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Vegetation of beach sand ridges and geomorphological processes in the valley of the Upper Myall River, NSW

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***Abstract*:** Natural vegetation of freely draining beach sand ridges in the valley of the Upper Myall River on the lower North Coast of NSW is sclerophyllous open forest or woodland. Based on previous experience on the nearby Eurunderee area, the vegetation on the sand ridges was classified into three types. These were mapped using aerial photographs and field observation. In transects, each 50 m long, the presence of species was scored in 10, 5 X 5 m quadrats. 48 such transects were used sampling all three types of vegetation on the sand ridges and also vegetation in periodically waterlogged sites adjacent to the ridges. Data from the transects, subjected to an ordination using principal components analysis, revealed clear separation between vegetation of the ridges and that of periodically waterlogged sites. In the ordination, vegetation of the ridges formed a continuum with the three types occupying characteristic parts of the continuum, reflecting their respective distributions on sands with different geomorphological histories. The most grassy, tallest forest, termed Dry Sclerophyll Forest (DSF) is on sands either recently disturbed or deposited (Holocene) or closely overlying other substrates. *Banksia serrata* occurs in DSF. The least grassy, most sclerophyllous, lowest forest or woodland, termed Dry Heath Forest (DHF), occurs on sands apparently little disturbed since they were laid down in the Pleistocene. *Banksia aemula* occurs in DHF. An intermediate forest, in which *Banksia aemula* and *Banksia serrata* occur together, Intermediate Dry Forest (IDF), is most widely found on the sand mass close to Bombah Broadwater. This sand is postulated to have been reworked during the last Glacial Period. In short, the vegetation of these sand ridges largely varies with time since they were laid down or last disturbed in a major way. Preliminary observations indicate the degree of podsolization of their soils is similarly related to this variation in time.

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Introduction

Vegetation varies with environment in space and time. This variation is not random as environments act selectively on species. How variation in vegetation arises and is maintained in the dispersal, survival and reproduction of plants can only rarely be studied directly, as, for example, in studies of Heyligers (2006 & 2009) on colonisation by vegetation of prograding dunes. On surfaces that have been vegetated for hundreds of years or longer, spatial variation of vegetation can be described in floristic and structural terms and related to environmental variation. In some cases, variation of vegetation can be related to age of land surfaces. In the Myall Lakes National Park, this has been shown by Clements (1988) on freely draining coastal sands in the Fens Embayment of Thom *et al.* (1992) and by Myerscough & Carolin (1986) in the Eurunderee Embayment. In the Eurunderee Embayment of Thom *et al.* (1992), vegetation differed on Holocene sands,

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sands laid down in the Late Glacial and on Pleistocene sands (Myerscough & Carolin 1986). Age of a surface is important in development of its soil (Jenny 1941), and, in freely draining sands, the degree of podsolization can be directly related to their age (Thompson 1981).

Preliminary observation of vegetation of freely draining coastal sands in the Upper Myall River valley indicated similar variation, even though coastal sands in the valley are basically a Pleistocene beach ridge system (Thom *et al*. 1992). This paper describes variation in vegetation on ridges of this system and the extent that it may be related to processes that may have modified them since their deposition.

Coastal sand ridges in the Upper Myall river valley are several kilometres inland from the current coastline, the furthest inland being 15–16 kilometres from the modern beach (Shepherd 1970, Thom *et al*. 1992). The ridges are higher in elevation above present mean sea level, 5.5 to 6.5 m, than other Pleistocene beach sand ridges in the region, 3 to 5 m (Thom *et al*. 1992). Since their deposition as beach ridges some 125,000 years ago, they have been affected by the Upper Myall River, which flows through them to Bombah Broadwater (Thom *et al*. 1992). They have also been affected by the Postglacial Marine Transgression, evident in deposits in Bombah Bog (Martin 1986). Bombah Bog lies on the eastern side of the river between the southern end of the Pleistocene beach ridges and a large, higher mass of sand that lies between Bombah Bog and Bombah Broadwater (Fig. 1). This large mass of sand adjacent to the lake is more complex according to Thom *et al*. (1992) than the rest of the Pleistocene beach ridges and shows some features of aeolian effects in its formation.

Vegetation of the sand ridges and of the sand mass adjacent to the lake is open-forest or woodland (*sensu* Specht 1970), and is highly sclerophyllous and fire-prone; much of it burnt between 18 and 20 September 2009. Lower lying ground in the swales between the ridges and in Bombah Bog is periodically waterlogged, and is mostly treeless and carries wet heath or swamp, both of which are also very fire-prone. The ridges and intervening lower ground and their vegetation are thus "wallum", the term used by Coaldrake (1961) and Griffith *et al*. (2003) to cover vegetation and environment of coastal lowlands of northern New South Wales and south-eastern Queensland largely deposited during the Pleistocene.

In describing variation in vegetation on freely draining sands in the Eurunderee Embayment, Myerscough & Carolin (1986) used the names Dry Sclerophyll Forest, Dry Heath Forest and Intermediate Dry Forest for forests on Holocene, Pleistocene and Late Glacial sands respectively. They are all forests whose canopy trees are sclerophyllous with an understorey of sclerophyllous shrubs, dry sclerophyll forests as defined by Beadle & Costin (1952). They all fall within Keith's (2004) Coastal Dune Dry Sclerophyll Forests. They were differentiated both structurally and florisitically. Dry Sclerophyll Forest has the tallest trees, greatest abundance of grasses, and *Banksia serrata* as characteristic tree in the sub-canopy layer of smaller trees. Dry Heath Forest has lower, more widely spaced, trees with *Banksia aemula* as its characteristic smaller tree, few grasses and the restiad *Hypolaena fastigiata* particularly abundant in its understorey; in some areas, its trees are so widely spaced that it is woodland. Intermediate Dry Forest is intermediate both structurally and floristically between Dry Heath Forest and Dry Sclerophyll Forest with both *Banksia serrata* and *Banksia aemula* occurring as small trees in it.

In this study, the forests and woodlands on freely draining sands of the Upper Myall River valley are described and mapped as Dry Sclerophyll Forest, Intermediate Dry Forest or Dry Heath Forest of Myerscough & Carolin (1986). Their relative distributions are assessed against what is known or can be deduced about processes that have affected areas of sand since its deposition by the sea. The assessment is then compared to interpretation of variation of similar vegetation elsewhere.

Study Area

Location

The study area covers the beach sands that lie in the valley of the Upper Myall River between Buladelah and the Bombah Broadwater (Fig. 1), the most southerly of the large coastal lagoons that comprise the Myall Lakes.

Sediments and their geomorphological history

The beach sands of the Upper Myall River extend up its valley about 8 km from Bombah Broadwater (Fig. 1). The valley occupies the trough of the Myall syncline (Engel 1962, Thom *et al*. 1992), following its NW-SE strike. The sides of the syncline cradle the valley between almost parallel fairly steep ridges of hills to 100 m, and the width of the valley where the sand ridges lie is about 4 km (Thom *et al.* 1992). Beside the beach sands, this part of the valley has deposits of river alluvium. The areas of sand mapped in Fig. 1 include Pleistocene beach ridges whose morphology is clearly evident on aerial photographs, intervening swampy swales, areas mapped in Thom *et al.* (1992) as transgressive dune field with swamp, and Bombah Bog. In Bombah Bog, Martin (1986) showed that, on beach sand, marine materials were deposited during the brief Post-Glacial Marine Transgression, and then lacustrine sediments and finally peat were deposited above them. Beside areas of beach sand within the valley of the Upper Myall River, also mapped in Fig. 1 are sands associated with the lake shores.

The mapping and interpretation of areas in Fig. 1 largely follow those shown in Fig. 7–16, p. 251, of Thom *et al.* (1992), but differ as follows:

Sands shown at D4 in Fig. 1 as part of the Pleistocene beach sand system are treated as a transgressive dune by Thom *et al*. (1992).

A sand ridge (Bsr) is recognised associated with the western side of Boolambayte Lake. It runs southeast from rock-based ground near Korsmans Landing to the shores of Bombah Broadwater (G8 to F11 in Fig. 1). A very small outcrop

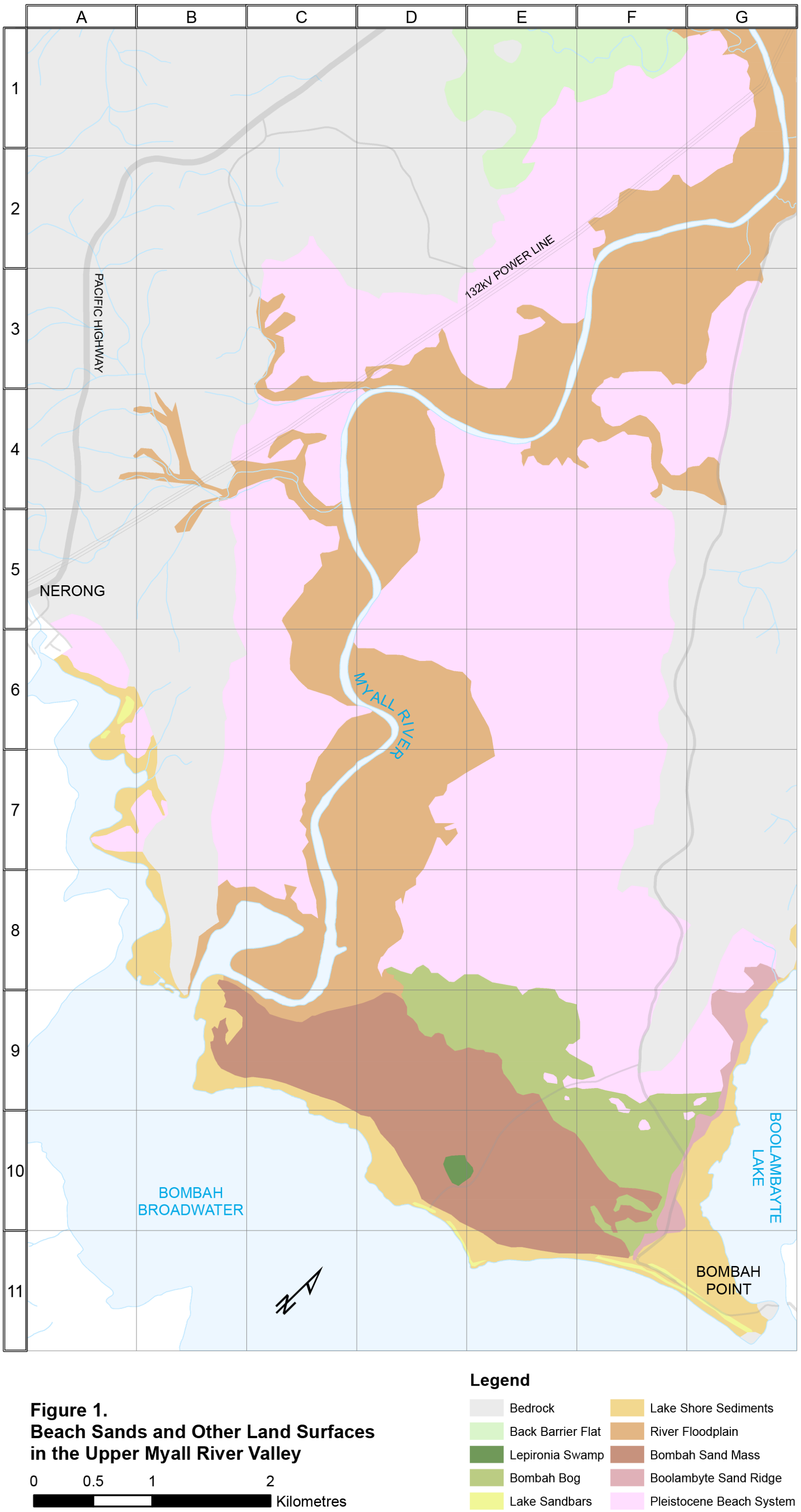

Fig. 1. Beach sands and other land surfaces in Upper Myall River valley: Bedrock (Ri); Back barrier flat (Pbf); Pleistocene beach system (Pib); Bombah sand mass (Bsm); Bombah Bog (Bb); Boolambyte sand ridge (Bsr); Lake shore sediments (Ls); Lake sand-bars (Lb); River flood plain (Fp). [Boundary between Fp and Ls (not drawn on map) arbitrarily placed at mouth of river, and extent of Fp where bounded by Ri on western part of map somewhat approximate.]

Table 1. Land surfaces in Upper Myall River valley and their characteristics

Surface	Name in Thom et al. (1992)	Characteristics	Vegetation	Similar Eurunderee area (Symbol in Myerscough & Carolin 1986)
Back barrier flat (Pbf)	Back barrier flat – Pleistocene	Low-lying, slowly draining, surface grading from sandy near, to cracking clay further from beach ridge	Wet heath	"Eastern Lagoon" (Pub)
Pleistocene beach system (Pib)	Inner Barrier strand plain – Pleistocene	Sand in beach ridges of low relief with intervening, periodocially water-logged, swales	Open-forest or woodland of eucalypts with sclerophyllous understorey on ridges; swales with wet heath or, in seepage zones, open-forest of *Eucalyptus robusta*	Differentiated Inner Barrier (Pib)
Bombah sand mass (Bsm)	Transgressive dune field – Pleistocene	Sand in long wide ridge of moderate relief with a water-filled depression.	Open-forest of eucalypts with sclerophyllous understorey, except for *Lepironia* swamp in water-filled lagoon and another swampy area	None, but some of its features are similar to Glacial dune complex (Pg)
Bombah Bog (Bb)	Generic name: Swamp – Holocene Specific site: Bombah Bog	Peat-filled depression between Pleistocene beach system and Bombah sand mass	Wet heath, and, in areas of surface drainage, open-forest of *Eucalyptus robusta*	None
Boolambayte sand ridge (Bsr)	None	Sand in ridge varying in relief from low to moderate	Open-forest of eucalypts with sclerophyllous understorey	None
Lake-influenced sediments	Freshwater swamp with Local lakeshore ridges – Holocene			
Lake shore sediments (Ls)		Mostly sands & muds below, at or slightly above mean lake water level	Mostly open-forest of paperbark and swamp oak	Lake silts and current lake shores (Ls)
Lake sand-bars (Lb)		Sand in low ridges above mean lake level freely draining	Open-forest or open-scrub	Relict sand-bars (Lb)
River floodplain (Fp)	Floodplain – Holocene	Alluvial sediment of flat to very low relief with some water-filled depressions	Open-forest to small billabongs with waterlilies or *Phragmite*s	None
Rock (Ri)	Bedrock	Gently sloping to steep hills to c. 100 m with soil mantle	Open-forest of eucalypts with mainly grassy understorey	Rock – inland (Ri)

of rock lies within it where it is closest to the current shores of Boolambayte Lake, which may have helped align the sand ridge at its formation. It was probably formed after the Postglacial Marine Transgression initiated Bombah Bog (Martin 1986). Boolambayte Lake may then have entered the Broadwater west of Bombah Point before the current lake sand bars running west from Bombah Point had formed. This sand ridge (Bsr) now divides the current lake shore sediments of Boolambayte Lake from Bombah Bog.

Bombah Bog (Bb) is bounded in the east by the sand ridge (Bsr). Bombah Bog drains south through a channel onto the shores of Bombah Broadwater. This channel, which is not mentioned in Thom *et al.* (1992), is shown as part of Bombah Bog in Fig. 1. As indicated in Fig. 1, small patches of the Pleistocene beach system are shown as remnant islands within eastern parts of Bombah Bog. At the time of the Postglacial Marine Transgression (Martin 1986), hardened coffee rock of their soil B horizon may have protected them from destruction by wave action, particularly as they are in what would have been the more protected eastern end.

The large complex sand body adjacent to the northern shores of Bombah Broadwater (Bsm) is bounded in the east by the channel draining onto the shores from Bombah Bog. Thom *et al.* (1992) show this complex body of sand running further east and north than it extends, including in it parts of the Boolambayte sand ridge (Bsr).

Table 1 gives further details of the areas mapped in Fig. 1.

Land use

Most land on the beach sands of the valley is now within Myall Lakes National Park. Broomham's (2010) history of the area that is now the park begins with the Worimi people, details European settlement and steps in formation of the present park. The national park extends up the valley from the lake to the S bend in the river at 4C–4E in Fig. 1. Most of the land north of the bend on each side of the river lies outside the national park, and is subject to various uses. This includes the most inland of the beach ridges, which was mined for rutile in the 1980s. There are also some small parcels of land on beach sand further south, at 8F in Fig. 1, that lie outside the national park, and small houses are on some of them.

Within the national park, Legge's Camp, now Myall Shores Resort, occupies two rock outcrops at Bombah Point and the sand bar that runs west along the lake shore from the southern outcrop. It has been a holiday camping area for the last hundred years (Broomham 2010). Also, on the Boolambayte sand ridge (Bsr), at 9G in Fig. 1, where a small outcrop of rock occurs, there is a patch with pines and other spp. not native to the area, presumably remains of an erstwhile garden.

On the alluvium on north-western areas mapped in Fig. 1, which lie outside the boundaries of the national park, most of the land is fenced and chiefly used for grazing cattle. Some alluvial areas within the national park were previously grazed by stock.

Some of the lower parts of the rock-based land either side of the valley have been cleared for grazing, but most of the rock-based land of the valley's sides is or has been State Forest; much of the forest on the north-western side of the valley is now part of the national park.

Methods

Data collection

Areas of freely draining sands in the valley (Fig. 2) were identified on black and white aerial photographs. The photographs were taken vertically above the land surface in the 1960s by the New South Wales Department of Lands. Each area of these sands over about a hectare was visited. Forest on it was mapped on the aerial photographs, drawing boundaries, where necessary, between Dry Sclerophyll Forest (DSF), Dry Heath Forest (DHF), or Intermediate Dry Forest (IDF). As indicated in the introduction, as in Myerscough & Carolin (1986), recognition of each of these types of forest was based on structural and floristic characteristics, the occurrence of *Banksia aemula* alone (DHF), of *Banksia serrata* alone (DSF), and co-occurrence of *Banksia aemula* and *Banksia serrata* (IDF). Vegetation on the swales between sand ridges and other periodically waterlogged areas is only represented by data from specific sites.

In 1982, floristic data were collected from 48 sites. Most sites were on freely draining sands, but some were in periodically waterlogged areas, in Wet Heath Forest (WHF), Wet Heath (WH) and Swamp (Sw), as defined in Myerscough & Carolin (1986). WH sites were in swales within the Pleistocene beach system, except for some WH sites on the Back barrier flat (Pbf). WHF sites appeared to be on ridge sites closer to the water table than other ridge sites.

Data from sites other than those with freely draining sands allowed the set of data from the ridges not only to be examined within the set but to be compared to data outside the set ("within-habitat" and "between-habitat" comparisons).

Sites were chosen to cover the ridges from north to south and east to west as well as the large sand mass adjacent to Bombah Broadwater (Bsm in Fig. 1). Location of each site (Fig. 2) was recorded on the relevant 1:25 000 topographic map. At each site, a 50-m transect was laid out, taking care that it was entirely within a single type of vegetation. Presence of species was recorded in successive 5 X 5 m quadrats along the transect, giving a maximum score of 10 for any species occurring in all the quadrats. Species of tree were recorded as present if any part of their canopy was above the quadrat and other species were recorded as present if they were rooted within the quadrat.

Boundaries between adjacent types of vegetation were also examined. Data were collected along six transects.

Four transects (T1–T4) were on the long beach ridge between D7 and F7 in Fig. 2. Three of these, T1, T2 and T3, crossed the ridge, examining change of vegetation across boundaries between freely draining sands of the ridge and adjoining periodically waterlogged areas. Relative levels of the ground surface were recorded at intervals along each transect, using a staff and an alidade. Depths to the watertable were also recorded at intervals, using an auger and allowing a short time in each hole for the water level to stabilise before measuring it. Variation in vegetation was recorded using point quadrats; contacts with a pin (c. 4.5 mm in diameter) placed every 0.5 m along the transect were recorded for common understorey spp. (those listed in Table 2 with some additional locally common spp.). Contacts were expressed over 10 m lengths of the transect (i.e. with a maximum of 20 contacts). Species of tree and larger shrub were recorded when the point quadrat was below their canopy. A more objective measure of their cover would have been the intersection of cross-wires with their canopy viewed through a moose-horn telescope (cf. Specht 2009). Their cover would have been over-estimated by simply recording being below their canopy.

In T4, along the ridge, relative levels of the surface and depths to the watertable were not measured, and contacts with understorey spp. and assessment of cover of tree and taller spp. of shrub were again made at 0.5 m intervals, but were expressed over 50 m lengths of the transects (i.e. with a maximum score of 100). The presence of additional species of trees, not "contacted" by the point quadrats, was recorded in successive 10 X 10 m quadrats along the transect, and heights of trees were subjectively estimated.

Two transect (T5 & T6) were in the Bombah sand mass (Bsm in Fig. 2 & Table 1). Along each of them, height of the ground surface above an adjacent periodically waterlogged area was recorded using a staff and alidade, and, using a hand auger, where they could be reached, depths were recorded to the watertable and soil B horizon. Along T5, data on the vegetation were collected as described for T1, T2 and T3, but also in T5 the number of trees were counted in successive 10 X 10 m quadrats along the transect.

Soils were examined in 1989 across the range of types of ridge vegetation. Nine sites were visited. In each site, within an area approximately 20 X 20 m, four holes were drilled with a hand auger until either a humus-stained B horizon or the water table was reached. In each hole, characteristics of the soil profile were noted, and samples collected of the A_1 (at 0–10 cm) and A_2 horizons (at approximately midway between the bottom of the A_1 and top of the B horizon or the watertable). In the laboratory, standard procedures of chemical analysis were used (Allen 1989). Total amounts of calcium, potassium, and magnesium in the samples were determined, digesting oven-dry soil heated in a mixture of nitric, perchloric and sulphuric acids, cooling and neutralizing the digest and then using an atomic absorption spectrophotometer to determine amounts of Ca, K and Mg. Total amounts of phosphorus in the samples were determined in the West Pennant Hills laboratory of the then Forestry Commission of N.S.W., treating soil in a muffle furnace at 550°C, extracting P in boiling hydrochloric acid, diluting the extract and then using ammonium molybdate with other reagents to determine colorimetrically amounts of P.

Analysis & presentation of data

A map of vegetation on freely draining sands in the valley and along the northern shores of Bombah Broadwater was prepared using aerial photographs and field observations onto a 1:25 000 base taken from relevant topographic maps (Fig. 3).

Plant names used are those listed with their authorities in the Royal Botanic Gardens and Domain Trust's plantnet (www.plantnet.rbgsyd.nsw.gov.au), accessed in May 2009. From the floristic data (Appendix 1), the most commonly and frequently occurring species were arranged according to their growth forms (Table 2) to facilitate floristic and structural description of the types of forest on the sand ridges.

The full floristic set of floristic data (Appendix 1) was used to explore variation in vegetation types over the sand ridges (within-habitat variation) and between vegetation of the ridges and that of nearby periodically water-logged sites in the swales and Back barrier flat (between-habitat variation). Two hypotheses were tested: (i) overall floristic differences exist between sites on freely drained sands and periodically waterlogged sites, and (ii) there is a gradient in floristic variation from Dry Sclerophyll Forest through Intermediate Dry Forest to Dry Heath Forest.

This was done by ordination, gradient analysis in the sense of ter Braak & Prentice (1988). The analysis uses scores of species within sites to assess similarities among all the sites. Two axes are extracted from the analysis that represent as much as possible of the total variation among the sites. The positions of individual sites plotted on the axes allow overall floristic variation among the sites to be assessed. The relative positions of sites in the ordination can also be explored against scores of individual species in the form of "biplots" (ter Braak & Prentice 1988). This is useful in assessing the particular association of common and frequent species of various growth forms with specific sorts of vegetation.

Three forms of ordination were tried, correspondence analysis (CA), detrended correspondence analysis (DCA) and principal component analysis (PCA). Salient features of each are described and explored by ter Braak and Prentice (1988). PCA was chosen as it gave the most readily interpreted pattern in positions of sites on the first two extracted by the analysis. In PCA, plots of sites with freely drained sands were widely spread on the second axis, while CA and DCA gave a tight clustering of these sites on both axes, showing their close similarity but almost completely masking floristic differences among them.

Results

Vegetation of freely drained sands

The vegetation of freely drained sands was mapped (Fig. 3) as Dry Sclerophyll Forest (DSF), Intermediate Dry Forest (IDF) or Dry Heath Forest (DHF), according to the occurrence of *Banksia serrata* alone (DSF), *Banksia serrata* and *Banksia aemula* together (IDF), or *Banksia aemula* alone (DHF). DHF is the most extensive, occurring over much of the area of the ridges of the Pleistocene beach system (Pib) (Figs. 1 & 3). IDF occurs extensively over the Bombah sand mass (Bsm), and in only small patches at some of the edges of the Pleistocene beach system (Pib) (Figs. 1 & 3). DSF covers the Boolambayte sand ridge (Bsr), the southern edge of Bsm, facing Bombah Broadwater, and its north-western edge, facing flood water moving down the Upper Myall River (Figs 1 & 3). On Pib, DSF is confined to areas either abutting the floodplain of the river or where sands probably shallowly overlie other substrata (Figs. 1 & 3).

Floristically, DSF, IDF and DHF are closely related (Fig. 4, Table 2). DSF and DHF form separate clusters of sites in the ordination, but IDF sites lie between them and overlap each of their clusters. In short, there is a continuum from DSF through IDF to DHF. Periodically waterlogged sites are separate from DSF, IDF and DHF on freely drained sites. Wet Heath Forest (WHF) sites, on apparently low-lying parts of beach ridges, cluster more closely to DSF, IDF and DHF than do Wet Heath (WH) sites (Transects 4, 19, 20, 23, 24, 25 & 41), which form a tight cluster on the right of the ordination diagram.

Dry Sclerophyll Forest (DSF), Intermediate Dry Forest (IDF) and Dry Heath Forest (DHF) differ structurally and floristically, though shrub species of their understoreys are fairly similar in their occurrence and frequency across them (Table 2). *Corymbia gummifera* is the most consistently and frequently occurring species of tree across the three types of forest (Table 2). *Angophora costata* has its highest frequency of occurrence in DSF, *Eucalyptus pilularis* in DSF and IDF, and *Eucalyptus signata* in DHF (Table 2, Fig. 5d).

Dry Sclerophyll Forest (DSF), in the top left of the ordination of data (Fig. 4), has high occurrence and frequency of *Banksia serrata* (Table 2, Fig. 5 (c)), *Pteridium esculentum*, *Themeda australis*, *Lomandra longifolia* and *Dianella caerulea* (Table 2, Fig. 5 (a)). Structurally, it has tall trees, 25–30 m (e.g. Table 3), and is open-forest (*sensu* Specht 1970). In contrast, Dry Heath Forest (DHF) has high occurrence and frequency of *Banksia aemula* (Table 2, Fig. 5 (c)) and *Hypolaena fastigiata* (Table 2, Fig. 5 (a)). Its trees are generally lower than those of DSF, varying from 25 to just over 10 m high (Table 3), and their cover varies such that DHF ranges structurally from open-forest to open-woodland (*sensu* Specht 1970). Some small areas within DHF are treeless and are thus Dry Heath (DH); larger patches of DH are mapped in Fig. 3, but smaller ones are not. Intermediate Dry Forest (IDF), structurally similar to DSF, has both *Banksia aemula* and *Banksia serrata*, and has relatively high occurrences of *Pteridium esculentum* and *Themeda australis* (Table 2).

Table 2. Species occurring with a frequency (Freq) > 30% (tree spp. > 20%) in one or more types of vegetation (Dry Heath Forest (DHF); Intermediate Dry Forest (IDF); Dry Sclerophyll Forest (DSF); Wet Heath Forest (WHF); Wet Heath (WH); Swamp (Sw)) and number of sites of their occurrence (No. maximum for DSF 13; IDH 5; DHF 18; WHF 4; WH 7; Sw 1).

Vegetation	**DSF**		**IDF**		**DHF**		**WHF**		**WH**		**Sw**	
	No.	**Freq**	**No.**	**Freq**	**No.**	**Freq**	**No.**	**Freq**	**No.**	**Freq**	**No.**	**Freq**
(i) Tree species												
Angophora costata	12	51	1	10	10	17	3	40	1	1		
Corymbia gummifera	13	47	5	68	17	43	2	38				
Eucalyptus pilularis	12	33	4	38	6	12						
Eucalyptus resinifera							3	33				
Eucalyptus robusta	1	1							2	11	1	40
Eucalyptus signata			1	4	12	28	1	25				
(ii) Banksia species												
Banksia aemula			5	60	18	100	1	8				
Banksia oblongifolia					3	2	2	48	4	33		
Banksia serrata	13	89	4	50								
(iii) Myrtaceous shrub spp.												
Callistemon citrinus							1	23	7	84	1	60
Leptospermum juniperinum							2	13	4	36	1	10
Leptospermum polygalifolium	2	3	1	2	13	41	4	73	4	16		
Leptospermum trinervium	5	8	5	70	15	47						
Melaleuca nodosa					6	12	2	43	2	9		
Melaleuca sieberi							4	68	4	50		
Melaleuca thymifolia							3	18	7	77		
(iv) Other shrub species												
Acacia suaveolens	10	32	5	40	11	17	1	3				
Acacia ulicifolia	13	41	5	56	13	29	2	30				
Bossiaea heterophylla	11	52	5	90	18	67						
Bossiaea rhombifolia	9	47	3	14	1	1						
Brachyloma daphnoides	5	15	4	56	12	22						
Dillwynia glaberrima	2	2	1	2	14	35						
Dillwynia retorta	6	20	5	70	11	23	2	38				
Eriostemon australasius	5	20	5	76	18	59						
Gompholobium virgatum	3	15	4	38	11	13						
Gonocarpus teucrioides	13	47	5	44	8	17	2	15				
Hibbertia fasciculata	2	2			12	34	1	5				
Hibbertia obtusifolia	13	72	5	76	13	39	1	3				
Leucopogon ericoides	5	13	4	56	8	11						
Leucopogon parviflorus	4	4	3	16	13	34			1	1		
Leucopogon virgatus	8	19	5	48	10	28						
Monotoca scoparia	5	5	3	12	16	46	1	3				
Phyllota phylicoides	3	9	4	44	10	18						
Pimelea linifolia	4	7	3	32	13	31	2	18	1	1		
Platysace linearifolia	7	35	4	44	16	53						
Ricinocarpos pinifolius	10	45	4	66	18	73						
Zieria laevigata			1	2	14	31	1	8				
(v) Pteridophytes												
Blechnum cartilagineum											1	30
Pteridium esculentum	13	100	5	98	13	60	1	8	1	6		
Selaginella uliginosa	1	1			6	13	3	20	6	33		
(vi) Grasses & lilies												
Dianella caerulea	13	45	3	12	5	3	2	5	1	1		
Entolasia stricta							3	30	6	44		
Imperata cylindrica	9	53	1	4			1	10				
Panicum simile	12	55	2	28	12	23	4	63	3	6		
Themeda australis	13	71	5	68	6	16	2	25	1	1		
(vii) Restiads, sedges & lomandra												
Baloskion pallens					6	17			4	24	1	100
Baumea arthrophylla									2	7	1	60
Chorizandra sphaerocephala									7	51	1	20
Hypolaena fastigiata	5	25	4	70	18	89	1	10				
Lepidosperma filiforme											1	90
Leptocarpus tenax					8	12	2	40	7	50		
Lomandra glauca	13	45	4	30	16	39	2	18				
Lomandra longifolia	13	76	4	52	10	32	2	45				
Ptilothrix deusta							3	48	1	6		
Schoenus brevifolius							2	40	7	91		
Sporadanthus interruptus					9	14	1	8	4	36		
(viii) Subshrub & herbs												
Pomax umbellata	12	53	4	34	5	8	1	8				
Trachymene incisa	9	22	4	22	6	19	2	38				
Villarsia exaltata									4	11	1	70
(ix) Xanthorrhoea												
Xanthorrhoea fulva							1	3	6	34		
Xanthorrhoea glauca	9	25	4	34	11	14.	1	25	1	1		

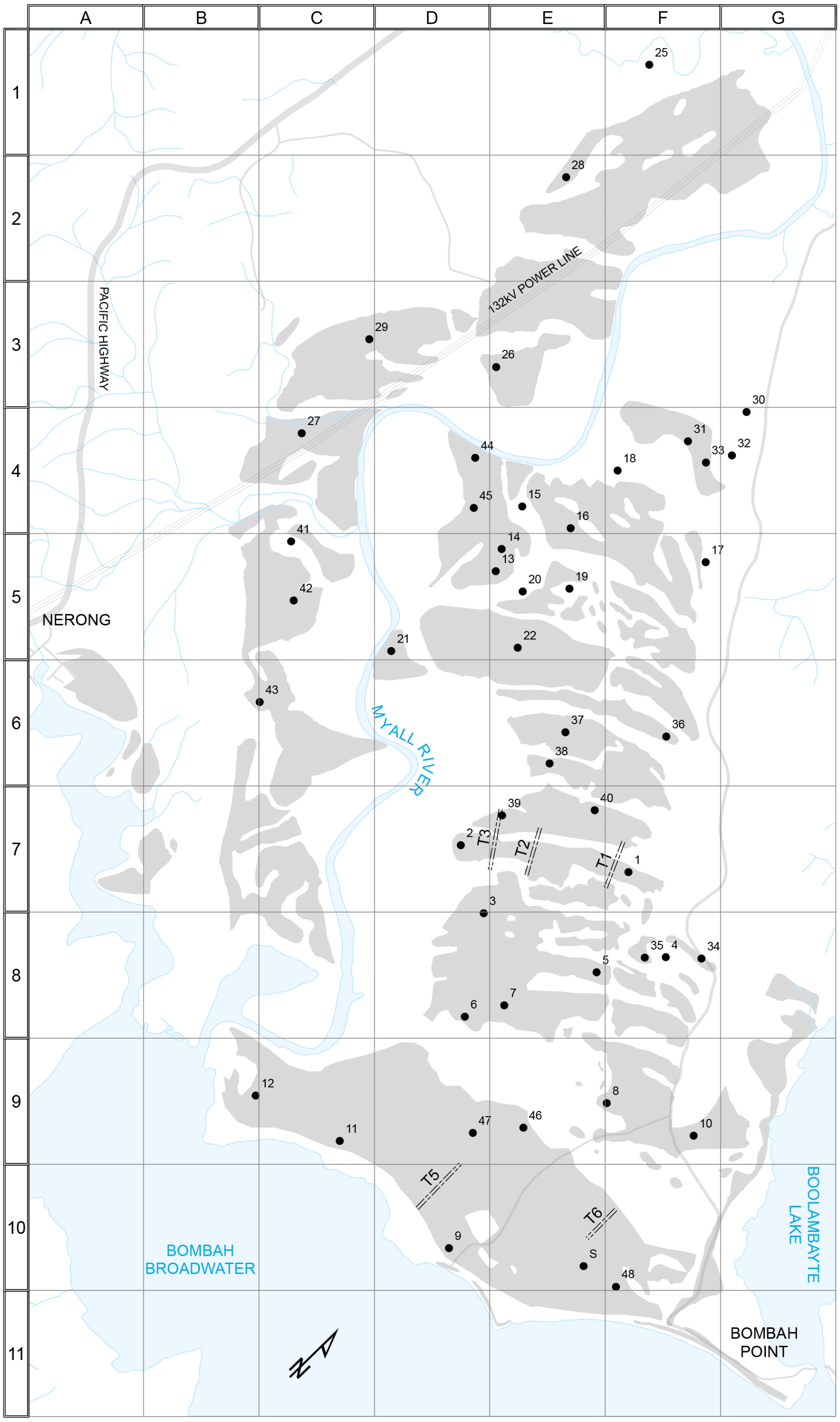

Figure 2.
Freely Draining Sand and Site Locations

0 0.5 1 2 Kilometres

Fig. 2. Location in Upper Myall River valley of freely draining surfaces on sand (shaded grey), 48 sites (•) where floristic data were collected (soil samples collected at Sites 16, 21, 22, 27, 28, 31, 35, 42 & S (soil sampled only)) and long transects (straight lines) across vegetation boundaries along which floristic variation was recorded (T1, T2, T3, T5 & T6; T4 ran along the ridge intersected by T1, T2 & T3). Sites 23 & 24 lie just beyond the upper boundary of the map (Their grid references are given in Appendix 1).

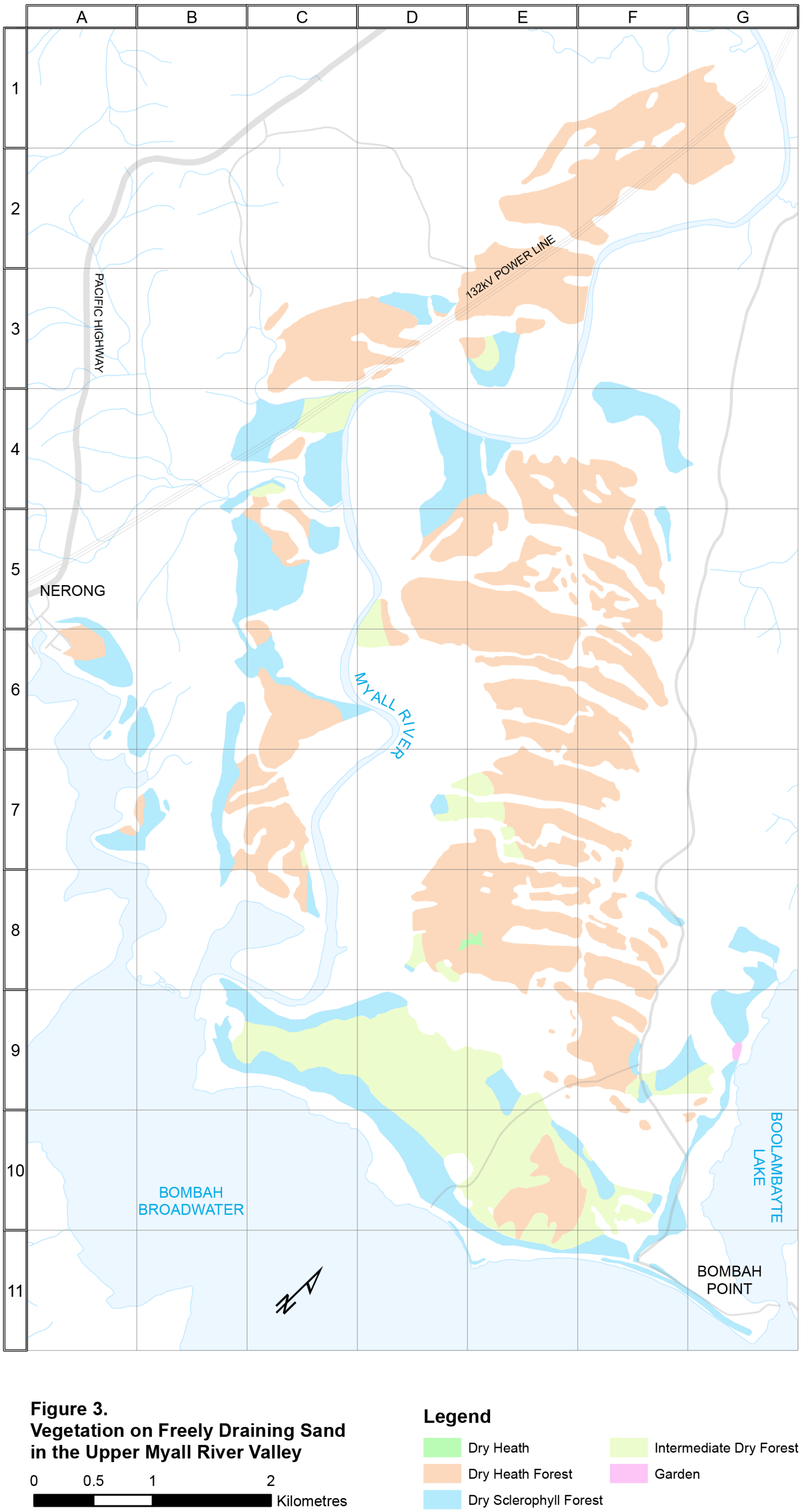

Fig. 3. Vegetation in Upper Myall River valley on freely draining sands: Dry Sclerophyll Forest (DSF); Dry Heath Forest (DHF); Intermediate Dry Forest (IDF); Dry Heath (DH); old garden.

Table 3. Transect 4: species cover (%) over 50 m lengths, presence (*) only in 10X50 m quadrats for trees, and 5X50 m for other species); spp. shown listed in Table 2 + Macrozamia communis.

Vegetation boundary	**DSF**		**DSF**	**IDF**							**IDF**	**DHF**						
Distance (m)	**50**	**100**	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**	**550**	**600**	**650**	**700**	**750**	**800**	**850**	**900**
Tallest tree height (m)	**25**	**30**	**26**	**22**	**24**	**24**	**24**	**23**	**20**	**22**	**21**	**24**	**25**	**23**	**12**	**20**	**17**	**12**
(i) Tree species																		
Angophora costata												*	6	*	*	12		10
Corymbia gummifera	16	24	31	*	1	19	29	34	4	24	4	*		*	*		24	
Eucalyptus pilularis	41	43	3	41	36	19	10	28	36	25	24	30	18	26				
Eucalyptus signata																		
(ii) Banksia species																		
Banksia aemula				14	1	9	*	26	19	2	15	7	23	8	26	15	1	15
Banksia oblongifolia																		
Banksia serrata	2	11	10	7	2	*	25	*	*	8	*							
(iii) Leptospermum & Melaleuca spp.																		
Leptospermum polygalifolium																4	1	
Leptospermum trinervium	1		2	7	*	12	6	2	18	15	12	8	9	9	3	11	4	3
Melaleuca nodosa																		
(iv) Shrub species																		
Acacia suaveolens	1	*	*	1	*	*	1	1	*	*	2	7	3	*	*		*	
Acacia ulicifolia	*	*	*	2	3	3	*	1	4	3	*	2	3	1	3	*	3	*
Bossiaea heterophylla	2	14	13	20	11	9	14	8	12	11	13	14	21	2	3	1	1	8
Bossiaea rhombifolia	3	4	4	1	10	2	3	11	2	6	*	*						
Brachyloma daphnoides	*	3	13	4	11	6	2	*	10	4	5	5	3	9	3	*	5	*
Dillwynia glaberrima			2	*	*	2	*	*	3	2	6	*	2	5	4	13	2	9
Dillwynia retorta		1	*	*	*	*		*	*	*	*	2	*	1	1	1	5	1
Eriostemon australasius	4		*	5	*	8	1	*	5	1	4	3	6	5	7	2	1	*
Gompholobium virgatum										2								
Gonocarpus teucrioides	6	2	2	2	*	2	2	2	4	6	*	1	7	*	*		*	1
Hibbertia fasciculata													1		5	3	4	1
Hibbertia obtusifolia	8	13	2	15	4	6	11	5	8	5	4	3	9	*				1
Leucopogon ericoides	*			*	*	*					*	*	*	*	2	13	10	3
Leucopogon parviflorus	3		*	*	*		1	*	2	4	2	1	*			*		
Leucopogon virgatus	1	1	*	1	1	*	*	*	3	4	5	1	1	3	4	*	*	1
Monotoca scoparia				*	*	2	3	*	2	*	1	2	6	9	7	1	1	*
Phyllota phylicoides										3	*	8	24	*	*		1	
Pimelea linifolia				2		2	*	*	6	*	*	*	2	1	1	3	*	4
Platysace linearifolia	18	16	20	11	14	6	24	10	16	8	7	5	21	9				2
Ricinocarpos pinifolius	*	21	10	9	5	13	14	3	9	7	3	8	10	18	2	6	2	4
Zieria laevigata												*	2	2	1	4	3	2
(v) Pteridophytes																		
Pteridium esculentum	31	20	6	11	13	12	12	7	4	5	5	9	13	*			1	1
Selaginella uliginosa																		
(vi) Grasses & lilies																		
Dianella caerulea	24	1	4	3	*	*	*	*	1	*	*	*	*	*				*
Entolasia stricta																		
Imperata cylindrica																		
Panicum simile	5	2	*	4	4	3	4	4	*	3	4	5	6	3	1	*	*	3
Themeda australis	5	12	10	6	24	8	14	13	8	12	4	1	11	3	1			
(vii) Restiads, sedges & lomandra																		
Baloskion pallens																		
Hypolaena fastigiata					6	1		25	26	48	27	42	66	37	81	81	79	77
Lomandra glauca	*	*	3	2	1	*	6	2	*	*	*	*	5	1	*	4	2	2
Lomandra longifolia	14	36	10	13	14	4	8	3	1	1	*	1	2	1				*
Schoenus brevifolius																		
Sporadanthus interruptus																		
(viii) Subshrub & herbs																		
Pomax umbellata	3	4	1	6	7	7	10	7	1	3	3	3	4	*		*	*	1
Trachymene incisa																3	*	4
(ix) Xanthorrhoea																		
Xanthorrhoea fulva																		
Xanthorrhoea glauca	*			4	*		5			4	6	7	*	2	12		*	2
(x) Cycad																		
Macrozamia communis	25	26	1	5	6	*	*				*							
Bare ground	**6**	**2**	**15**	**2**	**16**	**11**	**9**	**1**	**3**	**7**	**12**	**9**	**2**	**8**	**3**	**7**	**4**	**4**

950 16	**1000 13**	**1050 22**	**1100 24**	**1150 21**	**1200 17**	**1250 18**	**1300 21**	**1350 15**	**1400 18**	**1450 18**	**1500 16**	**1550 15**	**1600 16**	**1650 12**	**1700 18**	**1750 15**	**1800 16**	**DHF 1850 22**	**Total cover score**
14	7	20	11	8	38	8	24	32	31	21	3	12	*		10	*	*	30	297
	*	*	25	7	*	6	15	10	13	5		*		*	*	3	30	2	326
																			380
*			17	*	*	*			12	*	41		46	11	16			8	151
8	24	13	10	18	16	17	8	12	7	20	26	24	24	47	13	5	11	21	505
													1						1
																			65
				1	21	*			*	*	8	16	24	21	25	24	5		150
*	2	*	*		*	*	5	*	*	*	*	2	*	*	6	6	3	7	153
					1						17	11	2	1	2	7	*		41
	1	*	3	*		1	*			*	*							*	21
*	1	*	2	*	2	*	*	*	*	*	*	*	*	1	*	1	*	1	36
5	7	4	4	4	5	15	1	1	2	3	1			*		1	3	4	237
																			46
2	*	1	*		*		2	*	*	*	*						*	*	88
9	1	*	4	10	19	*	*		3	4	7	3	3	6	4	6	*		129
3	1	*	1	*	1	2	7	*	2	1	2	*	1	*			1	7	41
*	*	*	*	*	5	*	1	*	2	1	*	*	*			1	*	*	62
																			2
*	*	*	*	1	*	1	*	3	6	*	1			*				1	50
1	1	*	1	3	5	6	*	1	2	6	9	5	*	1	1	1	3	*	60
			*	*		*	*	*											94
5	6	*	*	*		2			*	*	*								41
*		2	*		3	*		*				*	1	2	5	6	3	*	35
*	1	*	1				3	1	1	*						1	1	*	35
2	*	1	*	*	1	2	2	*	*	1	1	1	*	*	*	2	*		47
	5	9	*	6	1							*		2					59
*	*	*	*	8	3	4	3	5	3	5	7	4	*	1		*	1	*	65
1				10	17	5	*			*	12	5	8	15	5	7	7		279
1	7	4	2	14	21	3	3	1	3	3	*	1	2	1	2	4	12	*	228
1	3	4	*	2	*	*	*	*	*	*	1	*	1	2	*	3	1	3	35
1	1	6	3	3	5	5	2	1	2	3						*	1	6	189
												2	*	3	3	2	*		10
					*	*	*												33
																		7	7
																		6	6
2	1	2	3	3	*	3	1	*	*	*	*						1	16	83
																		1	133
											7	26	17	37	35	20	*		142
80	65	66	66	74	59	76	67	70	67	82	40	66	63	62	45	60	41	41	1786
*	2	*	1	2	2	*	*	*	*		3	2	*	1	4	2	*	*	47
*		*	1	2	1		1											10	123
																		10	10
															10	6			16
1	*		2	*					3									21	87
11	4	7	3	3	5	4	1	*	3	*	*						1		49
											1		1						2
	*	*				*		*	*	5		7	*	*	1	1	*		56
																			63
6	**15**	**13**	**5**	**4**	**3**	**9**	**7**	**7**	**13**	**3**	**2**	**3**	**7**	**6**	**5**	**2**	**11**	**2**	**244**

Table 4. Soil profiles of 9 ridge sites based on four holes per site; Veg, vegetation type; A_1 horizon sampled at 0–10 cm deep; other horizons (depth to top), Wt, watertable.

Site	**27**	**31**	**42**	**21**	**S**	**6**	**22**	**28**	**35**
Veg	DSF	DSF	DSF	IDF	DHF	DHF	DHF	DHF	DHF
A_1	Dark humus-rich	Dark humus-rich	Burnt much charcoal	Dark humus-rich	Dark humus-rich	Dark humus-rich	Dark humus-rich	Dark humus-rich	Dark humus-rich
A_2	Bleached (0.7–1.1 m)	Yellow – bleached (30–80 cm)	Bleached (1.0 –1.3 m)	Bleached (1.3–1.4 m)	Bleached (0.8–1.2 m)	Light brown – bleached (45–70 cm)	Bleached (1.2–1.3 m)	Grey (55–80 cm)	Light brown – bleached (0.9–1.1 m)
B	Dark to light brown mottled slightly hardened (0.9–1.4 m)	Light brown mottled soft (0.5–1.0 m)	Black slightly indurated (2.3–2.9 m)	Very dark brown indurated (2.3–2.7 m)	(Not reached before watertable)	Dark brown, indurated mat of roots at its top (60–90 cm)	(Not reached before watertable)	(Not reached before watertable)	(Not reached before watertable)
Wt					(c. 3.1 m)	(c.1.4 m)	(c. 2.3 m)	(c.1.2 m)	(c. 1.4 m)

Table 5. Mean (SE) total calcium (Ca), potassium (K), magnesium (Mg) and phosphorus (P) in A1 and A2 horizons in soils of 9 sites (p.p.m. by weight in oven-dry soil)

Site	**27**	**31**	**42**	**21**	**S**	**16**	**22**	**28**	**35**
Veg type	**DSF**	**DSF**	**DSF**	**IDF**	**DHF**	**DHF**	**DHF**	**DHF**	**DHF**
A1									
Ca	219	166	426	386	351	125	434	143	106
	29	17	132	77	68	62	147	56	5
K	58	183	76	45	52	84	78	80	37
	6	13	12	8	13	31	12	7	4
Mg	66	92	179	70	142	102	124	87	39
	16	17	46	15	16	52	21	16	5
P	16	20	16	16	16	21	17	19	15
	0	2	3	2	2	7	2	2	2
A2									
Ca	0	25.6	0	0	0	0	0.6	0	0
	0	4.9	0	0	0	0	0.6	0	0
K	3.7	148.7	2	0	0	0.3	0	0	0
	1.1	33.5	0.7	0	0	0.3	0	0	0
Mg	0	37.2	0	1.3	0	0.4	3.9	3.8	7.7
	0	8.6	0	1.1	0	0.4	2.3	1.9	3.2
P	3.3	8.5	2	2.3	2.3	3.5	2	3.3	4.3
	0.3	0.9	0	0.3	0.3	0.3	0	0.3	0.9

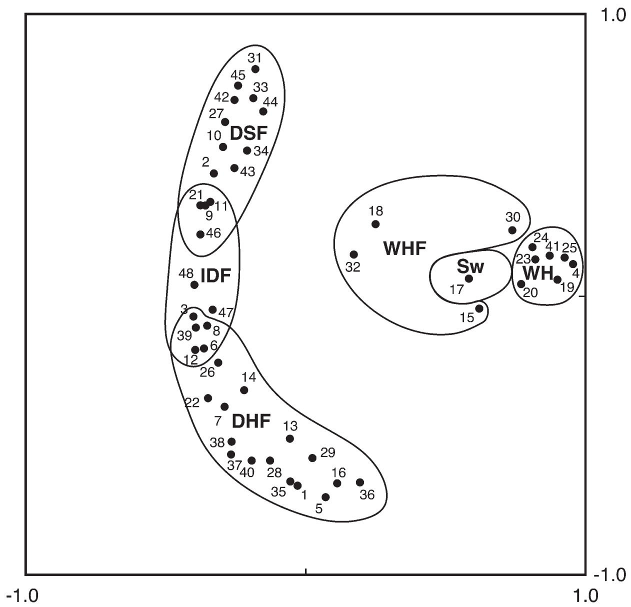

Fig. 4. Ordination of floristic data from 48 transects on the first two axes extracted from a principal components analysis. Numbers indicate the individual transects, and boundaries enclose transects assigned to Dry Sclerophyll Forest (DSF), Intermediate Dry Forest (IDF), Dry Heath Forest (DHF), Wet Heath Forest (WHF), Wet Heath (WH), and Swamp (Sw).

Soils and vegetation

In all nine sites investigated, the soils were podzols. In the three DSF soils, the B horizons were shallower and less indurated than in other sites where the B horizon was reached, and it was also above the watertable (Table 4). In all five DHF sites, the watertable was reached before the B horizon; in four sites, a B horizon was not reached.

In soils of all nine sites levels of Ca, K, Mg and P decreased markedly from the A_1 to the A_2 horizon (Table 5). In the A_1 horizon, sites differed in levels of each of the four nutrients, but the differences are not associated with types of vegetation carried by the sites. Site 31 had much higher levels of nutrients than the other sites. Site 31 appears to be on sand thinly overlying other sediments. The A_2 horizon of its soil, shallow and yellow-bleached, clearly differs from the A_2 horizons of the soils of the other sites, and may contain material other than just beach sand.

Vegetation and local variation

Observations at specific locations on long transects (Tables 3, 6 & 7, Appendices 2, 3 & 4) illustrate structural and floristic variation between DSF and IDF, and IDF and DHF (see particularly Table 3), and confirm that DSF, IDF and DHF occur on better drained sands than surrounding lower surfaces.

Such less well drained surfaces carry vegetation ranging from Wet Heath on sands with water tables only slightly higher than on adjoining sand ridges, to incised drainage channels with *Eucalyptus robusta* Swamp Forest, to open water with *Phragmites australis*. This is illustrated along Long Transects 1, 2 and 3 (Appendices 2, 3 & 4) that intersected the 1.8 km sand ridge along which Long Transect 4 ran (Table 3). The most easterly, Transect 1 (App. 2) crossed Wet Heath at 40–70 m and 250–320 m where the watertable was only 10–40 cm higher than on adjoining ridges carrying DHF. The

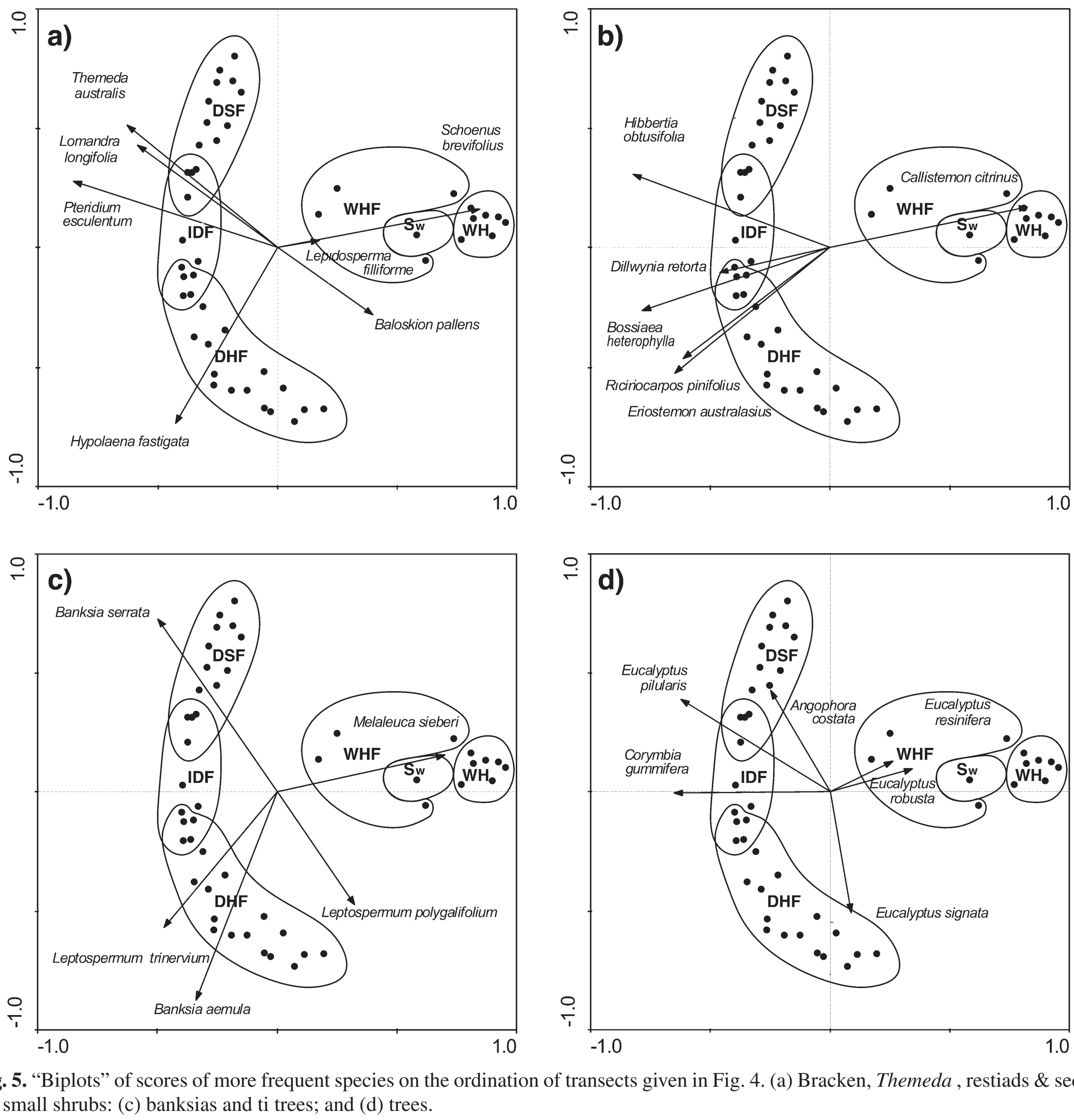

Fig. 5. "Biplots" of scores of more frequent species on the ordination of transects given in Fig. 4. (a) Bracken, *Themeda* , restiads & sedges; (b) small shrubs: (c) banksias and ti trees; and (d) trees.

Table 6. Transect 5 (bearing 360 degrees): species cover over 10 m length (max. score 20); species shown listed in Table 2 + Xylomelum pyriforme & Baloskion tetraphyllum.

Distance (m)	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**190**	**200**	**210**	**220**	**230**	**240**
Height of surface (m)	**0.9**	**2.4**	**7**	**10.9**	**12.6**	**12.6**	**12**	**11.9**	**10.5**	**9.1**	**7.7**	**7**	**6.6**	**6.5**	**6.4**	**6.5**	**6.5**	**6.5**	**6.6**	**6.6**	**6.7**	**6.6**	**6.6**	**6.5**
Depth to B horizon (m)	**1.3**	**1.9**	**1.2**	**2.2**	**3.3**	**2.4**	**3**	**2.5**	**2.6**	**>4**	**>4**	**>4**		**>4**		**>4**		**1**		**1.8**		**1.6**		**1.8**
No. of canopy & sub-canopy trees per 100 sqm:																								
Angophora costata			2		1	1	1	1		1	1			1	1	1				1		1		
Banksia aemula																								
B.aemula >3m high																								
Banksia serrata	4	14	10	3	7	6	7	16	14	13	7	5	4	13	6	7	8	6	5	10	7		3	1
B.serrata >3m high		1			1	1	1	1	1	1		1	1	2	1			5	2	1	2		1	
Corymbia gummifera				4		1						1				1	3	1	1	1		2	2	
Eucalyptus pilularis			2								1		2		1	1	1		1	1	1			
Eucalyptus signata																								
Xylomelum pyriforme																								
(i) Tree species																								
Angophora costata	8	17	14		11	20	15	18	15	20	19	20	5		8	17	19					8		
Corymbia gummifera			7	16	9						3	2		17				16	18	12		8	20	5
Eucalyptus pilularis			2	2									16	19	8		5	10		11	14	10		13
Eucalyptus robusta	15																							
Eucalyptus signata																								
(ii) Banksia species																								
Banksia aemula																								
Banksia serrata			1				1				1	3	11	3	11	1		2	7		3			
(iii) Myrtaceous shrub spp.																								
Leptospermum juniperinum	1																							
Leptospermum trinervium					1												1							
(iv) Other shrub species																								
Acacia suaveolens								1											1	1			2	
Acacia ulicifolia	5	1	2		1						6	1	3	4	2			2	2		2			2
Bossiaea heterophylla							2	1	2	2	1													
Bossiaea rhombifolia			7	2	2														1					1
Dillwynia retorta	1	10	11	8	5	1		6			6	7	5	7	7	6	12	11	8	6	2	1	6	8
Eriostemon australasius						1	2						1					1	2				1	
Gompholobium virgatum										2									1					
Gonocarpus teucrioides			1					1		2	1						2						1	
Hibbertia obtusifolia							1					1												
Leucopogon ericoides			1	2			4							1					2		2	1	3	2
Leucopogon parviflorus																								
Leucopogon virgatus							1		1					1										
Monotoca scoparia							3				1			1	1	1	2							
Phyllota phylicoides						6	3	6	6					1				3						3
Pimelea linifolia																								
Platysace linearifolia								2		1	1	1			1			1					1	
Ricinocarpos pinifolius			1		3	1	2	1	3	3		2		1	2	4	1	4	2	1	4	1	1	
(v) Pteridophytes																								
Blechnum cartilagineum	1																							
Pteridium esculentum	10	6	8	4	4	9	8	5	7	4	4	8	7	3	8	8	4	3	5	1	1	6		1
(vi) Grasses & lilies																								
Dianella caerulea														1		1								
Imperata cylindrica																								
Panicum simile										1	1													
Themeda australis									4	2			4			5	3	1						

250 6.4	**260 6.5 >4**	**270 6.4**	**280 6.3 >4**	**290 6.4**	**300 6.5 >4**	**310 6.5**	**320 6.6 1.5**	**330 6.6**	**340 6.6 2**	**350 6.5**	**360 6.4 >3**	**370 6.3**	**380 6.3 >4**	**390 6.2**	**400 6.2 >4**	**410 6.2**	**420 6.1 >4**	**430 6**	**440 6 >2**	**450 6**	**460 6 >4**	**470 6.1**	**480 6.1 >4**	**490 6.2**	**500 6.3 4**	Total Number
																										13
											2	3	5	2	10	7	6	2	2	3	1	6				49
											2	3	5	1	5	7	6	2		2		2				35
1	5	2	4	2	1	4	3	3	5	1			2	2	2		1		1	1	1	6	15	12	10	260
1	1		2			2	3	3	4				2	2	2		1		1	1		1	4	2		55
1	1		1				3			1	1		1	2	2	1	1			1	1	1	1		2	38
1	1	1		1	2	1			1	1	1															21
																				1						1
								2																		2
																										Total cover score
																										234
	4	8	20	4	5	12	20	2	10	19	20	4		15	12	12	14	4	17		12	20	6		3	376
14	20	17	8		15	4																				188
																										15
																			7	20	10	2				39
											2	15	20	7	10	4	9	10		1			2			80
	6			11				8	5													1	2	1	4	82
																										1
												1			2			4	2	4	1	1	2			19
1	1	1				1			2		1					1			1		1					15
						2		1	3	2			1	1	1	4	1		2	2	2	2				57
		1	3						2					2			1				1	1			1	20
1	2		1	1	2	3	3	1																		27
6		1		2	1	1	4		2		1		3	1				1	4	3	5	2	1	1	2	175
1		1	4	2				3				1		2		1		1	2	1			1		1	29
2				1		1	1	2	1			1	2	1	2	1	1	1				2	1			23
2				1				1	1					1							1					15
			1					1											1		1					6
1						2				5		2	1								1	1			1	32
					1																					1
	1											2					1					1	1		1	10
				4		1	1	5				2	1		1	1	3	2	3	1		1	1	1		37
	2		1	7	1	2	1	2			2						1	5	2	6	6	4	1		2	73
														1	1				1							3
	1	2		1	4	1	1	2	1	1			2	5	5	1	2	1	4		1		1	1	1	46
	5	3	2			1	2	4	2		1	2	1	3	2	3		1	1	2	1	2				75
																										1
6	4		3	2	5	5	6	7	3	9	5	10	6	2	2	3	5	2	3	5	4	1	7	2	3	234
															1											3
								1							1											2
																										2
1	7			4	2	8	3	1	1		3	1	2	6	5	1	1			1	1		1			68

Table 6 (cont.)

Distance (m)	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**190**	**200**	**210**	**220**	**230**	**240**
Height of surface (m)	**0.9**	**2.4**	**7**	**10.9**	**12.6**	**12.6**	**12**	**11.9**	**10.5**	**9.1**	**7.7**	**7**	**6.6**	**6.5**	**6.4**	**6.5**	**6.5**	**6.5**	**6.6**	**6.6**	**6.7**	**6.6**	**6.6**	**6.5**
Depth to B horizon (m)	**1.3**	**1.9**	**1.2**	**2.2**	**3.3**	**2.4**	**3**	**2.5**	**2.6**	**>4**	**>4**	**>4**		**>4**		**>4**		**1**		**1.8**		**1.6**		**1.8**
(vii) Restiads, sedges & lomandra																								
Baloskion tetraphyllum	13	9																						
Hypolaena fastigiata													6	8	15	12	13	14	14	10	11	10	14	14
Leptocarpus tenax	5																							
Lomandra glauca					1			1	2	1				2				1		2				
Lomandra longifolia				2						2		2	6	1	1		1	2	2		1		2	
(viii) Subshrub & herbs																								
Pomax umbellata			1				1																	
(ix) Xanthorrhoea																								
Xanthorrhoea glauca		4		2	16	12		2	2		4						1			5	3		2	
Bare ground				**1**			**1**		**1**							**1**						**1**		

most westerly, Transect 3 (App. 4) commenced in a drainage channel 0–30 m in vegetation somewhat intermediate between Swamp and Wet Heath, crossed a deeper drainage channel with *Eucalyptus robusta* Swamp Forest at 200–240 m and ended at its lowest point at the edge of the river floodplain in Swamp with *Blechnum indicum*, *Chorizandra sphaerocephala* and *Phragmites australis*. The two ridges crossed by Long Transect 3 stand about 7 m above the river floodplain.

In the Bombah sand mass (Bsm), a similar difference occurs in height (6–6.5 m) between adjoining swampy ground and the relatively level central area crossed by Long Transect 5 (Table 6). At the southern, lakeside, end of the transect, from 0–120 m, there is a ridge rising to 12 m with a steep scarp slope facing the lake. This ridge is shown in Murphy's (1995) Soil Landscape map. On this ridge, *Angophora costata* and juvenile *Banksia serrata* were generally more common than in the rest of the transect. Depths to the B horizon varied along the transect without any particular pattern.

In Long Transect 6, which traversed DHF, IDF and DSF, depths to the B horizon appeared to be greatest beneath IDF, where height of the surface above the edge of Bombah Bog was greatest; Bombah Bog was reached at 330 m (Table 7).

Sand masses and their vegetation

The two most extensive types of sand mass, the Pleistocene inner Barrier strand plain (Pib) and the Bombah sand mass (Bsm) have DSF, IDF or DHF on freely draining sites, whereas the Boolambayte sand ridge (Bsr) has only has only DSF. DSF also occurs on some lake sand bars such as on the bar running west from Bombah Point and those just east of Nerong. Small sand bars between the Bombah sand mass and the shores of Bombah Broadwater carry open-scrub (*sensu* Specht 1970) of *Banksia integrifolia* and *Banksia serrata* and other species of shrubs.

On the Boolambayte sand ridge (Bsr), DSF varies in its understorey from north to south. In the south, it is more sclerophyllous with a higher density of *Banksia serrata* than in the north where the understorey is quite mesophyllous. About 700 m from its northern end, there is a small patch of pines and other spp. not endemic to the site, clearly an erstwhile garden. A tiny outcrop of rock is present. Augering the soil within 2 to 5 m from the outcrop encountered rock at 0.6 to 1.8 m deep.

Dry Heath Forest (DHF) occupies most of the freely draining sands of the Pleistocene inner Barrier strand plain (Pib) (Fig. 3). There is little variation apparent in DHF related to distance of the ridges from the sea; *Eucalyptus signata* is however the most common species of tree on the most inland ridge but not on other ridges. Dry Sclerophyll Forest (DSF) occurs on the plain in two situations. The first, where sand lies close to substrata other than beach sand, carries DSF usually with some species, such as *Allocasuarina* spp. that usually occur on rock-based soils (see Transects 10, 27, 31, 33, 42 & 43 (Fig. 2 & App. 1)). The second is where fluvial disturbance might have been expected to have occurred since the original marine deposition of the sand (see Transects 2, 44 & 45 (Fig. 2 & App. 1)). Intermediate Dry Forest (IDF) occurs on the plain close to DSF, again where fluvial disturbance might have been expected (see Transects 21 & 39 (Fig. 2 & App. 1)).

In contrast, on the Bombah sand mass (Bsm), Intermediate Dry Forest (IDF) is the most extensive vegetation (Fig. 3). Dry Sclerophyll Forest (DSF) occurs in bands along edges, most extensively where disturbance from the river, lake, wind or the brief Postglacial marine incursion (Martin 1986) would have been expected. Dry Heath Forest (DHF) is limited to an area near the eastern end of the sand mass.

Discussion

Vegetation & geomorphological processes

Geomorphological processes are summarised in Thom *et al*. (1992) for the two sand masses originally laid down about 125,000 years ago, the Pleistocene beach system (Pib) and the Bombah sand mass (Bsm).

250	**260**	**270**	**280**	**290**	**300**	**310**	**320**	**330**	**340**	**350**	**360**	**370**	**380**	**390**	**400**	**410**	**420**	**430**	**440**	**450**	**460**	**470**	**480**	**490**	**500**	
6.4	**6.5**	**6.4**	**6.3**	**6.4**	**6.5**	**6.5**	**6.6**	**6.6**	**6.6**	**6.5**	**6.4**	**6.3**	**6.3**	**6.2**	**6.2**	**6.2**	**6.1**	**6**	**6**	**6**	**6**	**6.1**	**6.1**	**6.2**	**6.3**	
	>4		**>4**		**>4**		**1.5**		**2**		**>3**		**>4**		**>4**		**>4**		**>2**		**>4**		**>4**		**4**	
																										22
10	6	5	7	3	6	4	7	5	10	6	7	6	8	6	7	5	9	10	1	4	9	10	6	8	16	322
																										5
		1	2	2	1		1	2					2	1						1	1		1			25
							1	1	1										2							27
													2													4
4		1	4	5		14	5	1	1	2			6	7	2	7	10	7			1		2	13	4	149
1																**1**		**1**								**8**

How Bombah Bog was formed in the Postglacial between Bsm and Pib is based on data of Martin (1986). Recognition of residual "islands" of Pib in north-eastern portion of Bombah Bog is from this study, with an explanation that the coffee rock of the indurated B horizon of their soils protected these small areas from destruction by wave action during the brief Postglacial Marine Transgression. Recognition of the Boolambayte sand ridge (Bsr) also derives from this study. It is suggested that it formed after the Postglacial Marine Transgression as waters drained from Boolambayte Lake into Bombah Broadwater over an approximately one-kilometre wide channel between Bombah Point and the eastern end of the Bombah sand mass (Bsm). It is suggested that as the Boolambayte sand ridge (Bsr) formed, it blocked Bombah Bog off from contact with Boolambayte Lake, and that Bombah Bog then began to drain into Bombah Broadwater through the present drainage channel between the western side of the southen end of Bsr and the eastern end of Bsm. It is suggested that, subsequently, the present lake sand bar formed growing westward from the western end of rocks at Bombah Point, eventually blocking off the channel there between Bombah Broadwater and Boolambayte Lake, leaving only the present narrow channel interconnecting the lakes east of Bombah Point.

Thom et al. (1992) and Murphy (1995) did not recognise the eastern drainage channel from Bombah Bog into Bombah Broadwater, and showed a continuous connection between sands of Boolambayte sand ridge (Bsr) and those of Bombah sand mass (Bsm), assigning their deposition to the Pleistocene.

Evidence from vegetation is consistent with the sequence of geomorphological processes postulated in this study. The recent origin suggested for the lake sand bar running west from Bombah Point is consistent with the presence in its vegetation of both *Banksia serrata* and *Banksia integrifolia*. *Banksia integrifolia* does not occur either in the area of this study are or in the Eurunderee area (Myerscough & Carolin 1986) except on fairly recently deposited sands. Its trees are confined to *Angophora costata*, though the development of the sand bar as a camping ground over the last 100 years (Broomham 2010) may have seen removal of other species of tree. Elsewhere more than one species of tree occur in Dry Sclerophyll Forest (DSF).

Dry Sclerophyll Forest (DSF) is the sole vegetation of freely draining sands of Boolambayte sand ridge (Bsr), consistent with the origin of Bsr following the Postglacial Marine Transgression that, on Martin's (1986) evidence, initiated Bombah Bog (c. 8,000 years ago).

On the Pleistocene sands of Pib and Bsm, DSF only occurs in places where either the sands lie close to other substrata or where fluvial disturbance or recent wind or wave activity near lake shores might have been expected.

On Bsm, DSF, on the steep scarp face facing the lake and high ridge inland of this, gives way further inland to Intermediate Dry Forest (IDF) (Table 6). IDF is the most widespread vegetation of Bsm. In that regard, it is similar to the sand mass in the Eurunderee area that Thom *et al*. (1992) suggested was formed into its present shape in Glacial times by strong westerly winds; Myerscough and Carolin (1986) showed that much of the vegetation of freely draining areas of this sand mass was IDF. Thom *et al*. (1992) suggest that much of the surface of Bsm was similarly affected by westerly winds in Glacial times (c. 20,000 years ago). It is only in an area near the eastern end of Bsm that DHF occurs, which may be expected to have been relatively sheltered from westerly winds in Glacial times, and thus little disturbed.

DHF is the predominant vegetation of freely draining areas of the Pleistocene beach system (Pib). This is consistent with most of these areas having had little disturbance since they were laid down 125,000 years ago.

Vegetation & nutrient status

Nutrient status, in the sense of working capital of nutrients in circulation in the vegetation/soil system (Beadle & Burges 1949), was hypothesised by Myerscough and Carolin (1986) to be graded in the Eurunderee area from being highest in DSF, through IDF to lowest in DHF. There is nothing in this study that would refute this. Indeed, observations are consistent with it. Firstly, the generally taller, less open, tree canopy of DSF than DHF, together with a more grassy, less sclerophyllous, understorey indicate more biomass and higher quantities of

Table 7. Transect 6 (bearing 360 degrees).

Approximate vegetation boundary											**DHF**	**IDF**					
Distance (m)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160
Height of surface (m)	4.5	4.4	4.2	3.9	3.6	3.4	3.4	3.5	3.5	3.5	3.5	3.7	4.1	4.3	4.2	4.1	4.2
Depth to B horizon (m)	>4		>4		1.1		0.9		1.6		1.8		2.4		2.7		3.1
Depth to water table (m)	3.8		3.5		3		3		2.9		3.2		4		3.8		4

Approximate vegetation boundary							**IDF**	**DSF**									
Distance (m)	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330
Height of surface (m)	4.5	4.9	5.6	6	6.4	6.1	5.6	5	4.4	3.7	3.6	3	2.3	1.6	0.9	0.4	0
Depth to B horizon (m)		4		4		4		4		3.9		3		2.1			
Depth to water table (m)										3.5		2.7		2		1.6	

nutrients per unit area than in DHF. Secondly, the small sample of soils examined (Table 3) indicates that the DSF soils are young podzols lacking the highly indurated B horizons of the highly developed podzols of those DHF sites in which B horizons were reached. It can be argued that the younger the podzol the more likely is it to contain reserves of nutrients. Furthermore, in some of the DHF sites the watertable was reached before the B horizon. It is probable that their podzols were formed soon after the Pleistocene beach ridges were deposited 125,000 years ago and that their B horizons became progressively deeper as sea levels fell. As sea levels rose on the onset of the Holocene, rising watertables would have been expected to have submerged their B horizons. Thus, three processes of nutrient depletion would have been expected over time in the Pleistocene beach ridge sands carrying DHF. The first would have been loss of nutrients in numerous bushfires; the second, leaching out of nutrients in podzol formation; and, the third, loss in soil volume available for roots to garner nutrients as the watertable rose. The first and second processes would be expected to be occurring in the DSF sites, but not to have occurred over a long duration as in DHF sites, and the third process not to have occurred at all.

Variation in vegetation

Vegetation varies in a continuous way across DSF, IDF and DHF based on their floristic composition (Fig. 4). The distributions and abundances of numerous, widely ranging spp. of understorey shrubs are probably largely responsible for the tight clustering of DSF, IDF and DHF under the technique of ordination used. Some of these species are obligate-seeders, only regenerating from seed after fires of all but the lowest intensities (see Myerscough *et al*. 1995 for fire behaviour of many of them in heaths of the Eurunderee area). The relative occurrence of *Banksia aemula* and *Banksia serrata* distinguished DSF (*Banksia serrata* alone), IDF (*Banksia serrata* and *Banksia aemula* together) and DHF (*Banksia aemula* alone). *Banksia aemula* appears to occur solely on old deposits of sand, at least in the southern parts of its range. South of Newcastle, these are aeolian Pleistocene sands deposited close to coastal cliffs, such as at Wyburn Head and La Perouse (Benson 1986), with the notable exception of its occurrence much further inland on old alluvial sands at Agnes Banks (Benson 1981). There is variation across DSF, IDF and DHF in their relative grassiness; DSF the most grassy, and DHF the least but with the greatest abundance of the restiad *Hypolaena fastigiata*. The banksias, grasses and *Hypolaena fastigiata* are all resprouting species, some of whose mature plants survive even the most intense fires and after fire sprout fresh leafy shoots. All the species of tree in DSF, IDF and DHF are resprouters. *Corymbia gummifera* occurs with almost uniform abundance across DSF, IDF and DHF. *Eucalyptus signata*, a less abundant species, is almost entirely confined to DHF, and does not occur at all in DSF.

Variation occurs within DSF, IDF and DHF. Floristic variation in DSF is apparent between sites close to substratum other than sand and sites solely on sand. In DHF, structural variation is apparent between sites where tree cover is low, woodland or open-woodland sites, and those where it is higher, open-forest sites. Possibly, this variation in DHF relates to relative nutrient status of sites.

Nomenclature of vegetation

The close floristic similarity of DSF, IDF and DHF justifies their inclusion in Keith's (2004) Coastal Dune Dry Sclerophyll Forests.

The original choice of the names Dry Sclerophyll Forest (DSF), Intermediate Dry Forest (IDF) and Dry Heath Forest (DHF) by Myerscough and Carolin (1986) is open to criticism. It is using Dry Sclerophyll Forest in a local restricted sense, while dry sclerophyll forest is defined by Beadle and Costin (1952) as a very broad category of vegetation. However, the names Dry Sclerophyll Forest (DSF), Intermediate Dry Forest (IDF) and Dry Heath Forest (DHF) were retained in this study to allow ready comparison to vegetation of the nearby Eurunderee area.

Vegetation similarities in other areas

The Eurunderee area and the Upper Myall River valley differ in the way DHF and DSF are distributed across their sand masses, and indeed in their sand masses. The Eurunderee area, as used here and in Myerscough and Carolin (1986), includes the Eurunderee Embayment of Thom *et al*. 1992 and the large triangular Holocene transgressive dunefield lying between the Big Gibber and Seal Rocks that runs inland to the shores of Myall Lake and reaches its most northerly extent close to the entrance to Smiths Lake. The vegetation of these Holocene dunes, some of which reach 100 m in altitude, is, except just behind the beach front, DSF. The DSF reaches up to 40 m, tall open-forest of Specht (1970), and as low as 2–4 m in sites exposed to onshore winds without much apparent floristic variation (Myerscough & Carolin 1986). The Upper Myall River valley lacks any Holocene sand of the Outer Barrier or transgressive dunefield. The only wholly Holocene sand masses in the Upper Myall River valley appear to be the rather small Boolambayte sand ridge (Bsr), which carries DSF, and the even smaller lake sand bars (Lb). In short, DSF is extensive and well developed in the Eurunderee area across extensive Holocene sands, but such sands are almost lacking in the Upper Myall River valley, and areas of DSF in it are mostly confined to sites where Pleistocene sands affected by wind or flows of water since their deposition or sand thinly overlies other substratum.

In contrast, in the Upper Myall River valley DHF is much more widespread and well developed than in the Eurunderee area. Its Pleistocene beach ridges are higher and more extensive than in the Eurunderee area (Thom *et al.* 1992). In the Eurunderee embayment, DHF occurs on higher freely drained sands of the more inland of its Pleistocene beach ridges, but is not extensive. Not present in the Upper Myall River valley, but occurring in the Eurunderee area are a few patches of aeolian Pleistocene dunes such as on the north-eastern slopes of the Big Gibber and areas near Smiths Lake-; parts of these carry DHF (Myerscough & Carolin 1986), but, again, these are limited in extent. DHF in the Upper Myall River valley has a significant population of *Eucalyptus signata*, while only a few isolated trees of this species occur on Pleistocene sands in the Eurunderee Embayment (Myerscough & Carolin 1986).

The Eurunderee area and the Upper Myall River valley are rather similar in the occurrence and distribution of IDF on their sands. In each, IDF occurs most extensively on sands that Thom *et al*. (1992) suggest were moved and redeposited by wind in the Postglacial; sands, respectively, in the Pg area of Myerscough & Carolin (1986) and Bombah sand mass (Bsm) of this study. Both areas are also similar in each enclosing a *Lepironia* swamp in a small lagoon with relatively deep water. IDF also occurs in both this study and the Eurunderee area between DSF and DHF where edges of Pleistocene sand deposits appear to have secondarily disturbed; for instance, near the entrance to Smiths Lake in the Eurunderee area (Myerscough & Carolin 1986).

The Eurunderee area of Myerscough and Carolin (1986) with its large Holocene field of transgressive high dunes covered by particularly well developed DSF is unique on the coast of New South Wales. The Pleistocene beach system of the Upper Myall River valley with its extensive areas of DHF is much more typical of other Wallum country that lies in coastal areas between the Hunter valley and south-eastern Queensland, as described by Coaldrake (1961), Griffith *et al.* (2003) and Griffith & Wilson (2007).

Wider context of the vegetation

The forest of the freely drained sands of the Upper Myall River valley and other Wallum country fall within Keith's (2011) subformation of Dry Sclerophyll Forests. They are closely related to vegetation on other high-quartz sediments as defined by Keith (2011). Nevertheless, the increased grassiness of the understorey from DHF to DSF in this study parallels a similar general trend in the Dry Sclerophyll Forest subformation of Keith (2011) from forests on high-quartz to those on more felsic sediments. This increased grassiness of the understorey from DHF to DSF probably also conforms to Grime's (1979) continuum of increasing competitive species and less stress-tolerant species with increasing levels of plant nutrients in the soil and vegetation.

The vegetation of the freely drained sands of the Upper Myall River valley conforms to the sort of vegetation expected under the "Nutrient-Poverty/Intense-Fire Theory" of Orians & Milweski (2007). It does not fit within Hopper's (2009) category of "Old Climatically Buffered Infertile Landscapes (OCBILs)", as the sands of the valley are not an "old" landscape in Hopper's sense as the earliest sands in the beach ridges were only laid down about 125,000 years ago (Thom *et al.* 1992). Their vegetation does not show the high degree of endemism expected in the OCBILs of Hopper (2009).

Vegetation type and population dynamics

Population dynamics of species may differ across types of vegetation. DSF and DHF would be expected to differ in rates at which individuals of resprouting species turn over. Turn-over of individuals might be expected to be slower in the less fertile DHF than in DSF. This could be tested within species that occur in both DSF and DHF, such as *Hypolaena fastigiata* and *Pteridium esculentum* (Table 2). In Britain, growth of rhizomes and production of fronds have been extensively studied over many years in *Pteridium aquilinum* (L.) Kuhn (see review of Marrs & Watt 2006). It would be instructive to compare patterns of rhizome growth and frond production between DSF and DHF, and perhaps, using DNA analyses, to look at the extent of individual clones of bracken in DSF and DHF. If estimates of rates of spread of individual clones could be made in each of DSF and DHF, their relative extents could then be used to estimate their ages and how often clones are established from sporelings in each. Similarly, using DNA analyses, the suggestion could also be tested of clonal spread from lateral growth and subsequent fragmentation of lignotubers in species such as *Corymbia gummifera* (Mullette 1978) and *Banksia aemula* (Siddiqi 1971, Myerscough & Carolin 1986). In *Banksia aemula*, establishment from seedlings appears to be a rare event in Dry Heath on Pleistocene beach ridges of the Eurunderee embayment (Myerscough 2009); it may also be rare in DHF, and some mature individuals may not only be long-lived but have originated by fragmentation of lignotubers over long periods. DNA analyses might also be used to test whether individual clones of *Hypolaena fastigiata* are widely spread along particular beach ridges, indicating that establishment of plants from seed is relatively rare in that species. If a particular clone were found in DHF on at least two ridges, now separated by periodically waterlogged habitat, it might indicate that that the clone had become established before the Holocene rise in sea level had raised water tables. In short, it is postulated that turn-over in individuals in long-lived resprouting species is longer in DHF than in DSF. Various aspects of this hypothesis can be tested by further observations, probably using DNA analyses to identify clones and their extents.

Conservation of vegetation of old beach ridges

Conservation of old beach ridges and their vegetation is an issue along the whole of the NSW coastline (Griffith & Wilson, 2007, Paine *et al*., 2010, Tozer *et al*. 2010). Their geomorphology, vegetation and soils have intrinsic scientific interest, and, as outlined above, are a fertile field for research. Their vegetation is an element in the whole mosaic of native vegetation that is sought to be conserved across the landscape (eg. Tozer *et al*. 2010, Keith 2011).

In common with other systems of old beach sand ridges, that of the Upper Myall River valley faces change from rise of sea level and from development. The vegetation mapped in Fig. 3 is now out of date because significant areas of native vegetation have been altered by developments on the most inland of the sand ridges north of the boundary of the national park. Rise of sea level could raise water tables further restricting areas of freely draining sands and their vegetation. Should the Outer Barrier dunes be breached, for instance, near Mungo Brush, a marine transgression might recur, similar to the one in the Postglacial described by Martin (1986) that initiated Bombah Bog.

Conclusion

In the Upper Myall River valley, Dry Heath Forest (DHF), Intermediate Dry Forest (IDF) and Dry Sclerophyll Forest (DSF) occur on freely drained beach sands. DHF is the most widespread, occurring on Pleistocene sands of beach ridges that appear to have little disturbed since they were deposited c. 125,000 years ago. DSF occurs on the edges of Pleistocene beach sand ridges where they have either been disturbed by wind or water since their deposition or where they shallowly overlie other substrata. DSF also occurs on small areas of Holocene sand deposited in the valley; namely, well developed sand bars on part of the shores of Bombah Broadwater, and the Boolambayte sand ridge (Bsr), that is postulated to have formed on the western side of the southern end of Boolambayte Lake, isolating Bombah Bog from Boolambayte Lake. IDF most extensively occurs on the Bombah sand mass (Bsm), a Pleistocene sand mass that Thom *et al*. (1992) suggest was reworked by strong westerly winds in the Postglacial. Small areas of IDF also occur between DSF and DHF on edges of some ridges of the Pleistocene beach system (Inner Barrier strand plain of Thom *et al*. (1992)), where sands of the ridges would have been affected by river water. In short, variation in vegetation on sand ridges in the Upper Myall River valley can be related to geomorphological processes and when the processes occurred.

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Appendix 1: Species and their scored presence (max. 10) in each of 48 transects (50 x 5 m)

Transect	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Map ref. Easting	307	296	301	313	310	304	307	318	318	325	305	297	282	280	279	283	293	283	286	284	281	287
Map ref. Northing	49	41	38	47	42	31	35	36	18	39	17	15	58	61	63	65	71	71	61	58	48	56
Vegetation	DHF	DSF	DHF	WH	DHF	DHF	DHF	DHF	DSF	DSF	DSF	IDF	DHF	DHF	WHF	DHF	Sw	WHF	WH	WH	IDF	DHF
Acacia baueri															1							
Acacia elongata																				2		
Acacia longifolia										2												
Acacia quadrilateralis					9																	
Acacia suaveolens	3	1	2			3	2	7	1		4	8		2							1	7
Acacia terminalis																		4				
Acacia ulicifolia	5	2	10			1	5	10	8	4	2	9		2		1		3			4	2
Actinotus helianthi	4													5		2						4
Allocasuarina littoralis																						
Allocasuarina torulosa																						
Amperea xiphoclada	3				1		2	1	3						1	3		2				
Angophora costata	5								4	4	1		5	6	1	3		6			5	
Anisopogon avenaceus																						
Aotus ericoides													1		5				1			
Astroloma pinifolius								1													2	
Axonopus affinis																						
Baeckea imbricata					4																	
Baloskion pallens	6			2	3								3				10		6			
Baloskion tetraphyllum	8						6						8	5		8				8		
Banksia aemula	10		10		10	10	10	10				10	10	10		10					3	10
Banksia oblongifolia	1			4											9	1			8	4		
Banksia robur																				4		
Banksia serrata		9							9	8	8	2									7	
Banksia spinulosa var. *collina*																						
Baumea acuta				7																		
Baumea arthrophylla				4													6					
Baumea juncea																						
Baumea rubinosa																						
Baumea teretifolia																			1	3		
Billardiera scandens																						
Blandfordia grandiflora															5				2			
Blechnum cartilagineum																	3					
Blechnum indicum																						
Boronia falcifolia																				8		
Boronia parviflora																				2		
Boronia pinnata	4				7		1	1		1			6	1	1	3		3		2		
Boronia sp.																						
Bossiaea ensata			1			7	5		2		3	1										6
Bossiaea heterophylla	8	10	10		5	10	7	8	6	6		9	9	7		2					9	9
Bossiaea rhombifolia		9				2			3	9	9	2										
Brachylomadaphnoides		5	2			5		1	8		5	8				1					6	5
Caesia parviflora var. *vittata*																			1			
Callistemon citrinus				9													6		6	9		
Calochlaena dubia																						
Calytrix tetragona						5										5						2
Casuarina glauca																						
Caustis pentandra																						6
Chorizandra sphaerocephala				5													2		2	4		
Coleocarya gracilis			2																			
Conospermum taxifolium		1	4			2			1	2	1	1									2	3
Conyza bonariensis																					1	
Convolvulus erubescens																						
Corymbia gummifera	2	4	4		6	3	9	10	8	3	5	5	5	3		4		10			4	6
Cotula coronopifolia																						
Cymbopogon refractus										1												
Dampiera stricta																4						
Dampiera sylvestris																						
Daviesia ulicifolia																		3				
Digitaria parviflora																						

23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
256	253	262	270	263	263	262	286	285	289	287	315	312	302	295	295	296	301	268	272	275	274	277	316	314	329
96	96	95	70	56	82	65	83	77	79	77	48	45	59	54	51	45	51	48	46	38	64	62	29	26	25
WH	?WH	WH	DHF	DSF	DHF	DHF	?WHF	DSF	WHF	DSF	DSF	DHF	DHF	DHF	DHF	IDF	DHF	WH	DSF	DSF	DSF	DSF	DSF	IDF	IDF
1																		3							
																					8		1		
												1	1											1	
			1	8		1		3	1		2				2	3	1		4	8		2	9	6	2
									2											1					
			7	2	1			6	9	10	2	4			1	3	3		3	1	4	6	3	6	6
			6											6	8		8								
				1					4	2										2					
								4																	
					1	7							3	1	1		1								
				3	1	2		7	9	7	7		2	2	3		1	1	10	5	6	4	8		
																				1					
						4					2		1												1
																	1			1					
							9	4	2																
													7												
8	1					8						1	9												
					3	1					5	1	9				4	3		2					
			10		10	10			3			10	10	10	10	8	10							1	8
		7							10				2												
		4																6							
				8				10		9	10								9	10	9	9	8	10	6
							1																		
		4					10																		
1																									
							1																		
5																		1							
2	9																	1							
								2													2				
		2																1							
3																		1							
																		1							
						4			1		1	6	1							1				6	
							3																		
			4	3							3			1	2	5				1			5	5	
			8	10	1	6				3	8	6	1	9	9	10	6		5	5	4	4	7	7	10
				2												4			7	8		9	5	1	
			7	1	2							1	1	5	8	8	2						1	6	
10	10	7					9											8							
										3											8				
					5				1					4	9		3								
							3																		
7	1	9																8							
									6					2	2	5	2							1	
				2										5	4				1	1				3	
							3																		
			6	6	2			5	5	4	3	9	2	2	2	7	2		4	6	5	4	4	9	9
							1																		
																				1					
						4							2												
											5	1								2					
								1	1												1				

Transect	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Map ref. Easting	307	296	301	313	310	304	307	318	318	325	305	297	282	280	279	283	293	283	286	284	281	287
Map ref. Northing	49	41	38	47	42	31	35	36	18	39	17	15	58	61	63	65	71	71	61	58	48	56
Vegetation	DHF	DSF	DHF	WH	DHF	DHF	DHF	DHF	DSF	DSF	DSF	IDF	DHF	DHF	WHF	DHF	Sw	WHF	WH	WH	IDF	DHF
Dianella caerulea		4	1				1		5	4	4			1				1			2	1
Dillwynia floribunda																			1	9		
Dillwynia glaberrima	7	1	1		6	6	1						6	2		7					1	
Dillwynia retorta			1				1	9	4	5	3	8		5				7			6	2
Dodonaea triquetra																						
Doryanthes excelsa																						
Drosera auriculata																						
Drosera peltata	6				10																	
Drosera spathulata																						
Echinopogon ovatus																		4				
Empodisma minus				1											9					3		
Entolasia marginata																						
Entolasia stricta				5														8	1	3		
Epacris microphylla																				2		
Epacris obtusifolia																				7		
Epacris pulchella	1							1		1		2		4		1		4				
Eragrostis brownii										1												
Eragrostis parviflora																					2	
Eriostemon australasius	4	1	8		5	9	6	7	6	1	9	8	2	7		1					5	10
Eriocaulon scariosa																						
Eucalyptus amplifolia																						
Eucalyptus pilularis		5	3			5			3	2	2	4		3							7	3
Eucalyptus resinifera																		5				
Eucalyptus robusta																	4			1		
Eucalyptus signata	1				3		3	4					9		10	4						
Eurychorda complanata																				6		
Euryomyrtus ramosissima	1																					
Exocarpos cupressiformis																						
Exocarpos strictus								1		4												
Gahnia clarkei																						
Gahnia sieberiana																				1		
Gleichenia dicarpa																						
Glochidion ferdinandi																						
Glycine clandestina																						
Glycine tabacina		1									1										1	
Gompholobium latifolium	2	2					5	4	1	3	7											
Gompholobium pinnatum																		6				
Gompholobium virgatum var. *virgatum*			1			4	1	1	10			8		1		4					2	2
Gonocarpus micrantha																		1	2	1		
Gonocarpus teucrioides	2	6	8			5	5	2	7	1	6	3				2		2			9	5
Goodenia heterophylla		1																6				
Goodenia paniculata				3																		
Goodenia stelligera																			1			
Gratiola pedunculata																						
Haemodorum planifolium			1	4		3	2				2		2		1	7			1		1	4
Hakea teretifolia																						
Hardenbergia violacea		1						4	4	3	2							2				
Hemarthria uncinata																	1					
Hibbertia aspera																						
Hibbertia fasciculata	8				5		4						9	6	2	5						
Hibbertia linearis	6		1		2		4					1		1								1
Hibbertia obtusifolia		8	9			8	3	9	8	5	9	5	4	4							7	5
Hibbertia salicifolia																				5		
Hibbertia scandens																						
Hovea linearis																						
Hydrocotyle tripartita																						
Hypericum japonicum																		1				
Hypolaena fastigiata	8		7		10	9	10	10		8	7	10	9	7		9						10

23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
256	253	262	270	263	263	262	286	285	289	287	315	312	302	295	295	296	301	268	272	275	274	277	316	314	329
96	96	95	70	56	82	65	83	77	79	77	48	45	59	54	51	45	51	48	46	38	64	62	29	26	25
WH	?WH	WH	DHF	DSF	DHF	DHF	?WHF	DSF	WHF	DSF	DSF	DHF	DHF	DHF	DHF	IDF	DHF	WH	DSF	DSF	DSF	DSF	DSF	IDF	IDF
	1		1	1			1	2		3	8								8	3	6	5	6	3	1
				2	4	8							8	5	1		1								
			2		7				8	4		5		3	2	8	4			1			9	9	4
																					9				
																				2					
												1													
												1	6												
1		1																3							
								1		1										1					
		3																1							
5	8																	2							
	10	7					3		1									5							
																		1							
									4			1	1							1				2	
									1										2	4					
								1	1																
			10		4	5						5	1	9	8	8	6						9	9	8
3																									
							2																		
			4	2				4			2			3		6			5	4	4	7	3		2
							7		1																
										1								7							
					1	6						7	2	2			8							2	
		3																4							
																							1		
							4		1	2								1							
		3																							
																		1							
								2												1	2	1			
				4															1	1	2	4			
								1		5															
								3	4	5	10								3	4	4				3
									4																
			2		4									2	1				2				7	4	5
2	2	1					1		2									8							
				9				6	4	4	8				1	6			3	2	2	3	4	3	1
6	3						4																		
																		5							
2																									
						6			1					5	5		3	1		3			1		
		5																5							
				3						1						2				1	2		8	1	2
9	4						3											1							
																				1					
				1	6							2	3	5	3		5			1					
												9			4		3			8		2			
			9	10	5	1		7	1	9	4			4	4	8	5		4	3	9	8	9	8	10
								1		1															
				2				1														1	1		
							2																		
							5																		
			1		10	10			4			10	10	10	10	5	10		1	10			6	10	10

Transect	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Map ref. Easting	307	296	301	313	310	304	307	318	318	325	305	297	282	280	279	283	293	283	286	284	281	287
Map ref. Northing	49	41	38	47	42	31	35	36	18	39	17	15	58	61	63	65	71	71	61	58	48	56
Vegetation	DHF	DSF	DHF	WH	DHF	DHF	DHF	DHF	DSF	DSF	DSF	IDF	DHF	DHF	WHF	DHF	Sw	WHF	WH	WH	IDF	DHF
Imperata cylindrica										6								4			2	
Indigofera australis																					2	
Ischaemum australe																						
Isopogon anemonifolius																						
Kennedia prostrata		3																1				
Kennedia rubicunda																						
Kunzea capitata																				1		
Laxmannia gracilis																						
Lepidosperma elatius																						
Lepidosperma filiforme																	9					
Lepidosperma laterale																						
Leptocarpus tenax	3			10									2	1	7	6			10	4		
Leptomeria acida																						
Leptospermum juniperinium				3											1		1			10		
Leptospermum liversidgei																	1		3	10		
Leptospermum polygalifolium	9			1	8		3	1					10	5	10	8		7	5	1		
Leptospermum trinervium	6	3	8		5		6	1	3		2	8		8							4	7
Lepyrodia muelleri				2																		
Lepyrodia scariosa															3			5				
Leucopogon ericoides							1	8	8	2	2	7		4		1					7	1
Leucopogon lanceolatus											4											
Leucopogon parviflorus	5	1	1		7		2					3	8	4		1					3	
Leucopogon virgatus		3	7			6	3	2	5	1	7	5		2							7	3
Lobelia anceps																						
Lomandra glauca	2	3	6			6	2	2	10	5	7	4	3	6	5	4		2			6	3
Lomandra longifolia		9	5			3	2	10	8	8	8	2	6	5				8			10	
Lomatia silaifolia																						
Macrozamia communis		7																				
Melaleuca decora																						
Melaleuca ericifolia																						
Melaleuca nodosa	4				4		2									9		7	4			
Melaleuca qinquenervia																						
Melaleuca sieberi				9											9			4	7			
Melaleuca thymifolia				10											1			1	9	3		
Melichrus procumbens																					1	
Micrantheum ericoides		6	1			4		1	6	2	3										3	3
Microlaena stipoides																		4				
Mirbelia rubiifolia																		3				
Monotoca elliptica								1	1	8												
Monotoca scoparia	3	1	2		4	7	4					2	4	6							2	7
Olax stricta						2			1			1										2
Opercularia aspera																						
Oxalis corniculata																						
Panicum simile	1	6	8	1		5	2	2	2	2	6	5		7	3			10	1		9	6
Paspalidium aversum																						
Paspalidium constrictum																						
Paspalum orbiculare																						
Patersonia glabrata											8											
Patersonia sericea																						
Persoonia lanceolata	1			2			1													4	1	
Persoonia levis			1				2		1	1	3				1	2		2				
Persoonia linearis																						
Philydrum lanuginosum																	1					
Phyllota phylicoides					2			7		3	3	6	1	2		5						1
Phragmites australis																						
Pimelea linifolia	8				1	1	2	1	3		2	1	5	3		4		2			10	1
Platylobium formosum																						
Platysace lanceolata																						
Platysace linearifolia	6	10	9		7	7	5	10	9		1	6	7	1		6						5

23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
256	253	262	270	263	263	262	286	285	289	287	315	312	302	295	295	296	301	268	272	275	274	277	316	314	329
96	96	95	70	56	82	65	83	77	79	77	48	45	59	54	51	45	51	48	46	38	64	62	29	26	25
WH	?WH	WH	DHF	DSF	DHF	DHF	?WHF	DSF	WHF	DSF	DSF	DHF	DHF	DHF	DHF	IDF	DHF	WH	DSF	DSF	DSF	DSF	DSF	IDF	IDF
				7				7		10	9								10	4	8	8			
											4										1				
							2																		
															1										
										1											7	1			
																				1					
																		2							
																				1					
		4																							
				1																					
1	1	3				3			9			5	1		1			6							
																							2	3	
		5					4											7							
		1																3							
			2		4	10	2		10		1	4	8				1	4		3				1	
			10		5	7						8	2	4	6	9	2		1	1				7	7
5	5	3					2																		
		5							2																
			1		2												2			1			4	10	4
				2				3			4								1	6	7	9			1
			6	1	4	6						8	8		1	2		1	2	1					
			7	2	7					1				3	10	6				2			4	3	3
							2																		
			6	1	9	6		2		2	3	1	9		4	1	1		8	2	2	8	6		4
			10	7	6	10		7	10	4	8				1	5			9	8	7	7	9		9
																				2					
				1										1											
							7																		
2	1																								
		2				2			10			1													
										1															
		10					10		4									9							
5	10	9					5											8							
								1		2															
											1			2		3				4				3	2
										1															
																		1							
				4				1												2	3	2		2	1
			7	2	8	2			1	1	1	6	6	8	5	2	4						1		
							1																		
							2																		
			4	7		1	4	7	8	7	3			2	3		1	2	6	7	9	9			
							5																		
							1																		
							6																		
								1								1		1							
			1	1																			3	1	
									1																
		1		1				6		2	2			4	1	1	1		2	4	1	3	1		
					1			3														1			
												2		6	1	1	6						6	9	6
5	3																								
		1			8				5					7	4		10		1				3	5	
				3				10		6											10	5			
					5																				
						6					10	8	2	7	8	9	1		4	3			8	4	3

Transect	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Map ref. Easting	307	296	301	313	310	304	307	318	318	325	305	297	282	280	279	283	293	283	286	284	281	287
Map ref. Northing	49	41	38	47	42	31	35	36	18	39	17	15	58	61	63	65	71	71	61	58	48	56
Vegetation	DHF	DSF	DHF	WH	DHF	DHF	DHF	DHF	DSF	DSF	DSF	IDF	DHF	DHF	WHF	DHF	Sw	WHF	WH	WH	IDF	DHF
Polyscias sambucifolia																						
Pomax umbellata		9	5			2	2		7	7	1	1		4				3			10	
Poranthera corymbosa									2													
Poranthera microphylla																					2	
Pratia pedunculata																						
Pseudanthus orientalis	1								1		1					3		1				
Pteridium esculentum	5	10	9			9	10	10	10	10	10	10	9	10							10	8
Ptilothrix deusta				4											8			8				
Pultenaea paleacea																						
Pultenaea villosa																						
Ricinocarpos pinifolius	9	8	8		10	9	2	5	9	2	10	7	2	1		5					10	10
Schizaea bifida					1			2			1											
Schoenus brevifolius				10											8				10	6		
Schoenus ericetorum			2			2	1															2
Schoenus maschalinus																						
Selaginella uliginosa	2			5	7								1	4	4			2		2		
Senecio aff. *lautus*		1									1											
Smilax glyciphylla																						
Sporadanthus interruptus	1			6	6		1						1	2		2		3		10		
Sprengelia incarnata				1																5		
Stackhousia viminea																			1			
Stylidium debile	1				2										6				5			
Stylidium graminifolium																		2				
Tetratheca ericifolia																1						
Tetratheca thymifolia	2				4				2	4	8	4										
Thelionema caespitosum																3						1
Themeda australis		8	7			10	1	7	8	9	9	7									7	3
Thysanotus juncifolius																						
Trachymene incisa			7			7	4		1			1	8	7				10			7	
Tricoryne simplex			2						2	2	5										8	
Villarsia exaltata				1													7		1			
Viminaria juncea				4																		
Viola hederacea																						
Wahlenbergia communis																						
Woollsia pungens																						
Xanthorrhoea fulva				10															10	1		
Xanthorrhoea glauca	3	1	1		4		1	2	8	2	4	7			10	1						1
Xanthorrhoea mac8ronema																						
Xanthosia pilosa										3				2							3	
Xyris gracilis														1	1							
Xyris juncea	1			1	1																	
Zieria laevigata	4		2		2		2					1	5	7		3		3				

23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
256	253	262	270	263	263	262	286	285	289	287	315	312	302	295	295	296	301	268	272	275	274	277	316	314	329
96	96	95	70	56	82	65	83	77	79	77	48	45	59	54	51	45	51	48	46	38	64	62	29	26	25
WH	?WH	WH	DHF	DSF	DHF	DHF	?WHF	DSF	WHF	DSF	DSF	DHF	DHF	DHF	DHF	IDF	DHF	WH	DSF	DSF	DSF	DSF	DSF	IDF	IDF
								2		3															
				2				7		1	8				1				5	5	8	9		1	5
														4											
				3															4		5	3			1
							6				1														
		1			5								2	1			1								
			10	10		4		10	3	10	10			10	6	10	8	4	10	10	10	10	10	9	10
							3																		
		10					1																		
	9						1																		
			10	2	8	7					5	10	8	10	9	9	8		1		8	4	9	7	
		1				1																	3		
10	10	10					8											8							
														1	7		2								
							2																		
2	1	7				5			2				5					6		1					
							1																		
		5				4						4	5					4							
																		1							
		1																							
	1												7												
						5																			
			3										1												
						3		2		1	7	3							5	1		1			4
				9			3	9	7	5	1				1	10		1	9	9	2	6	8	4	6
		1						1																	
								7	5	7	6						1		1	1	3	1	1	2	1
				6				4		3									4	3		3	1		
4																		2							
6																		1							
							8																		
											1														
												1													1
	1	1					1											1							
								2		2		7		1	2	2	3	1		8		3	3	7	1
				3				1		1	1										5	1			
			2																						
			6		3	7						2		4	4		4								

Appendix 2: Transect 1 (bearing 340 degrees): species cover over 10 m lengths (Max. score 20): spp. shown listed in Table 2 + *Leptospermum liversidgei* and *Baloskion tetraphyllum*

Distance (m)	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**190**	**200**
Height of surface (m)	**1.3**	**1.3**	**1.2**	**1.2**	**1.0**	**1.0**	**1.3**	**1.4**	**1.3**	**1.3**	**1.3**	**1.2**	**1.1**	**1.1**	**1.0**	**0.9**	**0.8**	**0.7**	**0.7**	**0.5**
Water table depth (m)				**0.9**	**0.7**	**0.8**	**0.7**	**0.9**	**1**	**1**	**1**	**0.9**	**1**	**1**	**1**	**1**	**1**	**1**	**1.1**	**1**
Tallest tree height (m)	**12**	**1.5**	**3**			**5**		**5**	**10**	**10**	**15**	**3**		**3**	**12**	**12**	**15**	**5**	**2**	**4**
(i) Tree species																				
Angophora costata	7															6	5			
Corymbia gummifera									1	3							8		11	3
Eucalyptus robusta																				
Eucalyptus signata	4							1			6				14	1	1	7		
(ii) Banksia species																				
Banksia aemula		3	3					4	2	3	1	6		5		3	4	10	1	7
Banksia oblongifolia	1	6	7	6																
(iii) Myrtaceous shrub spp.																				
Callistemon citrinus					4	1														
Leptospermum juniperinum																				
Leptospermum liversidgei				5	12	2	15	4												
Leptospermum polygalifolium	5	8	10	4				4	6	3	2	6	4							4
Leptospermum trinervium															1	13	1	6	1	3
Melaleuca nodosa								3		2	7	10	8	4	2	2				
Melaleuca sieberi				5	2	8	6													
Melaleuca thymifolia				3	14	4	2													
(iv) Shrub species																				
Acacia suaveolens																		1		
Acacia ulicifolia			1													1	1		1	
Bossiaea heterophylla									1							4	6	5	2	1
Dillwynia glaberrima	1	1	1						1	1					7					
Dillwynia retorta															1		1	1		
Eriostemon australasius																1				
Gonocarpus teucrioides			1												2		1			
Hibbertia fasciculata		2	1	1				1	5	1					1			3		
Leucopogon parviflorus									2											1
Monotoca scoparia										1						2		1		1
Pimelea linifolia			1					2		1	3	5	1	2	1	1	1		1	
Platysace linearifolia	8	1	2	1				4	4	2	1			1		7	3		2	5
Ricinocarpos pinifolius		1						1	2	1					3	2	1		4	1
Zieria laevigata		1							4			1				2	1		2	
(v) Pteridophytes																				
Selaginella uliginosa			2					3	5											
(vi) Grasses & lilies																				
Entolasia stricta			1	4	10	1	1													
Panicum simile	2	2					1			1										
(vii) Restiads, sedges & lomandra																				
Baloskion pallens	4	8	2	2	19	20	3	8	10	2										2
Baloskion tetraphyllum	1	2	9												9	16	16	18	16	9
Baumea arthrophylla				3		3	2													
Chorizandra sphaerocephala					10	1	8													
Hypolaena fastigiata	14	15	2						14	19	18	19	20	19	16	7	13	1	6	13
Leptocarpus tenax		1	2	2	10	9	8	5	1											
Lomandra glauca	1	2						1		1										1
Schoenus brevifolius					1	9	7													
Sporadanthus interruptus	5	3	4	13	2		7	7	1											
(viii) Subshrub & herbs																				
Trachymene incisa	2	2	3							1	1						1			
Villarsia exaltata					11	15	1													
(ix) Xanthorrhoea																				
Xanthorrhoea fulva				11	1		6	7												
Xanthorrhoea glauca	1	6	12	1				1			2				4	2		4	6	4
Bare ground	**1**	**1**	**1**											**1**	**1**					

210	**220**	**230**	**240**	**250**	**260**	**270**	**280**	**290**	**300**	**310**	**320**	**330**	**340**	**350**	**360**	**370**	**380**	**390**	**400**	
0.5	**0.5**	**0.4**	**0.2**	**0.0**	**0.2**	**0.1**	**0.2**	**0**	**0.2**	**0.3**	**0.3**	**0.3**	**0.4**	**0.5**	**0.5**	**0.6**	**0.5**	**0.6**	**0.5**	
0.9	**0.9**	**0.9**	**0.7**	**0.5**	**0.6**	**0.6**	**0.7**	**0.6**	**0.7**	**0.8**	**0.8**	**1**	**1.2**	**1**	**1.2**	**1.1**	**1.1**	**1**	**1.1**	
4	**4**	**10**	**10**	**5**					**1.5**	**5**			**5**	**5**	**6**	**10**	**10**	**4**	**10**	
																				Total cover score
																				Total
	2	1														4				25
																11	9			46
			1	5						2										8
		14	6										5	3	6	2	10		10	90
7	1	5	2										1	9	6			9	5	97
									2	13	7	1	1							44
					3	3			1											12
						1	5	2	12	5										25
			5	3			1			4	5	2	2							60
6	10	13									2	9	13	7	8	5	4	9	9	151
9															1	1				36
														1	3	2	2	6	4	56
				7	4	5	3	1	3	9	2	2								57
			2	5	12	12	8	15	6		2									85
																				1
															1	2				7
																	2	1		22
1															2	1	4		1	21
																				3
																				1
																				4
2	3												1					1	1	23
1														1	2	2				9
																			1	6
																				19
6	1																1			49
	1	1													1	1		4	2	26
	2																			13
						4	2	1				4	1	2						24
			4	11	6			1	6	2	5									52
																				6
14	15	9	12	3							5	6			1		4	3	1	153
	1	11												3	13	10	5	11	9	159
				11	15	12	8	11	9											74
			2	12	6	4	1	8	2	1										55
12	4	6												7	9	2	5	9	8	258
	9		5	1	10	10	11	3	3		7	6	6	1	3	3	7			123
1																	2	1	1	11
			3	13	19	18	12	16	16	9	4	3								130
7	4	3							1		1	12	8	3	4		1		3	89
																				10
			2	9					2											40
		17	15	2		5	5	5		7	5	5	15	15						121
															2					45
																				5

Appendix 3: Transect 2 (bearing 330 degrees): species cover over 10 m lengths (max. score 20): spp. shown listed in Table 2 + 7 other spp. (*Banksia robur*, *Leptospermum liversidgei*, *Blechnum indicum*, *Gleichenia dicarpa*, *Baloskion tetraphyllum*, *Baumea rubinosa* & *Empodisma minus*)

Distance (m)	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**190**	**200**
Height of surface (m)	**1.8**	**1.8**	**1.6**	**1.1**	**0.4**	**0.5**	**0.5**	**1.2**	**1.5**	**1.6**	**1.6**	**1.5**	**1.4**	**1.4**	**1.4**	**1.3**	**1.3**	**1.4**	**1.5**	**1.6**
Water table depth (m)				**1**	**0.2**	**0.2**	**0.6**	**1**	**1.2**	**1.3**	**1.2**	**1.2**	**1.2**	**1**	**1**	**1.2**	**1.2**	**1.2**	**1.3**	**1.3**
Tallest tree height (m)	**15**		**12**	**6**	**4**	**3**	**10**	**10**	**20**	**20**	**20**	**15**	**15**	**10**	**6**	**6**		**5**	**8**	**7**
(i) Tree species																				
Angophora costata								2											10	
Corymbia gummifera	4				1							5								
Eucalyptus robusta						6	3	3												
Eucalyptus signata			5						2	19	4	2	18	17						
(ii) Banksia species																				
Banksia aemula	9	2		2	7			2	9		2	2	1		5	5		3	5	10
Banksia robur																				
(iii) Myrtaceous shrub spp.																				
Callistemon citrinus																				
Leptospermum juniperinum					4	11	17	5												
Leptospermum liversidgei					4	11	4	2												
Leptospermum polygalifolium								5	2	2							2			
Leptospermum trinervium	3		5	3						1									4	6
(iv) Shrub species																				
Acacia ulicifolia				2												1		1		2
Bossiaea heterophylla	1	2	2					1	2										1	
Brachyloma daphnoides																				
Dillwynia glaberrima									3	4	1			2	1	1	1			
Dillwynia retorta			1	1					2	1	1									2
Eriostemon australasius	1	5	1	2															1	
Gompholobium virgatum		1																		
Gonocarpus teucrioides																				
Hibbertia fasciculata											1			1			1			
Hibbertia obtusifolia	4	2		1																
Leucopogon ericoides											1								1	2
Leucopogon parviflorus			1																	
Leucopogon virgatus	1									1		1								
Monotoca scoparia		3	2	1	2							2								2
Phyllota phylicoides																				
Pimelea linifolia													4	1		1	1		1	
Platysace linearifolia	2	4	2	1												2				
Ricinocarpos pinifolius	2	2	6						1		1								1	1
Zieria laevigata			1								1		3	1			1	3	3	
(v) Pteridophytes																				
Blechnum indicum					2	11	12	1												
Gleichenia dicarpa					1	9	13	1												
Pteridium esculentum	1		3								1								1	
Selaginella uliginosa								2												
(vi) Grasses & lilies																				
Entolasia stricta						1	1	3												
Panicum simile													1	1				1		
Themeda australis													2							
(vii) Restiads, sedges & lomandra																				
Baloskion pallens															3	3	1			
Baloskion tetraphyllum						12	17	8	6											
Baumea arthrophylla					1	2														
Baumea rubinosa																				
Chorizandra sphaerocephala					1															
Empodisma minus					1	15	12	1												
Hypolaena fastigiata			4	6					11	17	9	8	3	11	16	11	11	13	15	12
Leptocarpus tenax																				
Lomandra glauca														2	3	1		1		
Lomandra longifolia											1									
Schoenus brevifolius																				
Sporadanthus interruptus					11	5	3	9												
(viii) Subshrub & herbs																				
Pomax umbellata												1	2	3						
Trachymene incisa															1	1				
Villarsia exaltata								1												
(ix) Xanthorrhoea																				
Xanthorrhoea fulva						3	1	3												
Xanthorrhoea glauca								2												
Bare ground	**3**	**7**	**2**	**8**							**4**	**5**	**1**	**1**	**2**	**1**	**5**	**1**	**1**	**1**

210	**220**	**230**	**240**	**250**	**260**	**270**	**280**	**290**	**300**	**310**	**320**	**330**	**340**	**350**	**360**	**370**	**380**	**390**	**400**	
1.6	**1.6**	**1.5**	**1.5**	**1.3**	**1.2**	**1**	**0.9**	**0.4**	**0**	**0**	**0.7**	**0.7**	**0.5**	**0.8**	**1.1**	**1.4**	**1.4**	**1.5**	**1.5**	
1.4	**1.3**	**1.3**	**1.2**	**1**	**0.9**	**0.7**	**0.7**	**0.7**	**0.1**	**0.1**	**0.9**	**0.7**	**0.8**	**1.7**	**1.3**	**1.1**	**1.2**	**1.2**	**1.3**	
10	**6**	**6**	**20**	**20**	**20**	**20**	**15**		**8**	**8**	**8**	**14**	**14**	**6**	**8**	**18**	**18**	**6**	**4**	
																				Total
			2	10	15	1						7	1			7				55
																				10
							6		9	10	2			4						43
			10	10			2					6	12		12	4	11			134
10	6	3	3	1	3		4								1	7	3	3	2	110
									2	5	5									12
									5	9	7		4	13						38
								1	2	8	7			5						60
								12	3		10		7	8	1					62
					5	16	9	8	3			6	9	6	12	4	1			90
		6																1		29
2																				8
4																			2	15
1	3																	2	2	8
				1	1													4		19
			3	1												1				13
2	3		1	1	2														1	20
																				1
									1											1
		1																		4
		1																		8
		1										1								6
						2														3
	1	1																		5
2	1		1									1								17
																			4	4
1								1	1									2		13
					1	1										1		2		16
2	3			1	1													1	1	23
	1				1	1							1				1			18
								1	6	8	2									43
								1	13	12	5									55
2	1			1	1	6									1	2	1		1	22
						2	1	2			2		1	3	1					14
								2	5	1	2		1	17						33
1	1																			5
																				2
					3															10
				4		12	10	3	16	11	6		9	6	9		8			137
									5	10	3		2			9				32
									5	14	2									21
										13	6									20
									7	13	6			1						56
15	13	8	19	11	1												10	19	18	261
												12			4	3				19
1																			1	9
																				1
													1		1	5				7
						5	12	14	1	2	13	9	11	11	5					111
																				6
																				2
									1	1										3
							4	10	1		4	3	13	5	3					50
															4					6
	2	**3**		**1**												**1**	**2**		**1**	**52**

Appendix 4: Transect 3 (bearing 325 degrees): species cover score over 10 m lengths (Max. score 20); shown listed in Table 2 + 9 other spp. (*Banksia robur*, *Leptospermum liversidgei*, *Blechnum indicum*, *Gleichenia dicarpa*, *Phragmites australis*, *Baloskion tetraphyllum*, *Baumea rubinosa*, *Empodisma minus* & *Gahnia sieberiana*)

Distance (m)	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**190**	**200**	**210**	**220**	**230**	**240**
Height of surface (m)	**4.3**	**4.6**	**5.5**	**6.8**	**7.1**	**7.1**	**7**	**7.1**	**7.1**	**7.1**	**7.3**	**7.3**	**7.4**	**7.3**	**7.4**	**7**	**6.7**	**5.7**	**4**	**3.2**	**2.9**	**2.7**	**2.6**	**2.7**
Water table depth (m)	**0.3**	**0.4**	**1**			**2.8**	**2.8**		**2.7**			**2.8**				**2.5**		**1.3**	**1**	**0**	**0**	**0**	**0**	**0.1**
Tallest tree height (m)			**10**	**20**	**30**	**30**	**20**	**6**	**20**	**20**	**10**	**20**	**25**	**20**	**20**	**6**	**8**	**7**	**5**	**8**	**8**	**5**	**5**	**6**
(i) Tree species																								
Corymbia gummifera			1	3	5	5			2	12							3	4						
Eucalyptus pilularis				8	20	5	16					9	4	3	15									
Eucalyptus robusta																				7	12	1	6	6
(ii) Banksia species																								
Banksia aemula				1	2		7	8		7	11		5			5	2	6	4					
Banksia robur	2	5	1																		1		3	
Banksia serrata													1	2										
(iii) Myrtaceous shrub spp.																								
Callistemon citrinus	8	1																		1	3	1	4	12
Leptospermum juniperinum	2	7	5																	6	14	4	7	4
Leptospermum liversidgei	15	10	5																					
Leptospermum polygalifolium			2																6				2	
Leptospermum trinervium						1			1	2			3	4	3	11	6	1						
(iv) Other shrub species																								
Acacia suaveolens				4	2		1	2	2		3	1		2										
Acacia ulicifolia										2	2	1	1	1	2	1		1	2					
Bossiaea heterophylla				5	1	3	1	3	4	4		2	5	7	4	3	1	2	1					
Bossiaea rhombifolia					1	4	5	4	1	1														
Brachyloma daphnoides								2	4	2	1			4	2	1	1							
Dillwynia glaberrima				1			2		1	2	3					1	1							
Dillwynia retorta																		1						
Eriostemon australasius												1	1	1		2								
Gonocarpus teucrioides				1	1		1	1	1	1						3		1	1					
Hibbertia fasciculata																			1					
Hibbertia obtusifolia				2	3	1	2	2	1	3				1	1		2	3	3					
Leucopogon ericoides												1							1					
Leucopogon parviflorus																								
Leucopogon virgatus				2		2	1	2	1	1	1					2	1							
Monotoca scoparia					1	2		1	2				1	2	1									
Phyllota phylicoides				2																				
Pimelea linifolia						4					1						1		1					
Platysace linearifolia				4	1		1	6	3	1	7	1	1	4		5	1	6	6					
Ricinocarpos pinifolius				1		1	3	1	2	2	1	1		1	1	3			2					
Zieria laevigata							1																	
(v) Pteridophytes																								
Blechnum indicum	1	6	10																	12	5	1	5	4
Gleichenia dicarpa	5	18	6																	7			3	11
Pteridium esculentum			2	2	2		2	1	1	2	4	2	5	1	1		2		6	2				
Selaginella uliginosa																								
(vi) Grasses & lilies																								
Dianella caerulea																								
Entolasia stricta	4	10	6																	4	2	2	4	3
Panicum simile								1			3	2	2				1		1					
Phragmites australis																								
Themeda australis				3	1	4	4	8	3	3	8	1	3	2	5	3	8	7	2					
(vii) Restiads, sedges & lomandra																								
Baloskiontetraphyllum	2	3	12	1															5	15	19	10	13	20
Baumea arthrophylla		6	1																	2	13	4	4	6
Baumea rubinosa	4	1																		2	10	18	17	6

250	**260**	**270**	**280**	**290**	**300**	**310**	**320**	**330**	**340**	**350**	**360**	**370**	**380**	**390**	**400**	**410**	**420**	**430**	**440**	**450**	**460**	**470**	**480**	**490**	**500**	
3.6	**4.9**	**5.6**	**6**	**6.2**	**6.4**	**6.6**	**6.7**	**6.8**	**6.7**	**6.6**	**6.5**	**6.3**	**6.1**	**5.9**	**5.9**	**5.6**	**4.2**	**2.1**	**1.7**	**1.6**	**1.3**	**0.8**	**0.4**	**0**	**0**	
1.4	**1.4**		**2**	**2.6**								**2.6**			**2.1**		**1.4**	**0.7**	**0.9**	**0.5**	**0.3**	**0.8**	**0.5**	**0.1**	**0.2**	
6	**30**	**30**	**15**	**25**	**25**	**25**	**30**	**10**	**25**	**25**	**25**	**30**	**30**	**25**	**25**	**25**	**15**	**20**	**10**	**10**	**6**	**8**	**10**	**4**		Total cover score **Total**
		12	11	10		2	4					7	4	8	20	19	5	6								143
	9	18		1	19	11	7		6	18	12	9	9													199
2																		1	9	16	3	4	7	3		77
		3	5				7				6	6		5	6	7	9	2								114
1																						6	4			23
								4	2		6	3														18
1																					1					32
6																				3	7	16	9			90
																				2	6	3	1			42
2	7	1		1														4	7							32
		2	2	4	3	6	3	10	11	7	12		4	2		2										100
		2	3	3	6	2									1											34
							1																			14
1	1	4	3	2	1	1	3	4		3		2			1		1	2								75
					1					1	1	3	1													23
															1											18
																										11
		5		1			1			1							2									11
			3	2		1	2	2	2	3	3	1			2	1		2								29
									1			2		2			1									17
												2														3
		2	2	1	1	2	2	1		2	1															38
																		2								4
	2		1								3							1								7
											1			1	1											16
		2		1				1	1		1			1				1								18
				1	2	3	2	2					3													15
																										7
	2		4	6	2	2	2	3	4	5	3	3	2	3	7	4	1	1								101
		4	5	3	1	1	3		2		3	2	4		2	2	2	1								54
																										1
8																			3	8		4	12	13	15	107
4																					7	5				66
1	1	1	4		1	2	3	2	5		6	2	1		3	3	3	4	1	1	1	2				82
																						1				1
	2	2			1														2	1						8
4																			4	16	3	8	12	2		84
														2	2											14
																								3	8	11
		2				3	8		3	2		3	1	9	5	3	1									105
13	7	2															4	8	17	13	1	8	4			177
																					2					38
																				3	14	11	10	20	19	135

Distance (m)	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**190**	**200**	**210**	**220**	**230**	**240**
Height of surface (m)	**4.3**	**4.6**	**5.5**	**6.8**	**7.1**	**7.1**	**7**	**7.1**	**7.1**	**7.1**	**7.3**	**7.3**	**7.4**	**7.3**	**7.4**	**7**	**6.7**	**5.7**	**4**	**3.2**	**2.9**	**2.7**	**2.6**	**2.7**
Water table depth (m)	**0.3**	**0.4**	**1**			**2.8**	**2.8**		**2.7**			**2.8**				**2.5**		**1.3**	**1**	**0**	**0**	**0**	**0**	**0.1**
Tallest tree height (m)			**10**	**20**	**30**	**30**	**20**	**6**	**20**	**20**	**10**	**20**	**25**	**20**	**20**	**6**	**8**	**7**	**5**	**8**	**8**	**5**	**5**	**6**
Chorizandra sphaerocephala																							4	1
Empodisma minus	17	12	2																				6	
Gahnia sieberiana	8	10	1																				3	2
Hypolaena fastigiata				11	8	1	1		1	4	3			2	3	6	1	9	2					
Lomandra glauca								1		2				1	1									
Lomandra longifolia										1		2				1			2					
Sporadanthus interruptus			6																	2				
(viii) Subshrub & herbs																								
Pomax umbellata								1	1	2	3	4	3	1			3							
Villarsia exaltata			2																		1	3	1	
(ix) Xanthorrhoea																								
Xanthorrhoea fulva		1	5	2													4	2						
Xanthorrhoea glauca					2																			
Bare ground						**1**	**2**	**2**	**3**	**2**	**1**	**1**			**1**			**3**						

Appendix 5. Species not recorded in standard transects (see Appendix 1), mostly encountered in long transects.

Species	**Transect / position**
Caleana major	4 / 100–200, 300, 500–550 m
Cassytha glabella	4/700
Cassytha pubescens	4/700
Comesperma defoliatum	1/85 m
Endiandra sieberi	4 / first 10 m
Macarthuria neo-cambrica	c. 900 m near Tr. 4 (collected Jan 2010)
**Spartothamnella juncea*	2/50–80 m & 3/10–20 & 470–480 m
Styphelia sp.	4 / 650–700, 1150 m
Xylomelum pyriforme	5/330 m

* possibly *Durringtonia paludosa* (Steve Griffith pers. com.)

250	**260**	**270**	**280**	**290**	**300**	**310**	**320**	**330**	**340**	**350**	**360**	**370**	**380**	**390**	**400**	**410**	**420**	**430**	**440**	**450**	**460**	**470**	**480**	**490**	**500**	Total cover score
3.6	**4.9**	**5.6**	**6**	**6.2**	**6.4**	**6.6**	**6.7**	**6.8**	**6.7**	**6.6**	**6.5**	**6.3**	**6.1**	**5.9**	**5.9**	**5.6**	**4.2**	**2.1**	**1.7**	**1.6**	**1.3**	**0.8**	**0.4**	**0**	**0**	
1.4	**1.4**		**2**	**2.6**								**2.6**			**2.1**		**1.4**	**0.7**	**0.9**	**0.5**	**0.3**	**0.8**	**0.5**	**0.1**	**0.2**	
6	**30**	**30**	**15**	**25**	**25**	**25**	**30**	**10**	**25**	**25**	**25**	**30**	**30**	**25**	**25**	**25**	**15**	**20**	**10**	**10**	**6**	**8**	**10**	**4**		
																					1					6
																				6	11	2				56
																				2	15	3				44
		11	16	4		1	2		2	3	4	6	7	12	8	4										132
																										5
									1	2		1						2	1							13
	5																1	2		5	1	3	1			26
																										18
																										7
																										14
						1	6						1													10
	1	**1**	**1**		**1**	**1**		**2**	**1**			**2**	**2**					**4**	**1**							**33**