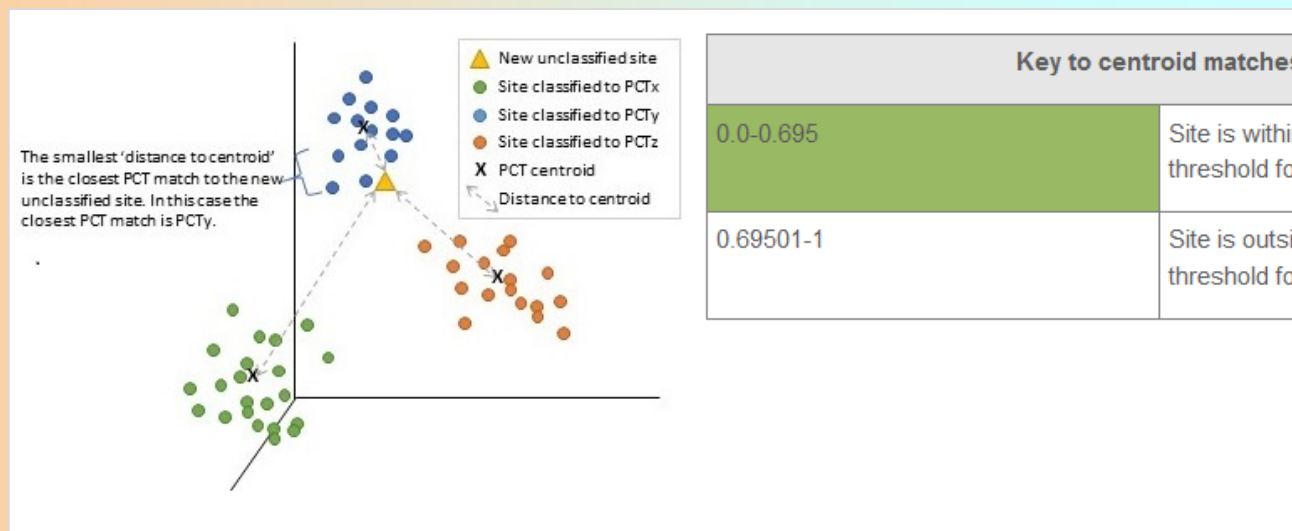


Lake Macquarie Vegetation Map Units Alignment to Eastern NSW PCTs: Stage 2 (Lowlands)



August 2023

Report to

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This document should be cited as:

Bell, S.A.J. (2023) *Lake Macquarie Vegetation Map Units Alignment to Eastern NSW PCTs: Stage 2 (Lowlands)*. Unpublished Report to Lake Macquarie City Council. August 2023. Eastcoast Flora Survey.

Cover image: Screen grab from the PCT Tool application (<https://bionet.shinyapps.io/vegplot/>)

Acknowledgements: Thanks to Robbie Economos (LMCC) for overseeing this work, and Daniel Connolly (DPE EES) for discussions concerning the use and interpretation of the PCT Tool.

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1.0 Background

Lake Macquarie City Council (LMCC) is seeking to align local-scale vegetation community mapping units (Bell & Driscoll 2016) with the Eastern New South Wales Plant Community Type (ENSW PCT) classification (DPE 2022). Alignments completed in 2022 identified a number of vegetation units where insufficient data was available to enable confident allocations. Four scenarios which made alignment particularly difficult for 80 of the 130 LMCC map units were outlined:

- No clear match (7 LMCC map units)
- Low confidence in alignment; a 'poor match' (17 LMCC map units)
- Reasonable confidence in alignment; a 'moderate match' (52 LMCC map units)
- Other units with no existing plot data (4 LMCC map units)

Stage 1 of the PCT allocation process was completed in 2022, following discussions with EES staff at the Department of Planning and Environment to address and align 24 map units. Stage 2 (current) involves the collection of new floristic plots data for 19 further map units from lowland areas of the LGA where limited data prevents confident allocations. This report summarises the findings of the Stage 2 work.

2.0 Methods

2.1 Target Map Units

Vegetation mapping completed for Lake Macquarie Local Government Area (LGA) was largely based on an intuitive classification but supported by a working numerical classification across the LGA using available data at that time (Bell & Driscoll 2016). A full numerical classification incorporating sampling of all mapped units for the entire LGA has not yet been completed, allowing for the possibility that some defined map units may be merged with others if found to be limited in their distinctiveness.

Table 1 summarises the 19 map units identified for Stage 2 whereby insufficient floristic data prevents a confident PCT allocation process. Ideally, a minimum of five full floristic plots within each map unit allows for the capture of floristic and structural variations within each unit, and a better PCT match. However, due to spatial limitations or excessive clearing, not all units can be sampled to this extent.

2.2 New Plot Sampling

For each target map unit, up to seven potential new plot sampling locations were identified within GIS. This involved review of vegetation map layers (last updated in 2016) and selection of new sites acknowledging the positioning of existing plot data, and wherever possible citing new plots on public lands. Notes made during the mapping process (2007-2014) and contained within mapping data were also reviewed to filter out locations identified at the time as suitable for full floristic sampling.

New plots were sampled using standard techniques, consistent with the data bank of existing samples (currently 492 plots in Lake Macquarie). Plots were nominally 20 x 20m in size (0.04 ha) and positioned in areas representative of the surrounding vegetation type. All vascular plants species present in plots were recorded and applied a modified Braun-Blanquet cover abundance rating, where: 1 (<5% cover and rare); 2 (<5% cover and common); 3 (5-25% cover); 4 (26-50% cover); 5 (51-75% cover); and 6 (76-100% cover).

Collected data was entered into the NSW Government Vegetation Information System (VIS) database (<https://www.environment.nsw.gov.au/research/vegetationinformationsystem.htm>).

Table 1 Summary of Stage 2 map units from the Lake Macquarie lowlands requiring additional sampling.

Stage 2. New plot sampling (lowlands, moderate PCT match)	Existing Plots	New Plots*
Alluvial Bluegum - Spotted Gum Moist Forest (5e)	1	2
Alluvial Riparian Blackbutt Forest (5h)	1	2
Lake Macquarie Ironbark Forest (15i)	1	4
Buttonderry Footslopes Forest (30a)	2	3
West Wallsend Stringybark Forest (30i) *	2	3
Narrabeen Dune Forest (31k)	3	2
Awabakal Sand Mantled Blackbutt Forest (33d)	1	2
Coastal Sandplain Dry Heath (34c)	3	2
Alluvial Floodplain Woollybutt Forest (37b)	1	2
Swamp Mahogany - Tallowwood Swamp Forest (37g)	1	2
Apple Palm Gully Forest (39)	2	3
Phragmites Rushland (40a)	0	2
Forest Redgum – Paperbark Scrub-Forest (43f)	0	3
Coastal Sand Bottlebrush Wet Heath (44g)	2	3
Munmorah Impeded Sand Sedgeland (44l)	1	2
Freshwater Wetland Complex (46)	0	5
Coastal Headland Shrubland (51b)	2	3
Killingworth Snappy Gum Forest (111c)	2	3
Kahibah Snappy Gum Forest (119)	3	2
(19 map units)	Total new	50

* in some cases, proposed new plots differs from final plots actually sampled.

2.3 PCT Allocation

Allocation of new and existing plots within target map units to PCTs was completed using one of two methods. Preferentially, all plots were subjected to the Eastern NSW Plot to PCT Assignment Tool (<https://bionet.shinyapps.io/vegplot/>) for systematic allocation to PCTs. This tool uses a combination of floristic, environmental and spatial attributes to deliver a selection of plausible results, which are then reviewed by the user to select the best match. This system is not infallible, particularly for vegetation types that have limited data within the ENSW analysis dataset.

In situations where systematic allocation using the PCT Tool was not possible, manual review of data against all ENSW PCTs was undertaken. This focused particularly on dominant species and landscape positions.

3.0 Results

3.1 Plots Sampled

A total of 46 plots was sampled as part of this project (Figure 1), during June and July 2023. All data has been uploaded to the VIS database maintained by the NSW Department of Planning, Industry and Environment. Data is stored within the survey identification 'LAKEMGLGA5', and is accessible via registered login at https://www.environment.nsw.gov.au/AtlasApp/UI_Modules/YETI/

Note again that numerical classification for the entire Lake Macquarie LGA has not been undertaken as part of this project, but would be informative to direct PCT allocations for difficult units.

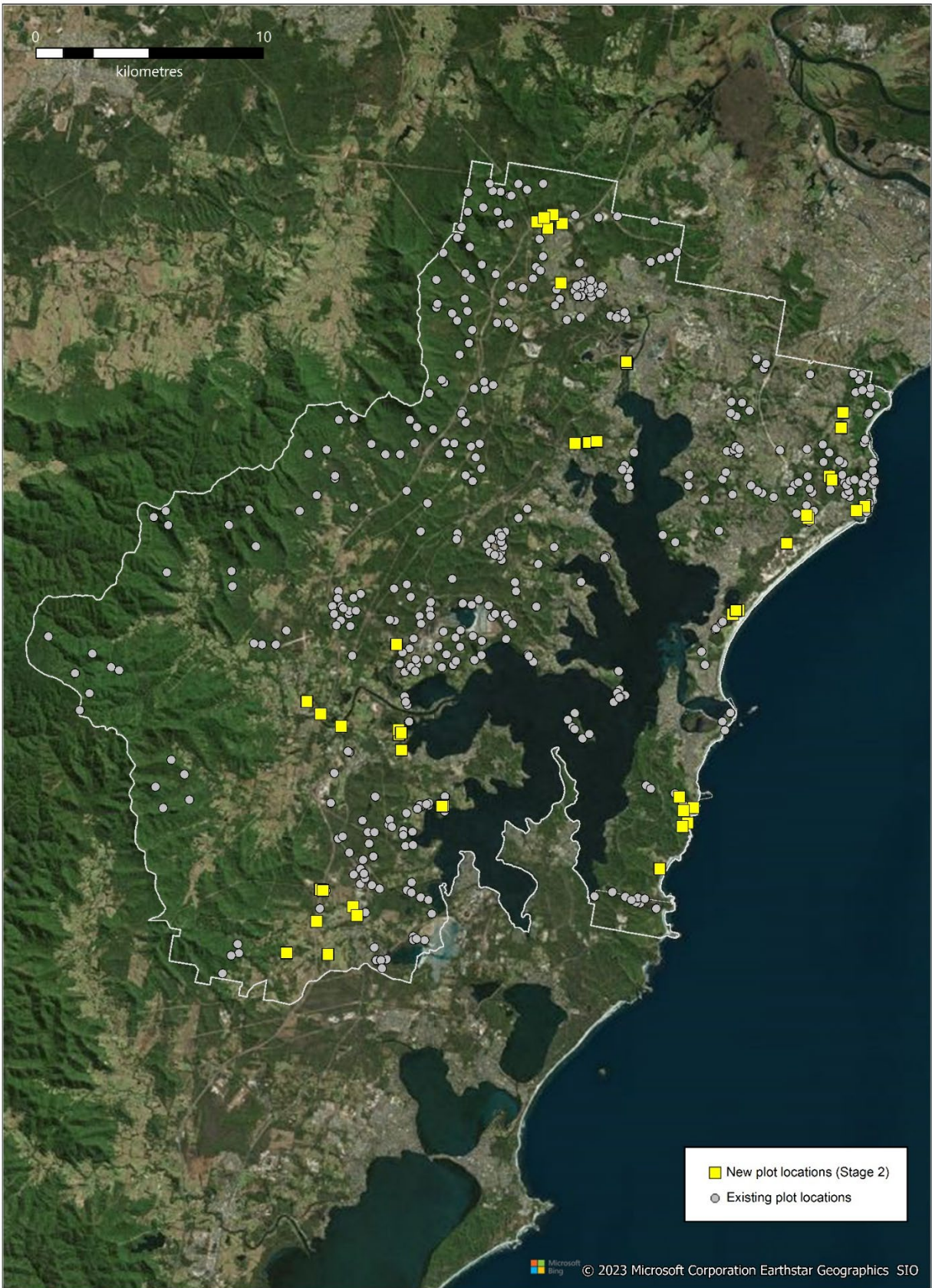


Figure 1 New plots sampled as part of this project.

3.2 PCT Allocation

Existing and new plot data for each map unit were merged and processed through the PCT Tool.

Eighteen of the 19 targeted Lake Macquarie Units were run through the PCT Tool to assist in determination of the most appropriate PCT (Table 2). Adequate replicated plot samples of Freshwater Wetland Complex (Unit 46) could not be attained despite considerable effort, and these units were consequently assessed manually.

Further comments on each of the targeted Units are included in the following text.

Unit 5e: Alluvial Bluegum- Spotted Gum Moist Forest (3 plots)

The highly restricted Alluvial Bluegum - Spotted Gum Moist Forest occurs on alluvial soils in the Wyee area of southern Lake Macquarie and has been mapped over 106 ha. The combination of *Eucalyptus saligna* with *Corymbia maculata* in the canopy is uncommon, but it was unclear if this combination was also reflected in a differing understorey relative to other moist alluvial units. Prior to the additional two plots completed under the current sampling program, just a single plot defined this type.

Analysis of all three plots through the PCT Tool resulted in poor correlations with defined PCTs. All five of the best matches for each plot were different, revealing a list of 15 potential PCTs with which to align. Unit 5e is highly restricted in Lake Macquarie, and several areas are highly disturbed and invaded by weeds. This constrains sample plot locations and may help to explain the poor alignments shown with PCTs. PCT 3435 Hunter Coast Lowland Flats Damp Forest was the closest to centroid, but fell above the temperature threshold defined for this PCT. The next closest was PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest, all within environmental thresholds. Floristically, PCT 3435 appears closer to the sampled sites, although there is substantial variation between sites. A review of the characteristic species method within the PCT Tool provided no clearer outcome.

Of the 15 potential best matches, manual assessment of all of these suggests **PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest** to be the best fit and provided 89% of the characteristic species for one of the three plots. PCT 3270 Shoalhaven Lowland Wet Gully Forest also shares similar elements but occurs on the NSW South Coast.

Unit 5e = PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest

Unit 5h: Alluvial Riparian Blackbutt Forest (3 plots)

Alluvial Riparian Blackbutt Forest occurs as narrow bands along the banks of major creeks such as Dora Creek and Cockle Creek, and extends into the Central Coast LGA. Within Lake Macquarie LGA, it has been mapped for just 13 ha. *Eucalyptus pilularis* is characteristic, but it was uncertain if this unit and Unit 123 (Cooranbong Blackbutt Tall Forest) represented the same type. The existing plot within this unit was added to by two new plots near Barnsley and Cooranbong in the current project. A third additional plot, also in Cooranbong, was also sampled from a low spur adjacent to Dora Creek, but it differs in its much drier understorey composition.

All four plots were assessed through the PCT Tool, with the three true riparian plots (MRSC7, QRB41, WLST3) delivering 13 potential valid matches within the upper five of each, most within environmental thresholds. Two PCTs (3230 Central Coast Escarpment Moist Forest; 3248 Northern Blackbutt-Turpentine Shrub Forest) occurred in two of the three plots ranked three and five, but neither of these occupies riparian zones on the coastal plains. A review of the remaining PCT matches suggests that **PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest** to be the best match, although the characteristic *Eucalyptus pilularis* that line the major creeks of Unit 5h is not represented here.

Table 2 Summary of PCT equivalents for nineteen Lake Macquarie mapping units, showing alignment method of match and confidence.

Unit	LMCC Community Name	PCT	Alignment Method	Confidence
5e	Alluvial Bluegum - Spotted Gum Moist Forest	PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest	PCT Tool	poor
5h	Alluvial Riparian Blackbutt Forest	PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest	PCT Tool	poor
15i	Lake Macquarie Ironbark Forest	PCT 4042 Lower North Riverflat Eucalypt-Paperbark Forest	PCT Tool	moderate
30a	Buttonderry Footslopes Forest	PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest	PCT Tool	good
30i	West Wallsend Stringybark Forest	PCT 3432 Hunter Coast Foothills Apple-Ironbark Grassy Forest	PCT Tool	good
31k	Narrabeen Dune Forest	PCT 4122 Cockle Creek Sandflat Scribbly Gum Forest	PCT Tool	moderate
33d	Awabakal Sand Mantled Blackbutt Forest	PCT 3234 Hunter Coast Lowland Spotted Gum Moist Forest	PCT Tool	poor
34c	Coastal Sandplain Dry Heath	PCT 3805 Southern Sandplain Heath	PCT Tool	good
37b	Alluvial Floodplain Woollybutt Forest	PCT 4013 Wyong Paperbark-Woollybutt Swamp Forest	expert assessment	moderate
37g	Swamp Mahogany - Tallowwood Swamp Forest	PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest	PCT Tool	moderate
39	Apple Palm Gully Forest	PCT 3039 Sydney Coastal Lilly Pilly-Palm Gallery Rainforest	PCT Tool	moderate
40a	Phragmites Rushland	PCT 3962 Coastal Floodplain Phragmites Reedland	PCT Tool	good
43f	Forest Redgum – Paperbark Scrub-Forest	PCT 3436 Hunter Coast Sandy Creekflat Low Paperbark Scrub	PCT Tool	poor
44g	Coastal Sand Bottlebrush Wet Heath	PCT 3908 Lower North Sands Wallum Bottlebrush Swamp Heath	PCT Tool	moderate
44l	Munmorah Impeded Sand Sedgeland	PCT 3907 Lower North Sands Swamp Scrub	PCT Tool	moderate
46	Freshwater Wetland Complex	PCT 3975 Southern Lower Floodplain Freshwater Wetland	expert assessment	moderate
51b	Coastal Headland Shrubland	PCT 3793 Hunter Coast Headland Clay Heath	PCT Tool	good
111c	Killingworth Snappy Gum Forest	PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest	PCT Tool	poor
119	Kahibah Snappy Gum Forest	PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest	PCT Tool	poor

Using the characteristic species method, plot MRSC7 supported 100% of PCT 4016 Clarence Floodplain Swamp Oak Forest, plot QRB41 supported 93% of PCT 3242 Lower North Ranges Turpentine Moist Forest, and plot WLST3 support 70% of PCT 3263 Watagan Range Turpentine-Mahogany Grassy Forest, but none of these make sense morphologically.

Unit 5h = PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest

Unit 15i: Lake Macquarie Ironbark Forest (5 plots)

Lake Macquarie Ironbark Forest was previously defined from just a single plot near Nords Wharf, on a narrow-exposed peninsula, and was mapped over only 22 ha within the LGA. Despite this, four new plots were sampled in the Morisset area during the current project, three within the largest mapped remnant off the end of Ironbark Road. These areas were found to differ both structurally and floristically from the existing Nords Wharf plot, yet all occur on residual Narrabeen sediment geology. Of interest in two of these new plots was the presence of the small tree *Acacia concurrens*, an uncommon species in Lake Macquarie where it reaches its southern limit.

Analysis of all five plots in this unit by the PCT Tool found there to be 14 potential PCT matches within the upper five alignments, most within environmental thresholds. Nine of these were represented by a single plot only, one (PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest) matched by two plots, two (PCT 3436 Hunter Coast Sandy Creekflat Low Paperbark Scrub; PCT 4020 Coastal Creekflat Layered Grass-Sedge Swamp Forest) matched by three plots, and a further two (PCT 3260 Sydney Foreshores Shale Forest; PCT 4042 Lower North Riverflat Eucalypt-Paperbark Forest) matched by four plots.

Review of these possibilities found that **PCT 4042 Lower North Riverflat Eucalypt-Paperbark Forest** provides the best match, as it occurs on elevated residual terraces at low elevation, although it does not appear to occur on low sedimentary rises near estuaries.

Unit 15i = PCT 4042 Lower North Riverflat Eucalypt-Paperbark Forest

Unit 30a: Buttonderry Foothills Forest (5 plots)

Buttonderry Foothills Forest was originally defined for the (former) Wyong LGA but does extend into southern Lake Macquarie LGA near Wyee, occupying 660 ha. It forms one of eight forms of the Unit 30 complex, and within Lake Macquarie just two plots defined it. Three new plots were sampled in road and railway reserves around Wyee.

When subjected to the PCT Tool, nine PCTs within threshold were revealed for the upper five matches of all five plots. One of these, PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest provided the best match in all five plots (top match in four of the five), with several other PCTs matching in four (PCT 4122 Cockle Creek Sandflat Scribbly Gum Forest; PCT 3581 Hunter Coast Foothills Apple Forest; PCT3432 Hunter Coast Foothills Apple-Ironbark Grassy Forest) plots, and two (PCT 3435 Hunter Coast Lowland Flats Damp Forest; PCT 3583 Hunter Coast Lowland Scribbly Gum Forest) plots.

On review, **PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest** provides the best match for Unit 30a.

Unit 30a = PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest

Unit 30i: West Wallsend Stringybark Forest (5 plots)

West Wallsend Stringybark Forest forms part of the wider MU30 complex which across the region shows considerable variation, including eight forms within Lake Macquarie LGA. Unit 30i was initially

identified only for the West Wallsend area in the north-east of the LGA, with two existing plots, and occupies 242 ha. Five new plots have now been sampled in this type, allowing for seven to be available for analysis through the PCT Tool.

Such analysis revealed plot matches with 15 PCTs, nearly all with floristic and environmental thresholds. One PCT provided a match across all seven plots (PCT 3432 Hunter Coast Foothills Apple-Ironbark Grassy Forest, the best match at five of the seven), while one (PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest) matched six plots, one (PCT3581 Hunter Coast Foothills Apple Forest) matched four plots, two (PCT 3433 Hunter Coast Foothills Spotted Gum-Ironbark Grassy Forest; PCT 3435 Hunter Coast Lowland Flats Damp Forest) matched three plots, two (PCT 3583 Hunter Coast Lowland Scribbly Gum Forest; PCT 3616 Sydney Hinterland Grey Gum Transition Forest) matched two plots, and eight PCTs represented by a single plot only.

On review, the best match was that present for all seven plots, **PCT 3432 Hunter Coast Foothills Apple-Ironbark Grassy Forest**, although the dominance of stringybark species in the canopy is described as a variation within this PCT, and ironbarks species are predominantly absent within Unit 30i.

Unit 30i = PCT 3432 Hunter Coast Foothills Apple-Ironbark Grassy Forest

Unit 31k: Narrabeen Dune Forest (5 plots)

The highly restricted Narrabeen Dune Forest, occupying just 3 ha in two locations in the Morisset area, is characterised by low sandy dunes of Narrabeen origin, and carrying species more typical of larger sand deposits. Three existing plots defined this type prior to the current sampling program, and a further two were sampled within the Lake Macquarie State Conservation Area. These plots by necessity were in close proximity to each other and one of the existing plots, such is the restricted nature of this unit.

All five plots analysed by the PCT Tool found a range of matching PCTs, most within floristic thresholds (although plot MRS97 had only one). PCT 4122 Cockle Creek Sandflat Scribbly Gum Forest was represented in all five plots (but outside of threshold in MRS97), other matches include four plots (PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest), three plots (PCT 3549 Lower North Sandplain Heathy Forest), two plots (PCT 3230 Central Coast Escarpment Moist Forest; PCT 3545 Coastal Sands Bloodwood Low Forest; PCT 3581 Hunter Coast Foothills Apple Forest; PCT 3583 Hunter Coast Lowland Scribbly Gum Forest; PCT 3634 Quorrobolong Sand Flats Forest), and three PCTs represent by single plots only.

On review, two forms of Unit 31k seem apparent; one dominated by *Eucalyptus haemastoma* (plots MRS97 and MRS98) on these low dune deposits, the other where *Eucalyptus racemosa* (plots CTH22, CTHJ7, SWNJ8) takes on this role. The best match for the first form appears to be PCT 3583 Hunter Coast Lowland Scribbly Gum Forest; however, the low dunal nature is not typical of that PCT. The second form is best matched with **PCT 4122 Cockle Creek Sandflat Scribbly Gum Forest**, although at present that PCT is defined only for Cockle Creek, and all three plots fall outside of its environmental thresholds. Despite this, PCT 4122 provides the best match collectively for Unit 31k.

Unit 31k = PCT 4122 Cockle Creek Sandflat Scribbly Gum Forest

Unit 33d: Awabakal Sand Mantled Blackbutt Forest (3 plots)

Awabakal Sand Mantled Blackbutt Forest, mapped for just 2 ha near Dudley, has been postulated to potentially represent a minor variant of the more widespread Coastal Narrabeen Shrub Forest (Unit 22). Only a single plot from Awabakal Nature Reserve previously defined this unit, but a further two

plots were sampled along the Fernleigh Track west of this reserve. These two plots were floristically different, potentially reflecting different fire histories.

Analysis of these three plots through the PCT Tool revealed the best five matches for each plot to all to be within floristic thresholds, and most within environmental envelopes. **PCT 3234 Hunter Coast Lowland Spotted Gum Moist Forest** matched all three plots (best match in two), while PCT 3176 Sydney Enriched Sandstone Moist Forest, PCT 3230 Central Coast Escarpment Moist Forest, PCT 3248 Northern Blackbutt-Turpentine Shrub Forest, and PCT 3250 Northern Foothills Blackbutt Grassy Forest all matched two plots.

On review, PCT 3234 is the likely best match although *Eucalyptus pilularis*, characteristic in Unit 33d, is not present in this PCT which typically supports high cover of *Corymbia maculata*. Of the remainder, PCT 3176 occurs in enriched sandstone gullies around Sydney, and only occurred as Match 4 or 5 in two plots; PCT 3230 does support *Eucalyptus pilularis* in the canopy but is more representative of slopes and escarpments on the Central Coast; PCT 3248 is described for areas north of Bulahdelah, but only occurred as Match 4 or 5 for two plots; and PCT 3250 is characterised by a grassy ground layer which is frequently burnt, mainly on the North Coast and Central Coast ranges. Although not a good match, PCT 3234 appears to be the best available given all plots met threshold.

Unit 33d = PCT 3234 Hunter Coast Lowland Spotted Gum Moist Forest

Unit 34c: Coastal Sandplain Dry Heath (5 plots)

Coastal Sandplain Dry Heath occurs on shallow sands in the Awabakal Nature Reserve and Munmorah State Conservation Area, where *Banksia aemula* and a range of other shrub species are characteristic. In total, 58 ha have been mapped for the LGA and three plots defined this unit. A further two plots were sampled from Awabakal Nature Reserve under the current sampling program, both in long unburnt areas. One plot supported higher densities of *Leptospermum laevigatum* than might be expected in this type, and may consequently comprise older mine rehabilitation.

The PCT Tool run on these five plots found nine potential PCT matches, although only half of these were within floristic and environmental thresholds.

Two PCTs (PCT 3802 Lower North Sandplain Wallum Heath, 4 out of 5 plots within threshold and best match in 1 plot; PCT 3805 Southern Sandplain Heath, all 5 plots within threshold and best match in 4 of 5 plots) were represented in all five plots, one in four plots (PCT 3800 Bouddi Headland Wallum Heath, mostly outside of threshold), four in two plots (PCT 3545 Coastal Sands Bloodwood Low Forest; PCT 3794 Lower North Coast Headland Clay Heath; PCT 3799 Agnes Banks Woodland; PCT 3801 Far North Sandplain Wallum Heath), and with two PCTs represented by single plots.

On review, the best match appears to be **PCT 3805 Southern Sandplain Heath** due to the higher match of species and better performance of these five plots in the PCT Tool, although there is reportedly a transition between this PCT and PCT 3802 Lower North Sandplain Wallum Heath on the Central Coast, previously considered to be around Norah Head.

Unit 34c = PCT 3805 Southern Sandplain Heath

Unit 37b: Alluvial Floodplain Woollybutt Forest (1 plot)

Woollybutt (*Eucalyptus longifolia*) is a rare species within Lake Macquarie, although it may once have been more widespread in low lying areas near to the lake. Remnant trees are known from Edgeworth, Warners Bay and Eleebana, but nowhere does it occur in structurally and floristically intact vegetation. Inspection of the best available stand of Unit 37b off the end of Thomas Street at Edgeworth found

the area to be in very poor condition (Figure 2), with scattered trees over a dense grassland of exotic species (*Setaria* spp., *Eleusine indica*, etc). Some areas support *Melaleuca linariifolia* and *Melaleuca decora*, but little other native species are present. Sampling a plot in this area to inform the most appropriate PCT would be of little use due to the paucity of native species. Further investigation off the end of Patterson Street parallel to Cockle Creek also failed to locate any more areas suitable for sampling.

The PCT Tool was run on the single existing plot from this Unit and revealed only two matches within floristic and (mostly) environmental thresholds. The best match was for PCT 4021 Coastal Creekline Dry Shrubby Swamp Forest, with a distance to threshold of 0.678, and the second was PCT 3996 Coastal Sand Swamp Mahogany Dry Forest, with a distance to centroid of 0.688.

On review, the best match (although unsubstantiated) is **PCT 4013 Wyong Paperbark-Woollybutt Swamp Forest**, which was not represented in the PCT Tool output. This reasoning follows the allocation within the ENSW classification of plots sampled within more intact remnants of swamp woodland around Porters Creek Wetland within Central Coast LGA, which form the basis of PCT 4013. The alternatives, PCT 4021 Coastal Creekline Dry Shrubby Swamp Forest and PCT 3996 Coastal Sand Swamp Mahogany Dry Forest, occur on alluvial floodplains and coastal sandplains respectively, but these do not fully match the locations of Lake Macquarie stands, nor the dominance of *Eucalyptus longifolia*. Ideally, further plot sampling might clarify PCT alignment, but realistically this is unlikely due to the scarcity of intact remnants available to sample within Lake Macquarie.

Unit 37b = PCT 4013 Wyong Paperbark-Woollybutt Swamp Forest



Figure 2 Remnant Woollybutt (*Eucalyptus longifolia*) forest at Edgeworth, showing dense ground layer of exotic grasses.

Unit 37g: Swamp Mahogany- Tallowwood Swamp Forest (3 plots)

Swamp Mahogany - Tallowwood Swamp Forest has been mapped for a single drainage line near Wyee in southern Lake Macquarie LGA, occupying just 3 ha where it is bisected by the M1 Motorway. It is

characterised by *Eucalyptus robusta* and *Eucalyptus microcorys* in the canopy, with the latter species particularly unusual in this lowland swamp forest landscape. Two new plots were sampled during the current program, providing a total of three for analysis through the PCT Tool. One of these new plots had been formerly cleared as part of motorway construction activities decades earlier but has regenerated reasonably well.

Analysis within the PCT Tool found all potential matches to be floristically and environmentally within thresholds, and two PCTs (PCT 4042 Lower North Riverflat Eucalypt-Paperbark Forest; PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest, best match in 2 of the 3 plots) were represented in all three plots. Three other PCTs (PCT 4020 Coastal Creekflat Layered Grass-Sedge Swamp Forest; PCT 4047 Northern Swamp Mahogany-Bottlebrush Swamp Forest; PCT 4049 South Coast Floodplain Grassy Swamp Forest) were represented in two plots, and three others were represented by single plots.

On review, the best match is considered to be **PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest** both floristically and geomorphologically, despite *Eucalyptus microcorys* not being represented within it.

Unit 37g = PCT 4044 Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest

Unit 39: Apple Palm Gully Forest (5 plots)

Apple Palm Gully Forest is characterised by the palm *Livistona australis* within the canopy and shrub layers and occurs in narrow alluvial gullies in and around the Munmorah State Conservation Area. It has been mapped across just 21 ha of the Wallarah Peninsula in that area, and was defined by two plots. A further three plots have now been sampled under the present project, and all five have been analysed through the PCT Tool.

PCT Tool analysis revealed inconsistent responses for the five sampled plots. Only four of the five plots fell within the floristic threshold for any defined PCT, and all fell within required environmental envelopes. PCT 3074 Hunter Coast Lowland Grey Myrtle Wet Forest and PCT 3134 Illawarra Seacliffs Littoral Rainforest each had three plots within threshold, while **PCT 3039 Sydney Coastal Lilly Pilly-Palm Gallery Rainforest** was represented by two plots. All three of these PCTs were represented in the top five possible matches for four of the five analysed plots.

On review, PCT 3039 was considered the best match for Lake Macquarie data, although this is by no means a clear alignment. Of the others, PCT 3134 has been defined for a specific rainforest type below the Illawarra cliffs, while PCT 3074 supports low abundance of *Livistona australis* and high abundance of *Backhousia myrtifolia*, the opposite of that occurring in Lake Macquarie.

Unit 39 = PCT 3039 Sydney Coastal Lilly Pilly-Palm Gallery Rainforest

Unit 40a: Phragmites Rushland (2 plots)

Phragmites Rushland is a floristically simple vegetation type that has been mapped over 33 ha within the LGA, much of it within man-made dams and other water bodies. No existing floristic plots were previously sampled, but under the current sampling program data from two plots has now been collected. It was found that many areas previously mapped as Phragmites Rushland have transitioned either to *Typha orientalis* reedlands or have become heavily infested with *Lantana camara* and other weeds. The two plots sampled to date are possibly not representative of the larger expanses that can develop around coastal estuaries, but floristically there are few differences.

The PCT Tool found these two plots to be within floristic thresholds and most environmental thresholds for three PCTs: **PCT 3962 Coastal Floodplain Phragmites Reedland** (Match 1 or 2 for both), PCT 3963 Estuarine Reedland (Match 2 for one plot), and PCT 3997 Hunter Coast Sandplain Sedge Paperbark Wetland (Match 1 for one plot).

On review, PCT 3962 provides the best match for Unit 40a, since PCT 3963, although floristically very similar, is described as occupying locations with greater marine exposure, while PCT 3997 is currently defined as occurring within coastal barrier dunes.

Unit 40a = PCT 3962 Coastal Floodplain Phragmites Reedland

Unit 43f: Forest Redgum – Paperbark Scrub-Forest (3 plots)

Forest Redgum – Paperbark Scrub-Forest is one of three closely related paperbark scrub-forests that develop on hard setting alluvial clays around estuaries. A total of only 11 ha has been mapped within Lake Macquarie LGA, and it is unknown how much of this has developed following previous clearing events. Prior to the three plots sampled at Teralba, Morisset and Eraring under the current program, there were no plot data from within the LGA.

Assessment through the PCT Tool found poor alignment and little consistency between the three plots. PCT 3436 Hunter Coast Sandy Creekflat Low Paperbark Scrub was the best represented (3 of 3 plots, but only two within threshold), followed by PCT 4042 Lower North Riverflat Eucalypt-Paperbark Forest with two within threshold plots. A further ten PCTs were represented by single plots, but only four of these were within threshold.

Review of the best matches suggests that **PCT 3436 Hunter Coast Sandy Creekflat Low Paperbark Scrub** is the most appropriate match, given the characteristic dominance of *Melaleuca nodosa*, emergent eucalypts including *Eucalyptus tereticornis*, and presence on low-lying alluvial clay loams. The alternative, PCT 4042 Lower North Riverflat Eucalypt-Paperbark Forest, is more broad-ranging and encompasses a variety of forest types.

Unit 43f = PCT 3436 Hunter Coast Sandy Creekflat Low Paperbark Scrub

Unit 44g: Coastal Sand Bottlebrush Wet Heath (5 plots)

Coastal Sand Bottlebrush Wet Heath has been mapped across 8 ha in the Belmont and Jewells area of eastern Lake Macquarie and has been defined by two existing plots. *Callistemon citrinus* is characteristic in this type, occurring over a dense sedge layer, but it remains unknown how these heaths relate to other similar wet heaths in the region. Three new plots were sampled at Belmont South under the current sampling program.

The PCT Tool run on all five plots found poor matching, with only 6 of 30 potential matches falling within floristic thresholds and approximately half outside of environmental thresholds. Those with at least some plots within thresholds were PCT 3908 Lower North Sands Wallum Bottlebrush Swamp Heath (5 plots, 2 within threshold) and PCT 4007 Northern Sands Paperbark Sedge Low Forest (2 plots within threshold), PCT 3985 Coastal Floodplain Swamp Paperbark Scrub (single plot) and PCT 4000 Northern Estuarine Paperbark Sedge Forest (single plot).

On review, **PCT 3908 Lower North Sands Wallum Bottlebrush Swamp Heath** is the best match for Unit 44g, and potentially represents the 'rare' southern form of this community where *Callistemon pachyphyllus* is replaced by *Callistemon citrinus*. Alternative matches (e.g. PCT 4007) are swamp forests rather than open heaths, or fell outside of floristic and/or environmental thresholds.

Unit 44g = PCT 3908 Lower North Sands Wallum Bottlebrush Swamp Heath

Unit 44l: Munmorah Impeded Sand Sedgeland (3 plots)

Less than 1 ha of Munmorah Impeded Sand Sedgeland has been mapped within Lake Macquarie LGA, at Jewells Swamp. This unit ranges from open sedgeland to wet heath with a dense sedge ground layer, and its relationship with Unit 44g requires further investigation. The single existing plot sampled there has now been increased to three plots following recent sampling. The highly restricted nature of this unit meant that all three plots lie near one another.

Analysis through the PCT Tool revealed four PCTs represented each within two of three plots, but only one of these (PCT 3908 Lower North Sands Wallum Bottlebrush Swamp Heath) was within threshold for both plots. Other PCTs were either within threshold for one of two plots (PCT 3907 Lower North Sands Swamp Scrub; PCT 3923 Sydney Coastal Sandstone Creekline Swamp Heath; PCT 4007 Northern Sands Paperbark Sedge Low Forest), or within threshold and represented by a single plot only (PCT 3906 Northern Lowland Clay Wet Heath; PCT 3921 Coastal Sydney Sand Saw-sedge Wet Shrubland).

Review of all possibilities suggests **PCT 3907 Lower North Sands Swamp Scrub** to comprise the best match for Unit 44l, due to the more diverse shrub layer over a sedge understorey on a remnant sand plain.

Unit 44l = PCT 3907 Lower North Sands Swamp Scrub

Unit 46: Freshwater Wetland Complex (0 plots)

Freshwater wetlands in Lake Macquarie were likely only originally present in the larger alluvial valleys such as around Mandalong and Cooranbong, and in some low-lying parts of other smaller alluvial plains. Wetlands such as this are dynamic, and changing floristic and structural elements occur regularly depending on prevailing weather and associated hydrological flows. Many of the wetlands mapped for Lake Macquarie (61 ha in total) and inspected to gather plot data for this project have now transitioned to different vegetation types. These areas now often support reedlands of *Typha orientalis* and/or *Phragmites australis*, or in agricultural areas monocultures of *Carex appressa* (Figure 3). Wetlands mapped for the lower reaches of Crokers Creek at Redhead are actually monocultures of the exotic Torpedo Grass (*Panicum repens*) and were not sampled (Figure 4). Other difficulties encountered when attempting to sample Unit 46 were that many of the mapped areas are on private lands or were inaccessible due to flooding and high-water levels. No samples of this Unit could therefore be attained.



Figure 3 Area mapped as Freshwater Wetland Complex at Mandalong, showing monoculture of *Carex appressa* with remnant surrounding Cabbage Gum (*Eucalyptus amplifolia*) forest.

As a consequence, PCT allocation has been undertaken manually through review of PCTs within the freshwater wetland alliance. **PCT 3975 Southern Lower Floodplain Freshwater Wetland** has been selected as the best PCT match due to the geomorphological and geographical position of Lake Macquarie wetlands within eastern NSW, and the variable nature of the floristic dominants. Further sampling, both within Lake Macquarie and elsewhere is required to strengthen this alignment.

Unit 46 = PCT 3975 Southern Lower Floodplain Freshwater Wetland



Figure 4 Crokers Creek at Redhead, mapped as Freshwater Wetland Complex, but found to be dominated by the exotic Torpedo Grass (*Panicum repens*).

Unit 51b: Coastal Headland Shrubland (5 plots)

Coastal Headland Shrubland is relatively well defined regionally although within Lake Macquarie sample data has been lacking. An area of 87 ha was mapped for the LGA. The two existing plots have now been raised to five in total, following new data from the Pinny Beach and Catherine Hill Bay area. New plots ranged from regrowth following fire or partial clearing, to a long unburnt location.

The PCT Tool returned only five of twenty-five potential PCT matches within floristics and environmental thresholds across the five plots. PCT 3793 Hunter Coast Headland Clay Heath was the best match in four of the five plots, although one was outside of threshold. PCT 3789 Coastal Headland Clay Heath was also present in all five plots, but only one of these was within threshold. Other potential matches include PCT 3407 Central Headland Grassland in three plots (all outside threshold), PCT 3794 Lower North Coast Headland Clay Heath in three plots (outside threshold), PCT 3796 Northern Lowland Graminoid Clay Heath in two plots (outside threshold), and PCT 3441 Lower Hunter Clay Heath for two plots (outside threshold).

Review of these potential matches suggests the best to be **PCT 3793 Hunter Coast Headland Clay Heath**, although some elements are perhaps a better match with the similar PCT 3789 Coastal Headland Clay Heath.

Unit 51b = PCT 3793 Hunter Coast Headland Clay Heath

Unit 111c: Killingworth Snappy Gum Forest (5 plots)

Killingworth Snappy Gum Forest is characterised by *Eucalyptus racemosa* and has been mapped across 174 ha for the Killingworth area in north-eastern Lake Macquarie, and also around Fassifern. Existing

data (2 plots) from Killingworth was added to in the current sampling program through the addition of three plots from Fassifern (5 plots in total).

Analysis through the PCT Tool found all potential matches to be within floristic thresholds, and most within environmental thresholds. PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest was returned in all five plots, four of them as the best match. Other potential matches include PCT 4122 Cockle Creek Sandflat Scribbly Gum Forest in all five plots, PCT 3583 Hunter Coast Lowland Scribbly Gum Forest in four plots, PCT 3794 Lower North Coast Headland Clay Heath in three plots, PCT 3432 Hunter Coast Foothills Apple-Ironbark Grassy Forest in two plots, and PCT 3573 Northern Lowland Scribbly Gum-Bloodwood Forest also in two plots.

On review, the best available match for Unit 111c is **PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest**, although this is of low confidence given *Eucalyptus racemosa* is noted as a dominant only for the Kincumber area near Gosford. All other potential matches are dominated by other eucalypts, occur well outside of the Lake Macquarie region, or are heathlands rather than open forests. PCT 4122 Cockle Creek Sandflat Scribbly Gum Forest is perhaps the closest floristically; however, that unit occurs on alluvial sands associated with a major creek, and not the hills and slopes typical of Unit 111c.

Unit 111c = PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest

Unit 119: Kahibah Snappy Gum Forest (5 plots)

Closely related to Unit 111c, Kahibah Snappy Gum Forest is also characterised by *Eucalyptus racemosa* but with a different understorey composition. It has been mapped across 129 ha in the north-eastern parts of the LGA. The three existing plots were increased by two to five under the current program.

Output from the PCT Tool revealed all twenty-five potential PCT matches to be within floristic thresholds, and most within environmental thresholds. The most frequent matches were similar to that returned for Unit 111c, with PCT 3581 Hunter Coast Foothills Apple Forest, PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest and PCT 4122 Cockle Creek Sandflat Scribbly Gum Forest all occurring in all five plots. Other matches include PCT 3259 Sydney Coastal Shale-Sandstone Forest, PCT 3583 Hunter Coast Lowland Scribbly Gum Forest, PCT 3432 Hunter Coast Foothills Apple-Ironbark Grassy Forest, and PCT 3592 Sydney Coastal Enriched Sandstone Forest each present in two plots.

On review, like Unit 111c the most appropriate match for Unit 119 is **PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest**. This is not a confident match, however, as the characteristic presence of *Eucalyptus racemosa* in the canopy is not noted for the Lake Macquarie area, yet apart from PCT 4122 Cockle Creek Sandflat Scribbly Gum Forest which occurs on alluvial sands there is no better alternative where this species is dominant.

Unit 119 = PCT 3582 Hunter Coast Lowland Apple-Bloodwood Forest

4.0 Discussion

The nineteen Lake Macquarie mapping units assessed in Stage 2 of the PCT attribution project have delivered the best available matches with PCTs defined in the NSW Plant Community Type classification. With the addition of newly collected plot data, some of these have been relatively straight forward and have allowed selection of the most appropriate PCT when run through the PCT Tool. Other units, however, have been problematic and although the Tool provides a range of plausible matches close to centroids and based on floristic and environmental alignments, review of landscape position and/or geographical location restricts straight adoption.

Alluvial-based communities in particular are quite difficult to provide reasonable matches with PCTs, largely because descriptions for potential matches include a variety of canopy dominants that can characterise a particular PCT in different locations. This makes it difficult to apply to Lake Macquarie units which, in the absence of a full LGA-wide numerical analysis of plot data, are largely driven by canopy dominants in their classification. An example of this is Unit 37g Swamp Mahogany – Tallowwood Swamp Forest, which has been highlighted within Lake Macquarie for one creek line near Wyee where *Eucalyptus microcorys* co-dominates the canopy. This species is typically found on the coastal ranges, not in alluvial drainage lines, but by necessity alignment to PCT results in its inclusion in a wide-ranging alluvial swamp type where *Eucalyptus microcorys* is actually absent.

Coastal forests characterised by *Eucalyptus racemosa* remain difficult to resolve in the NSW classification. Again, several units within Lake Macquarie have been defined on the basis of this species dominating the canopy, yet the best available match is a PCT where this species is absent except for the Kincumber area on the Central Coast. A notable exception to this rule is the narrowly defined PCT 4122 Cockle Creek Sandflat Scribbly Gum Forest which occurs on alluvial sands at Cockle Creek, mirroring the Lake Macquarie Unit 122 (Cockle Creek Dune Forest) upon which it is based.

Freshwater Wetlands within Lake Macquarie have also been problematic to sample to facilitate use of the PCT Tool. Since the original mapping of these areas up to a decade ago, land-use changes in some areas have altered significantly such that they now represent different community types. No new samples within this type could be collected, hence allocation to PCT has been undertaken manually. However, the NSW classification itself does not include a detailed classification of freshwater wetlands, hence the paucity of field data is a regional rather than local issue. Large areas of former and current freshwater wetland areas are also held in private lands, restricting potential sampling opportunities.

Any application of the NSW PCTs to the locally defined mapping units in Lake Macquarie needs to acknowledge the different techniques by which they were defined. While both classifications are based on extensive field data relative to their study areas, the Lake Macquarie intuitive classification is driven by dominant canopy species and landscape position first, and then understorey composition: there has been no numerical classification of full floristics for the entire LGA. By contrast, the NSW PCT classification is driven by full numerical analysis of plot data across all of eastern NSW which in some cases has led to PCTs where a variety of canopy species may be dominant in different areas. This creates problems for field recognition without the need to run a numerical analysis of new plot data. The PCT Tool is an attempt to circumvent the need for such additional data analyses and to guide the selection of PCT matches, which it does well, but there remains a considerable level of expert input still required. At the local level, selecting PCTs where a range of dominant canopy species is plausible makes alignment difficult for the canopy-driven Lake Macquarie units.

5.0 References

Bell, S.A.J. & Driscoll, C. (2016) *Volume 1: Vegetation Mapping Report, Lake Macquarie Local Government Area. Stages 1 - 6*. Unpublished Report to Lake Macquarie City Council. March 2016. Eastcoast Flora Survey.

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