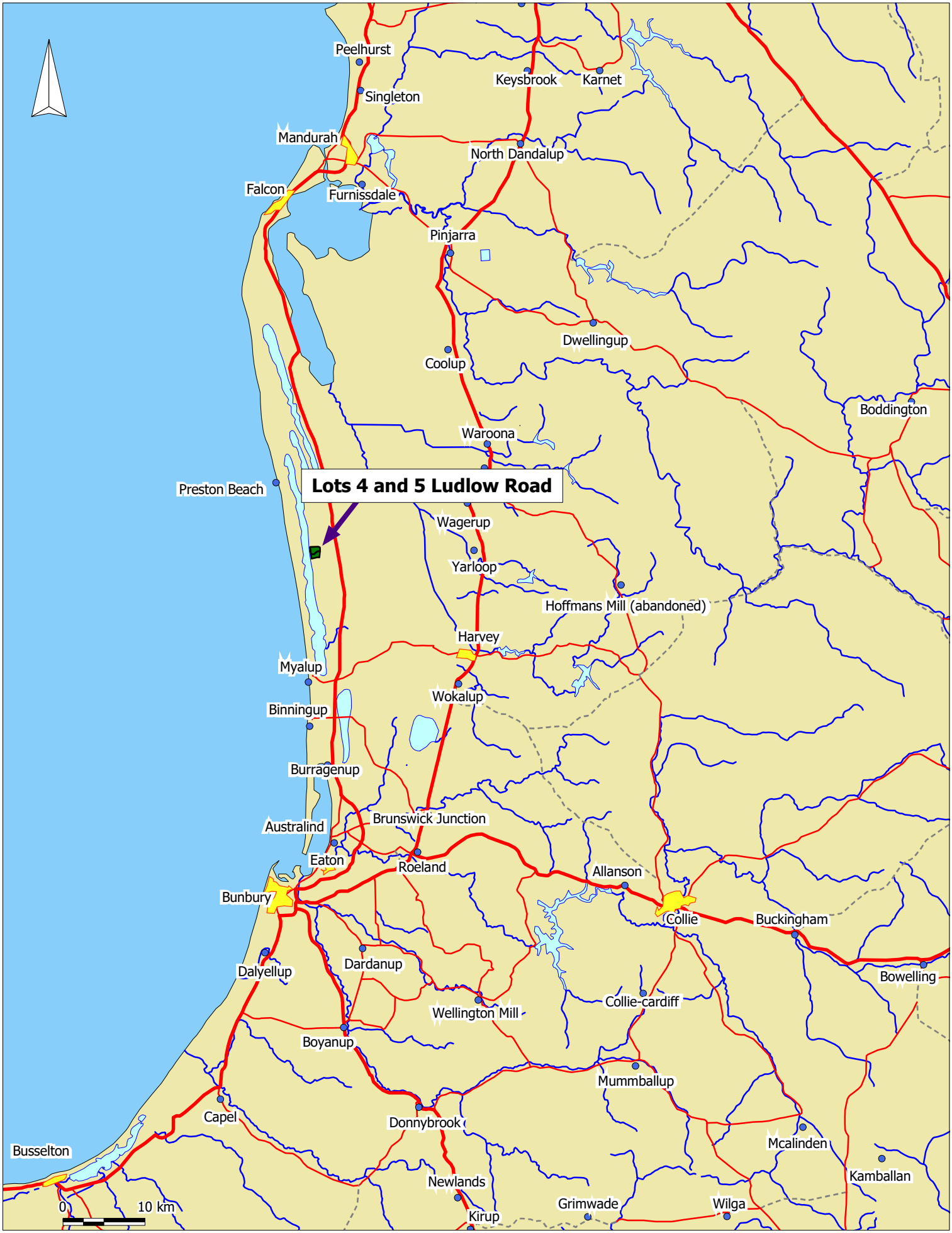
Also, the habitat could potentially support vegetation of floristic community type (FCT) 26a '-*Melaleuca huegelii – Melaleuca systena* shrublands of limestone ridges'. FCT 26a is listed as a Threatened Ecological Community (TEC) with the rating of 'Endangered' under Western Australian criteria. FCT 26a occurs on skeletal soils of large limestone ridges to the north of Perth and to the south of Mandurah (Gibson *et al.* 1994).

2 Methods

2.1 Field Survey

The field survey was conducted by botanists from Plantecology Consulting over one day on the 19th November 2018. A targeted search for priority flora was conducted by walking in parallel transects approximately 10 – 20 m apart (more closely spaced in denser vegetation).

A survey of the vegetation within the site was undertaken at 3 sampling points, each 100 m^2 (10 m x 10 m) and located in the best condition vegetation (Figure 2). Within each plot, all observable vascular plant species were recorded. The species data recorded was qualitative (presence/absence) as this was the type of data used in the original Swan Coastal Plain survey (Gibson *et al.*, 1994).



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Datum: GDA94
Projection: Australia MGA94 (50)

Client: B & J Catalano
Project: Flora and Vegetation Assessment
Location: Lots 4 & 5 Ludlow Rd Myalup

Figure 1:

Locality Plan

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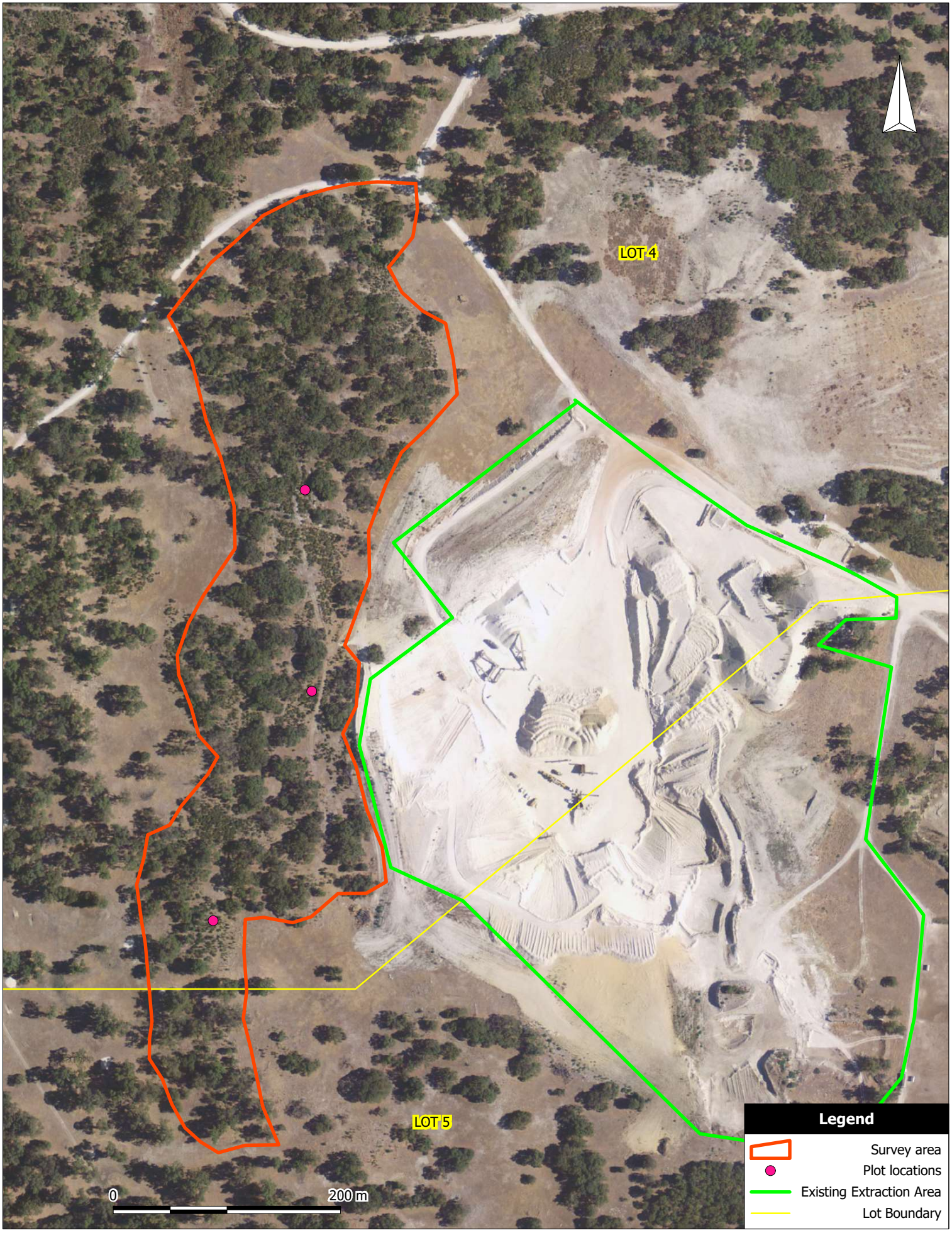

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Scale: 1:4200
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Air Photo Source: Nearmap Dec 2017
Datum: GDA94
Projection: Australia MGA94 (50)

Client: B & J Catalano
Project: Flora and Vegetation Assessment
Location: Lots 4 & 5 Ludlow Rd Myalup

Figure 2:

Survey Area

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2.2 Data analysis

The remnant vegetation of the southern Swan Coastal Plain was surveyed by Gibson *et al*. (1994) to provide an understanding of the major floristic gradients across the region. The major plant communities (or FCTs) were defined by classifying the data according to the similarities in species composition between plots. When determining the FCT of a new record, a floristic analysis of species composition provides the most robust method that is consistent with the original classification.

Presently, a single consistent method for the determination of FCTs for vegetation data in the Swan Coastal Plain is not available. Therefore, it is preferable to use multiple methods and compare the output for the most likely result. All analyses described below were undertaken using R packages Cluster, Vegclust and Vegan.

2.2.1 Hierarchical Clustering

Hierarchical agglomerative clustering is the usual first stage in classifying vegetation data into community types. This involves calculating the similarity (or more often, the dissimilarity) between plots within the dataset and then sequentially fusing the plots into groups according to their similarity. This type of method was used in the analysis of the original Swan Coastal Plain dataset (Gibson *et al*. 1994), but its use as the basis for assigning new plot data to the regional classification has some drawbacks. Firstly, a hierarchical clustering only applies to the relationships between plots, and the relative distances between them, within that particular dataset. The addition of new data often alters the relative distances and disrupts the clustering output. Secondly, as an unsupervised method, hierarchical clustering does not define rules for the membership of the defined groups, and so the addition of new plots requires the rebuilding of the entire hierarchy (De Cáceres and Wiser 2012).

The data for the Swan Coastal Plain regional survey (Gibson *et al.* 1994) was downloaded from the NatureMap website. This is largely similar to the original survey except for one site (OATES-1), which has now been excluded. The species nomenclature of the original dataset was updated to be consistent with current usage. Where original names could not be matched clearly to the updated usage, those taxa were removed from the analysis. The data from the three surveyed sites of the Ludlow Rd survey was added to the matrix both together and also one plot a time, which served to remove any effect of spatial correlation between the new plots. Each new dataset was then analysed calculating the Bray-Curtis distance coefficient (or resemblance measure) and the flexible beta linkage method (beta = -0.1). Assignment of the Ludlow Rd plots was to the nearest distinct group by inspection of the resulting dendrogram.

2.2.2 Non-hierarchical clustering

Non-hierarchical clustering methods often allow new plot data to be added to previous classifications because they are based on the concept that each group or cluster is represented by a prototype i.e. either a centroid or a medoid (a 'type' plot) (De Cáceres and Wiser 2012). Therefore, new observations can be assigned to an existing classification by calculating the distance to the nearest prototype (which may be considered a membership criterion). This approach is to be preferred to the hierarchical reconstruction approach because it defines numerical rules that can be consistently applied. However, it also means the original classification needs to be re-analysed using a different method, which can be problematic because not all sites from the original classification may be diagnostic for their respective clusters.

For the analysis of the Ludlow Rd data, the same updated Swan Coastal Plain dataset was used as for the hierarchical clustering analysis. After calculating a Bray-Curtis distance matrix, the dataset was then analysed using Fuzzy C-Means clustering in the R package 'Vegclust'. A fuzziness

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coefficient of 1.1 was chosen to minimise influence from noisy data points. FCTs with too few plots to reliably define determine a prototype (e.g. FCT 14 with two plots) were removed from the analysis. Similarly, some plots that were regularly being misclassified (such as those from clusters with large internal heterogeneity) were also removed. The final dataset consisted of 344 plots with 1316 taxa representing 38 FCTs. Each site of the Ludlow Rd data was then assigned a FCT using function 'vegclass' in the Vegclust package.

It should be noted that this approach for FCT assignment is preliminary and will need to be refined further before it can be used consistently. For example, the assignment of sites to dryland FCTs gives robust and consistent results. Sampling of seasonally-inundated wetlands, however, often gives problematic results as these floristic types show a greater degree of floristic overlap between groups and/or require additional sampling to provide a clearer differentiation between such groups. Also, disturbed sites with a high proportion of introduced taxa often give spurious results.

3 Results

3.1.1 Flora and Vegetation

The main vegetation types within the site were a *Eucalyptus decipiens* open woodland on the shallow soils over limestone of the ridge crest and upper slopes (Plate 1) and a *Eucalyptus gomphocephala* woodland on the deeper soils of the lower slopes (Plate 2). These vegetation types were rated as being in a 'Completely Degraded' condition, as the native understorey was largely absent and replaced by weed species and the original structure has been almost entirely lost. The crest and upper slopes also supported patches of *Melaleuca systena* shrubland, which was rated as being in a 'Degraded' condition. Thee patches supported more native species (mainly shrubs) than the woodland areas, but aggressive weed species such as **Gomphocarpus fruticosus* were prevalent.

No priority flora were observed during the survey.

3.1.2 Hierarchical analysis

The results of the hierarchical analysis show that plots 1 and 3 were assigned to FCT 29a – Coastal shrublands on shallow sands, while Plot 2 was assigned to FCT 24 - Northern Spearwood shrublands and woodlands (relevant parts of the dendrograms are shown in Figures 1:3). When all the Ludlow Rd plots were analysed together, they were assigned to FCT 24 (not shown).

3.1.3 Non-hierarchical analysis

The results of the FCT assignment by non-hierarchical analysis are shown in Table 1. The results show the highest similarity to either FCT 29a or FCT 6 each plot, although the strengths of membership (similar to a probability) are not strong and not much greater than to other groups. This is likely due to the number of weed species within the site, which is evidenced by the highest strength of membership for Plot 2 being to FCT 6 (weed dominated wetlands). The strength of membership to FCT 6 for Plots 1 and 3 was each approximately 19%.

The strength of membership for FCT 26a is very low and, as FCT 26a is a distinct group within the Swan Coastal Plain dataset, it is highly unlikely that vegetation within the site would be a part of this FCT.

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Table 1: Results of non- hierarchical analysis for plots from the Ludlow Rd survey (Strength of membership shown in brackets).

Plot	FCT of nearest group	FCT of 2nd nearest group	FCT of 3rd nearest group	Strength of membership to FCT 26a
Plot 01	29a (26.6%)	6 (19.8 %)	13,15,16,17 (14.4%)	0.38%
Plot 02	6 (25.3%)	29a (23.0%)	13,15,16,17 (16.8%)	0.07%
Plot 03	29a (34.1%)	13,15,16,17 (22.4%)	6 (19.5%)	0.08%

4 Discussion

Although the results of the FCT assignment were inconclusive, it is most likely that the shrubland areas on the ridges are part of FCT 29a – 'Coastal shrublands on shallow sands'. FCT 29a is a Priority 3(i) Ecological Community under Western Australian criteria, which indicates this vegetation type, although poorly known, has several to many occurrences, a significant proportion of which is not under threat. This result is consistent with the description of FCT 29a as being mostly heaths of shallow soils over near-coastal limestone from Yalgorup to Seabird on the Quindalup Dune System. This FCT has no consistent dominant species and is often quite weedy (Gibson *et al.* 1994). The appropriate FCT for the woodland areas was not examined, as these areas are now mostly 'parkland cleared' and any analysis would produce spurious results.

The vegetation condition within the site ranged from 'Degraded' to 'Completely Degraded'. This was reflected in the equivocal results of the cluster analysis for FCT assignment and is probably due to past use for stock grazing. A significant proportion of the taxa recorded were weeds, some of which were aggressive species such as **Gomphocarpus fruticosus, *Euphorbia terracina* and *Ehrharta longiflora.* This condition compromises the botanical values of the site and it could not be returned to a more natural structure without the input of considerable resources.

The vegetation within the site is highly unlikely to be part of FCT 26a. FCT 26a is a very distinct group within the SCP dataset with a high mean species richness (50.2 species per plot), and assignment of plots when present is normally quite clear. This result is supported by the description for FCT 26a as occurring on massive limestones with skeletal soil. Although all the Ludlow Rd plots included outcropping limestone, these areas mainly supported *Eucalyptus decipiens* Woodland, which does not form part of FCT 26a.

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5 Conclusion

In summary, the results of this survey and analysis indicate that the vegetation within the site at Ludlow Rd is most likely to belong to FCT 29a, which is a Priority 3(i) community under Western Australian criteria, but the ecological values of the site have been compromised by past land uses and the currently degraded condition.

Should you require any further information or have any other queries, please feel free to contact me.

Sincerely yours,

Dr. Shane Chalwell

Plantecology Consulting

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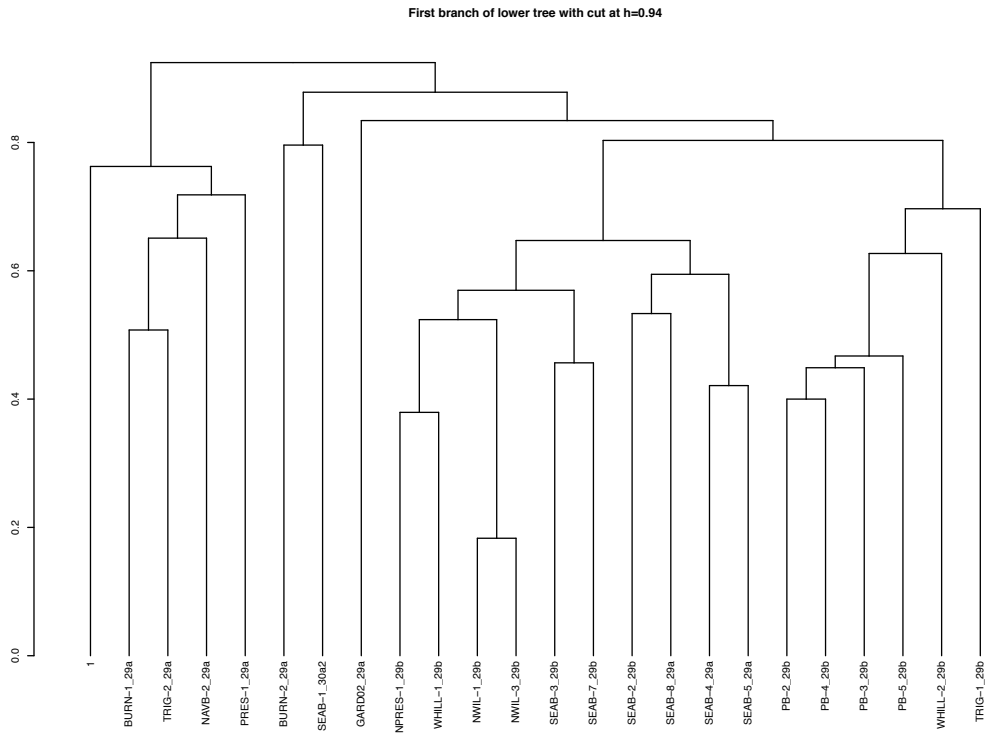

Figure 1: Partial dendrogram of hierarchical clustering showing relationship of Plot 1 to the Swan Coastal Plain dataset sites.

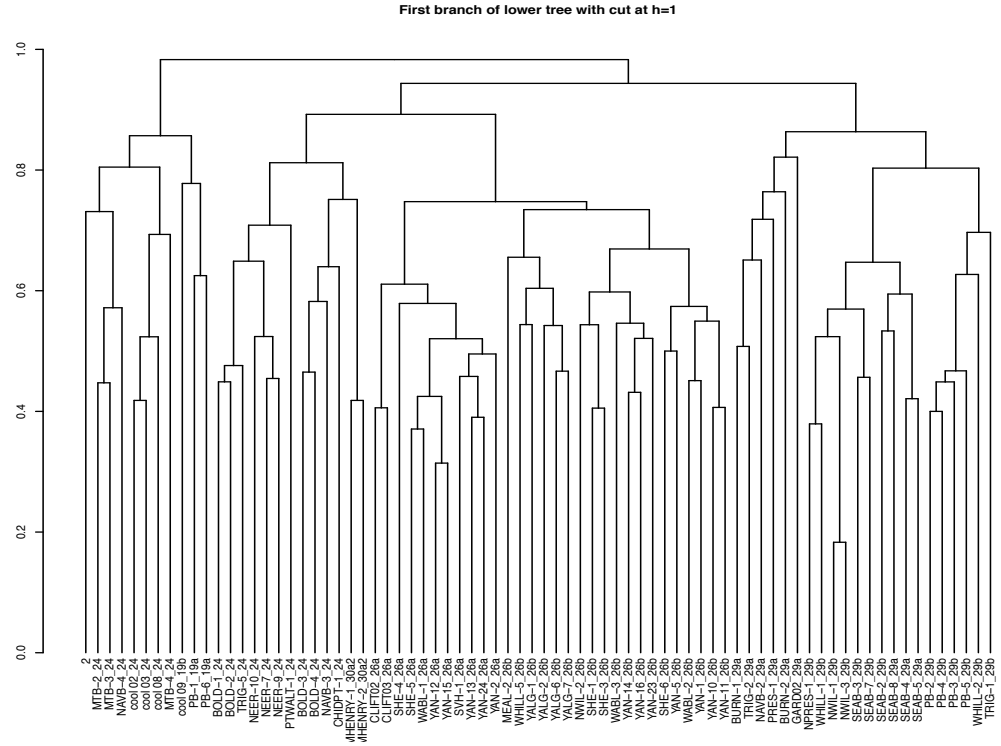

Figure 2: Partial dendrogram of hierarchical clustering showing relationship of Plot 2 to the Swan Coastal Plain dataset sites.

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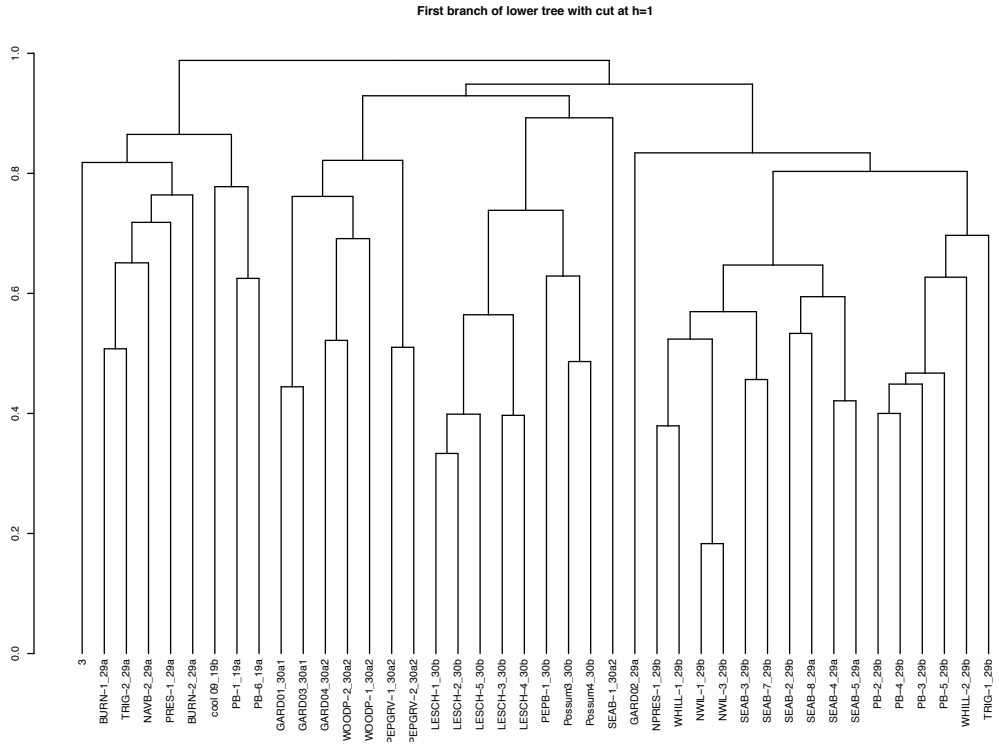

Figure 3: Partial dendrogram of hierarchical clustering showing relationship of Plot 3 to the Swan Coastal Plain dataset sites.

5 References

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De Cáceres, M and Wiser, S.K. (2012) Towards consistency in vegetation classification*, Journal of Vegetation Science*, 23: 387-393

Gibson, N, Keighery, BJ, Keighery, GJ, Burbidge, AH and Lyons, MN (1994), *A floristic survey of the southern Swan Coastal Plain*, Unpublished Report for the Australian Heritage Commission prepared by the Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc), Perth.

Keighery, BJ (1994), *Bushland plant survey: A Guide to Plant Community Survey for the Community*, Wildflower Society of WA (inc), Nedlands, Western Australia.

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Plates

Plate 1: *Eucalyptus decipiens* Woodland

Plate 2: *Eucalyptus gomphocephala* Woodland

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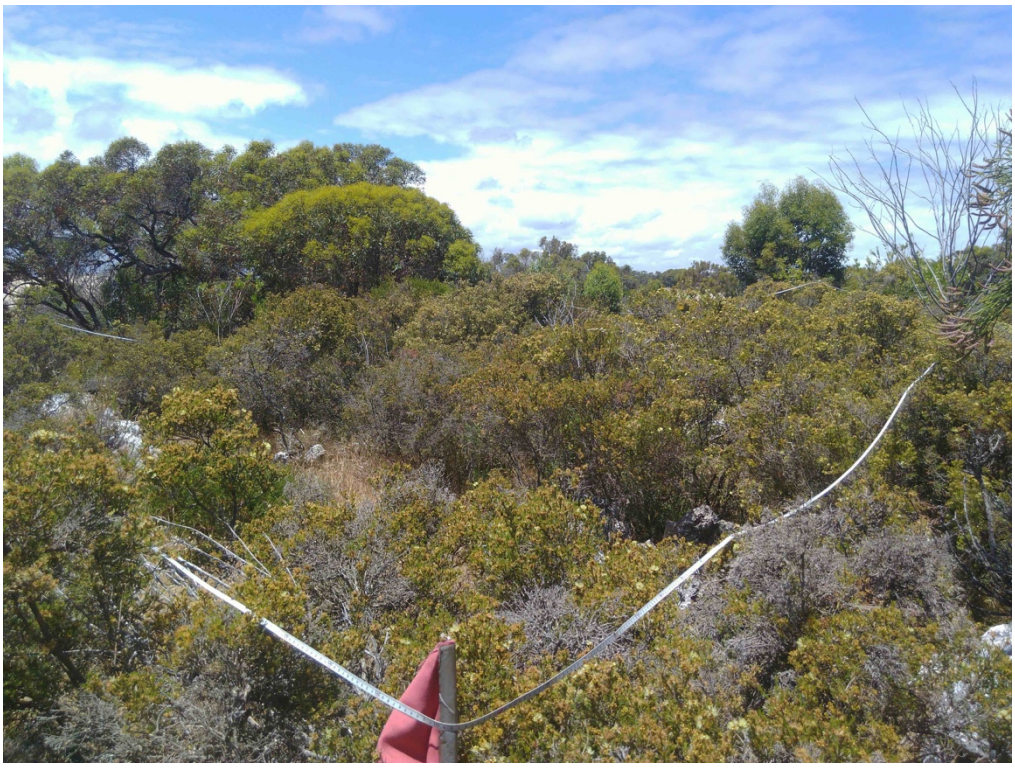

Plate 3: View of Plot 1 from northwest corner

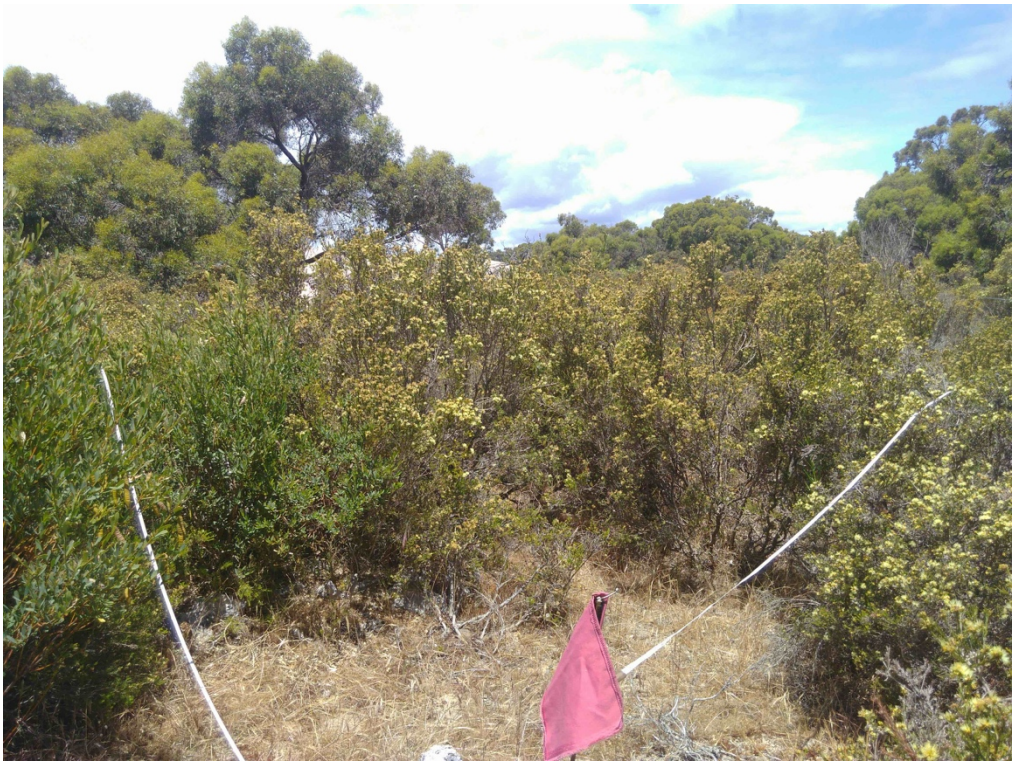

Plate 4: View of Plot 2 from northwest corner

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Plate 5: View of Plot 3 from northwest corner

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Appendix A

Taxa recorded within the survey site (* = Introduced taxon).

Agonis flexuosa
Anthocercis ilicifolia subsp. *ilicifolia*
Austrostipa flavescens
* *Avena barbata*
Banksia attenuata
Banksia dallanneyi
* *Bromus diandrus*
Cassytha glabella
* *Crassula glomerata*
Desmocladus apser
* *Ehrharta calycina*
* *Ehrharta longiflora*
* *Erodium botrys*
Eucalyptus decipiens subsp. *decipiens*
Eucalyptus gomphocephala
* *Euphorbia terracina*
* *Freesia alba x leichtlinii*
* *Galium murale*
* *Geranium molle*
* *Gomphocarpus fruticosus*
Hakea prostrata
Hibbertia hypericoides subsp. *hypericoides*
Hibbertia racemosa
* *Hypochaeris glabra*
Isolepis cernua var. *setiformis*
* *Lagurus ovatus*
* *Leucopogon parviflorus*
* *Lolium rigidum*
Lomandra micrantha subsp. *micrantha*
* *Lotus subbiflorus*
* *Lupinus cosentinii*
* *Lysimachia arvensis*
Melaleuca huegelii subsp. *huegelii*
Melaleuca systena

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Nuytsia floribunda
* *Orobanche minor*
* *Rhagodia baccata*
* *Solanum linnaeanum*
* *Solanum nigrum*
Solanum symonii
* *Sonchus oleraceus*
Templetonia retusa
Tricoryne elatior
* *Trifolium campestre* var. *campestre*
* *Vulpia myuros*

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Appendix B

Vegetation Condition Scale (Keighery 1994)

Vegetation Condition	Definition
Pristine (1)	Pristine or nearly so, no obvious signs of disturbance.
Excellent (2)	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.