Myall Lakes National Park, the Boolambayte Sand Ridge: its Extent, Vegetation, Geomorphology and Marks of European Settlement

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The Boolambayte sand ridge (Bsr), recognized by Myerscough and Carolin (2014), is part of the Pleistocene sand barrier system mapped by Thom et al. (1992) and Hashimoto and Troedson (2008) in the valley of the Upper Myall River to the shores of Bombah Broadwater. Bsr comprises areas of sand on the south-western shore of Two-Mile Lake (the western arm of Boolambayte Lake). Features of Bsr reported in Myerscough and Carolin (2014) were based largely on interpretation of aerial photos; this study is based on observations on the ground. As a result, Bsr is defined more precisely. Freely draining sands were found to be in discontinuous patches along the lake shore. All patches were deposited before their eastern edges became the current lake shore, except one, which appeared to have formed as a lake sand bar. Evidence indicates that, until probably the last 2 - 3 m of the Holocene rise in sea level, waters of Two-Mile Lake joined Bombah Broadwater at the end of the lake bar running west from Bombah Point. Investigation of the vegetation of freely draining sites along Bsr shows that, though they carry Dry Sclerophyll Forest (DSF) of Myerscough and Carolin (1986 & 2014), the understoreys of most of them contain more wet heath plant spp. than do sites with DSF on sands in central parts of the Upper Myall River Valley, as described in Myerscough and Carolin (2014). Also described are various effects of European settlement to which the area has been subjected, particularly in its southern third.

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INTRODUCTION

Coastlines around the world were moulded to their present forms by various events that include world-wide changes in sea levels through the Pleistocene and Holocene. Toward the end of the Pleistocene, c. 20,000 years ago, in the glacial period, sea level was about 125 m below its present level (Lewis et al. 2013). As evidence reviewed by Lewis et al. (2013) shows, sea level thence rose, across the transition from the Pleistocene to the Holocene, about 12,000 years ago, reaching a maximum level, c. 1-2 m higher than present, about 7,500 years ago. This rise in sea level was experienced across generations of Aboriginal people living along the coast of New South Wales. Worimi people occupied the Myall Lakes area in the early 19th century when European settlers began arriving in the area (Broomham 2010). Broomham (2010) describes interaction between the settlers and the Worimi people. At first, there was little organised European settlement in the area, due to its being much of the grant of land to the Australian Agricultural Company. The company did little with the grant and it eventually reverted to the Crown. It was only in the 1860s that settlement round the lakes became significant.

Osborne and Robertson (1939) found the Myall Lakes area more attractive for scientific work than comparable coastal areas in New South Wales, as it was less disturbed by Europaean settlement. Following their initial study, subsequent scientific studies include geomorphological investigations of its lakes and sands (Thom 1965, Shepherd 1970, Thom et al. 1992), its vegetation (rainforests (Clough 1979), vegetation of some of its sand masses (Myerscough and Carolin 1986, 2014) and lakeside

forest (Baumann 2008)), and surveys of the waters of the lakes and their biota (NSW Office of Environment and Heritage NSW 2012).

The relatively low level of development of the area and its hinterland has made it valuable in conservation, both locally as a National Park (NPWS 2002), and internationally as a Ramsar site (NSW Office of Environment and Heritage 2012). Its northermost lake, Myall Lake, appears to be unique in Australia in having gyttja (NSW Office of Environment and Heritage 2012).

Coastal sand covers much of Myall Lakes National Park. Most of it was deposited in two periods of high sea level, in the last Pleistocene interglacial period about 125,000 years ago and in the late Holocene period (Thom et al. 1992). Thom et al. (1992) term Pleistocene coastal sands the Inner Barrier, and coastal sands deposited seaward of it during the Holocene the Outer Barrier. The Holocene sands in the southern parts of Myall Lakes National Park are deposited partly as beach ridges and partly as wind-blown dunes. North of Mungo Brush, sands of the Outer Barrier are entirely dunes (see Thom et al. (1992)).

Pleistocene beach sand ridges of the Inner Barrier lie inland up to 16 km from the present coastline in the Upper Myall River valley (Thom et al. 1992). In the Upper Myall River valley, Thom et al. (1992) showed that some parts of the Pleistocene beach sand ridges had later been disturbed by river action and other ways. Myerscough and Carolin (2014) showed that vegetation in freely draining sites on these beach sands differed between sites largely undisturbed since deposition and those disturbed by river action or in other ways. In their investigation, Myerscough and Carolin (2014) adopted the classification of Thom et al. (1992) of sands of the Upper Myall River valley but slightly modified it. This included recognition of Pleistocene beach sand bordering on and somewhat modified by waters of Boolambayte Lake, which they termed the Boolambayte sand ridge (Bsr).

Myerscough and Carolin (2014), however, did not survey Bsr on foot, nor sample floristically the vegetation of any site along it. Here, results of foot surveys of Bsr are described, and areas of freely drained sands recognised along it. Some of these areas were sampled floristically. This allowed floristical variation of the sites to be assessed along the length of Bsr, and against the floristical variation described among sites on other sands in the Upper Myall River valley described by Myerscough and Carolin (2014).

From results of the foot survey and floristical analyses of this study, the extent and nature of Bsr given in Myerscough and Carolin (2014) are redefined. Also, effects of European settlement, noted during foot survey on both Bsr and areas immediately adjacent to it, are outlined.

THE STUDY AREA

The study area (Fig. 1) includes the south-western sandy shores of Two-mile Lake (western arm of Boolambayte Lake). Its southern tip adjoins the western end of the sandbar (Lb in Fig. 1) running west from the rocky ground of Bombah Point. Thence, its boundary runs approximately north along the lake shore, to the start of the rocky lake shores that continue further north. From there, the boundary of the study area runs inland to include an isolated area of beach sand before meeting Hocking and Dees Track (Fig. 1). Then it follows Hocking and Dees Track south and south-west until it joins the road from Bulahdelah to Bombah Point. It follows the road as it crosses Bombah Bog. It then continues south, along the margin of Bombah Bog and then the eastern bank of the channel that drains water from Bombah Bog into Bombah Broadwater (Fig. 1). This channel, probably a key hydrological feature of Bombah Bog, is described on p. 20 of Myerscough & Carolin (2014).

Fig. 1 shows cadastral boundaries in the study area together with tracks, some of these now disused and not shown on modern maps, and roads in the area. Most of the land within the cadastral boundaries shown reverted to Crown ownership with declaration of the area as part of Myall Lakes National Park. More topographical and other details of the study area are available in NSW Government 1:25,000 maps, Myall Lake and Bombah Point, and geological details of rock-based hills are mapped in 1:100,000 geological maps, Bulahdelah and Port Stephens. The study area is included in the 1:100,000 Forster map sheet of coastal Quaternary sediments (Hashimoto & Troedson 2008).

METHODS

The length of Bsr from its southern tip to its northern end was walked, and the extent of its freely draining sands and their vegetation were recorded using GPS (Fig. 2) .

Floristic data were recorded from nine sites, using transects each 50-m long consisting of 10 5X5-m quadrats, as described in Myerscough and Carolin (2014). Each site chosen was on freely drained sand. In it, species observed to be present in each 5X5-

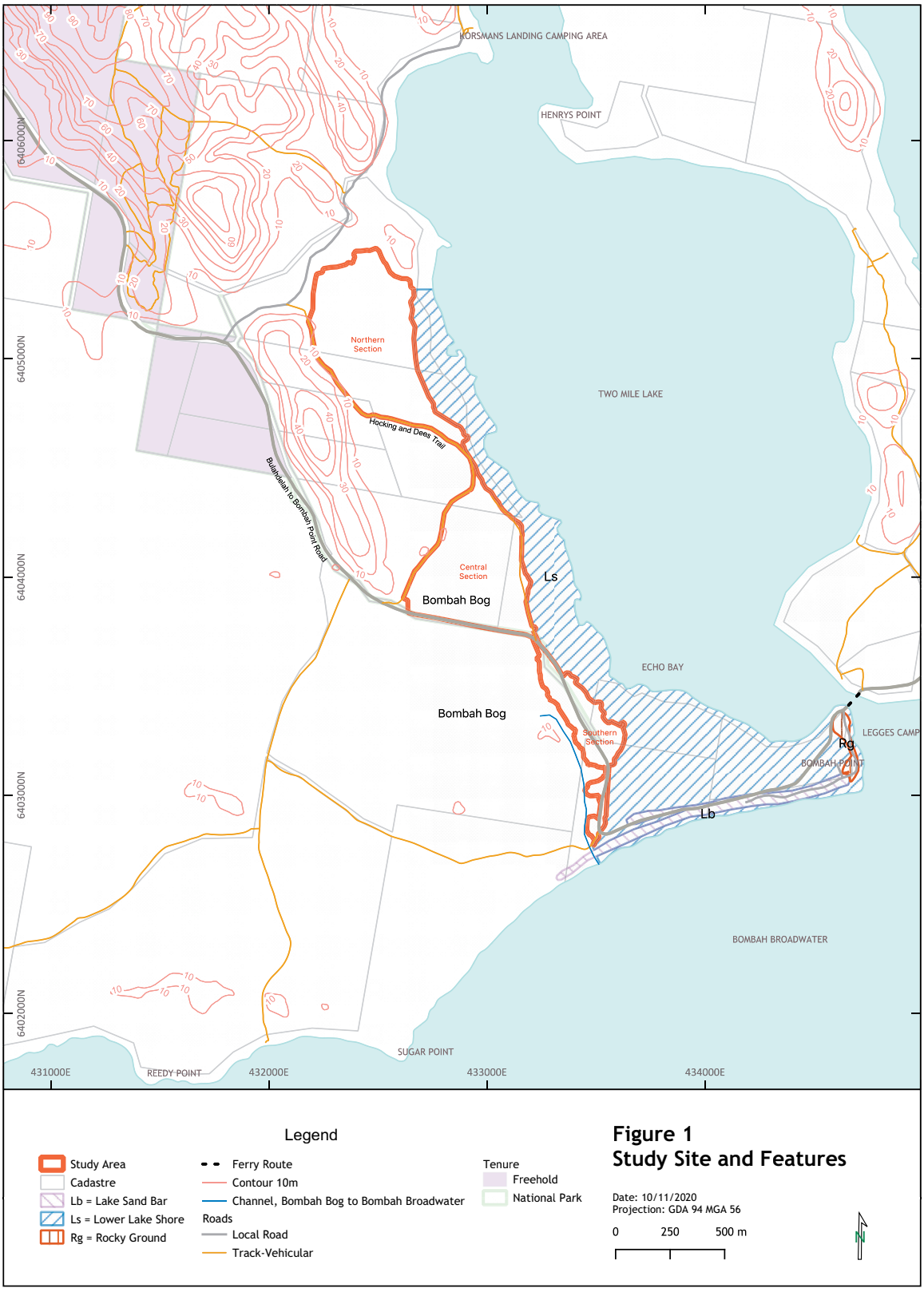

Figure 1. Salient features of the study area and areas surrounding it.

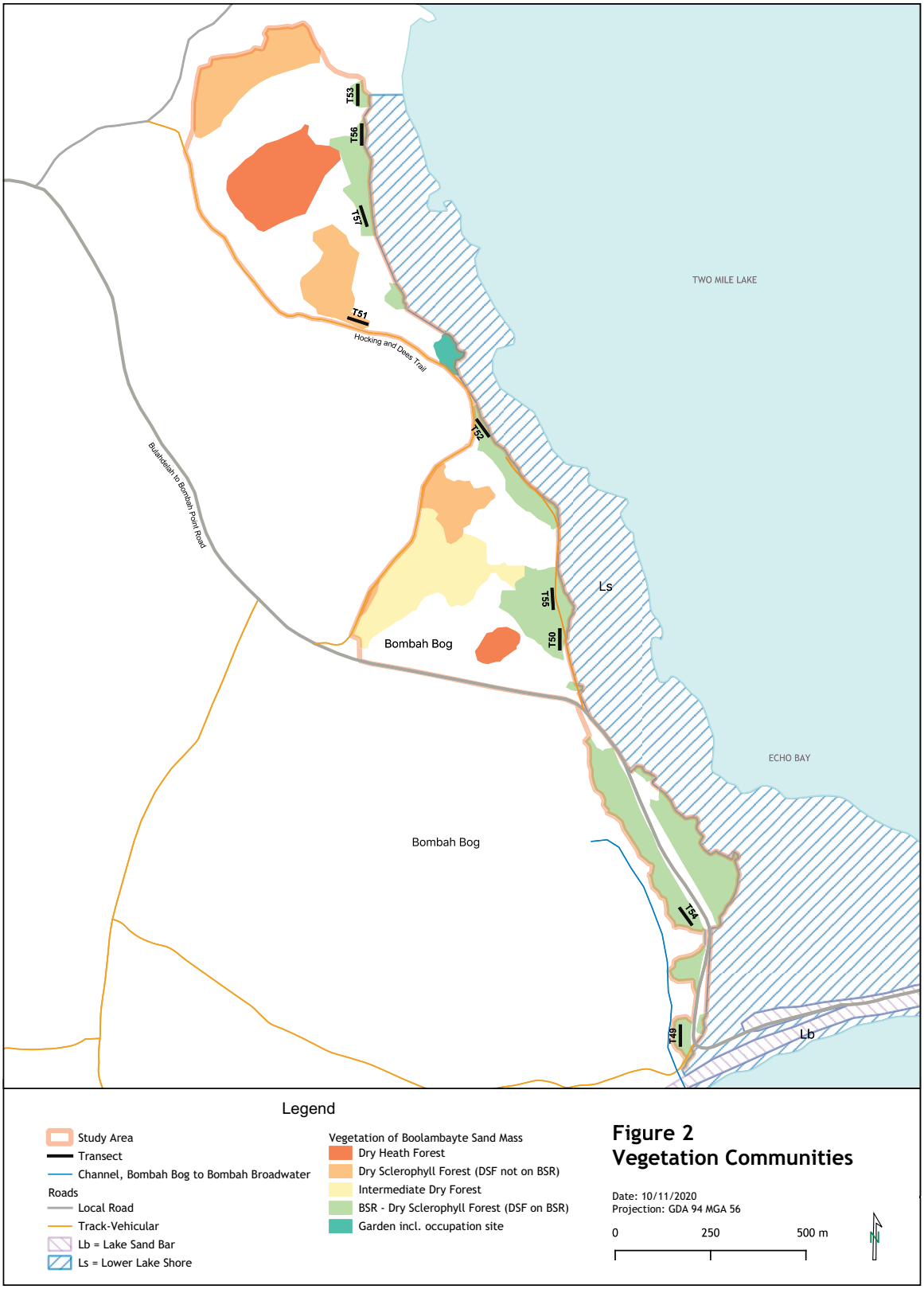

Figure 2. Map of types of sclerophyll forest on freely draining sands in the study area. The bars indicate the positions of the nine transects used to gather floristic data (See Table 1 for further details of the transects & Appendix 1 for species recorded in them).

m quadrat were recorded. The score for species in a transect thus varied from 10, when a species was recorded in all quadrats, to zero, when it was not recorded in any. At each site, to check that it was on coastal sand and its soil was a podsol, shallow soil cores were examined at randomly chosen positions, four in most sites, but at three in some. Eight of the nine sites surveyed were on areas of Bsr, three sites on its northern section, three on its central and two on its southern section. The ninth was on an area of sand close to the northern section of Bsr, but inland on sand of the Pleistocene beach system of Myerscough and Carolin (2014) [Inner-Barrier-strand Plain of Thom et al. (1992)].

The floristic variation across the nine sites was explored by a principal components analysis (PCA) (ter Braak and Prentice 1988), and displayed on the first two components derived that expressed the highest amount of the floristic variation among the sites.

Most of the commonly occurring species in the nine sites surveyed also occurred in sites recorded in the broader floristic survey of sands of the Upper Myall River valley of Myerscough and Carolin (2014) (see Appendix 1). Mostly, it is more rarely occurring spp. of this survey that are not recorded in the earlier survey.

Using species recorded in both this survey and in Myerscough and Carolin (2014), sites were displayed on the ordination of Myerscough and Carolin (2014). This allows some assessment of the floristic relatedness of these sites to those recorded by Myerscough and Carolin (2014). The relative positions of the nine sites in this survey on the ordination of the 48 sites of the previous survey were calculated from the accumulated scores of spp. in the nine sites on the first two components of the principal components analysis of the 48 sites. This calculation was done without disturbing the relative positions of the original 48 sites and merely allowed the relative positions of the nine sites of this survey to be displayed in relation to the 48 sites of the earlier survey.

The names of vegetation types used in Myerscough and Carolin (1986 & 2014) are retained in this study. Their names of forest types on freely drained beach sands require comment. They are Dry Sclerophyll Forest (DSF), used in a local, restricted sense, rather than its more usual general sense, as defined by Beadle and Costin (1952), and names Intermediate Dry Forest (IDF) and Dry Heath Forest (DHF) used only in Myerscough and Carolin (1986 & 2014). As explained in Myerscough & Carolin (1986 & 2014), DSF is relatively more grassy and less heathy in its understorey with tall trees and only *Banksia serrata,* IDF has a more heathy understorey with both *Banksia serrata* and *B. aemula*, and DHF has the most heathy understorey with shorter, sparser, trees and only *Banksia aemula* occurring. DSF is characteristic of Holocene sands or Pleistocene sands recently disturbed or shallowly deposited over rock and DHF characteristic of deeper sands deposited in the Pleistocene and not significantly disturbed recently.

RESULTS

All beach sand grains encountered in the study area were small, rounded, bleached, mainly quartz, with a probable Pleistocene provenance, as described in Thom et al. (1992). All nine sites investigated were on podsolized coastal sand (Table 1).

Table 1. Transects: Height of tree canopy and depth of soil profile (wt, to watertable; B, to B horizon).

Part of Bsr	Northern			Central			Southern		Not on Bsr
Transect No.	53	56	57	52	55	50	54	49	51
Approx height of trees (m)	30	30	24	32	22	22	25	25	30
Mean soil depth (m)	1.2 (wt)	1.2 (wt)	1.2 (B)	0.53 (wt)	1.3 (wt)	0.89 (wt)	0.70 (wt)	> 3.1	0.77 (wt)
Range	1.16-1.26	1.18-1.27	1.05-1.25	0.50-0.55	1.25-1.37	0.75-0.95	0.60-0.80		0.66-0.85
No. of cores drilled	3	3	3	4	4	4	4	4	4

Boolambayte Sand Ridge (Bsr): its configuration and adjoining systems

The Boolambayte Sand Ridge (Bsr) is part of the upper shoreline of the south-western corner of Boolambayte Lake. The lower part of this shore is an extensive area of lake shore sediments (Ls in Table 1 of Myerscough & Carolin 2014), submerged much of the time, occupied by Fringing Forest (Myerscough & Carolin 1986), mainly *Melaleuca quinquenervia* trees with characteristic understorey (Myerscough & Carolin 1986) (Figs. 1 & 2).

Freely drained sands of Bsr carrying Dry Sclerophyll Forest are not continuous along this stretch of the shore of Two Mile Lake (the western arm of Boolambayte Lake) (Fig. 2), as was incorrectly indicated in Myerscough and Carolin (2014). They are in discontinuous patches, extending in a line approximately south from the rocky shore at their northern end to their southern end, close to the shore of Bombah Broadwater. Between the patches of freely drained sands of Bsr carrying Dry Sclerophyll Forest, the upper shore line of the lake is marked by a change from Fringing Forest (Myerscough and Carolin 1986), mainly *Melaleuca quinquenervia* trees with characteristic understorey, inland, to Swamp Forest of Myerscough & Carolin 1986, in which *Eucalyptus robusta* trees are characteristic .

Bsr has distinct northern, central and southern sections, strikingly different inland in adjoining land and vegetation. The southern and central sections are bounded on their inland sides by other sand-based systems; the central by the north-eastern end of Bombah Bog, and the southern by the south-eastern edge of Bombah Bog and a major drainage channel that carries water from Bombah Bog to Bombah Broadwater. The northern section of Bsr, though apparently immediately bounded by other sands, is relatively close to rocks of hilly country in an arc from north to west of the Bsr sands, and they probably receive water draining laterally through them from this hilly country.

Northern

The northern section of Bsr extends south from a rocky point on the lake shore to close to the southern boundary of what was freehold land (Fig. 1). It consists of patches of DSF (Fig. 2) which are mostly adjoined inland by Swamp Forest of Myerscough and Carolin (1986), whose trees are mostly *Eucalyptus robusta* but with some *Melaleuca quinquenervia* and, in this area, *Callicoma serratifolia* as a subcanopy small tree.

Further inland, up to the boundary of the study area on Hocking and Dees Track (Fig. 2), there are freely drained sands with forest. In the north-western top of the area, is an area of sand deposited as a beach over rock carrying DSF. It is separated from other areas of sand further south-east by gently sloping swampy rocky ground bearing *Melaleuca* spp. scrub close to Hocking and Dees Track, but giving way to Swamp Forest with *Eucalyptus robusta* further downslope to the east, and this in turn to a flatter area of apparently colluvial ground with *Eucalyptus pilularis* with *Baloskion tetraphyllum* and other species of damp ground.

Further south, adjoining Hocking and Dees Track (Fig. 2), there is freely drained sand carrying DSF. In the past, this was probably more extensive. Alongside its eastern boundary is an approximately rectangular area of sand (c. 100 X 250 m) that was cleared, except for one large blackbutt (*Eucalyptus pilularis*), height 41 m, girth at breast height of 9.1 m (GPS: S 32° 29.500': E 152° 16.993').

Some distance from Hocking and Dees Track, more or less in the centre of this northern section, there is a patch of sand supporting DHF. For a short distance, its eastern side adjoins the largest patch of DSF in this northern section of Bsr.

Close to where Hocking & Dees Track turns sharply south-west is the occupation site on partly rocky ground with remains of a garden that includes planted trees, eg., *Pinus* cf. *patula*, *Toona ciliata*, coral trees, and just across Hocking & Dees Track, a well grown *Strelitzia nicolai*.

Central

The central section of Bsr consists of two sand masses; a northern sand bar, anchored in the north close to rocky ground exposed in the occupation site, and a southern inverted pear-shaped area. Between the southern tip of the northern sand bar and the northern boundary of the southern area, there is swampy ground. On it, moving west from the lake shore, the vegetation changes from Fringing Forest to Swamp Forest. This area of Swamp Forest extends north-east behind the northern sand bar of Bsr.

In contrast, the southern pear-shaped area of Bsr is bounded on its western side by Bombah Bog with its complex of Wet Heath/Swamp Forest vegetation. A strip of Intermediate Dry Forest (IDF) extends from the northern end of its boundary with Bombah Bog. The southern side of this strip continues west as part of the northern boundary of Bombah Bog, while the eastern side runs NW, bounded on the East by Swamp Forest, until it meets the southern end of an area of DSF (Fig. 2).

Southern

The southern section of Bsr is bounded on its western side by the south-eastern corner of Bombah

Bog and then by the large channel carrying drainage water from Bombah Bog into Bombah Broadwater. Its whole length has been much altered as it carries a stretch of the road from Buladelah to Bombah Point and a wide easement along the road for powerlines. It does not reach the lake shore of Bombah Broadwater but ends in a small steep-sided ridge much higher than any other part of Bsr (reaching 6 m above sand at its base on its eastern side).

Vegetation of Boolambayte sand ridge

The vegetation of freely draining sands of Bsr was consistently found to be Dry Sclerophyll Forest (DSF) as defined in Myerscough and Carolin (1986). There is only one place where DSF on Bsr directly adjoins IDF. That is in the central section as mentioned above. In the southern section, on the northern end of its north-western side, there are a few isolated indivduals of *Banksia aemula* on the south-eastern edge of Bombah Bog.

Species encountered in sampling eight sites on Bsr and in a ninth site (locations of sites indicated in Fig. 2) close to it are given in Appendix 1. Most of the species recorded occurred also in sites sampled in Myerscough & Carolin (2014); those that did not are indicated in Appendix 1.

The two southermost sites (Sites 49 and 54) are floristically closely aligned and clearly separated from the rest of the sites sampled, in the central and northern parts of Bsr (Fig. 3 a). They are sites with more topographical variation than the other sites. The other, central and northern, sites have more understorey species characteristic of wetter sites, eg, *Leptospermum polygalifolium* and *Baloschion tetraphyllum* (Fig. 3 b). A similar indication of Sites 49 and 54 having understoreys more characteristic of drier sites is borne out when scores of species in sites from this study are superimposed on the ordination diagram from Myerscough & Carolin (2014). On that diagram, the positions of Sites 49 and 54 are closer to DSF sites of that study than are the other sites of this study, which are close to WHF sites in that study (Fig. 4).

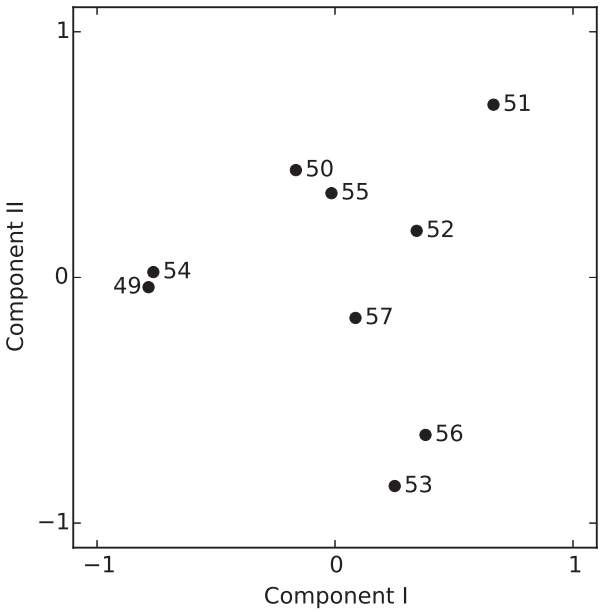

Figure 3. (a) Ordination of floristic data from 9 transects on the first axes extracted from a principal components analysis. Numbers indicate individual transects.

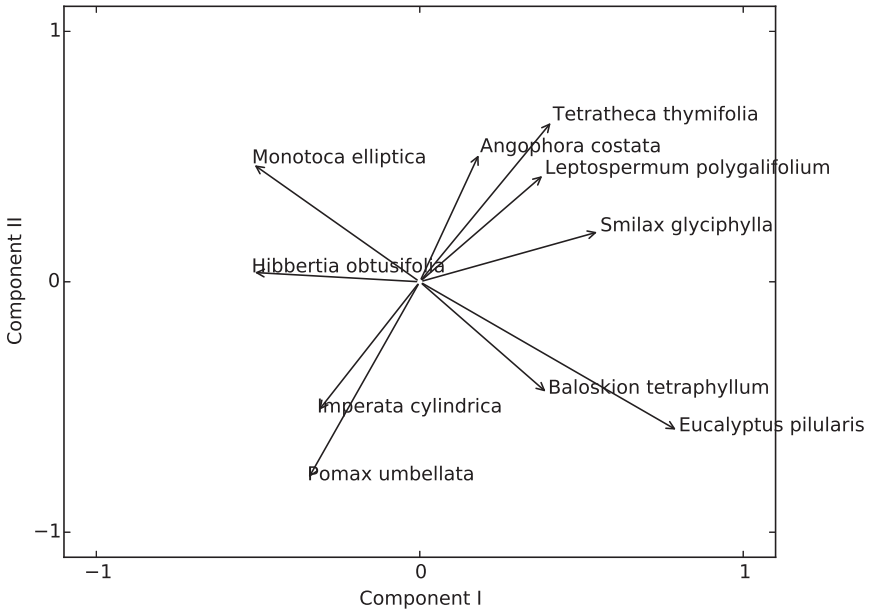

Figure 3 (b) "Biplots" of species contributing to the relative positions of the transects in the ordination shown in (a).

Trees of the northern section of Bsr and the northernmost site of the central section (Site 52) are generally taller than those of sites further south (Table 1). Site 57, the southernmost site in the northern

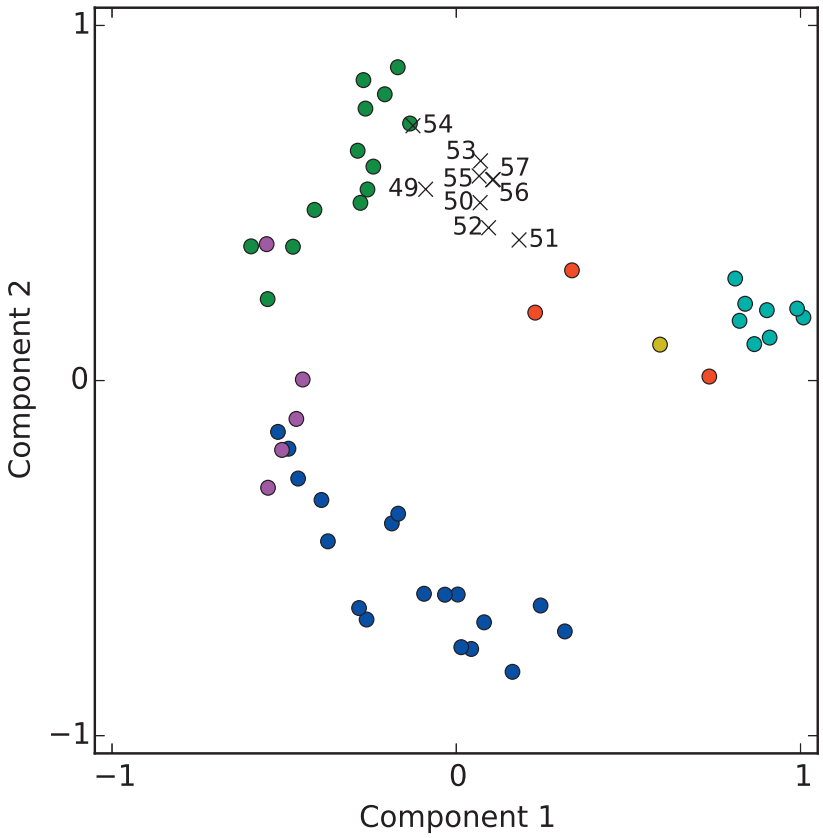

Figure 4. Relative positions of the nine transects of this study on the ordination of 48 transects of the study of Myerscough & Carolin (2014) of vegetation of sands of the Upper Myall River valley. (X, transects of this study; on left side of figure: blue dots, DHF; peuce dots, IDF; dark green dots, DSF; on right side of figure: red dots, Wet Heath Forest (WHF); single yellow dot, Swamp (S); light-blue dots, Wet Heath (WH). (For definition of WHF, WH and S, see Myerscough & Carolin (2014))).

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section, is an exception, having less tall trees, similar in height to those in transects from the southern end of the central section and from the southern section (Table 1).

Fig. 5 is an amended version of Fig. 3 of Myerscough and Carolin (2014), incorporating alterations made in mapping vegetation in this study.

Effects of European settlement

Effects of European settlement are least in the central section and greatest in the southern section of the Boolambayte sand ridge.

In the northern section, most of the effects of settlement lie inland of the patches of freely draining sand supporting DSF that identify Bsr. These include remains of fencing on what is probably a patch of colluvium, the clearing of an area of sand and the occupation site itself, where it is not now clear whether there was any segment of Bsr. Some areas of patches identified as Bsr appear more deficient in *Banksia serrata* than would be expected. This might reflect cutting or grubbing of *Banksia serrata* for firewood.

In the central section, the southern inverted pear-shaped area of Bsr was serviced by a track, which had at its northern end, until recently, the remains of an old ice chest and some empty bottles.

Much of the southern section carries a stretch of the Bulahdelah to Bombah Point road and easement for powerlines, that obliterated the natural vegetation. In the remaining DSF of the Bsr along the western edge of road, there are signs of extraction of timber. In the southermost, steep-sided ridge which stands 6 m above the surrounding land, there are trenches across its crest, almost certain evidence of felled timber having been dragged across it. Nearer Bombah Bog, there is a patch of presumptive DSF, where there is a marked scarcity of canopy trees but plentiful *Banksia serrata*. Possibly, canopy trees were taken to provide a base on which to build the road across Bombah Bog.

DISCUSSION

Geomorphology

The Boolambayte sand ridge is a chain of mostly low-lying but freely draining patches of sand running south from the southermost point of rocky shore on the western side of Two-Mile Lake (the western arm of Boolambayte Lake) to a point close to the northern shore of Bombah Broadwater. At this point, it almost abutts on the western end of the current sandy lake bar (Lb on Fig. 1) that runs west from the rock that forms Bombah Point. It is highly probable that, until recently, this was where much of the water from Two-

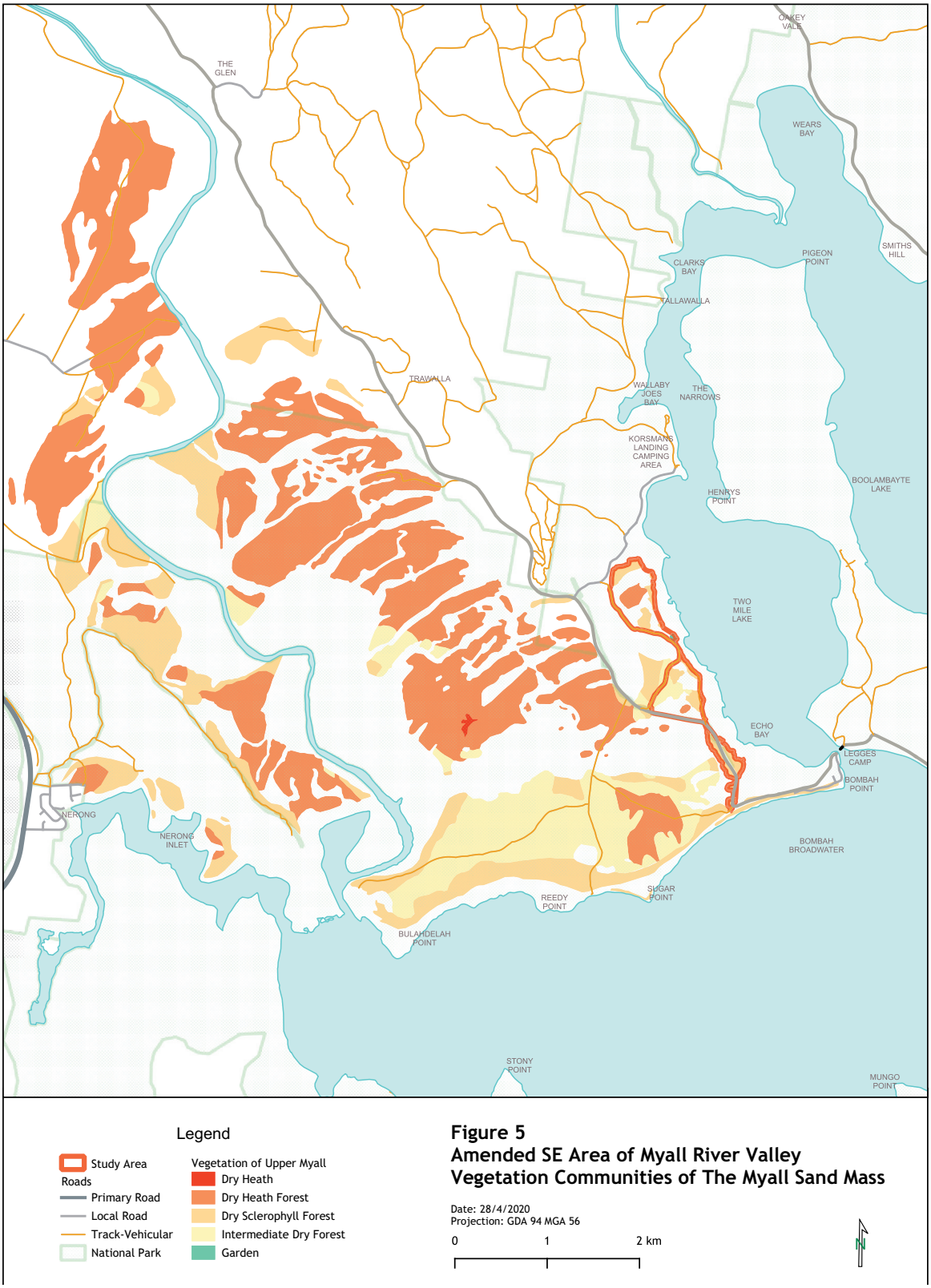

Figure 5. Corrected version of map of the vegetation of freely draining sands of the valley of the Upper Myall River.

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Mile Lake entered Bombah Broadwater. This would partly explain the very rectangular form Two-Mile Lake has to its seaward end, and entirely account for the alignment of the Boolambayte sand ridge. If this is so, it would only have been in the last phase of the Holocene rise in sea level that water from Two Mile Lake began flowing regularly over rocky ground in its current channel on the eastern side of Bombah Point into Bombah Broadwater.

Thus, the Boolambayte sand ridge is a series of low mounds of Pleistocene coastal sand bounded on their eastern side by sand redeposited by water movement between Two Mile Lake and Bombah Broadwater in more recent times.

In short, it is not a ridge in any sense, but, since Boolambayte sand ridge was given in Myerscough & Carolin (2014), to avoid confusion, the name is retained.

Northern section

Along the northern section of Bsr, its sand is that of the Inner Barrier strand plain – Pleistocene (Thom et al. 1992) [Pleistocene beach system (Pib) of Myerscough & Carolin (2014)].

Central section

Each of the two sand bodies that make up the central section of Bsr had its own origin.

The northern one appears to have largely formed as a lake sand bar extending south-east from the rock of the occupation site. The swampy ground running northwest behind the bar from the lake shore is probably the remains of a lagoon, bounded inland by sands of the Inner Barrier strand plain – Pleistocene (Thom et al. 1992) [Pleistocene beach system (Pib) of Myerscough & Carolin (2014)].

The southern mass of sand directly borders on Bombah Bog and is attached at its north to sands of the Inner Barrier strand plain – Pleistocene (Thom et al. 1992) [Pleistocene beach system (Pib) of Myerscough & Carolin (2014)]. It is probable that it itself was part of this sand plain but disturbed by the Postglacial marine incursion that initiated the formation of Bombah Bog (Martin 1986).

Southern section

The southern section of Bsr includes sand that may been disturbed by water draining southeast down a channel from Bombah Bog. Some of this sand disturbed by water draining from Bombah Bog may have been transported East beyond the general alignment of Bsr, so that sand extends out into Two-Mile Lake. This is likely to have happened after the present connection of Two-Mile Lake and Bombah Broadwater had formed East of Bombah Point.

The final 6-m high small ridge that forms the southern end of Bsr is probably an outlier of the Bombah sand mass (Bsm) of Myerscough and Carolin (2014) [Transgressive dune field – Pleistocene of Thom et al. (1992)], sliced off the eastern side of the Bombah sand mass by water draining from Bombah Bog on its western side and steepened on its eastern side by water draining into Bombah Broadwater from Two-Mile Lake.

Origins of the different sections of Bsr

The low height of the sand of northern and central sections of Bsr probably directly reflect the low height of the original deposits of sand inland of them. In the northern section these are sands of the Inner Barrier strand plain – Pleistocene (Thom et al. 1992). In central parts of this system in the Upper Myall River valley, 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). Why they are so much lower here probably relates to their having been deposited in a bay with a rocky headland to the east round which the tides would have continued to wash.

The small but relatively sharp ridge that marks the southern end of Bsr has a height that directly reflects that of the Pleistocene sand system, Bombah sand mass (Bsm) of Myerscough & Carolin (2014) [Transgressive dune field – Pleistocene of Thom et al. (1992)], from which, as argued above, it is thought to have been excised by streams of draining water.

Defining Bsr

The eastern boundary of Bsr, along the south-western shores of Two-Mile Lake (western arm of Boolambayte Lake), was defined by the junction of the upper shoreline with freely drained sands.

In Myerscough and Carolin (2014), definition of the western boundary of Bsr was based on aerial photo interpretation. In this study, it was based on ground observations, and on the strict criterion it was where DSF adjoins another type of vegetation. In most instances in the northern and southern sections of Bsr this adjoining vegetation was characteristic of sites that are periodically waterlogged. It is only one part of Bsr, the southern part of the central section, that part of it adjoined IDF, a forest found by Myerscough and Carolin 1986 & 2014 characteristically on freely draining sands recognised by Thom etal. (1992) to have been deposited or disturbed in the late Pleistocene, about the glacial maximum, c. 20,000 years ago. The whole of the western boundary of the southern section of Bsr adjoins periodically

waterlogged land. The northern approximately third of its length adjoins the southern-eastern corner of Bombah Bog. Here occasional individuals of *Banksia aemula*, characteristic of sand surfaces not recently disturbed, occur. The central and southern lengths of the boundary follow the eastern bank of the channel draining water from Bombah Bog into Bombah Broadwater.

As argued above, the disturbance of generally straight alignment of the eastern side of Bsr at its southern end is probably recent, occurring after waters of Two-Mile Lake and Bombah Broadwater were joined through the present channel east of Bombah Point.

In summary, only one element of Bsr has been formed de novo by processes along the shore of Two-Mile Lake. That is the lake sand bar in the northern end of the central section. All other elements are from pre-existing sand bodies whose eastern side has been modified by processes along this part of the shore of Two-Mile Lake.

Vegetation

Having vegetation of Dry Sclerophyll Forest (DSF), as well as being having freely draining sand adjoining the shoreline of Two-Mile Lake, was used in identifying the areas that make up Boolambayte sand ridge (Bsr). Analysis of the floristics of the eight sites sampled along Bsr showed the six sites sampled in the northern and central sections of Bsr had an understorey of species with greater affinity with wetter sites than the two sites sampled in the southern section of Bsr (Figs 3 & 4). In the northern section one site having DSF on Pleistocene sand, nearby to but inland from the Bsr, was also low-lying and close to the watertable and had very similar DSF vegetation to sites on the northern section of Bsr (Figs 3 & 4, Table 1).

The higher trees of most sites floristically sampled in the northern section of Bsr and the northermost site sampled in the central section may be related to their receipt of nutrients in water flowing into their root zones from nearby rocky ground. If this so, the existence of the central patch of DHF with much lower trees on sand also close to this rocky ground might be explained by local isolation from water flowing underground from adjacent rocky ground.

European settlement

European settlement has affected all three sections of Bsr.

Much of the southern section has had its vegetation removed and surface altered by building the southern end of the road from Bulahdelah to Bombah Point and associated easement for powerlines. There is evidence of extraction of trees from its southern end, and probable removal of trees from northern areas, possibly to provide a base for the building of the road across Bombah Bog.

The central section has been least affected, but had a track to part of the shore of the lake. From the remains of an old ice chest that were there in 2016 together with old bottles, it seems a small area on the Bsr sand may have been used by drinking parties, sent out here, possibly to provide as much quiet as possible in Legge's Camp itself.

The northern section falls within what used to be freehold land. Areas of DSF on Bsr appear relatively little affected by activities, though those may have included taking of *Banksia serrata* for fuel, and perhaps elimination of small patches of DSF close to the house site.

Inland from identified areas of Bsr, there are signs of a patch of fenced land on what appears to be colluvium. An area of DSF on sand appears to have been cleared, apart from one big blackbutt. Young trees and an understorey of bracken (*Pteridium esculentum*) and *Calochlaena dubia* have returned but few shrubs and no *Banksia serrata*, perhaps due to a lack of seed bank following cultivation. The site of the house and its garden are still very evident near the lake shore in the south-eastern corner of the area that was freehold.

Aboriginal occupation

In contrast to the obvious effects of the short time of European settlement in the area, signs of effects on it of its longterm Aboriginal occupation are, for me, a matter of conjecture. Probably, ancestors of present-day Worimi people would have witnessed the change of connection between Boolambayte Lake and Bombah Broadwater from a channel about 1 km west of Bombah Point to its present position adjacent to it on its eastern side. Perhaps, the obvious microtopographic variation of the eastern side of the southern section of Bsr may in part be related to activity of people on it. A similar explanation might be offered for its extension further east than the general alignment of the rest of Bsr.

CONCLUSION

Identification of Pleistocene beach sand affected by Two Mile Lake along its southwestern shore, originally based on aerial photography in Myerscough and Carolin (2014), and named the Boolambayte sand ridge (Bsr), has been upgraded

by observations on the ground. The alignment of Bsr indicates that, until recently, Two-Mile Lake (the western arm of Boolambayte Lake) has been chiefly connected to Bombah Broadwater about 1 km west of the present connection at Bombah Point. Bsr consists of a chain of freely drained areas of sand carrying Dry Sclerophyll Forest (DSF), as defined in Myerscough and Carolin (1986 & 2014). Bsr has three distinct sections, a northern, a central and a southern section. Sites floristically sampled on the northern and central sections had an understorey that included several species characterisitic of wet heath, whereas the two sites sampled on the southern section has an understorey more characteristic of drier sands. European settlement has affected all three sections of Bsr. The northern section was part of freehold land carrying a residence and evidently used as a small holding. Only a small area of the central section appears to have been used as a camp site for drinking parties possibly from Legges Camp. The southern section has been radically changed by building across it the southern end of the Bulahdelah to Bombah Point road and associated easement for powerlines.

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Appendix 1

Species and their scored presence (max. 10) in each of 9 transects (50 x 5 m) (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 June 2019) (*, species not in any transect recorded in the Upper Myall River Valley by Myerscough and Carolin (2014))

Transect	49	50	51	52	53	54	55	56	57	
Acacia longifolia	6		1	2		5	1			
Acacia melanoxylon								3	2	*
Acacia suaveolens		1	1	2		4				
Acacia ulicifolia	2		1	1		2				
Acianthus fornicatus	1			1	5	7		3	3	*
Allocasuarina littoralis			2							
Angophora costata		5	10	5	3	9	8	4	5	
Anisopogon avenaceus			1							
Baloskion tetraphyllum				10	5			6		
Banksia serrata	8	10	5	10	10	8	9	10	9	
Billardiera scandens	1									
Boronia pinnata			7							
Bossiaea heterophylla	3	4				3	2			
Brachyloma daphnoides		1								
Breynia oblongifolia	8			4	2	5		1	2	*
Caladenia carnea		3	2				2			*
Calochlaena dubia					3			2	10	
Calythrix tetragona						1				
Corymbia gummifera	8		2	7		7			6	
Dianella caerulea	8	10	6	9	5	8	8	6	10	
Dillwynia retorta	4	4	1	2		3	2			
Dodonaea triquetra	2					2				
Endiandra sieberi		1	1	2			1			*
Entolasia stricta			1							
Epacris microphylla						1				
Eriostemon australasius	4									
Eucalyptus pilularis			7	9	10			10		
Glochidion ferdinandi						3			4	
Glycine clandestina	5					5	2			
Glycine tabacina						1				
Gompholobium latifolium	4	1		5			2			
Gonocarpus teucrioides				1						
Goodenia heterophylla #	1									*
Hardenbergia violacea	1					1				
Hibbertia obtusifolia	4	3			1	8	2	1		
Hibbertia scandens			2		4			2	3	
Imperata cylindrica	7	4	4		9	10	5	7	8	

Kennedia rubicunda								1		
Leptomeria acida		1								
Leptospermum polygalifolium		1	8	4	1					
Leucopogon lanceolatus	3	2	3	1	2	4	2		1	
Leucopogon virgatus						1				
Lobelia purpurascens					1					*
Lomandra glauca	2	1				1				
Lomandra longifolia	6	7	4	7	8	9	9	6	7	
Machaerina rubinosa			1							
Macrozamia communis	2					1				
Marsdenia lloydii	5									*
Monotoca elliptica	8	7	3	5	1	8	7	1	2	
Myrsine howittiana									1	*
Notelaea venosa		2				4				*
Oxylobium robustum						1				*
Pandorea pandorana					7	1	4	3		*
Panicum simile						1				
Parsonia straminea					1			1		*
Patersonia sp.			1						1	
Persoonia lanceolata						1				
Phyllota phylicoides	1									
Platylobium formosum			3							
Platysace lanceolata	2	8		2	2	6	1			
Platysace linearifolia	5									
Pomax umbellata	10	3	2	1	10	8	6	10	5	
Pteridium esculentum	10	10	10	10	10	10	10	10	10	
Pterostylis sp.	1						1			*
Ricinocarpos pinifolius							1			
Smilax glyciphylla		1	9	4	2		2	4	7	
Synoum glandulosum									4	
Themeda triandra	3				4	6	1	1	1	
Tetratheca thymifolia		1	9	3			7	1	1	
Viminaria juncea				1						
Xanthosia pilosa	5									
Xanthorrhoea glauca	2	1	3	1	2	1		2	4	
Zieria laevigata				1		1				
# subsp. *eglandulosa*										
Identified by R.C. Carolin										