Department of
Environment and Conservation

A Preliminary Analysis of Floristic Quadrat Data from the Eastern Part of the South West Region (The Darkan-Boyup Brook Survey)

Morning mist in a wandoo woodland in Haddleton Nature Reserve

Russell Stephen Smith
Bunbury
June 2007

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Introduction

This report documents the preliminary analysis of floristic data from surveys carried out in the eastern part of the South West Region of the Department of Environment and Conservation during the period 2003-2006. The survey's main objective was to gather data on the distribution of species and do a preliminary assessment of the main vegetation types in an area stretching from the Collie -Williams Road to the Blackwood River (called the Darkan-Boyup Brook study area). Twenty five floristic quadrats from within the study area and just to the east and north taken from the Biological Survey of the Agricultural Zone (Keighery *et al.* 2004) were included in the cluster analysis with the 63 established as part of this study to increase the geographical coverage of plots and to reveal relationships between the vegetation of the study area and that in drier areas immediateley to the west.

While Beard (1979) and Smith (1974) mapped the vegetation of the area at 1:250,000 scale the vegetation units were based primarily on the physiognomy of the dominant stratum and the floristic dominants and the scale did not allow the separation out of geographically smaller units. Smith (op cit.) describes in general terms the areas mapped as "Wandoo Woodland" in the vicinity of Bowelling and Cordering (within the Darkan-Boyup Brook study area) and the areas mapped as "Jarrah-Wandoo Open Forest" at the eastern edge of the Collie sheet within the study area. Beard combined his vegegation units into systems – the Darkan-Boyup Brook study area encompasses three of his systems – the East Darling in the north, Bridgetown in the south west and Beaufort vegetation system in the south east.

Havel and Mattiske (2000) mapped vegetation complexes within the Darkan-Boyup Brook survey area – the vegetation complexes are units defined by a combination of floristics, climate and geomorphology and are partly based on landform mapping by the Department of Agriculture. The vegetation complexes mapped by Havel and Mattiske on which the sites in the Darkan-Boyup Brook survey were located are shown in Appendix 1.

Havel (1975a and 1975b) sub-divided the floristics of the northern jarrah forest continuum (between Mundaring and Collie) using multivariate analysis and defined site-types. However, none of Havel's sample plots were within the present study area being to the north and west, although some of his low-rainfall zone site-types approximate some of those within the study area described herein. Strehlein (1988) carried out a vegetation survey of the southern jarrah forest based on the collection of floristic data from plots with a 20 m radius. Strehlein's study area stretched from the southern limit of the Darkan-Boyup Brook study area to the southern and south western coasts. Several of the vegetation types that he recognized from the north east of his study area are similar to those described in this report, including types M, Y and A (see Table 2).

Table 1. Strehlein (1988) vegetation site-types from the drier north east of his study area (north east of Manjimup to Boyup-Cranbrook Road)

Strehlein Type	Dominant species and structure	Indicator species	Surface soil and landscape position
M	Wandoo-Jarrah forest with some Marri in sandier soils	*Acacia pulchella, Dryandra lindleyana, Hakea lissocarpha, Trymalium ledifolium, Astroloma ciliatum, A. pallidum, Desmocladus fasciculatus, D. flexuosa*	Brown or yellowish brown sandy loams or loamy sands with varying amounts of gravel on slopes
Y	Jarrah- Marri forest	*Bossiaea linophylla, B. ornata, Hypocalymma angustifolium, Leucopogon propinquus, Desmocladus fascicularis*	Black or dark grey clayey sand in broad flat drainage lines
A	Flooded gum woodlands with some *Eucalyptus decipiens* on low gravelly rises	*Acacia saligna, Allocasuarina humilis, Astroloma ciliatum, Desmocladus fascicularis, Melaleuca preissiana, M. viminea*	Yellowish brown sandy clay

Worsley Alumina & Dames and Moore (1981) report the results of a vegetation survey in the vicinity of the future Mt Whaleback minesite which lies about 20 km to the north of the Darkan-Boyup Brook study area. They identified seven communities ranging from heath, through wandoo woodland to jarrah-marri open forest, some of which have affinities to some of the vegetation groups described below.

The Biological Survey of the Agriculatural Zone (BSAZ) (Keighery *et al.*, 2004) surveyed 100 m^2 quadrats at 682 terrestrial sites and 813 wetland sites across the Western Australian wheatbelt, with a few beining located in the Darkan-Boyup Brook survey area as noted above. Vegetation at the terrestrial sites was classified into 25 high level groups and at the wetland sites into 39 high level groups. The BSAZ groups are very broad and the 'cut-off' points are at a much higher level than used in the analysis reported here, however the groups described in this report can sometimes be allocated to a BSAZ group and this gives some idea of the geaographical spread of similar vegetation across the south west of Western Australia.

Study area

Sixty three quadrats were set up in 2005 and 2006 in the Darkan-Boyup Brook study area from the Collie-Williams Road in the north to Boyup Brook in the south and from Hunt Forest Block near Wilga in the west to Capercup and Codganallup Pool on the Balgarup River in the east – covering an area 72 km north to south and 50 km east-west.

Rainfall in the Darkan-Boyup Brook study area ranges from 800 mm at the western extremity to about 550 mm in the east – most of it lies between the 600 and 700 mm isohyets. The quadrats included from the BSAZ in the Dryandra area are in a zone receiving about 480 mm annually.

Percy (2000) describes the relationship between Beard's mapping of the vegetation systems (groupings of his vegetation types) in the Katanning Area Land Resources Survey (the western part of which encompasses most of the Darkan-Boyup Brook study area) and the soil-landscape systems mapped by her survey (see also Table 2).

> "Beard combined vegetation types into vegetation systems which he defined as " ... a particular series of plant communities recurring in a catenary sequence or mosaic pattern linked to topographic, pedological and/or geological features" (Beard 1969, as cited in Beard 1980). He used broad generalisations to associate vegetation with landform position and soils. For example, in the Jingalup Vegetation System he found jarrah (*Eucalyptus marginata*), marri (*E. calophylla* syn. *Corymbia calophylla*) and wandoo (*E. wandoo*) woodland on the gravelly summits, marri and wandoo woodland on the slopes and flooded gum (*E. rudis*) along the drainage lines. Beard combined the vegetation systems into botanical districts or subdistricts.
>
> The Katanning survey area is in the South-West Botanical Province and covered by the Darling (Menzies Subdistrict), Avon and Roe Botanical Districts. These are further subdivided into 10 vegetation systems. ..... The location of the botanical districts and vegetation systems bears only broad similarity to the soil-landscape zones and systems described in this report. The Darling Botanical District (Menzies Subdistrict) corresponds to the Western Darling Range Zone and most of the Eastern Darling Range Zone. It also coincides with the west of the Zone of Rejuvenated Drainage, in particular the Farrar, Beaufort and western parts of the Carrolup Soil-Landscape Systems....In each description of soil-landscape system, the most common vegetation species and communities are listed with the corresponding vegetation system(s) as mapped by Smith (1974) and Beard (1980). The soil series descriptions also indicate the native vegetation commonly found on these soils.
>
> Although vegetation can be a useful soil indicator, a one-to-one relationship between soil types, landform position and vegetation is rare. For example, York gum (*E. loxophleba*) is usually associated with reddish brown loamy soils on slopes but is common on grey shallow sandy duplex soils on the broad valley flats along the Coblinine River east of Katanning."

Percy (2000) goes on to give an overview of the geology and soils for the two soil-landscape zones in which the Darkan-Boyup Brook study area falls – these being the East Darling Zone in the west of the area and the Zone of Rejuvenated Drainage to the east.

Eastern Darling Range Zone

The Eastern Darling Range Zone is a moderately to strongly dissected lateritic plateau on granite with eastward flowing streams in broad shallow valleys. Eocene sediments also occur. Soils are mainly formed in laterite colluvium or on weathered granite.

This zone contains large remnants of undulating plateau covered by deeply weathered lateritic soils. Valleys dissected into the underlying granitic bedrock by the Blackwood River and its tributaries separate them. A feature is the broad, flat areas of Eocene sedimentary deposits high in the landscape, often bearing remnants of ancient rivers and lakes systems. The western boundary between the Western and Eastern Darling Range Zones follows the catchment divide between the Blackwood and Collie Rivers. The western boundary with the Zone of Rejuvenated Drainage lies where most of the broad plateau with lateritic soils had been eroded leaving small isolated scattered remnants of lateritic soils....

The soils on the plateau remnants are yellow and pale sandy gravels and yellow loamy gravels with small areas of yellow and pale deep sands. Between the plateau remnants are valleys or areas of undulating rises and low hills covered with yellow loamy and sandy gravels and yellow and red loamy duplex soils. On the eastern edge of this zone towards Darkan and Boscabel, grey deep sandy duplex soils become increasingly common.

Zone of Rejuvenated Drainage

The Zone of Rejuvenated Drainage is an erosional surface of gently undulating rises to low hills. It contains continuous stream channels that flow in most years. Colluvial processes are active with most soils formed in colluvium or weathered granitic rock. Small gravelly remnants of the laterite profile remain on hill crests and are often flanked by steep breakaways....

Rises and low hills are capped with sandy gravels or, less often, loamy gravels and are surrounded by breakaways. Grey deep sandy duplex soils dominate the slopes and valley flats. These soils have mottled yellow, grey or, less commonly, brown clayey subsoils. The subsoils are usually sodic and range from neutral to slightly acidic. Red to reddish brown sandy or, less commonly, loamy duplex soils are common on the slopes and are formed on weathered dolerite or gabbro. The broad alluvial plains of the Arthur, Beaufort and Hillman Rivers lie within this zone. The soils are usually grey sandy duplexes and often affected by salinity.

Table 2. Description of Vegetation Systems for the Darkan-Boyup Brook Study Area – (based on Percy, 2000, p. 22; sourced from Smith 1974 and Beard 1979, 1981,).

System	Gravels on hill crests	Hillslopes	Drainage lines and valleys	Other features
Darling Botanical District (Menzies Subdistrict)				
East Darling	*Eucalyptus marginata-Corymbia calophylla* open forest	*Eucalyptus marginata-Corymbia calophylla* open forest on sandy soils, *Eucalyptus wandoo and E. patens* woodland on loams	*Eucalyptus patens, E. rudis, E. wandoo* woodland	*Melalueca preissiana, Banksia littoralis low woodlands* and *M. viminea shrublands* on damp sandy flats
Beaufort	*Eucalyptus astringens, E. wandoo* woodland with some *E. marginata* and/or *E. gardneri*	*C. calophylla* and *E. wandoo* woodland	*E. occidentalis* and *E. wandoo* open woodland with shrub understorey	*E. loxophleba, E. occidentalis* woodland on aeolian sands
Bridgetown	*Eucalyptus marginata-Corymbia calophylla* forest	*Eucalyptus marginata-Corymbia calophylla* forest	*Eucalyptus rudis, Melaleuca rhaphiophylla*	*Corymbia calophylla-E. wandoo* woodland also common

Methods

The 63 quadrats established for the Darkan-Boyup Brook survey were placed in a range of landscape positions from swamp edges to the tops of lateritic ridges. Appendix 2 summarises the landscape position and soil details for each of the quadrats used in the vegetation classification analysis and Appendix 3 gives locational details as well as the soil-landscape map unit the quadrats used in the floristic analysis occurred on. The locations of the Darkan-Boyup Brook survey quadrats and also those used from the BSAZ are shown in figures 1 and 2.

Figure 1. Location of sites for 100m^2 quadrats in the northern part of the Darkan-Boyup Brook survey area

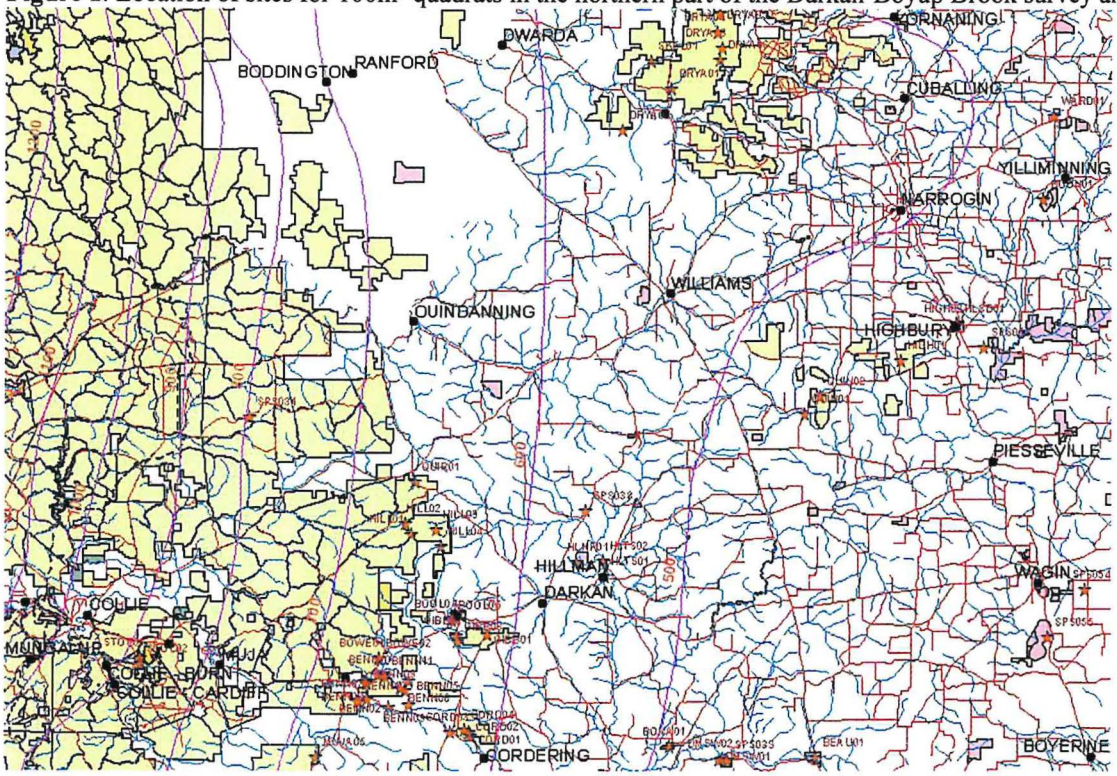
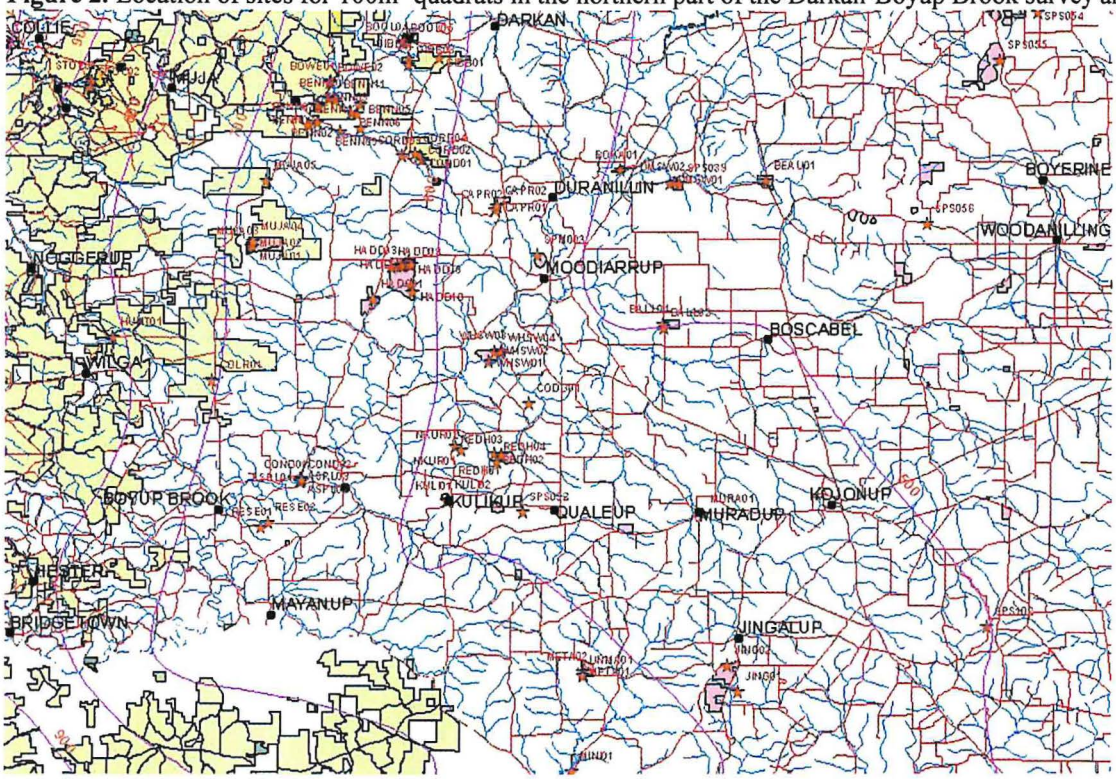


Figure 2. Location of sites for 100m^2 quadrats in the northern part of the Darkan-Boyup Brook survey area



The 10m x 10m quadrats set up for the Darkan-Boyup Brook survey were marked at each corner with fence droppers and their locations recorded with a GPS unit as well as being shown on a 'mud map' on the back of the survey recording form. A photograph of each quadrat was taken a, few metres back from the quadrat, from the south west and north east corners. The landscape position of the quadrat as well as a colour and texture description of the surface soil including whether there was gravel or rock present were also recorded. Each vascular species within the $100m^2$ quadrat and tree species from an unmarked 20m x 20m quadrat extending out from 2 sides of the 10m x 10m quadrat were recorded. Cover/abundance using a 5 point scale was recorded for many but not all quadrats and was not used in the multivariate analysis. Taxa not able to be identified in the field were collected and some were processed for inclusion in the regional and State herbaria.

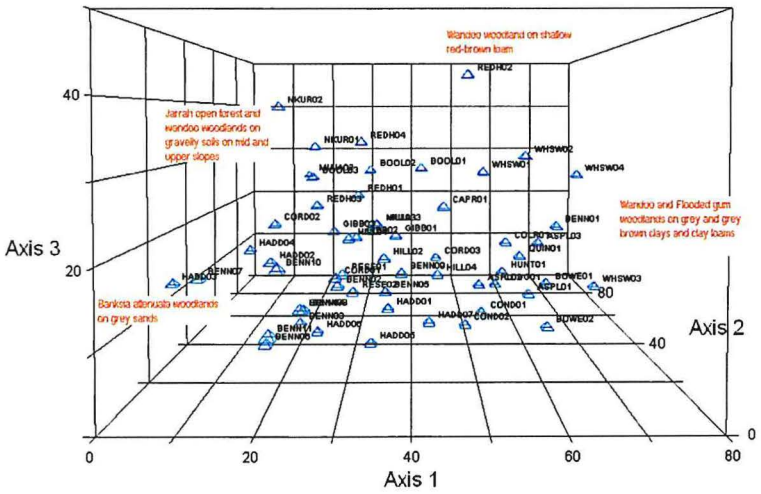
The multivariate analysis was carried out using the software program PC-ORD (McCune & Metford, 1999). Both ordination (on 234 species in 57 quadrats from the Darkan-Boyup Brook survey dataset) and cluster analysis on the full dataset were carried out. Before analysis all singleton species were removed from the dataset. Ordination was done using Detrended Correspondence Analysis (DCA) and clustering was carried out using the Bray-Curtis (Sorenson) distance measure and the Group Average (UPGMA) linkage method.

Results

Ordination

Low values of Axis 1 of the DCA ordination was associated with sites carrying Jarrah-*Banksia attenuata* woodland on sandy soils and those with wandoo and flooded gum woodland clays and clay loams on valley floors which high values on the axis (Figure 3). Quadrats in species rich wandoo and *Eucalyptus decipiens* woodlands on heavy gravels had low values on Axis 2 while the two species-poor quadrats adjacent to Lake Ngartaminny had very high values on this axis. The separation of quadrats along Axis 3 on the DCA ordination is difficult to ascribe to any geographical or edaphic influences – however, quadrats in Red Hill Nature Reserve and 'North Kulicup' Nature Reserve, which are geographically close to each other, had relatively high values and quadrats at the edge of Dingo Swamp in Haddleton Nature Reserve and on alluvial loams at Asplin Bridge reserve had relatively low values.

Figure 3. Ordination from the Detrended Correspondence Analysis of floristics of 57 quadrats established for the Darkan-Boyup Brook survey



Clustering

Nine groups encompassing 64 quadrats were recognized and described from the clustering analysis, two groups containing 25 quadrats in all, almost exclusively composed of sites outside the Darkan-Boyup Brook survey area were not described. The number of quadrats within the groups varies from 2 to 16. Codes, provisional names and comments on the nine groups are given in Table 3. More details on the groups (including most frequent species) are given in Appendix 4.

Groups A and B, composed of woodlands and shrublands found on loam and clay loam soils on alluvial terraces of the Blackwood River and the floors of minor valleys contain one recognized threatened community – "Woodlands and shrublands of the alluvial soils of the upper Blackwood River" (Smith, 2005). Some sites within these groups probably would fall within Groups 20.1 (Southwestern claypan basins) and 20.2 (Herb-rich southwestern lake and claypan margins) identified by the Biological Survey of the Agricultural Zone (Lyons *et al.*, 2004). Much more sampling is required to further define these groups.

Group C which is comprised of Wandoo and Wandoo-Marri woodlands on gravelly loams or shallow rocky loams has some affinities with Group I1W as defined and mapped by Worsley Alumina Pty Ltd and Dames & Moore (1981) which was a wandoo woodland on lower slopes with *Trymalium lediflorum, Gompholobium mraginatum* and *Xanthorrhoea preissii* in common.

Group D, Jarrah-Marri and Jarrah-Marri-Wandoo woodlands and open forest on gravelly or rocky grey-brown or yellow-brown soils on mid and upper slopes was widespread and the only community identified that was relatively well sampled (16 quadrats). It is notable that this community occurred in four different vegetation complexes as mapped by Havel and Mattiske (2000).

Group E included two sites within the Dingo Swamp basin which were atypical and would most likely form a distinct community as a result of further sampling and analysis. This group also includes a quadrat from Dryandra Forest about 80 km away to the north east in a lower rainfall zone. There is no doubt that this group could be divided further following further sampling of sites between Hillman Blaock in the north and Haddleton Nature Reserve in the south.

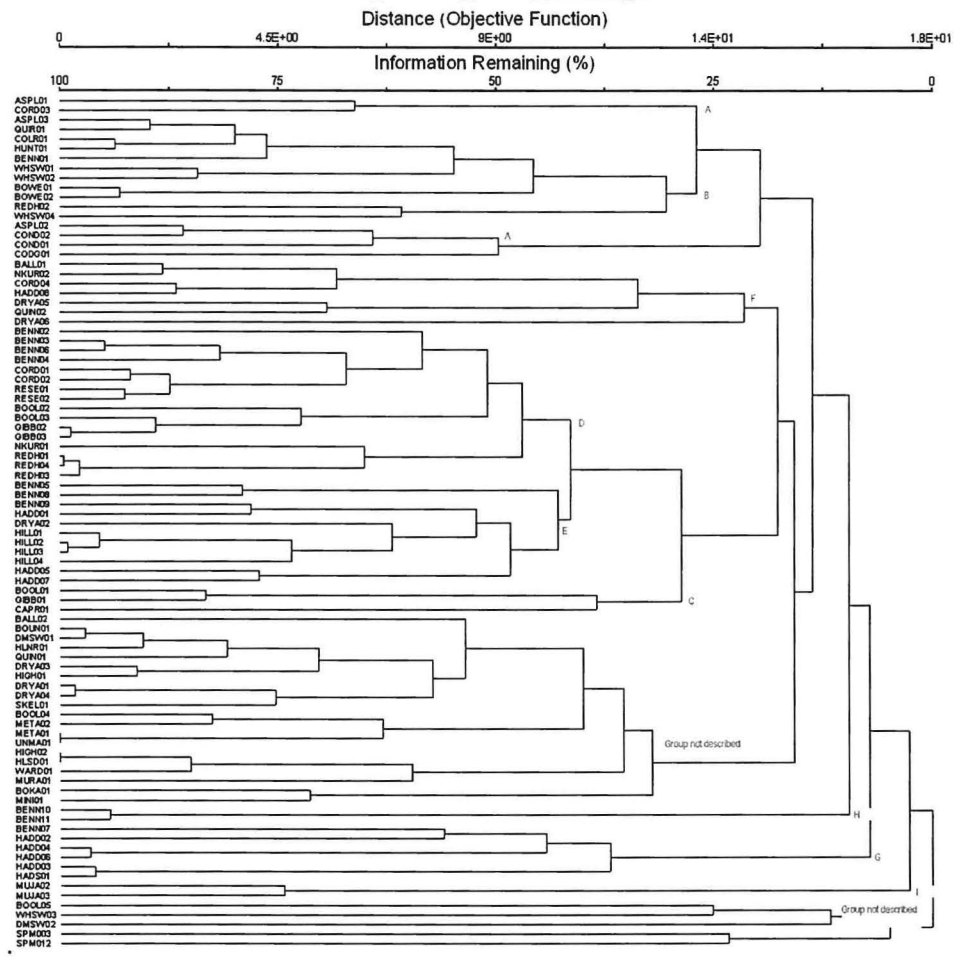
Group F is notable both for its species-richness and because it has a number of species with eastern distributions, eg. *Gastrolobium ovatum, Rinzia fumana, Synaphea obtusata, Melaleuca seriata* and *Lepidobolus preissianus*. It is interesting that the vegetation grouping that appears to be part of a transition between the flora of the Avon-Wheatbelt and the Jarrah Forest IBRA regions occurs on heavy gravels and apparently not elsewhere in the Darkan-Boyup Brook survey area.

Group I is an anomalous group in that it is based on only two quadrats, further sampling around Lake Ngartaminny in Muja Conservation Park and near other wetlands in the area is needed to illucidate whether the vegetation types or associations area really as restricted and unusual as they appear to be.

Table 3. Vegetation groups resulting from the cluster analysis of 57 quadrats from the Darkan-Boyup Brook survey area and 32 quadrats from the Biological Survey of the Agricultural Zone.

GROUP	NAME	COMMENTS
A	Wandoo, Wandoo-Marri and Jarrah-Marri open woodlands and *Hakea varia-Acacia saligna* shrublands on alluvial loams and clay-loams (6 quadrats)	Requires further survey effort. Species-poor (14-20 species per 100^2 m) open woodlands and shrublands on grey-brown, brown and red-brown loams and sandy loams along creeklines and on alluvial flats. ASPL01 and ASPL02 are located in the proposed threatened ecological community "Woodlands and shrublands of the alluvial soils of the upper Blackwood River (Condinup and Darkan 5f soil-landscape sub-systems)" (Smith, 2005)
B	Wandoo woodlands with herbaceous understories on clay loams and loams on valley floors (12 quadrats)	Widespread vegetation group, average 28 spp. per 100 square metre quadrat (range: 14-42 spp.). Quite variable in composition, further sampling would split this group into several. Several quadrats occur within the proposed threatened ecological community "Woodlands and shrublands of the alluvial soils of the upper Blackwood River (Condinup and Darkan 5f soil-landscape sub-systems)" (Smith, 2005). Has a relatively high number of exotic annual species.
C	Wandoo and Wandoo-Marri woodlands on gravelly loams or shallow rocky loams (3 quadrats)	This vegetation group is poorly sampled, further survey might distinguish the woodlands on granite from those on gravel. Wandoo and Wandoo-Marri woodlands of this type are widespread in the eastern part of the Jarrah Forest IBRA region
D	Jarrah-Marri and Jarrah-Marri-Wandoo woodlands and open forest on gravelly or rocky grey-brown or yellow-brown soils on mid and upper slopes (16 quadrats)	A very widespread group associated with the Yalanbee, Pindalup, Lukin 2 and Sandalwood Vegetation Complexes (Havel *et al.*, 2000).
E	Wandoo and Wandoo-Marri woodlands on yellow-brown and grey-brown sandy loams and loams on lower slopes (11 quadrats)	HADD05 and HADD07, with Jarrah-Paperbark-*Actinostrobus* woodland and Wandoo-Saltwater paperbark woodland respectively, are atypical sites, further survey will likely lead to sub-division of this group
F	Species-rich Eucalypt woodlands and mallees of grey and dark brown sandy loams and gravelly sands and loamy sands of upper slopes (7 quadrats)	This group is quite diverse and has a variety of structurally dominant species including *Eucalyptus marginata, E. wandoo, E. accedens* and the mallees *E. falcata* and *E. drummondii*. It mostly occurs to the east of the South West Region in the Avon-Wheatbelt IBRA Region, but occurs in Haddleton NR and near Cordering. Species richness ranges from 25 to 57 species per $100m^2$, with an average of 47. Further survey would probably lead to it being split into several new groups.
G	Jarrah-*Banksia attenuata*, Jarrah-Marri and Jarrah-Marri-*Melaleuca preissiana* open forest and woodlands on grey sands (5 quadrats)	Further survey would result in the Jarrah-*Banksia attenuata* woodland on deeper dry sands and Jarrah-Marri-*Melaleuca preissiana* woodland on damp sands being put into separate groups from the Jarrah forest on sandy gravels.
H	Species-rich woodlands on heavy gravels (2 quadrats)	This group is found on yellow-brown sandy gravels in the Yalanbee (Y5) vegetation complex in the Bennelaking area – although only two quadrats were sited in it, it is quite widespread within Bennelaking and adjacent forest blocks. Has a number of taxa associated with the Avon-Wheatbelt IBRA region to the east.
I	Lake Ngartaminny woodlands and shrublands (2 quadrats)	One quadrat was structurally dominated by *Eucalyptus marginata, Eucalyptus rudis* and *Corymbia calophylla* and the other by *Acacia extensa, Astartea scoparia* and *Melaleuca lateritia* (one other quadrat, MUJA01, needs to be re-surveyed). This group is likely to be a very restricted set of vegetation associations found only at the margins of Lake Ngartaminny and associated swamps – further survey work to establish its extent is required. High score on Axis 2 of the DCA ordination.

Figure 4. Cluster diagram of 89 quadrats form the Darkan-Boyup Brook survey and the Biological Survey of the Agricultural Zone classified using the Bray-Curtis distance measure and the UPGMA linkage method.



References

Beard J.S. (1979). Vegetation Survey of Western Australia, 1 : 250 000 Series. The Vegetation of the Pinjarra Area. Vegmap Publications, Applecross.

Beard, J.S. (1981). Vegetation Survey of Western Australia. Swan. Map and Explanatory Notes, Sheet 7, 1:1,000,000 Series, University of Western Australia Press, Perth.

Havel J.J. (1975a). Site–vegetation mapping in the northern jarrah forest (Darling Ranges). I. Definition of site–vegetation types. Forest Department, Western Australia, Bulletin No. 86.

Havel J.J. (1975b). Site–vegetation mapping in the northern jarrah forest (Darling Range). II. Location and mapping of site–vegetation types. Forest Department, Western Australia, Bulletin No. 87.

Havel, J. J. & Mattiske, E. M., (2000). Vegetation mapping of south west forest regions of Western Australia / prepared by Mattiske Consulting Pty Ltd, J.J. Havel and E.M. Mattiske; prepared for CALMScience, Department of Conservation and Land Management and Environment Australia.

Heddle, E.M., Longeragan, D.W. & Havel, J.J. (1980). Vegetation Complexes of the Darling System Western Australia in 'Atlas of Natural Resources, Darling System Western Australia'. Dept. of Conservation & Environment (WA), Perth.

Keighery, G. J., Halse, S. A., McKenzie, N. L., & Western Australian Museum. (2004). A biodiversity survey of the Western Australian agricultural zone. Records of the Western Australian Museum. Supplement 67.

Lyons MN, Gibson N, Keighery GJ, Lyons SD (2004). Wetland flora and vegetation of the Western Australian wheatbelt. Records of the Western Australian Museum. Supplement 67, pp. 39-89

McCune, B. & Metford, M.J. (1999). PC-ORD. Multivariate Analysis of Ecological Data, Version 4. MjM Software Design, Gleneden Beach, Oregon, USA.

Percy, H.M. (2000). Katanning Area Land Resources Survey. Land Resources Series No. 16. Agriculture Western Australia.

Smith, F.G. (1974). Vegetation Survey of Western Australia, 1:250,000 series. Collie. Western Australian Department of Agriculture, Perth, Western Australia.

Smith, R.S. (2005). Woodlands and shrublands of the alluvial soils of the upper Blackwood River (Condinup and Darkan 5f soil-landscape sub-systems); Vegetation associations and draft species list. Unpublished report, Department of Environment and Conservation, Bunbury.

Strehlein, G.J. (1988). Site classification in the southern jarrah forest of Western Australia. Research Bulletin No. 2. Department of Conservation and Land Management.

Worsley Alumina Pty Ltd and Dames & Moore (1981). Worsley Alumina Project : flora and fauna studies. Phase one 1981. Worsley Alumina.

APPENDIX 1. Vegetation complexes as mapped by Havel and Mattiske (2000) on which sites established in the Darkan-Boyup Brook survey were located.

Vegetation Complex	Description
Condinup (CP2)	Woodland to low open forest of *Eucalyptus rudis-Melaleuca rhaphiophylla* on valley floors in the semiarid zone.
Coolakin (Ck)	Woodland of *Eucalyptus wandoo* with mixtures of *Eucalyptus patens, Eucalyptus marginata* subsp. *thalassica* and *Corymbia calophylla* on the valley slopes in arid and perarid zones.
Darkin 1 (Dk1)	Woodland of *Eucalyptus marginata subsp. marginata-Eucalyptus wandoo-Corymbia calophylla* over *Dryandra sessilis* on uplands in the arid zone.
Darkin 5f (Dk5f)	Woodland of *Eucalyptus rudis-Melaleuca* spp. on lower slopes, low forest of *Casuarina obesa* and shrubland of *Melaleuca* spp. on broad valley floors in the arid zone.
Farrar 4 (Fa4)	Woodland of *Eucalyptus rudis* on slopes and tall shrubland of *Melaleuca viminea* on lower slopes in the arid zone.
Lukin 2 (LK2)	Woodland of *Eucalyptus wandoo* with some mixtures of *Eucalyptus marginata* subsp. *thalassica* and *Corymbia calophylla* on the valley slopes with occasional Eucalyptus rudis on valley floors in semiarid and arid zones.
Newlgalup 2 (NWf2)	Woodland of *Eucalyptus rudis-Eucalyptus patens* with occasional *Eucalyptus wandoo* on footslopes on valley slopes in the semiarid zone.
Pindalup (Pn)	Open forest of *Eucalyptus marginata* subsp. *thalassica-Corymbia calophylla* on slopes and open woodland of *Eucalyptus wandoo* with some *Eucalyptus patens* on the lower slopes in semiarid and arid zones.
Qualeup (QUs)	Woodland of *Eucalyptus marginata* subsp. *marginata-Banksia attenuata-Banksia grandis* on lower sandier slopes in the semiarid zone.
Qualeup (QUw)	Woodland of *Eucalyptus marginata* subsp. *marginata-Corymbia calophylla* on drier soils ranging to woodland of *Eucalyptus rudis-Melaleuca rhaphiophylla* and low woodland of *Melaleuca preissiana-Banksia littoralis* on lower slopes in the semiarid zone.
Sandalwood (SD)	Woodland of *Eucalyptus marginata* subsp. *marginata* with some *Corymbia calophylla* and *Eucalyptus wandoo* over *Hakea prostrata* and *Dryandra sessilis* on steeper uplands in the semiarid zone.
Swamp (S)	Mosaic of low open woodland of *Melaleuca preissiana-Banksia littoralis*, closed scrub of Myrtaceae spp., closed heath of Myrtaceae spp. and sedgelands of *Baumea* and *Leptocarpus* spp. on seasonally wet or moist sand, peat and clay soils on valley floors in all climatic zones.
Yalanbee (Y5)	Mixture of open forest of *Eucalyptus marginata* subsp. *thalassica-Corymbia calophylla* and woodland of *Eucalyptus wandoo* on lateritic uplands in semiarid to perarid zones.

APPENDIX 2. Summary of site characteristics.

Group	Site Code	Landscape Position	Formation, dominant species	Vegetation Complex	Soil Colour	Soil Type	Gravel/Rock Quantity
A	COND02	Plain	Wandoo-marri woodland	Condinup (CP2)	Grey-Brown	Loam	
A	COND01	Plain	Wandoo-Marri-Flooded gum-Rock sheoak woodland	Condinup (CP2)	Brown	Clay Loam	
A	CODG01	Lower Slope	Wandoo-Marri woodland	Farrar 4 (Fa4)	Red-Brown	Clay Loam	
A	CORD03	Lower Slope	Marri woodland	Lukin 2 (LK2)	Grey-Brown	Sandy Loam	
A	ASPL01	Lower Slope	Shrubland	Newlgalup 2 (NWf2)	Grey-Brown	Loam	
A	ASPL02	Lower Slope	Jarrah-Marri woodland	Newlgalup 2 (NWf2)	Grey-Brown	Clay Loam	
B	ASPL03	Lower Slope	Wandoo woodland	Condinup (CP2)	Grey-Brown	Clay Loam	
B	QUIR01	Lower Slope	Wandoo woodland	Coolakin (Ck)	Yellow-Brown	Loam	
B	WHSW02	Mid Slope	Wandoo woodland	Darkin 1 (Dk1)	Red-Brown	Loam	
B	WHSW01	Lower Slope	Wandoo woodland	Darkin 5f (Dk5f)	Light Grey	Sandy Loam	
B	WHSW03	Lower Slope	Flooded gum-Wandoo woodland	Darkin 5f (Dk5f)	Grey	Clay	
B	WHSW04	Lower Slope	Flooded gum woodland	Darkin 5f (Dk5f)	Grey	Clay Loam	
B	COLR01	Lower Slope	Wandoo woodland	Pindalup (Pn)	Grey-Brown	Loam	
B	HUNT01	Lower Slope	Wandoo woodland	Pindalup (Pn)	Grey-Brown	Clay Loam	
B	REDH02	Mid Slope	Wandoo woodland	Sandalwood (Sd)	Red-Brown	Loam	Medium rock
B	BENN01	Plain/Flat	Wandoo woodland	Swamp (S)	Grey-Brown	Clay Loam	
B	BOWE01	Plain	Wandoo woodland	Swamp (S)	Grey-Brown	Clay Loam	
B	BOWE02	Plain	Wandoo woodland	Swamp (S)	Grey-Brown	Clay Loam	
C	CAPR01	Plain	Wandoo woodland	Darkin 5f (Dk5f)	Yellow-Brown	Loamy Sand	Heavy gravel
C	GIBB01	Mid Slope	Wandoo woodland	Pindalup (Pn)	Yellow-Brown	Loam	Medium gravel
C	BOOL01	Mid Slope	Wandoo-Marri woodland	Swamp (S)	Red-Brown	Loam	Heavy rock
D	CORD01		Jarrah-Wandoo open forest	Lukin 2 (LK2)	Yellow-Brown	Sandy Loam	Medium gravel
D	CORD02	Lower Slope	Jarrah-Marri open forest	Lukin 2 (LK2)	Yellow-Brown	Sandy Loam	
D	RESE02	Lower Slope	Jarrah-Marri woodland	Lukin 2 (LK2)	Brown	Loam	Medium gravel
D	NKUR01	Mid Slope	Wandoo-Jarrah-Marri woodland	Lukin 2 (LK2)	Brown	Sandy Loam	Heavy gravel
D	BENN02	Mid Slope	Wandoo-Jarrah-Marri woodland	Pindalup (Pn)	Yellow-Brown	Sandy Loam	Light gravel
D	BENN03	Mid Slope	Wandoo-Jarrah-Marri woodland	Pindalup (Pn)	Grey-Brown	Sandy Loam	Heavy gravel
D	RESE01	Upper Slope	Marri-Wandoo woodland	Sandalwood (Sd)	Brown	Clay Loam	Heavy rock
D	REDH01	Upper Slope	Marri-Jarrah-Wandoo open forest	Sandalwood (Sd)	Grey-Brown	Sandy Loam	Medium gravel
D	REDH04	Mid Slope	Wandoo woodland	Sandalwood (Sd)	Grey-Brown	Sand	Heavy gravel
D	REDH03	Upper Slope	Jarrah-Marri open forest	Sandalwood (Sd)	Grey-Brown	Sandy Loam	Heavy gravel
D	BENN06	Upper Slope	Wandoo-Jarrah-Marri open forest	Yalanbee (Y5)	Yellow-Brown	Sand	Heavy gravel
D	BENN04	Upper Slope	Jarrah-Sheoak open forest	Yalanbee (Y5)	Yellow-Brown	Sand	Heavy gravel
D	BOOL02	Mid Slope	Wandoo-Marri open forest	Yalanbee (Y5)	Red-Brown	Loam	Heavy rock
D	BOOL03	Upper Slope	Wandoo-Jarrah open forest	Yalanbee (Y5)	Grey-Brown	Sandy Loam	Heavy gravel
D	GIBB02	Upper Slope	Jarrah-Marri-Wandoo open forest	Yalanbee (Y5)	Grey-Brown	Sand	Heavy gravel
D	GIBB03	Mid Slope	Jarrah-Marri-Wandoo open forest	Yalanbee (Y5)	Grey-Brown	Sand	Heavy gravel
E	HILL03	Lower Slope	Marri-Wandoo woodland	Lukin 2 (LK2)	Grey-Brown	Sandy Loam	
E	DRYA02	Lower Slope	Wandoo-Marri woodland	not mapped	Dark Grey	Gritty Loam Sand	
E	BENN05	Lower Slope	Wandoo woodland	Pindalup (Pn)	Yellow-Brown	Sandy Clay	Light gravel
E	HILL01	Mid Slope	Wandoo-Marri-Jarrah open forest	Pindalup (Pn)	Yellow-Brown	Sandy Loam	Light gravel
E	HILL02	Lower Slope	Marri-Wandoo woodland	Pindalup (Pn)	Grey-Brown	Sandy Loam	Light gravel
E	HILL04	Lower Slope	Marri-Flooded gum woodland	Pindalup (Pn)	Yellow-Brown	Sandy Loam	
E	HADD05	Lower Slope	Jarrah-Paperbark-Actinostrobus woodland	Qualeup (QUs)	Light Grey	Sand	
E	HADD07	Lower Slope	Wandoo-Saltwater paperbark woodland	Qualeup (Qus)	Grey-Brown	Sandy Loam	
E	HADD01	Lower Slope	Wandoo woodland	Qualeup (QUw)	Grey-Brown	Loamy Sand	
E	BENN08	Lower Slope	Wandoo-Marri woodland	Yalanbee (Y5)	Red-Brown	Loam	Medium rock

E	BENN09	Lower Slope	Wandoo woodland	Yalanbee (Y5)	Brown	Loam	Heavy rock
F	BALL01	Upper Slope	Jarrah-Wandoo woodland	not mapped	Dark Grey	Sand	
F	CORD04	Upper Slope	Jarrah open forest	not mapped	Dark Grey	Loamy Sand	Heavy Gravel
F	HADD08	Mid Slope	Jarrah open forest	not mapped	Grey-Brown	Loamy Sand	
F	DRYA05	Upper Slope	Eucalyptus drummondii-E. facata mallee woodland	not mapped	Dark Brown	Loamy Sand	Medium gravel
F	DRYA06	Mid Slope	Eucalyptus accedens woodland	not mapped	Dark Brown	Sandy Loam	
F	QUIN02	Mid Slope	Wandoo woodland	not mapped	Pale Brown	Sand	
F	NKUR02	Upper Slope	Jarrah open forest	Sandalwood (Sd)	Orange-Brown	Sandy Loam	Medium gravel
G	HADD04	Lower Slope	Marri-Jarrah-Paperbark open forest	Qualeup (Qus)	Grey-Brown	Sandy Loam	
G	HADD06	Lower Slope	Marri-Jarrah-Paperbark woodland	Qualeup (Qus)	Grey	Sand	
G	HADD02	Mid Slope	Jarrah open forest	Qualeup (Quw)	Grey	Sand	Heavy gravel
G	HADD03	Mid Slope	Jarrah-Banksia attenuata woodland	Qualeup (QUw)	Light Grey	Sand	
G	HADS01	Mid Slope	Jarrah-Banksia attenuata woodland	Qualeup (QUw)	Grey	Sand	
G	BENN07	Mid Slope	Banksia attenuata-Jarrah woodland	Yalanbee (Y5)	Grey-Brown	Sand	
K	BENN10	Mid Slope	Eucalyptus decipiens mallee woodland	Yalanbee (Y5)	Yellow-Brown	Sand	Heavy gravel
K	BENN11	Mid Slope	Wandoo woodland	Yalanbee (Y5)	Yellow-Brown	Sand	Heavy gravel
L	MUJA02	Swamp Edge	Melaleuca lateritia-Astartea scoparia-Acacia extensa-Boassiea linophylla closed heath	Qualeup (Quw)	Grey-Brown	Sandy Loam	
L	MUJA03	Lower Slope	Flooded gum-Jarrah-Marri-Paperbark woodland	Qualeup (Quw)	Grey	Sand	

APPENDIX 3. Location of Darkan-Boyup Brook survey sites and Biological Survey of the Agricultural Zone sites used in the floristic classification

ID	SITE_NAME	SITE_CODE	DATE_1	DATE_2	BOTANIST	LATITUDE	LONGITUDE
120	Asplin Bridge 1	ASPL01	22-Nov-05		R. Smith	-33.8071	116.4906
121	Asplin Bridge 2	ASPL02	22-Nov-05		R. Smith	-33.8053	116.4919
122	Asplin Bridge 3	ASPL03	22-Nov-05		R. Smith	-33.8044	116.4920
72	Ballock Road 1	BALL01			BSAZ staff	-33.6469	116.9386
73	Ballock Road 2	BALL02			BSAZ staff	-33.6497	116.9400
366	Beaufort Bridge 1	BEAU01			BSAZ Staff	-33.4992	117.0668
124	Bennelaking 1	BENN01	15-Nov-05		R. Smith	-33.4402	116.5031
198	Bennelaking 2	BENN02	27-Sep-06		R. Smith/BNC	-33.4476	116.5402
199	Bennelaking 3	BENN03	27-Sep-06		R. Smith/BNC	-33.4446	116.5654
200	Bennelaking 4	BENN04	27-Sep-06		R. Smith/BNC	-33.4297	116.5613
201	Bennelaking 5	BENN05	27-Sep-06		R. Smith/BNC	-33.4204	116.5651
202	Bennelaking 6	BENN06	28-Nov-06		R. Smith/BNC	-33.4281	116.5543
203	Bennelaking 7	BENN07	28-Nov-06		R. Smith/BNC	-33.4378	116.5136
204	Bennelaking 8	BENN08	28-Nov-06		R. Smith/BNC	-33.4219	116.5138
205	Bennelaking 9	BENN09	27-Nov-06		R. Smith/BNC	-33.4207	116.5130
206	Bennelaking 10	BENN10	27-Nov-06		R. Smith/BNC	-33.4136	116.5266
207	Bennelaking 11	BENN11	27-Nov-06		R. Smith/BNC	-33.4153	116.5354
208	Bennelaking 12	BENN12			R. Smith/BNC	-33.4408	116.5013
74	Bokal 1	BOKA01			BSAZ staff	-33.4881	116.8867
125	Boolading 1	BOOL01	15-Nov-05		R. Smith	-33.3554	116.6209
209	Boolading 2	BOOL02			R. Smith/BNC	-33.3517	116.6224
210	Boolading 3	BOOL03			R. Smith/BNC	-33.3498	116.6266
75	Boolading 4	BOOL04			BSAZ staff	-33.3561	116.6186
76	Boolading 5	BOOL05			BSAZ staff	-33.3572	116.6178
77	Boundain NR 1	BOUN01			BSAZ staff	-32.9247	117.3467
126	Bowelling 1	BOWE01	15-Nov-05		R. Smith	-33.3964	116.5292
127	Bowelling 2	BOWE02	15-Nov-05		R. Smith	-33.3973	116.5283
130	Capercup Nature Reserve 1	CAPR01	12-Oct-06		R. Smith	-33.5254	116.7332
368	Capercup Nature Reserve 3	CAPR02			BSAZ Staff	-33.5249	116.7341
367	Capercup Nature Reserve 2	CAPR02			BSAZ Staff	-33.5288	116.7305
131	Codganollup Pool Reserve	CODG01	12-Oct-06		R. Smith	-33.7269	116.7733
132	Collie River South	COLR01	10-Nov-05		R. Smith	-33.7025	116.3825
133	Condinup (Asplin) Bridge 1	COND01	12-Oct-06		R. Smith	-33.8053	116.4898
134	Condinup (Asplin) Bridge 2	COND02	12-Oct-06		R. Smith	-33.8049	116.4918
211	Cordering North 1	CORD01	27-Sep-06	9-Nov-06	R. Smith/BNC	-33.4770	116.6414
212	Cordering North 2	CORD02	27-Sep-06	9-Nov-06	R. Smith/BNC	-33.4733	116.6391
213	Cordering North 3	CORD03	27-Sep-06	9-Nov-06	R. Smith/BNC	-33.4729	116.6161
78	Cordering North 4	CORD04			BSAZ staff	-33.4703	116.6333
79	Dead Man's Swamp 1	DMSW01			BSAZ staff	-33.5017	116.9483
80	Dead Man's Swamp 2	DMSW02			BSAZ staff	-33.5006	116.9528
81	Dryandra 1	DRYA01			BSAZ staff	-32.8108	116.8897
82	Dryandra 2	DRYA02			BSAZ staff	-32.8544	116.8292
83	Dryandra 3	DRYA03			BSAZ staff	-32.7692	116.9522
84	Dryandra 4	DRYA04			BSAZ staff	-32.7533	116.9453
85	Dryandra 5	DRYA05			BSAZ staff	-32.7342	116.9486
86	Dryandra 6	DRYA06			BSAZ staff	-32.7814	116.9492
141	Gibbs Road Res (TR66/25) 1	GIBB01	15-Nov-05		R. Smith	-33.3731	116.6620
214	Gibbs Road Res (TR66/25) 2	GIBB02	28-Sep-06	31-Oct-06	R. Smith/BNC	-33.3738	116.6239
215	Gibbs Road Res (TR66/25) 3	GIBB03	28-Sep-06	31-Oct-06	R. Smith/BNC	-33.3803	116.6250
216	Haddleton NR 1	HADD01	26-Sep-06	13-Nov-06	R. Smith/BNC	-33.5862	116.6105
217	Haddleton NR 2	HADD02	26-Sep-06	13-Nov-06	R. Smith/BNC	-33.5863	116.6142
218	Haddleton NR 3	HADD03	26-Sep-06	13-Nov-06	R. Smith/BNC	-33.5854	116.6172
219	Haddleton NR 4	HADD04	26-Sep-06	13-Nov-06	R. Smith/BNC	-33.5822	116.6237
220	Haddleton NR 5	HADD05	26-Sep-06	13-Nov-06	R. Smith/BNC	-33.5804	116.6257
221	Haddleton NR 6	HADD06	26-Sep-06	13-Nov-06	R. Smith/BNC	-33.5843	116.6246
222	Haddleton NR 7	HADD07	26-Sep-06	13-Nov-06	R. Smith/BNC	-33.5846	116.6273
87	Haddleton NR 8	HADD08			BSAZ staff	-33.6058	116.6275

ID	SITE_NAME	SITE_CODE	DATE_1	DATE_2	BOTANIST	LATITUDE	LONGITUDE
369	Haddleton NR 9	HADD09			BSAZ Staff	-33.5875	116.6032
370	Haddleton NR 10	HADD10			BSAZ Staff	-33.6129	116.6298
88	Haddleton Springs 1	HADS01			BSAZ staff	-33.6203	116.5806
89	Highbury 1	HIGH01			BSAZ staff	-33.0908	117.1714
90	Highbury 2	HIGH02			BSAZ staff	-33.0528	117.2408
223	Hillman Block 1	HILL01	27-Sep-06	31-Oct-06	R. Smith/BNC	-33.2688	116.5688
224	Hillman Block 2	HILL02	27-Sep-06	31-Oct-06	R. Smith/BNC	-33.2581	116.5611
225	Hillman Block 3	HILL03	27-Sep-06	31-Oct-06	R. Smith/BNC	-33.2639	116.5990
226	Hillman Block 4	HILL04	27-Sep-06	31-Oct-06	R. Smith/BNC	-33.2818	116.6046
91	Hillman NR 1	HLNR01			BSAZ staff	-33.2981	116.7719
92	Hillman Siding 1	HLSD01			BSAZ staff	-33.0528	117.2408
371	Hillman Townsite 1	HLTS01			BSAZ Staff	-33.3131	116.8061
372	Hillman Townsite 2	HLTS02			BSAZ Staff	-33.2963	116.8050
147	Hunt Block 1	HUNT01	10-Nov-05		R. Smith	-33.6574	116.2607
311	Lake Jasper 7	JASP07			Warren Survey staff	-34.4108	115.7792
373	Jingalup 1	JING01			BSAZ Staff	-34.0247	117.0328
374	Jingalup 2	JING02			BSAZ Staff	-33.9978	117.0199
101	Kulicup 1	KULI01			BSAZ Staff	-33.8275	116.6703
375	Kulicup 2	KULI02			BSAZ Staff	-33.8264	116.6710
93	Metabinup NR 1	META01			BSAZ staff	-34.0067	116.8392
94	Metabinup NR 2	META02			BSAZ staff	-34.0039	116.8392
95	Mininup NR 1	MINI01			BSAZ staff	-34.1053	116.8264
227	Muja Conservation Park 1	MUJA01	27-Sep-06	13-Oct-06	R. Smith/BNC	-33.5651	116.4314
228	Muja Conservation Park 2	MUJA02	27-Sep-06	13-Oct-06	R. Smith/BNC	-33.5659	116.4316
229	Muja Conservation Park 3	MUJA03	27-Sep-06	13-Oct-06	R. Smith/BNC	-33.5656	116.4315
230	Muja Conservation Park 4	MUJA04	27-Sep-06	13-Oct-06	R. Smith/BNC	-33.5607	116.4334
231	Muja Conservation Park 5	MUJA05			R. Smith/BNC	-33.4980	116.4499
96	Muradup 1	MURA01			BSAZ staff	-33.8417	116.9886
47	North Kulicup 1	NKUR01	15-Sep-05		A. Webb	-33.7717	116.6816
48	North Kulicup 2	NKUR02	15-Sep-05		A. Webb	-33.7756	116.6893
97	Quinns 1	QUIN01			BSAZ staff	-33.1461	117.0536
98	Quinns 2	QUIN02			BSAZ staff	-33.1275	117.0725
161	Quindanning Road 1	QUIR01	5-Dec-05		R. Smith	-33.2147	116.5728
162	Red Hill 1	REDH01	14-Sep-05	28-Nov-05	R. Smith	-33.7823	116.7367
163	Red Hill 2	REDH02	14-Sep-05	28-Nov-05	R. Smith	-33.7784	116.7305
164	Red Hill 3	REDH03	14-Sep-05	28-Nov-05	R. Smith	-33.7797	116.7393
165	Red Hill 4	REDH04	14-Sep-05	28-Nov-05	R. Smith	-33.7876	116.7322
166	Reservoir 1	RESE01	22-Sep-06	13-Nov-06	R. Smith	-33.8540	116.4420
167	Reservoir 2	RESE02	22-Sep-06	13-Nov-06	R. Smith	-33.8493	116.4496
99	Skelton 1	SKEL01			BSAZ staff	-32.7828	116.8650
100	Lake Towerinning	SPM003			BSAZ Staff	-33.5747	116.7833
102	Lake Campion	SPM012			BSAZ Staff	-31.1411	118.3381
103	Hotham River	SPS013			BSAZ Staff	-32.6431	116.9747
104	Nalyerin Lake	SPS031			BSAZ Staff	-33.1475	116.3708
105	Qualeup Lake	SPS032			BSAZ Staff	-33.8386	116.7644
106	Meeking Lake	SPS038			BSAZ Staff	-33.2453	116.7836
107	Dead Man's Swamp	SPS039			BSAZ Staff	-33.5014	116.9594
108	Arthur River Flats Lake	SPS053			BSAZ Staff	-33.0769	117.2744
109	Puntapin Rock	SPS054			BSAZ Staff	-33.3253	117.4006
110	Parkeyerring Lake	SPS055			BSAZ Staff	-33.3747	117.3544
111	Bushy Swamp	SPS056			BSAZ Staff	-33.5431	117.2661
112	Ngopitchup Swamp	SPS102			BSAZ Staff	-33.9575	117.3422
182	Stockton 1	STOC01	04-Oct-05		R. Smith	-33.3949	116.2362
183	Stockton 2	STOC02	04-Oct-05	06-Nov-05	R. Smith	-33.4013	116.2354
113	Unmakea NR 1	UNMA01			BSAZ staff	-34.0067	116.8392
114	Wardering Spring NR 1	WARD01			BSAZ staff	-32.8381	117.3586
193	Wild Horse Swamp 1	WHSW01	04-Nov-05		R. Smith	-33.6840	116.7223
194	Wild Horse Swamp 2	WHSW02	04-Nov-05		R. Smith	-33.6744	116.7303
195	Wild Horse Swamp 3	WHSW03	05-Nov-05		R. Smith	-33.6730	116.7384
196	Wild Horse Swamp 4	WHSW04	05-Nov-05		R. Smith	-33.6762	116.7376

APPENDIX 4. VEGETATION GROUP DESCRIPTIONS

GROUP A

Quadrats: (6) ASPL01, CORD03, ASPL02, COND02, COND01, CODG01

Group Name: Wandoo, Wandoo-Marri and Jarrah-Marri open woodlands and *Hakea varia-Acacia saligna* shrublands on alluvial loams and clay-loams

Typical species

LATIN NAME	Fidelity (6 quadrats)
Acacia saligna	5
Corymbia calophylla	4
Mesomelaena tetragona	4
**Briza maxima*	3
Chorizandra enodis	3
Desmocladus asper	3
Eucalyptus wandoo	3
Haemodorum simplex	3
Hakea varia	3
Hypocalymma angustifolium	3
Lepidosperma tenue	3
Neurachne alopecuroidea	3
Patersonia occidentalis	3
Sowerbaea laxiflora	3
Acacia extensa	2
Agrostocrinum scabrum	2
Billardiera heterophylla	2
Conostylis aculeata	2
Drosera gigantea	2
Eucalyptus marginata	2
Kennedia prostrata	2
Stylidium uniflorum	2
Tricoryne humilis	2
Xanthorrhoea gracilis	2
Xanthorrhoea preissii	2

Comments: Requires further survey effort. Species-poor (14-20 species per 100^2 m) open woodlands and shrublands on grey-brown, brown and red-brown loams and sandy loams along creeklines and on alluvial flats. ASPL01 and ASPL02 are located in the proposed threatened ecological community "Woodlands and shrublands of the alluvial soils of the upper Blackwood River (Condinup and Darkan 5f soil-landscape sub-systems)" (Smith, 2005)

APPENDIX 4. VEGETATION GROUP DESCRIPTIONS

GROUP B

Quadrats: (12) ASPL03, QUIR01, BENN01, COLR01, HUNT01, WHSW01, WHSW02, WHSW03, BOWE01, BOWE02, REDH02, WHSW04

Group Name: Wandoo woodlands with herbaceous understories on clay loams and loams on valley floors

Typical species

LATIN NAME	Fidelity (12 quadrats)
Eucalyptus wandoo	10
Neurachne alopecuroidea	10
**Briza maxima*	8
**Briza minor*	8
**Parentucellia latifolia*	7
Podolepis gracilis	7
Sowerbaea laxiflora	7
**Anagallis arvensis*	6
Drosera gigantea	6
Haemodorum simplex	6
Tricoryne humilis	6
**Vulpia bromoides*	6
**Aira cupaniana*	5
Hyalosperma cotula	5
Hypocalymma angustifolium	5
Stylidium crassifolium	5

Comments: Widespread vegetation group, average 28 spp. per 100 square metre quadrat (range: 14-42 spp.). Quite variable in composition, further sampling would split this group into several. Several quadrats occur within the proposed threatened ecological community "Woodlands and shrublands of the alluvial soils of the upper Blackwood River (Condinup and Darkan 5f soil-landscape sub-systems)" (Smith, 2005). Has arelatively high number of exotic annual species.

APPENDIX 4. VEGETATION GROUP DESCRIPTIONS

GROUP C

Quadrats: (3) BOOL01, GIBB01, CAPR01

Group Name: Wandoo and Wandoo-Marri woodlands on gravelly loams or shallow rocky loams

Typical species

LATIN NAME	Fidelity (3 quadrats)
**Briza maxima*	3
Eucalyptus wandoo	3
Gompholobium marginatum	3
Hibbertia hypericoides	3
Neurachne alopecuroidea	3
Tetratheca virgata	3
Acacia pulchella	2
**Aira caryophyllea*	2
Austrodanthonia pilosa	2
Austrostipa semibarbata	2
Borya sphaerocephala	2
Desmocladus flexuosus	2
Dryandra lindleyana	2
Haemodorum simplex	2
Hakea lissocarpha	2
Kennedia prostrata	2
Stackhousia monogyna	2
Xanthorrhoea preissii	2

Comments: This vegetation group is poorly sampled, further survey might distinguish the woodlands on granite from those on gravel. Wandoo and Wandoo-Marri woodlands of this type are widespread in the eastern part of the Jarrah Forest IBRA region.

APPENDIX 4. VEGETATION GROUP DESCRIPTIONS

GROUP D

Quadrats: (16) BENN02, BENN03, BENN06, BENN04, CORD01, CORD02, RESE01, RESE02, BOOL02, BOOL03, GIBB02, GIBB03, NKUR01, REDH01, REDH04, REDH03

Group Name: Jarrah-Marri and Jarrah-Marri-Wandoo woodlands and open forest on gravelly or rocky grey-brown or yellow-brown soils on mid and upper slopes

Typical species

LATIN NAME	Fidelity (16 quadrats)
Desmocladus fasciculatus	15
Hakea lissocarpha	14
Eucalyptus marginata	13
Trymalium ledifolium	13
Corymbia calophylla	12
Leucopogon capitellatus	11
Acacia pulchella	10
Hibbertia commutata	10
Dryandra lindleyana	9
Lepidosperma tenue	9
Bossiaea ornata	8
Lagenophora huegelii	8
Chamaescilla corymbosa	7
Austrostipa campylachne	7
Bossiaea eriocarpa	7
Lagenophora huegelii	7
Stackhousia monogyna	7
Neurachne alopecuroidea	6
Xanthorrhoea preissii	6
Austrodanthonia setacea	6
Craspedia variabilis	6
Dampiera linearis	6
Eucalyptus wandoo	6
Gompholobium marginatum	6
Hypocalymma angustifolium	6
Podolepis gracilis	6

Comments: A very widespread group associated with the Yalanbee, Pindalup, Lukin 2 and Sandalwood Vegetation Complexes (Havel *et al.*, 2000).

APPENDIX 4. VEGETATION GROUP DESCRIPTIONS

GROUP E

Quadrats: (11) BENN05, BENN08, BENN09, HADD01, DRYA02, HILL01, HILL02, HILL03, HILL04, HADD05, HADD07

Group Name: Wandoo and Wandoo-Marri woodlands on yellow-brown and grey-brown sandy loams and loams on lower slopes

Typical species:

LATIN NAME	Fidelity (11 quadrats)
Lagenophora huegelii	11
Eucalyptus wandoo	9
Hibbertia commutata	9
Neurachne alopecuroidea	9
Bossiaea eriocarpa	8
Chamaescilla corymbosa	8
Stackhousia monogyna	8
Acacia pulchella	7
Desmocladus asper	7
Conostylis aculeata	6
Corymbia calophylla	6
Desmocladus fasciculatus	6
Drosera erythrorhiza	6
Gompholobium marginatum	6
Hakea lissocarpha	6
Hypocalymma angustifolium	6
**Hypochaeris glabra*	6
Austrodanthonia setacea	5
Austrostipa semibarbata	5
Baeckea camphorosmae	5
Hypoxis occidentalis	5
Macrozamia riedlei	5
Trachymene pilosa	5

Comments: HADD05 and HADD07, with Jarrah-Paperbark-*Actinostrobus* woodland and Wandoo-Saltwater paperbark woodland respectively, are atypical sites, further survey will likely lead to sub-division of this group.

APPENDIX 4. VEGETATION GROUP DESCRIPTIONS

GROUP F

Quadrats: (7) BALL01, NKUR02, CORD04, HADD08, DRYA05, QUIN02, DRYA06

Group Name: Species-rich Eucalypt woodlands and mallees of grey and dark brown sandy loams and gravelly sands and loamy sands of upper slopes

Typical species:

LATIN NAME	Fidelity (6 quadrats)
Lepidosperma leptostachyum	7
**Hypochaeris glabra*	6
Neurachne alopecuroidea	6
Opercularia vaginata	6
Chamaescilla corymbosa	5
Drosera macrantha	5
Levenhookia pusilla	5
Millotia tenuifolia	5
Tetraria octandra	5
Trachymene pilosa	5
**Aira caryophyllea*	4
Allocasuarina humilis	4
Conostylis setigera	4
Desmocladus fasciculatus	4
Eucalyptus marginata	4
Lomandra sericea	4
Poranthera microphylla	4
Eucalyptus wandoo	2
Eucalyptrus drummondii	1
Eucalyptus falcata	1
Eucalyptus accedens	1

Comments: This group is quite diverse and has a variety of structurally dominant species including *Eucalyptus marginata, E. wandoo, E. accedens* and the mallees *E. falcata* and *E. drummondii*. It mostly occurs to the east of the South West Region in the Avon-Wheatbelt IBRA Region, but occurs in Haddleton NR and near Cordering. Species richness ranges from 25 to 57 species per $100m^2$, with an average of 47. Further survey would probably lead to it being split into several new groups.

APPENDIX 4. VEGETATION GROUP DESCRIPTIONS

GROUP G

Quadrats: (5) BENN07, HADD02, HADD04, HADD06, HADD03, HADS01

Group Name: Jarrah-*Banksia attenuata*, Jarrah-Marri and Jarrah-Marri-*Melaleuca preissiana* open forest and woodlands on grey sands

Typical species:

LATIN NAME	Fidelity (6 quadrats)
Bossiaea eriocarpa	6
Eucalyptus marginata	6
Acacia extensa	4
Desmocladus fasciculatus	4
Drosera erythrorhiza	4
Hypolaena exsulca	4
Kunzea recurva	4
Lagenophora huegelii	4
Lepidosperma squamatum	4
Xanthosia huegelii	4
Banksia attenuata	3
Conostylis setigera	3
Drosera stolonifera	3
Hibbertia hypericoides	3
Macrozamia riedlei	3
Persoonia longifolia	3
Petrophile linearis	3
Phlebocarya ciliata	3
Stirlingia latifolia	3

Comments: Further survey would result in the Jarrah-*Banksia attenuata* woodland on deeper dry sands and Jarrah-Marri-*Melaleuca preissiana* woodland on damp sands being put into separate groups from the Jarrah forest on sandy gravels.

APPENDIX 4. VEGETATION GROUP DESCRIPTIONS

GROUP H

Quadrats: (2) BENN10, BENN11

Group Name: Species-rich woodlands on heavy gravels

Typical species:

LATIN NAME	Fidelity (2 quadrats)
Acacia pulchella	2
Allocasuarina humilis	2
Calothamnus sanguineus	2
Conostylis pusilla	2
Drosera glanduligera	2
Hemigenia humilis	2
Lepidosperma tenue	2
Neurachne alopecuroidea	2
Rinzia fumana	2
Stylidium repens	2
Astroloma pallidum	1
Daviesia longifolia	1
Desmocladus fasciculatus	1
Dryandra armata	1
Dryandra nivea subsp. *nivea*	1
Dryandra squarrosa subsp. *squarrosa*	1
Eucalyptus decipiens	1
Eucalyptus wandoo	1
Gompholobium marginatum	1
Hibbertia acerosa	1
Lepidobolus preissianus	1
Leptospermum erubescens	1
Loxocarya cinerea	1
Lysinema ciliatum	1
Melaleuca seriata	1
Olax benthamiana	1
Petrophile serruriae	1
Petrophile striata	1
Tetratheca virgata	1
Tripterococcus brunonis	1

Comments: This group is found on yellow-brown sandy gravels in the Yalanbee (Y5) vegetation complex in the Bennelaking area – although only two quadrats were sited in it, it is quite widespread within Bennelaking and adjacent forest blocks. Has a number of taxa associated with the Avon-Wheatbelt IBRA region to the east.

APPENDIX 4. VEGETATION GROUP DESCRIPTIONS

GROUP I

Quadrats: (2) MUJA02, MUJA03

Group Name: Lake Ngartaminny woodlands and shrublands

SPECIES	No. PLOTS
Bossiaea linophylla	2
Caesia micrantha	2
Dianella revoluta	2
Lepidosperma longitudinale	2
Microtis media	2
Pelargonium littorale	2
Tricoryne elatior	2

Comments: One quadrat was structurally dominated by *Eucalyptus marginata, Eucalyptus rudis* and *Corymbia calophylla* and the other by *Acacia extensa, Astartea scoparia* and *Melaleuca lateritia* (one other quadrat, MUJA01, needs to be re-surveyed). This group is likely to be a very restricted set of vegetation associations found only at the margins of Lake Ngartaminny and associated swamps – further survey work to establish its extent is required. High score on Axis 2 of the DCA ordination.