

Vegetation of Werakata National Park, Hunter Valley, New South Wales

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Abstract: Werakata National Park (32° 50 S, 151° 25 E), near Cessnock in the Hunter Valley of New South Wales, conserves 2145 ha of mostly open forest vegetation, which was formerly widespread in the lower Hunter Valley. Six vegetation communities are delineated; Lower Hunter Spotted Gum – Ironbark Forest occupies most of the Park. All communities present are considered to be poorly conserved in the region and Werakata plays a critical role in the protection of these vegetation types. Two vegetation communities, Kurri Sand Swamp Woodland and Hunter Lowlands Redgum Forest, are listed as Endangered Ecological Communities under the NSW *Threatened Species Conservation Act 1995*, while others may warrant future listing. Considerable variation in the floristic composition of the Kurri Sand Swamp Woodland is apparent in the area and the implications are discussed. Populations of four vulnerable plant taxa — *Callistemon linearifolius*, *Eucalyptus parramattensis* subsp. *decadens*, *Eucalyptus glaucina*, *Grevillea parviflora* subsp. *parviflora*, and two rare plant taxa — *Grevillea montana*, *Macrozamia flexuosa*, together with several other regionally significant species occur within Werakata.

Recommendations are made on the conservation of plant taxa and vegetation communities in the Cessnock area, and on general reserve management. It is suggested that further areas be added to the reserve to consolidate and expand upon that which is already contained, particularly in regard to threatened species, and endangered and poorly conserved ecological communities.

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Introduction

Werakata National Park (32° 50 S, 151° 25 E) occupies 2145 ha of dry sclerophyll forest near Cessnock in the lower Hunter Valley of eastern New South Wales. It was gazetted as a conservation reserve in January 2002, as a result of joint Commonwealth and NSW forest reform process, having been previously managed by State Forests of NSW for timber production. Flora survey and mapping of the vegetation of Werakata National Park was undertaken on behalf of the Central Coast – Hunter Range region of the NSW National Parks and Wildlife Service, to examine the vegetation of the area from a management perspective, particularly in relation to fire (Bell 2001a). This paper presents the results of that survey.

Location and environmental setting

The Cessnock district comprises a mixture of urban, agricultural, mining, viticultural and bushland areas, including tracts of public bushland (e.g. Cessnock, Aberdare, Heaton, Pokolbin and Corrabare State Forests; Yengo, Watagans and Werakata National Parks; and Crown reserves). Werakata National Park occupies four distinct parcels of land centred around Cessnock. Previously managed by State Forests of NSW, they remain contiguous with this tenure (Table 1, Fig. 1). Regionally, Werakata NP lies within the largest patch of remnant vegetation on the Hunter Valley floor.

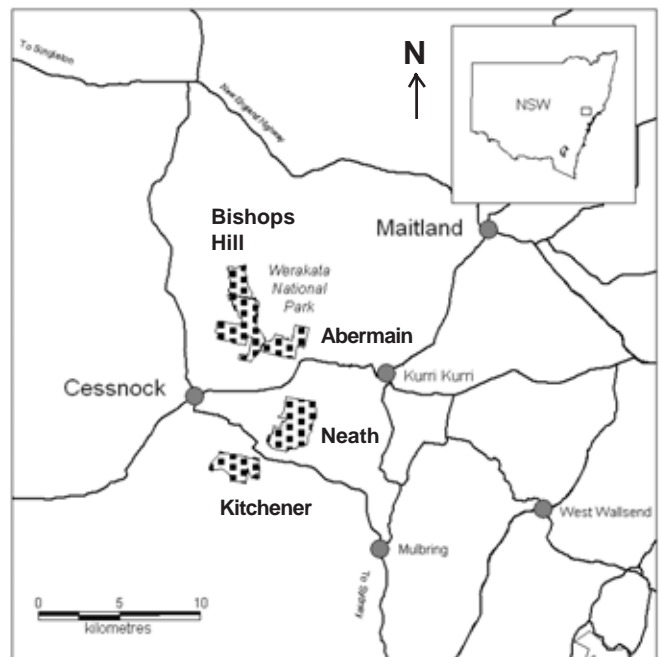


Fig. 1. Location of Werakata National Park

Table 1. Portion name, size and previous land uses, Werakata NP.

Portion size (ha)	Location	Previous tenure part of
Kitchener (361 ha)	between Kitchener & Kearsley, ~5km SE of Cessnock	Aberdare SF
Neath (652 ha)	between Neath & Mt Tomalpin, ~6km E of Cessnock	Aberdare SF
Abermain (316 ha)	between Abermain & Old Maitland Rd, Maitland Rd, ~6km ENE of Cessnock	Aberdare SF
Bishops Hill (816 ha)	between Old Maitland Rd & Lochinvar Rd, ~5km NNE of Cessnock	Cessnock SF

The lower Hunter Valley lies within the Sydney Basin bioregion which stretches from the upper Hunter Valley (Liverpool Range), to Port Stephens on the coast, and south to Batemans Bay. The bioregion covers approximately 36 655 km², and is composed of Mesozoic sandstones and shales; dissected plateaus; forests, woodlands and heaths; skeletal soils, sands and podzolics (Thackway & Cresswell 1995).

Werakata NP falls within a warm temperate climatic zone, with warm wet summers and cool dry winters. Rainfall generally peaks in late summer and early autumn, although local variations due to topography are evident. There is an annual average of 748 mm per year. Temperatures range from a daily average low of 4° C in July, to a high of 30° C in December, January and February (Table 2).

Table 2. Annual average climatic data for Cessnock, 80 m ASL (<10 km from all NP portions).

(Source: Bureau of Meteorology 2001).

Month	Mean rainfall (mm)	Temperature (°C)	
		Minimum	Maximum
January	79	17	30
February	88	17	30
March	78	16	29
April	66	12	25
May	59	8	21
June	60	6	18
July	45	4	18
August	40	5	19
September	42	8	22
October	55	11	25
November	59	14	28
December	76	16	30
Annual	748	–	–

Land use

Following the Comprehensive Regional Assessments (CRAs) of the late 1990s, Regional Forest Agreements (RFAs) were signed by State and Commonwealth governments for major forest areas of New South Wales. During this process, several broad forest ecosystems in the lower Hunter Valley were recognised as being poorly conserved and heavily depleted by past clearing (NPWS 1999). Portions of Cessnock and Aberdare State Forests were consequently transferred to national park estate to create Werakata National Park. Prior to gazettal as national park, Aberdare and Cessnock State Forests were managed for timber production, principally for their ironbarks, mostly *Eucalyptus fibrosa*, and Spotted Gum *Corymbia maculata*. Such timbers were used for mining props in the surrounding coal mines. Aberdare State Forest was originally proclaimed in 1963, with additions made during the 1970s (EJE Group 1995). Prior to this, timber from the forest was used in local underground coal mines and the building industry. The construction of privately owned railway lines for transportation of coal in the early 1900s facilitated this practice. Cessnock State Forest was proclaimed in 1942, and was extended several times during the 1940s and 1950s. Historical artefacts (e.g. railway cuttings & easements, switch houses) of significance apparently still remain in both areas (EJE Group 1995).

Based on known occupation elsewhere in the Hunter Valley, it is likely that this area also provided important homelands for Aboriginal people, though an archeological investigation (Kinhill Engineers 1995) found negligible evidence for occupation by Aboriginal people in Cessnock or Aberdare State Forests. The long history of European disturbance may have disturbed remaining artefacts.

Landforms, geology and soils

Werakata NP comprises gently undulating-to-steep hills with an elevational range of 40 to 110m ASL. Drainage is directed into two Hunter River sub-catchments, Black Creek catchment west of Neath, and Wallis/ Swamp Creek catchment to the east. The highest point in the local area is Mount Tomalpin (201m ASL), but this is not in the Park.

Geologically, Werakata NP lies predominantly within the Branxton Formation (Maitland Group) and Rutherford Formation (Dalwood Group) of the Permian sediments of the Hunter Valley, within the northern section of the Sydney geological basin (Rasmus et al. 1969). Soil landscapes (Kovac 1991; Kovac and Lawrie 1991) mapped within Werakata are; Aberdare (approx. 31% of the study area), Neath (34%), Rothbury (14%) and Branxton (21%) (Table 3). Kovac and Lawrie (1991) describe the soil landscapes as follows:

Aberdare: rolling low hills of Yellow (orange) Podzolic Soils on upper and mid slopes, Red Podzolics and Brown Podzolics on the steeper slopes, and Alluvial Soils (sands) in some drainage lines; **Neath:** gently undulating rises of grey Solodic soils in poorly drained areas associated with exposed coal seams, and Yellow Solodic Soils on the better drained lower slopes; **Rothbury:** undulating and rolling low hills of Red Podzolic Soils on upper slopes, Yellow Podzolics on midslopes, Yellow Solodic Soils and Brown Soloths on lower slopes, and Praire Soils in drainage lines; **Branxton:** undulating low hills and rises with many small creek flats, main soils being Yellow Podzolic Soils on midslopes, Red Podzolic Soils on crests, Yellow Soloths on lower slopes and drainage lines, and Alluvial Soils (sands) occur in some creeks with Siliceous Sands on flats within large valleys.

Table 3. Geology and soil landscapes occurring in Werakata National Park (from Kovac 1991).

Werakata Portion	Geology	Soil landscapes
Kitchener	Branxton Formation (Maitland Group)	Neath; Aberdare
Neath	Branxton Formation (Maitland Group)	Neath; Aberdare
Abermain	Rutherford & Farley Formations (Dalwood Group); Greta Coal Measures	Neath; Aberdare; Rothbury
Bishops Hill	Rutherford & Farley Formations (Dalwood Group)	Branxton; Aberdare; Rothbury

Table 4. Significant flora within a 20 km radius of the centre of Werakata National Park.

TSC = NSW Threatened Species Conservation Act 1995; End = Schedule 1 (Endangered); Vul = Schedule 2 (Vulnerable). See Briggs and Leigh (1996) for explanation of rare status codes.

Species	Status	Location	Source
<i>Eucalyptus castrensis</i>	TSC End	Singleton army base	Hill & Stanberg (2002)
<i>Persoonia pauciflora</i>	TSC End	North Rothbury	Patrick (1999)
<i>Callistemon linearifolius</i>	TSC Vul	Aberdare SF Werakata NP	Binns (1996) Binns (1996)
<i>Eucalyptus fracta</i>	TSC Vul	Pokolbin SF	NPWS Atlas
<i>Eucalyptus parramattensis</i> subsp. <i>decadens</i>	TSC Vul	Mulbring Road, Mulbring Tomalpin area Lomas Lane, Nulkaba	pers. obs. NPWS Atlas pers. obs.
<i>Eucalyptus pumila</i>	TSC Vul	Pokolbin SF	NPWS Atlas
<i>Tetradlea juncea</i>	TSC Vul	Heaton SF Sugarloaf Range	Binns (1996) NPWS Atlas
<i>Acacia</i> sp A	Rare (2RC)	Aberdare SF	Bell & Murray (2001)
<i>Callistemon shiressii</i>	Rare (3RC-)	Bow Wow Creek catchment	Bell & Murray (2001)
<i>Macrozamia flexuosa</i>	Rare (2K)	Bow Wow Creek catchment Neath North Rothbury	Bell & Murray (2001) Bell (1996) Patrick (1999)
<i>Eucalyptus fergusonii</i> subsp. <i>dorsiventralis</i>	Rare (2RC-)	Murrells Rd, Heaton SF Summit Point, Heaton SF Bow Wow Creek catchment	Bell (2000) Bell (2000) Bell & Murray (2001)
<i>Eucalyptus fergusonii</i> subsp. <i>fergusonii</i>	Rare (2RC-)	North Rothbury	Patrick (1999)
<i>Grevillea montana</i>	Rare (2KC-)	Neath Singleton army base	Bell (1996) pers. obs.

Previous botanical studies

Before the current work, there was no comprehensive vegetation survey of Werakata National Park. Binns (1996) completed four plot-based survey sites within the then Aberdare and Cessnock State Forests, as part of the Morisset Forestry District environmental impact assessment. This work involved survey of an area of approximately 112 000 ha incorporating fifteen State Forests. A total of 146 survey plots were undertaken across this area, representing a coverage of approximately 1 plot per 770 ha. Based on the four plots from what is now Werakata, Binns (1996) determined that Grassy Sclerophyll Forest (MORf1: *Eucalyptus punctata*, *Corymbia maculata*, *Allocasuarina torulosa*; & MORf4: *Eucalyptus fibrosa*, *Corymbia maculata*) dominated the reserve.

The Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS) undertook a survey, classification and mapping project for the Cessnock, Maitland, Newcastle, Lake Macquarie, Port Stephens, Wyong and Gosford LGAs (NPWS (2000). This study attempted to define and map all vegetation within a 563 000 ha area, and included Werakata. Vegetation communities determined by NPWS (2000) to be present comprised Central Hunter Riparian Forest (Unit 13), Lower Hunter Spotted Gum–Ironbark Forest (Unit 17), Hunter Lowlands Redgum Forest (Unit 19), and Kurri Sand Swamp Woodland (Unit 35).

Bell and Murray (2001) examined the ecological significance of the Bow Wow Creek catchment in the Quorrobolong Valley,

approximately 4km south-east of Werakata. This study provides useful distributional information on significant species, and identified a rainfall gradient along the Broken Back Range which is reflected in the regional vegetation.

Significant plant species in the Cessnock LGA were documented in Fallding and Bell (1996), and more recently in Murray et al. (2001). These are based on the NPWS Wildlife Atlas database, augmented with unpublished and personal records, and provide background information on those species potentially occurring in Werakata. Of particular interest is the recently discovered and highly endangered *Persoonia pauciflora*, which occurs within approximately 5 km of the park in similar habitat to that found in Werakata (Weston 1999). Table 4 summarises significant plant species previously known from within approximately 20 km of Werakata. Other regionally significant flora within this area include disjunct distributions of *Eucalyptus longifolia* and *Eucalyptus racemosa* along Sandy Creek Road (Bell & Murray 2001) and *Eucalyptus squamosa* in part of Aberdare State Forest (pers. obs.).

Methods

Survey of Werakata NP was structured so that new data could be incorporated with the large amount of existing regional data already available (e.g. NPWS 2000). Methods followed standard techniques so that re-analysis of all regional data, including that from Werakata, could be undertaken in the future. During the present study, funding was made available for 15–20 new sites to be surveyed.

Aerial photographic interpretation

Stereoscopic colour aerial photographs (Cessnock 1:25 000 scale 1994) were used to map broad vegetation patterns within Werakata. Photopatterns and visible trails were transferred onto a map overlay for survey site location and ground truthing. Broad structural vegetation types identified included Open Forest, Scrub, Swamp Forest and Cleared areas.

Site stratification

The selection of new field survey sites involved consideration of major environmental variables (as per Wilson et al. 1997). As there was little variation in topography and aspect throughout the reserve, sites were originally determined within a *soil landscape-broad vegetation* stratification, such that all possible combinations of these variables were sampled (Table 5). Due to the small size of the reserve relative to the number of *soil landscape-broad vegetation* strata (three broad vegetation classes by four soil landscapes = 12 strata), and the limited funding available, the location of sites was only broadly based on this structure. The final location of survey sites relied heavily on broad vegetation patterns observed through aerial photographic interpretation, but with reference to soil landscape distribution.

The number of replicates within each stratification class directly reflected the extent to which that class was represented within the reserve. Areas subjected to recent fire (generally <3 years) were avoided as far as possible. At the time of survey (January 2001), fire occurred in part of the reserve near Abermain, and hence only canopy dominants were evident in this area.

Table 5. Stratification of sampling sites and % within Werakata. Total area of vegetation, 2052 ha (excluding 93 ha cleared).

	Landscape broad vegetation			Total area ha (100%)
	Open-forest ha (87%)	Swamp Forest ha (5%)	Scrub ha (8%)	
Neath	664 (32%)	70 (3%)	83 (4%)	817 (39%)
Aberdare	519 (25%)	2 (0%)	2 (0%)	523 (25%)
Branxton	358 (1%)	20 (1%)	66 (3%)	444 (22%)
Rothbury	235 (12%)	9 (0%)	24 (1%)	268 (13%)

Floristic survey

Survey methods followed Wilson et al. (1997). Within each 0.04 ha survey site, all vascular plant species present were recorded and given a cover abundance rating, based on a modified Braun-Blanquet scale (see Walker & Hopkins 1990). Physical attributes (such as vegetation structure, soil type, elevation, slope, aspect, physiographical position) were recorded, and photographs taken for later reference. Previous familiarity with the vegetation assisted the identification of most species that were not flowering or fruiting during this time. Despite this, a small number of species could not be confidently assigned to subspecies or varietal rank with certainty. Voucher specimens of unknown or significant status were collected for later identification or

lodgement with the National Herbarium of New South Wales. Plant taxonomy followed that of Harden (1990–93; 2002) and Harden and Murray (2000), together with subsequent taxon-specific revisions which have been generally accepted by the National Herbarium of New South Wales.

Field survey was carried out over three months between December 2000 and February 2001. Seventeen full floristic plots were completed during the survey, and combined with the existing plot data totalled 21 sites. While moving between plots on foot and in 4WD vehicle, the distributions of vegetation community types were noted, and searches for significant plant species were made. Cropper (1993) and Keith (2000) indicate that the detection of rare or threatened plant species is often best achieved through general reconnaissance traverses. Levels of disturbance, weed invasion and fire history of the area could also be assessed.

Data analysis and vegetation classification

Cluster analysis (UPGMA using both the Bray-Curtis and Kulczynski coefficients of dissimilarity, and default settings) were performed on site data using the PATN Statistical Analysis Package (Belbin 1995a, 1995b), following similar works elsewhere (eg: Keith & Bedward 1999; Griffith et al. 2000). Belbin (1991) provides detailed discussion on how ecological data are analysed using this program. A review of taxonomy was undertaken prior to analysis to ensure consistent nomenclature was applied to the entire dataset, including existing State Forest data.

Vegetation mapping

Floristic communities for the whole of Werakata were mapped using a combination of broad vegetation types, cluster analysis of survey data, knowledge of the ground situation and re-examination of aerial photographs. The small size of the reserve and the high number of tracks and trails present facilitated detailed ground truthing of community boundaries. During this process, refinements to the regional mapping of NPWS (2000) were also undertaken.

Results

Floristic survey

A total of over 190 plant taxa were recorded during the survey (Appendix 1). Cluster analysis of vegetation data (21 sites) using the Bray-Curtis coefficient and the default PATN settings revealed the presence of six groups of sites at the 0.9 level of dissimilarity, upon which five vegetation communities are based (Figure 2). One additional community of very restricted distribution was not sampled, and hence does not occur in the dendrogram. Apparent discrepancies in parts of the dendrogram can be explained by disturbance history of the component sites, where *Melaleuca nodosa* becomes an important and dominant component in the understorey.

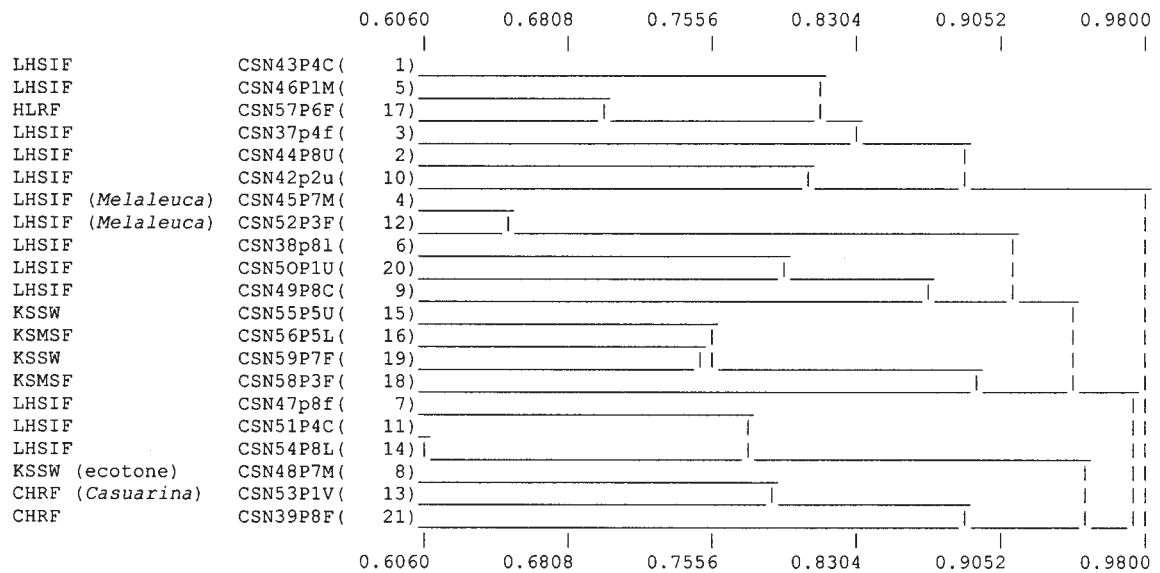


Fig. 2. Dendrogram of survey sites. LHSIF = Lower Hunter Spotted Gum-Ironbark Forest (Unit 1); CHRF = Central Hunter Riparian Forest (Unit 2); HLRF = Hunter Lowlands Redgum Forest (Unit 3); KSSW = Kurri Sand Swamp Woodland (Unit 4); KSMSF = Kurri Sand Melaleuca Scrub-Forest (Unit 5).

As far as possible the nomenclature of NPWS (2000) has been applied to the six vegetation communities delineated. Appendix 2 summarises the main features of the six vegetation communities identified. Patterns in vegetation distribution throughout Werakata are illustrated (Fig. 3), based on the original 1:25 000 scale mapping.

Significant taxa

Although small in area, Werakata National Park fills an important role in the conservation of vegetation communities and flora species that are poorly reserved throughout the lower Hunter Valley. The current study identified over 190 plant taxa and six vegetation communities. Werakata is part of a regional corridor linking sizeable areas of bushland around Cessnock (including State Forests), south to the Watagan Range (Bell & Murray 2001).

Species of conservation significance recorded within Werakata include four listed as vulnerable under the TSC Act (*Callistemon linearifolius*, *Grevillea parviflora* subsp. *parviflora*, *Eucalyptus glaucina*, *Eucalyptus parramattensis* subsp. *decadens*), two rare (*Grevillea montana*, *Macrozamia flexuosa*) and several species of regional significance (Table 6). Regional significance is based on the listing of species maintained by the Rare Plants Subcommittee of the Hunter Region Botanic Gardens. Specimens of all significant species have been lodged at the National Herbarium of New South Wales.

Callistemon linearifolius

Occurs in dry sclerophyll forest on the coast and adjacent ranges chiefly from the Georges River south of Sydney to the Hawkesbury River (Spencer & Lumley 2002). Binns (1996) recorded *Callistemon linearifolius* from four locations

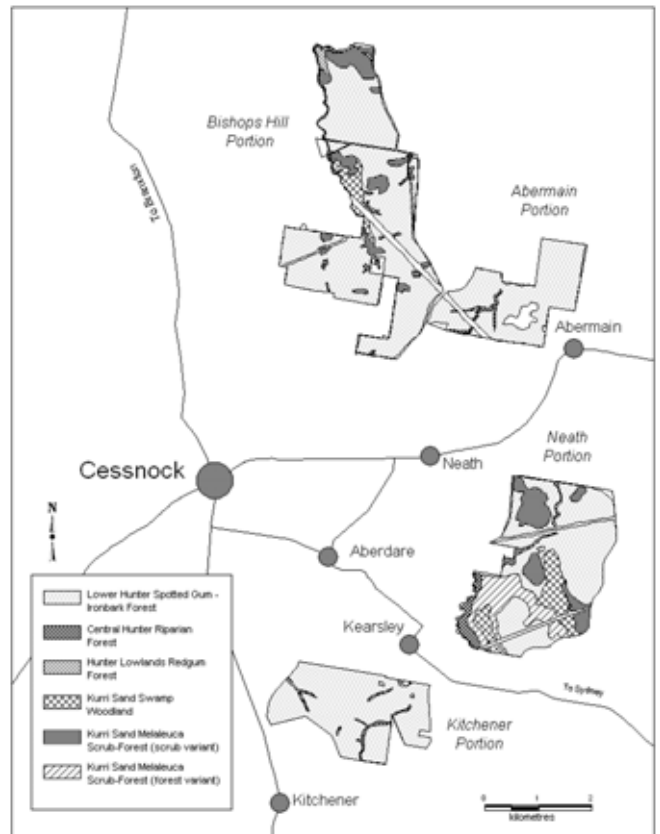


Fig. 3. Patterns in vegetation distribution in Werakata NP.

in Aberdare and Cessnock State Forests, two of which lie within Werakata. This species was also recorded in the Neath portion during the current survey, within the understorey of Lower Hunter Spotted Gum-Ironbark Forest [Unit 1]. Both existing and new records of *Callistemon linearifolius*

Table 6. Significant plant taxa, Werakata National Park.

Species	Significance	Occurrence in Werakata NP
<i>Callistemon linearifolius</i>	TSC Vul	Neath & Kitchener portions
<i>Grevillea parviflora</i> subsp. <i>parviflora</i>	TSC Vul	Kitchener portion
<i>Eucalyptus glaucina</i>	TSC Vul	north-western Bishops Hill portion
<i>Eucalyptus parramattensis</i> subsp. <i>decadens</i>	TSC Vul	Bishops Hill & Neath portions
<i>Grevillea montana</i>	Rare 2KC-	all portions
<i>Macrozamia flexuosa</i>	Rare 2K	all portions
<i>Acacia deanei</i> subsp. <i>deanei</i>	range extension onto NC	Neath portion
<i>Acacia linifolia</i>	uncommon on Permian Sediments	Bishops Hill portion
<i>Angophora bakeri</i>	restricted distribution	Kitchener and Bishops Hill portions
<i>Babingtonia pluriflora</i>	near Sth limit of distribution	Swamp Creek, Neath portion
<i>Corymbia eximia</i>	Nth limit of distribution	Kitchener portion, mostly on exposed crests
<i>Dianella prunina</i>	uncommon	Kitchener portion
<i>Eucalyptus canaliculata</i>	near Sth limit of distribution	Deadmans Creek, Bishops Hill portion
<i>Eucalyptus agglomerata</i>	atypical form	most areas
<i>Lomandra cylindrica</i>	northern limit of distribution	throughout the park

confirm that this species occurs within the North Coast botanical subdivision, and probably represent the known northern limit of the species. This species is currently listed as vulnerable (Schedule 2) on the NSW *Threatened Species Conservation Act 1995*, and carries a conservation risk code of 2RCi (Briggs & Leigh 1996).

Grevillea parviflora subsp. *parviflora*

A low-spreading, dense to erect open shrub 0.3–1 m tall, occurring from north-western Sydney to Cordeaux-Appin area, in moist heath or woodland on clay soils (Olde & Marriot 1995; McGillivray 2000). Within Werakata, this subspecies is locally common in the southern portion near Kitchener, where it occurs in the understorey of Lower Hunter Spotted Gum–Ironbark Forest [Unit 1] with *Grevillea montana*. No other locations were found in the reserve, although it is possible that this taxon occurs in small, localised populations throughout the area. Both *Grevillea parviflora* subsp. *parviflora* and *Grevillea parviflora* subsp. *supplicans* have been listed on the NSW *Threatened Species Conservation Act 1995*, the former as vulnerable (Schedule 2). *Grevillea parviflora* subsp. *parviflora* was previously not known from any conservation reserve in the Hunter Valley area, nor from elsewhere within its known distribution (NSW Scientific Committee 1998).

Eucalyptus glaucina

A tree to 30 m in height, locally frequent but sporadic in grassy woodland on deep, moderately fertile and well-watered soils near Casino and from Taree to Broke (Hill 2002). A small population of *Eucalyptus glaucina* is present in the north-western corner of the Bishops Hill portion of Werakata, where it occurs in Hunter Lowlands Redgum Forest [Unit 3] with *Eucalyptus tereticornis*, *Eucalyptus amplifolia* subsp. *amplifolia* and occasionally *Eucalyptus moluccana*. This site appears to have been grazed in the past, leaving an open grassy

understorey with only scattered shrubs in parts. On the northern side of Deadmans Creek (outside the reserve), the understorey appears less disturbed, and it is possible that further specimens of *Eucalyptus glaucina* occur there. Binns (1996) did not record *Eucalyptus glaucina* from anywhere within the Morisset forestry district, but suggested that if it did occur it would most likely be on the lower slopes or valley flats of Pokolbin State Forest (~15 km to the west). This species is currently listed as vulnerable (Schedule 2) on the NSW *Threatened Species Conservation Act 1995*, and is also listed as 3VCa by Briggs and Leigh (1996). Reserved populations of *Eucalyptus glaucina* are known only from Selection Flat Flora Reserve on the NSW North Coast, where more than 1000 individuals are thought to occur (Briggs & Leigh 1996).

Eucalyptus parramattensis subsp. *decadens*

A small, smooth barked tree, locally frequent in dry sclerophyll woodland on sandy soils in low, often wet sites at Tomago and Kurri (Hill 2002). Within Werakata *Eucalyptus parramattensis* subsp. *decadens* has a limited distribution mainly in association with the Neath soil landscape and occurs in the Kurri Sand Swamp Woodland [Unit 4] and nearby areas. Widely scattered individuals also occur in the Kurri Sand Melaleuca Scrub-forest [Unit 5], particularly in the zone of integration between these two communities. The vast majority of the Kurri population of this subspecies occurs outside Werakata. *Eucalyptus parramattensis* subsp. *decadens* is currently listed as vulnerable on Schedule 2 of the NSW *Threatened Species Conservation Act 1995*, and apart from the Werakata NP populations, there are no other occurrences within dedicated conservation reserve (Murray et al. 2001). Extensive populations of this subspecies do occur on the Tomago Sandbeds north of Newcastle, a protected area managed by the Department of Land and Water Conservation for emergency water supplies to the urban areas of Newcastle (Bell & Fallding 2002.).

Grevillea montana

A low shrub restricted to the southern rim of the Hunter Valley from Denman to Kurri Kurri (Makinson 2002; Olde & Marriott 1994). Binns (1996) indicated that this species occurs in both Cessnock and Aberdare State Forests, although there is no indication of population sizes at either location. During the current survey, *Grevillea montana* was found to be abundant in the Kitchener portion of the reserve, scattered in the Neath portion, abundant in the southern section of the Abermain portion, and locally abundant in the Bishops Hill portion. In most cases, the favoured habitat appears to be the sandy clay loams supporting the Lower Hunter Spotted Gum-Ironbark Forest [Unit 1], although it also occurs in the Kurri Sand Swamp Woodland [Unit 4]. This species is currently listed as a rare species by Briggs and Leigh (1996), with a conservation code of 2KC-. In recent years, survey work in national parks and other protected areas (e.g. Wollemi NP, Yengo NP, Myambat Logistics Company, Singleton Military Area) has revealed substantial populations which suggest the revision of this code to 2RCa (Bell 2001b).

Macrozamia flexuosa

A cycad occurring generally from Bulahdelah to Lake Macquarie (Hill 1998). It is distributed widely throughout Werakata, particularly in the southern portions where it often occurs with *Macrozamia reducta*. Sizable populations also exist in the southern section of the Bishops Hill portion. Habitat preference is generally tied to the Lower Hunter Spotted Gum – Ironbark Forest [Unit 1], tending to predominate more on conglomerate-derived soils. *Macrozamia flexuosa* is a rare species currently listed with a conservation code of 2K (Briggs & Leigh 1996). Reserved populations are known from Glenrock SRA (Bell 1998a), Lake Macquarie SRA and Pulbah Island NR (Bell 1998b), and within Council reserves in Lake Macquarie LGA (Bell & Helman in prog.).

Significant vegetation types

All six vegetation communities present within Werakata are considered to be poorly conserved in the region. Two are currently listed as Endangered Ecological Communities under the NSW *Threatened Species Conservation Act 1995*, while one community potentially qualifies for listing due to declines in distribution. The remaining three communities are considered significant at the local and regional level, and may warrant listing when further information becomes available.

Kurri Sand Swamp Woodland [Unit 4]

Kurri Sand Swamp Woodland (NPWS 2000) is listed as an Endangered Ecological Community (EEC) under the TSC Act, and is broadly consistent with some of the vegetation present in Werakata. However, there appear to be characteristic differences in the dominant and component species. As an example of these differences, the final determination for the Kurri Sand Swamp Woodland includes canopy species such as *Eucalyptus parramattensis* subsp. *decadens*, *Angophora*

bakeri, and occasionally *Eucalyptus signata* and *Eucalyptus sparsifolia*. In contrast, canopy species dominating in Unit 4 include *Angophora bakeri*, *Eucalyptus resinifera* subsp. *resinifera*, and *Eucalyptus agglomerata*, with *Eucalyptus parramattensis* subsp. *decadens* and *Corymbia gummifera* occasionally present. In addition, *Eucalyptus resinifera* subsp. *resinifera* and *Corymbia gummifera* are not included in the final determination of the Kurri Sand Swamp Woodland. Despite this, the overall description of the community, particularly its biophysical components, is consistent with the determination. Approximately 70 ha of this community have been mapped for Werakata.

The Kurri Sands Swamp Woodland and its variations also show strong affinities to vegetation on parts of the Cumberland Plain in western Sydney. Tozer (2003) describes and maps the natural vegetation of that area, and identifies four communities occurring on two different deposits of Tertiary alluvium. The distribution of these four communities is reportedly related to the extent of exposure of soils from three depositional phases, and local drainage conditions. Consequently, vegetation dominated by ironbarks, Castlereagh Ironbark Forest, occurs on soils with high clay content, while more sandy soils support Scribbly Gum, Castlereagh Scribbly Gum Woodland. Typically, soils with high clay content underlie sandy soil but tend to be exposed through erosion around the edges of deposits. Poorly-drained depressions support a swamp woodland, Castlereagh Swamp Woodland, while shallow deposits of Tertiary alluvium over shale soils, or localised concentrations of iron-indurated gravels, support a transitional forest, Shale Gravel Transition Forest. A fifth community, with a sparse canopy and a dense understorey of *Melaleuca nodosa*, Cooks River Clay Plain Scrub Forest, was included as a sub-unit of the Castlereagh Ironbark Forest.

When compared to the vegetation in the Kurri-Cessnock area, there are strong similarities evident. In particular, information available to date (both from work in Werakata and elsewhere) suggests that the Kurri Sands Swamp Woodland (in the broadest sense) would perhaps include a sand-based component characterised by Scribbly Gums (*Eucalyptus signata* and/or *E. racemosa*) and *Angophora bakeri*; a clay-based forest dominated by ironbarks; a clay-based scrub-forest dominated by *Melaleuca nodosa* (Unit 5: Kurri Sand Melaleuca Scrub-Forest); a drainage depression community where *Eucalyptus parramattensis* subsp. *decadens* is prevalent; and possibly a transitional forest where *Eucalyptus resinifera*, *Eucalyptus agglomerata* (atypical form) and *Angophora bakeri* occur (Unit 4: Kurri Sand Swamp Woodland). Extensive survey and analysis of the Kurri Sands proper is required to better understand these floristic relationships.

Hunter Lowlands Redgum Forest [Unit 3]

Hunter Lowlands Redgum Forest was identified as a regionally significant vegetation community by NPWS (2000), and has since been listed as an Endangered

Ecological Community under the NSW *TSC Act*. A reduction in area of approximately 73 % has been estimated by NPWS (2000) for this community since European occupation.

Within Werakata, this community is restricted to the far north-western corner of the Bishops Hill portion, where it occupies an area of approximately 7 ha. Although NPWS (2000) map the Hunter Lowlands Redgum Forest for several areas throughout Werakata, in reality this community is restricted to the one patch. The occurrence in Werakata is the only stand within a conservation reserve in the Hunter region, and consequently there is an urgent need to secure further reservation of this community elsewhere in the region. In addition, the stand in Werakata has added significance due to the presence of *Eucalyptus glaucina*, a species listed as vulnerable on the NSW *TSC Act 1995*.

Lower Hunter Spotted Gum–Ironbark Forest (Unit 1)

The Lower Hunter Spotted Gum–Ironbark Forest represents a vegetation type that was formerly quite widespread on the floor of the Hunter Valley (NPWS 2000). Forests between Beresfield and Cessnock represent the core of its distribution, although much of this occurs in State Forest and has been managed for timber production for many years. NPWS (2000) have mapped an extant distribution of 27000 ha, which they estimate represents a reduction of 59 % of its former range.

Werakata supports a sizeable component of the conserved portion of this vegetation type for the region. Approximately 1600 ha have been mapped from the current study, while NPWS (2000) report 1873 ha from all reserves. Consequently, Werakata plays a critical role in the regional conservation of this vegetation community.

Kurri Sand Melaleuca Scrub–Forest [Unit 5]

Small localised areas in close proximity to the Kurri Sand Swamp Woodland [Unit 4] support a dense *Melaleuca* scrub with occasional stunted eucalypt emergents, described in this paper as Kurri Sand Melaleuca Scrub–Forest [Unit 5]. This vegetation type occurs on clay pans probably associated with the sandy deposits that generally typify the Kurri Sands Swamp Woodland. It was not identified or mapped as distinct by NPWS (2000) in their regional vegetation study. This community differs substantially in floristic composition from the *TSC Act*-defined Kurri Sands Swamp Woodland [Unit 4], and characteristically comprises a very dense layer of (mostly) *Melaleuca nodosa* and *Melaleuca decora*, with low emergents of *Eucalyptus fibrosa* and *Eucalyptus parramattensis* subsp. *decadens*. Other areas form more of a forest structure where emergents of *Eucalyptus agglomerata* (atypical form) and *Eucalyptus resinifera* subsp. *resinifera* also occur, but still with the high abundance of *Melaleuca* species. These latter areas possibly represent transitional areas between this community and the Lower Hunter Spotted Gum–Ironbark Forest (Unit 1).

Within Werakata, this vegetation is restricted to localised patches associated with the Kurri Sand Swamp Woodland. It

is not known how much of this vegetation type has been included in the mapping of Kurri Sands Swamp Woodland by NPWS (2000), but it is highly likely that it is poorly conserved in the region. As with the Kurri Sand Swamp Woodland [Unit 4], further survey and analysis of plot data is required from throughout the general Kurri Sands area to clarify floristic relationships. Additional areas are also desirable for addition to the reserve.

Central Hunter Riparian Forest [Unit 3]

Most major streams within Werakata support a vegetation type that is most closely identifiable with the Central Hunter Riparian Forest (NPWS 2000). However, there are several floristic differences worthy of mention. Along parts of Swamp Creek, such as in the Neath portion of the reserve, a deeply incised channel supports fringing *Casuarina glauca* with *Melaleuca styphelioides* and *Melaleuca linariifolia*, over an understorey which includes *Baumea juncea* and *Phragmites australis*. The presence of *Casuarina* and *Baumea* here suggests a strong saline influence not evident elsewhere in the reserve.

Other drainage lines (particularly Deadmans Creek) support *Eucalyptus canaliculata* and intergrades of this species with *Eucalyptus punctata*. The latter occurs sporadically in the open forests on slopes and ridges, but rarely occurs along creeklines. The presence of *Eucalyptus canaliculata* is also of some interest, as it is likely that populations here approach the southern distributional limit of the species (Hill 2002). According to Hill (2002), populations in the Maitland – Singleton – Cessnock area are intermediate between *Eucalyptus canaliculata* and *Eucalyptus punctata*.

Discussion

Comparison with REMS vegetation mapping

The finer scale of investigation possible in Werakata has greatly improved upon the regional LHCCREMS framework (NPWS 2000). The following points summarise these improvements:

- the Neath portion of the reserve is far more complex than the NPWS (2000) mapping indicates, which shows extensive areas of Lower Hunter Spotted Gum Ironbark Forest with a small incursion of the Kurri Sand Swamp Woodland in the north-east;
- the Bishops Hill portion is shown by NPWS (2000) to support considerably more of the Kurri Sands Swamp Woodland than is evident on the ground;
- small areas of heath and scrub have been omitted from the NPWS (2000) mapping, probably an artefact of the API process employed;
- in general, the distribution of Hunter Lowlands Redgum Forest throughout most of the reserve as shown in the NPWS (2000) mapping does not correspond with the ground situation, and this community is in fact restricted to the far north-western corner of the Bishops Hill portion.

The main consequences of this revised Werakata mapping are that there is considerably less Hunter Lowlands Redgum Forest present within conservation reserves than originally depicted by NPWS (2000), and the distribution of the *TSC Act*-defined Kurri Sands Swamp Woodland as mapped by NPWS (2000) misrepresents both the location and extent of this community within the reserve. Other communities likely to be restricted in distribution were not delineated by NPWS (2000); their full extent in the region is currently unknown.

Management issues

Fire has traditionally been a common feature of the bushland around Cessnock since European settlement, particularly in the last 100 years, and the current floristic compositions of the vegetation communities present are likely to reflect this history. Arson has been a continuing problem for many years due to the close proximity of urban Cessnock and it is probable that much of the area has been subjected to fire on average every 2–3 years. Fires occurred in several areas around Cessnock, including Werakata, during summer 2000–2001.

As a result of past forestry activities much of the vegetation of Werakata consists of regrowth trees. Public access was not restricted, and illegal rubbish dumping, trail bike riding and car dumping have occurred unabated for many years. Numerous trails and tracks are evident through Werakata; rationalisation of these should be undertaken to assist in the control of rubbish dumping, arson and weed dispersal. Trail-bike riding, a common occurrence in the Park, promotes erosion to fire trails and creates a generally inhospitable and noisy environment. Rubbish dumping and localised weed invasion from garden refuse is problematic in some areas. The high edge-to-area ratio for the reserve exacerbates these problems.

Recommendations

Considering the extent and distribution of vegetation communities and significant plant species present within the current boundaries of Werakata National Park, it is recommended that:

- investigation be carried out in areas around Cessnock for representative examples of the endangered Kurri Sand Swamp Woodland to add to the reserve network. These areas should encompass the variations in the community identified during this study and any others that become apparent. A wider survey of the entire Kurri Sands vegetation is warranted in order to more completely document the natural variation within this community.
- the poor conservation status of all other vegetation communities present within Werakata suggest that additional reservation is similarly required, as the reserve represents the only conservation reserve in the region supporting examples of most of these.
- additional reservation of the vulnerable *Eucalyptus parramattensis* subsp. *decadens* from around Cessnock be pursued, as current protection is unlikely to conserve more than 100 plants.

- more broadly, there is an opportunity for a comparative survey of all similar sand-based vegetation in the Sydney Basin, in order to synthesise and better understand the floristic relationships occurring within them.

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Appendix 1. Species list – Werakata National Park

Plant taxa recorded from Werakata NP during 2000–2001, based on plot data. Species marked “*” represent exotic or introduced taxa. Vegetation communities have been listed for each taxa, as follows:

- 1 = Lower Hunter Spotted Gum – Ironbark Forest
- 2 = Central Hunter Riparian Forest
- 3 = Hunter Lowlands Redgum Forest
- 4 = Kurri Sand Swamp Woodland
- 5 = Kurri Sand Melaleuca Scrub-Forest
- 6 = Riparian Melaleuca Thicket

Ferns

ADIANTACEAE

Adiantum aethiopicum 2

DENNSTAEDTIACEAE

Pteridium esculentum 1 2 3 4

SINOPTERIDACEAE		FABACEAE: Faboideae	
<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>	1 2 3 4 5	<i>Bossiaea heterophylla</i>	4
Cycads		<i>Bossiaea obcordata</i>	4
ZAMIACEAE		<i>Daviesia genistifolia</i>	1 4 5
<i>Macrozamia flexuosa</i>	1 2 5	<i>Daviesia ulicifolia</i>	1 4
<i>Macrozamia reducta</i>	1	<i>Desmodium varians</i>	2 3
Dicotyledons		<i>Dillwynia retorta</i>	4 5
ACANTHACEAE		<i>Glycine clandestina</i>	1 2 3 4 5
<i>Pseuderanthemum variabile</i>	1 2 3 4 5	<i>Glycine microphylla</i>	2 3
APIACEAE		<i>Gompholobium uncinatum</i>	1 4 5
<i>Hydrocotyle peduncularis</i>	2 3 6	<i>Hardenbergia violacea</i>	1 2 3 4 5
<i>Platysace ericoides</i>	4	<i>Hovea linearis</i>	4 5
<i>Platysace lanceolata</i>	2 4 5	<i>Mirbelia pungens</i>	4
ARALIACEAE		<i>Mirbelia rubiifolia</i>	4 5
<i>Astrotricha obovata</i>	1 4 5	<i>Oxylobium pulteneae</i>	1 4 5
ASTERACEAE		<i>Podolobium ilicifolium</i>	1 4
<i>Brachycome multifida</i> var. <i>multifida</i>	1 3	<i>Pulteneae cunninghamii</i>	1
<i>Chrysocephalum semipapposum</i>	1 3	<i>Pulteneae villosa</i>	2 3
<i>Euchiton (Gnaphalium) sphaericum</i> *	1 2 3	FABACEAE: Mimosoideae	
<i>Helichrysum scorpioides</i>	1	<i>Acacia brownii</i>	1 4 5
<i>Olearia ramulosa</i>	1	<i>Acacia buxifolia</i> subsp. <i>buxifolia</i>	1 4 5
<i>Ozothamnus diosmifolius</i>	1 4 5	<i>Acacia deanei</i> subsp. <i>deanei</i>	2 3
<i>Senecio madagascariensis</i> *	1 2 3	<i>Acacia elongata</i> var. <i>elongata</i>	4 5
<i>Taraxacum officinale</i> *	1 2 3	<i>Acacia falcata</i>	1 5
<i>Vernonia cinerea</i> var. <i>cinerea</i>	1 2 3	<i>Acacia irrorata</i> subsp. <i>irrorata</i>	1 5
CAMPANULACEAE		<i>Acacia linifolia</i>	1 4
<i>Wahlenbergia communis</i>	1 4 5	<i>Acacia longifolia</i>	1 2 3
<i>Wahlenbergia gracilis</i>	1 4 5	<i>Acacia ulicifolia</i>	1 4 5
CASUARINACEAE		GOODENIACEAE	
<i>Casuarina glauca</i>	2	<i>Dampiera stricta</i>	4
CELASTRACEAE		<i>Goodenia heterophylla</i> subsp. <i>heterophylla</i>	1 4 5
<i>Maytenus silvestris</i>	1 3 4	<i>Goodenia rotundifolia</i>	1 4 5
CONVOLVULACEAE		HALORAGACEAE	
<i>Dichondra repens</i>	2 3 6	<i>Gonocarpus tetragynus</i>	1 3 4 5
<i>Polymeria calycina</i>	1 2 3	<i>Haloragis heterophylla</i>	2 3 6
DILLENIACEAE		LAURACEAE	
<i>Hibbertia acicularis</i>	1 4 5	<i>Cassytha glabella</i> forma <i>glabella</i>	1 2 3 4 5
<i>Hibbertia aspera</i>	1 4	LOBELIACEAE	
<i>Hibbertia diffusa</i>	2 3	<i>Pratia purpurascens</i>	1 2 3 6
<i>Hibbertia linearis</i>	2 4	LORANTHACEAE	
<i>Hibbertia pedunculata</i>	4	<i>Amyema gaudichaudii</i>	1 2
<i>Hibbertia vestita</i>	4	<i>Dendrophthoe vitellina</i>	1 3 4 5
DROSERACEAE		MYRSINACEAE	
<i>Drosera auriculata</i>	2	<i>Rapanea variabilis</i>	2 3
EPACRIDACEAE		MYRTACEAE	
<i>Astroloma humifusum</i>	1 4 5	<i>Angophora bakeri</i>	4 5
<i>Leucopogon virgatus</i>	4	<i>Angophora floribunda</i>	2 3
<i>Lissanthe strigosa</i> subsp. <i>strigosa</i>	1 4 5	<i>Babingtonia (Baeckea) pluriflora</i>	2
<i>Melichrus procumbens</i>	4	<i>Callistemon linearifolius</i>	1 3
<i>Melichrus urceolatus</i>	1 4 5	<i>Callistemon linearis</i>	1 4 5
<i>Monotoca scoparia</i>	4 5	<i>Corymbia eximia</i>	1
<i>Styphelia triflora</i>	1 4 5	<i>Corymbia gummifera</i>	4 5
EUPHORBIACEAE		<i>Corymbia maculata</i>	1
<i>Glochidion ferdinandi</i> var. <i>ferdinandi</i>	1 6	<i>Eucalyptus agglomerata</i>	1 4 5
<i>Phyllanthus gasstroemii</i>	2 3 6	<i>Eucalyptus amplifolia</i> subsp. <i>amplifolia</i>	3
<i>Phyllanthus hirtellus</i>	1 4 5	<i>Eucalyptus canaliculata</i>	2
<i>Phyllanthus virgatus</i>	3	<i>Eucalyptus capitellata</i>	1
		<i>Eucalyptus crebra</i>	1
		<i>Eucalyptus fibrosa</i>	1 5
		<i>Eucalyptus glaucina</i>	1
		<i>Eucalyptus globoidea</i>	1 2
		<i>Eucalyptus moluccana</i>	2

<i>Eucalyptus parramattensis</i> subsp. <i>decadens</i>	4 5	COMMELINACEAE	
<i>Eucalyptus punctata</i>	1	<i>Murdannia graminea</i>	2 3
<i>Eucalyptus resinifera</i> subsp. <i>resinifera</i>	4		
<i>Eucalyptus siderophloia</i>	1	CYPERACEAE	
<i>Eucalyptus tereticornis</i>	3 6	<i>Baumea juncea</i>	2
<i>Leptospermum parvifolium</i>	1 4 5	<i>Carex appressa</i>	2 3 6
<i>Leptospermum polygalifolium</i> subsp. <i>cismontanum</i>	1 4 5	<i>Fimbristylis dichotoma</i>	2 3
<i>Leptospermum trinervium</i>	4 5	<i>Gahnia aspera</i>	2 3
<i>Melaleuca decora</i>	1 5	<i>Gahnia radula</i>	1 5
<i>Melaleuca linariifolia</i>	2 3 6	<i>Lepidosperma gunnii</i>	1
<i>Melaleuca nodosa</i>	1 2 3 4 5	<i>Lepidosperma laterale</i>	1 3 4 5
<i>Melaleuca sieberi</i>	4 5		
<i>Melaleuca styphelioides</i>	2 6	HYPOXIDACEAE	
<i>Melaleuca thymifolia</i>	4 5	<i>Hypoxis hygrometrica</i> var. <i>hygrometrica</i>	2 3
<i>Syncarpia glomulifera</i>	1 2		
OLEACEAE		IRIDACEAE	
<i>Notelaea longifolia</i> forma <i>longifolia</i>	1 3	<i>Patersonia sericea</i>	4
OXALIDACEAE		LOMANDRACEAE	
<i>Oxalis chnoodes</i>	2 3	<i>Lomandra confertifolia</i> subsp. <i>pallida</i>	1 4 5
<i>Oxalis perennans</i>	1 2 3 5	<i>Lomandra cylindrica</i>	1 3 4 5
PITTIOSPORACEAE		<i>Lomandra filiformis</i> subsp. <i>coriaceae</i>	4 5
<i>Billardiera scandens</i> var. <i>scandens</i>	1 2 3 4 5	<i>Lomandra filiformis</i> subsp. <i>filiformis</i>	1 4 5
<i>Bursaria longisepala</i> var. <i>longisepala</i>	1 5	<i>Lomandra glauca</i>	4 5
<i>Bursaria spinosa</i> var. <i>spinosa</i>	1 5	<i>Lomandra longifolia</i>	2 3 6
<i>Pittosporum revolutum</i>	2 3	<i>Lomandra multiflora</i> subsp. <i>multiflora</i>	1 2 3
PLANTAGINACEAE		ORCHIDACEAE	
<i>Plantago debilis</i>	2 3	<i>Acianthus fornicatus</i>	2 3
POLYGALACEAE		<i>Pterostylis acuminata</i>	2
<i>Comesperma sphaerocarpum</i>	4	PHORMIACEAE	
PROTEACEAE		<i>Dianella caerulea</i> var. <i>caerulea</i>	1 4 5
<i>Banksia oblongifolia</i>	4 5	<i>Dianella caerulea</i> var. <i>cinerascens</i>	1
<i>Banksia spinulosa</i> var. <i>collina</i>	4	<i>Dianella prunina</i>	1 5
<i>Grevillea montana</i>	1 3 4 5	<i>Dianella revoluta</i> var. <i>revoluta</i>	1 3 5
<i>Grevillea parviflora</i> subsp. <i>parviflora</i>	1 5	POACEAE	
<i>Hakea dactyloides</i>	4 5	<i>Anisopogon avenaceus</i>	1 4 5
<i>Hakea sericea</i>	1 4 5	<i>Aristida ramosa</i> var. <i>ramosa</i>	1 2 3 5
<i>Isopogon anemonifolius</i>	4	<i>Aristida vagans</i>	1 2 3 4
<i>Lambertia formosa</i>	4	<i>Aristida warburgii</i>	4 5
<i>Persoonia linearis</i>	1 3 4 5	<i>Austrodanthonia longifolia</i>	1 3 4 5
RUBIACEAE		<i>Austrodanthonia tenuior</i>	13 4
<i>Opercularia diphylla</i>	1 2 3	<i>Austrostipa verticillata</i>	2 3
<i>Opercularia hispida</i>	2 3	<i>Axonopus affinis</i> *	2 3
<i>Pomax umbellata</i>	1 3 4 5	<i>Cymbopogon refractus</i>	1 5
RUTACEAE		<i>Dichelachne micrantha</i>	1 4 5
<i>Correa reflexa</i> var. <i>reflexa</i>	1 4 5	<i>Digitaria ramularis</i>	1 4 5 6
SANTALACEAE		<i>Echinopogon caespitosus</i> var. <i>caespitosus</i>	1 3 5
<i>Exocarpos cupressiformis</i>	1 3	<i>Echinopogon ovatus</i>	1 2 3 4 5
<i>Exocarpos strictus</i>	1 4	<i>Entolasia marginata</i>	2 3
THYMELIACEAE		<i>Entolasia stricta</i>	1 2 3 4 5
<i>Pimelea linifolia</i> subsp. <i>linifolia</i>	4	<i>Eragrostis brownii</i>	2 3 4 5
VIOLACEAE		<i>Imperata cylindrica</i> var. <i>major</i>	1 3 4 5
<i>Viola hederacea</i>	2 3 6	<i>Joycea pallida</i>	1 4 5
Flowering Plants		<i>Microlaena stipoides</i> var. <i>stipoides</i>	1 2 3 6
Monocotyledons		<i>Panicum simile</i>	1 4 5
ANTHERICACEAE		<i>Paspalidium criniforme</i>	3
<i>Caesia parviflora</i> var. <i>parviflora</i>	1 4 5	<i>Paspalidium distans</i>	1 2 3 4
<i>Laxmannia gracilis</i>	1 4 5	<i>Phragmites australis</i>	2
		<i>Poa sieberiana</i> var. <i>sieberiana</i>	1 3
		<i>Setaria gracilis</i> *	2 3
		<i>Sorghum leiocladum</i>	2 3
		<i>Themeda australis</i>	1 2 3 4 5
		XANTHORRHOACEAE	
		<i>Xanthorrhoea glauca</i> subsp. <i>glauca</i>	4 5
		Total taxa: 191	

Appendix 2: Vegetation community profiles

Vegetation community profiles have been developed for Werakata National Park, and are based on detailed survey and mapping work and/or reconnaissance. Communities have been delineated using the PATN Analysis Package (Belbin 1995a, 1995b), supported by ground truthing. The following points should be noted in regard to the information presented in these profiles:

Community name: where possible, community names have been chosen in keeping with those applied during the Lower Hunter and Central Coast REMS study (NPWS 2000).

REMS Classification: equivalent community names using the REMS classification (NPWS 2000) are included to enable consistency with this regional work.

Description: structural and floristic information is based on survey site data sheets and field reconnaissance, and presents the typical and most characteristic species for that community.

Rare and Threatened Species: known occurrences of rare or threatened plant species within a particular community are listed.

Relationship to other communities: factors linking a particular vegetation community to other related communities are detailed, together with the major separating features between these communities.

Distribution: the distribution of each community is provided in two categories within Werakata NP, and in other areas outside of it but within the LHCC region. Also provided in this section are indications of the determining factors in the community's distribution, and the reliability of mapping for that community and potentially included units.

Conservation significance: the conservation significance of each vegetation community is provided at a Local, Regional and National level, based on currently available information and local knowledge. Only proclaimed conservation reserves are included. Local significance refers to a 50 km radius around the Cessnock area; Regional significance to the Sydney Basin biogeographical region of Thackway and Cresswell (1995), while National significance is largely based on Specht et al. (1995). In some cases, insufficient information is available to place communities within a conservation context. These instances are prefixed '?' to indicate uncertainties.

Threats: potential or currently known threats are listed for each community, particularly where these may be controlled in some way to prevent deleterious effects on the community.

Other comments: any further comments considered relevant to particular communities are included in this section, such as the incidence of weed species, variations within a community.

Lower Hunter Spotted Gum–Ironbark Forest (Unit 1)

REMS Classification: *Lower Hunter Spotted Gum–Ironbark Forest (MU 17)*

Description No of Plots: 13

Lower Hunter Spotted Gum–Ironbark Forest represents a vegetation type characterised by Spotted Gum (*Corymbia maculata*) and various Ironbarks (predominantly *Eucalyptus fibrosa*). In the Cessnock area, other canopy species include *Eucalyptus agglomerata* (atypical form), and in some exposed locations *Corymbia eximia*. Historically, this vegetation type has been heavily logged or cleared throughout the lower Hunter Valley, and consequently canopy and understorey composition has been altered. Dominance by *Melaleuca nodosa* in the shrub layer is one indication of past disturbance.

Structure

Tree: 8–25 m, 20–40% cover. Small tree: 3–12 m, 5–40% cover. Tall shrub: 2–4 m, 5–40% cover. Shrub: 0.5–2 m, 20–60% cover. Ground: < 0.5 m, 20–40% cover.



Fig. 4. *Corymbia eximia* dominated woodland within the Lower Hunter Spotted Gum – Ironbark Forest (Unit 1).



Fig. 5. Lower Hunter Spotted Gum – Ironbark Forest (Unit 1), showing even-aged regrowth stands of *Corymbia maculata* and *Eucalyptus fibrosa*.

Floristics

Trees: *Corymbia maculata*, *Eucalyptus fibrosa*, *Eucalyptus agglomerata* (atypical form), *Corymbia eximia*.

Small trees: *Bursaria spinosa*.

Shrubs: *Grevillea montana*, *Daviesia ulicifolia*, *Bursaria longisepala* var. *longisepala*, *Lissanthe strigosa*, *Acacia elongata* var. *elongata*, *Astrotricha obovata*, *Melaleuca nodosa*, *Grevillea parviflora* subsp. *parviflora*, *Persoonia linearis*, *Leptospermum parvifolium*, *Isopogon anemonifolius*, *Podolobium ilicifolium*, *Acacia buxifolia*, *Hakea sericea*, *Syncarpia glomulifera* subsp. *glomulifera* (shrub form), *Dillwynia retorta*, *Acacia ulicifolia*.

Vines: *Cassytha glabella* forma *glabella*, *Hardenbergia violacea*, *Glycine clandestina*.

Herbs: *Platysace ericoides*, *Phyllanthus hirtellus* forma A, *Pomax umbellata*, *Goodenia rotundifolia*, *Hibbertia vestita*, *Gompholobium uncinatum*, *Oxylobium pultenaea*.

Graminoids: *Entolasia stricta*, *Aristida vagans*, *Dichelachne micrantha*, *Dianella revoluta* var. *revoluta*, *Eragrostis brownii*, *Panicum simile*, *Poa sieberiana* subsp. *sieberiana*, *Austroanthonia longifolia*, *Lomandra filiformis* subsp. *coriacea*, *Imperata cylindrica* var. *major*, *Joycea pallida*, *Lomandra multiflora* subsp. *multiflora*, *Lomandra cylindrica*, *Lomandra confertifolia* subsp. *pallida*, *Lomandra filiformis* subsp. *filiformis*, *Anisopogon avenaceus*, *Themeda australis*

Ferns: *Cheilanthes sieberi* subsp. *sieberi*

Sedges: *Lepidosperma laterale*

Cycads: *Macrozamia flexuosa*, *Macrozamia reducta*

Rare or Threatened Species

NSW TSC Act species: *Grevillea parviflora* subsp. *parviflora*.
Rare species: *Grevillea montana*, *Macrozamia flexuosa*

Relationship to other communities

The characteristic presence of *Corymbia maculata* and *Eucalyptus fibrosa* in the canopy clearly distinguish this type from all other communities in the Park. In areas where the canopy is low, there may be some confusion with the Kurri Sand Melaleuca Scrub-Forest (Unit 5), particularly in those areas where broad ecotones exist. In addition, areas with a disturbance history tend to support dense thickets of *Melaleuca nodosa* in the understorey, which again can be difficult to distinguish. In these cases, separation of the two communities is probably best achieved based on structure.

Distribution within Werakata NP

This vegetation type represents the most widespread community in the Park, and covers sizeable areas of the Kitchener, Abermain and Bishops Hill portions, and is also represented in the Neath portion to a lesser degree. 1600 ha of this vegetation type currently lies within the Park.

Outside Werakata NP

Lower Hunter Spotted Gum–Ironbark Forest is relatively widespread throughout the central and lower Hunter Valley areas, although many areas have been cleared or modified. This type merges with the Coastal Foothills Spotted Gum–Ironbark Forest in the Quorrobolong area. NPWS (2000) have mapped 26 917 ha of this type within the region.

Determining factors

Within Werakata, this vegetation type occurs on Permian-based yellow-brown or grey-brown clay soils on most ridges and slopes.

Mapping reliability and included units

Mapped from aerial photographic interpretation and field reconnaissance, and considered accurate. There may be some inclusion of Kurri Sand Melaleuca Scrub-Forest (Unit 5) in some areas where a broad ecotonal zone exists.

Conservation significance

Local: Poor (Werakata NP). Regional: Poor (no reservation known). National: Poor (No reservation known).

Threats

Fire: Inappropriate fire regimes may adversely affect this community, with frequent (<3 years) firing dramatically simplifying understorey vegetation.

Other comments

On some exposed crests where sandstone outcropping occurs, species such as *Corymbia eximia*, *Isopogon anemonifolius*, and *Acacia buxifolia* form a variation of the typical form of this community. Although survey was undertaken here, sufficient distinction could not be made to lift this variant to community status.

Central Hunter Riparian Forest (Unit 2)

REMS Classification: ? *Central Hunter Riparian Forest (MU 13)*

Description No of Plots: 2

Central Hunter Riparian Forest is a variable community occupying narrow zones along tributaries of the major creeks in the Park. Within the region this vegetation type has been largely disturbed or infiltrated with weed species. In Werakata, dominant canopy species include *Eucalyptus canaliculata*, *Angophora floribunda*, *Casuarina glauca* (in places), and various *Melaleuca* species. This vegetation most closely associates with the Central Hunter Riparian Forest as defined by NPWS (2000), although some floristic differences are apparent.

Structure

Tree: 10–25 m, 20–40% cover. Small tree: 8–10 m, 0–20% cover. Tall shrub: 4–6 m, 60–70% cover. Shrub: 0.5–3 m, 5–30% cover. Ground: < 0.5 m, 90–100% cover.

Floristics

Trees: *Angophora floribunda*, *Eucalyptus canaliculata*, *Eucalyptus moluccana*, *Eucalyptus fibrosa*, *Eucalyptus tereticornis*.

Small trees: *Melaleuca decora*, *Melaleuca styphelioides*, *Melaleuca linariifolia*, *Acacia irrorata* subsp. *irrorata*, *Casuarina glauca*.

Shrubs: *Bursaria longisepala* var. *longisepala*, *Lissanthe strigosa*, *Grevillea montana*, *Exocarpus strictus*, *Acacia longifolia*, *Bursaria spinosa*, *Melaleuca nodosa*, *Babingtonia pluriflora*

Vines: *Glycine clandestina*, *Glycine microphylla*, *Cassytha glabella forma glabella*.

Herbs: *Hibbertia linearis*, *Lomandra longifolia*, *Pomax umbellata*, *Pratia purpurascens*, *Oxalis perennans*, *Pseuderanthemum variabile*, *Plantago debilis*, *Gonocarpus tetragynus*.

Graminoids: *Themeda australis*, *Imperata cylindrica* var. *major*, *Aristida vagans*, *Dianella revoluta* var. *revoluta*, *Dichelachne micrantha*, *Austroanthonia tenuior*, *Poa sieberiana* subsp. *sieberiana*, *Dianella caerulea* var. *cinerascens*, *Echinopogon ovatus*, *Eragrostis brownii*, *Austrostipa verticillata*, *Aristida ramosa* var. *ramosa*, *Sorghum leiocladum*, *Phragmites australis*, *Microlaena stipoides* var. *stipoides*, *Cymbopogon refractus*, *Entolasia marginata*, *Digitaria ramularis*, *Echinopogon caespitosus* var. *caespitosus*.

Ferns: *Cheilanthes sieberi* subsp. *sieberi*, *Adiantum aethiopicum*, *Pteridium esculentum*.

Sedges: *Gahnia aspera*, *Baumea juncea*, *Lepidosperma laterale*.

Cycads: *Macrozamia flexuosa*.

Rare or Threatened Species

Rare species: *Grevillea montana*, *Macrozamia flexuosa*.

Relationship to other communities

Central Hunter Riparian Forest is closely related to the Hunter Lowlands Redgum Forest (Unit 3), through a sharing of canopy species such as *Eucalyptus tereticornis*, *Eucalyptus moluccana*, and *Angophora floribunda*, and several understorey species. However, Unit 3 generally does not support *Casuarina glauca* and *Eucalyptus canaliculata*, and occurs on flats and drainage depressions (not riparian zones). The levels of past disturbance shown in areas supporting both of these communities makes differentiation difficult. In Unit 3, redgum species (*Eucalyptus amplifolia* subsp. *amplifolia*, *Eucalyptus tereticornis*, *Eucalyptus glaucina*) clearly dominant, while these species are rare or absent in the Central Hunter Riparian Forest.

Distribution within Werakata NP

This vegetation type occurs along Swamp Creek in the Neath portion, Deadman's Creek in the Bishops Hill portion, and other minor creeks in the Abermain and Kitchener portions of the Park. 77 ha of this vegetation type currently lies within the Park.

Outside Werakata NP

Central Hunter Riparian Forest is relatively uncommon in the region, with most occurrences being heavily disturbed or modified through agricultural practices. NPWS (2000) have mapped 1187 ha of this vegetation type in the region, with only 5 ha in reserve.

Determining factors

This vegetation type occurs as a fringing community along the banks of major streams, generally in areas of high exposure (flat to gently undulating land) on Permian clays.

Mapping reliability and included units

Mapped from aerial photographic interpretation and field reconnaissance, and considered reasonably accurate.

Conservation significance

Local: Poor (Werakata NP). Regional: Poor (no reservation known). National: Poor (no reservation known).

Threats

Upstream processes: this vegetation type is likely to be sensitive to upstream disturbances such as erosion and water pollution, which allow the introduction of exotic plant species.

Other comments

The narrow bands of this community occurring along parts of Swamp Creek are in excellent condition. In these areas, the occurrence of *Casuarina glauca* and *Baumea juncea*, species normally associated with estuarine environments, are of particular botanical and conservation interest.

Hunter Lowlands Redgum Forest (Unit 3)

REMS Classification: *Hunter Lowlands Redgum Forest (MU 19)*

Description No of Plots: 1

In the far north-western corner of the Bishops Hill portion of the Park, a small area of Hunter Lowlands Redgum Forest occurs on a gentle flat adjacent to Deadman's Creek. The majority of this has been grazed in the past, and consequently the understorey has been reduced largely to grasses and herbs with scattered shrubs. Outside of the Park, this vegetation does not appear as disturbed and supports a denser understorey. Redgums (*Eucalyptus amplifolia* subsp. *amplifolia*, *Eucalyptus tereticornis*, *Eucalyptus glaucina*) characterise this community, with other species such as *Eucalyptus crebra*, *Eucalyptus moluccana*, and *Angophora floribunda* also present.

Structure

Tree: 18–20 m, 40–50% cover. Tall shrub: 3–6 m, 5–15% cover. Shrub: 1–2 m, 5–40% cover. Ground: < 0.5 m, 80–90% cover.

Floristics

Trees: *Eucalyptus amplifolia* subsp. *amplifolia*, *Eucalyptus tereticornis*, *Eucalyptus glaucina*, *Eucalyptus crebra*, *Eucalyptus moluccana*, *Angophora floribunda*.

Small trees: *Melaleuca decora*, *Acacia irrorata* subsp. *irrorata*.

Shrubs: *Exocarpus strictus*, *Grevillea montana*, *Callistemon linearis*, *Acacia ulicifolia*, *Pultenaea cunninghamii*, *Daviesia ulicifolia*, *Melaleuca nodosa*.

Vines: *Cassytha glabella* forma *glabella*.

Herbs: *Hypoxis hygrometrica* var. *hygrometrica*, *Helichrysum scorpioides*, *Vernonia cinerea* var. *cinerea*, *Pratia purpurascens*, *Desmodium varians*, *Laxmannia gracilis*, *Dichondra repens*, *Pomax umbellata*, *Polymera calycina*, *Opercularia hispida*, *Hibbertia linearis*, *Murdannia graminea*, *Goodenia rotundifolia*, *Haloragis heterophylla*, *Phyllanthus virgatus*, *Oxalis perennans*, *Hydrocotyle peduncularis*.

Graminoids: *Microlaena stipoides* var. *stipoides*, *Aristida vagans*, *Eragrostis brownii*, *Paspalidium distans*, *Echinopogon ovatus*, *Entolasia stricta*, *Austrodanthonia longifolia*, *Dianella caerulea* var. *caerulea*, *Lomandra confertifolia* subsp. *pallida*, *Panicum simile*

Ferns: *Cheilanthes sieberi* subsp. *sieberi*.

Sedges: *Fimbrostylis dichotoma*, *Lepidosperma laterale*.

Rare or Threatened Species

NSW TSC Act species: *Eucalyptus glaucina*. Rare species: *Grevillea montana*.

Relationship to other communities

Hunter Lowlands Redgum Forest is closely related to the Central Hunter Riparian Forest (Unit 2), through a sharing of canopy species such as *Eucalyptus tereticornis*, *Eucalyptus moluccana*, and *Angophora floribunda*, and several understorey species. However, Unit 2 generally also includes *Casuarina glauca* and *Eucalyptus canaliculata*, and is restricted to immediate riparian zones (not flats and drainage depressions). The levels of past disturbance shown in areas supporting both of these communities makes differentiation difficult. In the Hunter Lowlands Redgum Forest, redgum species (*Eucalyptus amplifolia* subsp. *amplifolia*, *Eucalyptus tereticornis*, *Eucalyptus glaucina*) clearly dominant, while these species are rare or absent in Unit 2.

Distribution within Werakata NP

This vegetation type occurs only adjacent to Deadman's Creek in the north-western corner of the Bishops Hill portion of the Park, where it occupies approximately 7 ha.

Outside Werakata NP

NPWS (2000) have mapped 4856 ha of their Hunter Lowlands Redgum Forest (MU 19) remaining in the region, with only 100 ha in reserve. This vegetation type as described by NPWS (2000) appears to be highly variable and difficult to define in some places.

Determining factors

Hunter Lowlands Redgum Forest occurs in open depressions and drainage flats on clay-based Permian Sediments, adjacent to relatively minor creeklines.

Mapping reliability and included units

Mapped from aerial photographic interpretation and field reconnaissance, and considered reasonably accurate. Boundaries can be difficult to define in areas where it merges with the surrounding Lower Hunter Spotted Gum–Ironbark Forest (Unit 1).

Conservation significance

Local: Poor (Werakata NP). Regional: Poor (no reservation known). National: Poor (no reservation known).

Threats

Grazing and clearing of this community has historically occurred throughout its range, and these threats remain where areas lie adjacent to agricultural lands.

Other Comments

The area supporting this vegetation type adjacent to Deadmans Creek supports an apparently isolated population of the vulnerable *Eucalyptus glaucina*.



Fig. 6. Kurri Sand Swamp Woodland (Unit 4), dominated by *Angophora bakeri*.

Kurri Sand Swamp Woodland (Unit 4)

REMS Classification: *Kurri Sand Swamp Woodland (MU 35)*

Description No of Plots: 3

Small areas within Werakata support vegetation having close affinities to the Kurri Sand Swamp Woodland (Unit 35) described by NPWS (2000), although significant differences in floristic composition are evident. In these areas, the canopy is dominated by *Angophora bakeri*, *Eucalyptus resinifera* subsp. *resinifera*, and *Eucalyptus agglomerata* (atypical form), with *Eucalyptus parramattensis* subsp. *decadens* and *Corymbia gummifera* occasionally present. Understorey vegetation is dominated by a range of shrubs typical of sand environments, but with clay species such as *Melaleuca nodosa* also prominent in some parts.

Structure

Tree: 5–12 m, 10–40% cover. Tall shrub: 1.5–3 m, 10–80% cover. Shrub: 0.5–1.5 m, 20–70% cover. Ground: < 0.5 m, 10–60% cover.

Floristics

Trees: *Angophora bakeri*, *Eucalyptus resinifera* subsp. *resinifera*, *Eucalyptus agglomerata* (atypical form), *Eucalyptus parramattensis* subsp. *decadens*, *Corymbia gummifera*.

Small trees: *Melaleuca sieberi*, *Melaleuca decora*.

Shrubs: *Banksia oblongifolia*, *Banksia spinulosa* var. *collina*, *Dillwynia retorta*, *Leptospermum trinervium*, *Acacia ulicifolia*, *Leptospermum polygalifolium* subsp. *cismontanum*, *Leucopogon virgatus*, *Isopogon anemonifolius*, *Bossiaea heterophylla*, *Monotoca scoparia*, *Melaleuca nodosa*, *Lambertia formosa*, *Melichroa procumbens*, *Hakea dactyloides*, *Melaleuca thymifolia*, *Exocarpus strictus*, *Hakea sericea*, *Callistemon linearis*, *Styphelia triflora*, *Leptospermum parvifolium*, *Hibbertia acicularis*.

Vines: *Cassytha glabella* forma *glabella*, *Mirbelia rubifolia*.

Herbs: *Platysace ericoides*, *Dampiera stricta*, *Drosera auriculata*, *Hibbertia vestita*, *Helicrysum scorpioides*.

Graminoids: *Lomandra cylindrica*, *Lomandra glauca*, *Anisopogon avenaceus*, *Entolasia stricta*, *Aristida warburgii*, *Eragrostis brownii*, *Xanthorrhoea glauca* subsp. *glauca*.

Sedges: *Gahnia radula*, *Lepidosperma gunnii*.

Orchids: *Acianthus fornicatus*.

Rare or Threatened Species

NSW TSC Act species: *Eucalyptus parramattensis* subsp. *decadens*

Relationship to other communities

Kurri Sand Swamp Woodland is distinctly different to all other vegetation within Werakata. The canopy combination of *Angophora bakeri*, *Eucalyptus resinifera* subsp. *resinifera*, and *Eucalyptus agglomerata* (atypical form) does not occur in other communities. *Eucalyptus parramattensis* subsp. *decadens* also occurs in Kurri Sand Melaleuca Scrub-Forest (Unit 5), but the very dense shrub layer of *Melaleuca nodosa*, and the absence of other key species (eg: *Angophora bakeri*, *Lambertia formosa*, *Leptospermum trinervium*, *Banksia spinulosa* var. *collina*) separates the two. In places in Unit 5, *Eucalyptus resinifera* subsp. *resinifera* co-dominates with *Eucalyptus agglomerata* (atypical form), but again the understorey composition separates the two.

Distribution within Werakata NP

This vegetation type occurs predominantly in the Neath portion of the Park, although the Bishops Hill portion also supports small areas. 70 ha of this vegetation type has been mapped.

Outside Werakata NP

NPWS (2000) have indicated that 2195 ha of their Kurri Sand Swamp Woodland (MU 35) remains in the region, and they map only 46 ha in reserve (ie: Werakata NP). This figure should now be amended to 70 ha. This vegetation type is restricted to the Kurri-Cessnock-Maitland area.

Determining factors

Kurri Sand Swamp Woodland occurs on level to slightly undulating sand deposits where drainage is relatively free-flowing.

Mapping reliability and included units

This community has been mapped from aerial photographic interpretation and field reconnaissance, and is considered accurate.

Conservation significance

Local: Poor (Werakata NP). Regional: Poor (no reservation known). National: Poor (no reservation known).

Threats

Fire: Frequent fire regimes may dramatically alter the current floristic composition of this community.

Other comments

Vegetation within this community does not conform readily to that described by NPWS (2000), but does lie broadly within its bounds. Soil drainage within this type dictates the floristic composition of differing stands. In some areas where soils are particularly clayey, understorey vegetation is dominated by *Melaleuca nodosa*. In more

sandy areas, this species is far less prominent and *Leptospermum trinervium* and *Leptospermum polygalifolium* dominate. Outside of the current Park boundaries, considerable areas of Kurri Sand Swamp Woodland (NPWS-mapped) occur. Further acquisition of lands supporting all forms of this vegetation type is recommended.



Fig. 7. Kurri Sand Melaleuca Scrub-Forest (Unit 5), showing *Melaleuca decora* and *Melaleuca nodosa*, and low emergent *Eucalyptus fibrosa* and *Eucalyptus parramattensis* subsp. *decadens*.

Kurri Sand Melaleuca Scrub-Forest (Unit 5)

REMS Classification: ? Kurri Sand Swamp Woodland (MU 35)

Description No of Plots: 2

Kurri Sand Melaleuca Scrub-Forest represents a vegetation type not delineated during the regional modelling process (NPWS 2000), but related to the Kurri Sand Swamp Woodland as identified there. It is characterised by dense stands of *Melaleuca* (*Melaleuca nodosa*, *Melaleuca decora*) with stunted emergents of mostly *Eucalyptus fibrosa* and *Eucalyptus parramattensis* subsp. *decadens* (variant 5a). In places, this vegetation type conforms to a forest structure where *Eucalyptus agglomerata* (atypical form) and *Eucalyptus resinifera* subsp. *resinifera* co-dominates with occasional *Eucalyptus fibrosa*, *Eucalyptus siderophloia*, and *Eucalyptus parramattensis* subsp. *decadens* (variant 5b). Most areas supporting this vegetation type are found in close proximity to Kurri Sand Swamp Woodland (Unit 4), and it is thought that clay deposits associated with the Kurri Sands determine its distribution.

Structure

Tree: 3–15 m, 5–20% cover. Small tree: 3–8 m, 30–40% cover. Tall shrub: 2–4 m, 5–15% cover. Shrub: 0.5–2 m, 60–100% cover. Ground: < 0.5 m, 5–60% cover.

Floristics

Small trees: *Eucalyptus fibrosa*, *Eucalyptus parramattensis* subsp. *decadens*, *Eucalyptus agglomerata* (atypical form), *Eucalyptus crebra* (extreme north), *Melaleuca decora*, *Eucalyptus resinifera* subsp. *resinifera*.

Shrubs: *Melaleuca nodosa*, *Melaleuca thymifolia*, *Callistemon linearis*, *Isopogon anemonifolius*, *Leucopogon virgatus*, *Lissanthe strigosa*, *Leptospermum parvifolium*, *Dillwynia retorta*, *Astroloma humifusum*, *Acacia ulicifolia*, *Hakea sericea*, *Astrotricha obovata*, *Hibbertia acicularis*, *Pultenaea cunninghamii*, *Bursaria longisepala* var. *longisepala*, *Grevillea montana*, *Banksia spinulosa* var. *collina*.

Vines: *Cassytha glabella* forma *glabella*.

Herbs: *Phyllanthus hirtellus* forma A, *Mirbelia pungens*, *Platysace ericoides*, *Goodenia rotundifolia*, *Hibbertia vestita*, *Drosera auriculata*, *Pratia purpurascens*.

Graminoids: *Aristida ramosa* var. *ramosa*, *Lomandra cylindrica*, *Anisopogon avenaceus*, *Entolasia stricta*, *Aristida vagans*, *Dianella*

revoluta var. *revoluta*, *Panicum simile*, *Lomandra filiformis* subsp. *coriacea*, *Eragrostis brownii*, *Imperata cylindrica* var. *major*, *Paspalidium distans*.

Ferns: *Cheilanthes sieberi* subsp. *sieberi*.

Sedges: *Gahnia radula*, *Lepidosperma gunnii*, *Lepidosperma laterale*.

Cycads: *Macrozamia flexuosa*.

Orchids: *Pterostylis* sp.

Rare or Threatened Species

NSW TSC Act species: *Eucalyptus parramattensis* subsp. *decadens*, *Callistemon linearifolius*. Rare species: *Grevillea montana*, *Macrozamia flexuosa*.

Relationship to other communities

Kurri Sand Melaleuca Scrub-Forest is most closely related to the Lower Hunter Spotted Gum–Ironbark Forest (Unit 1) and the Kurri Sand Swamp Woodland (Unit 4), through a sharing of often dense stands of *Melaleuca nodosa*. However, Unit 1 can be separated by the presence of a taller canopy of *Corymbia maculata* with *Eucalyptus fibrosa*, and a variety of understorey species, while Unit 4 is characterised by *Angophora bakeri*, *Eucalyptus resinifera* subsp. *resinifera*, and *Corymbia gunnifera* occurring with *Eucalyptus parramattensis* subsp. *decadens* in the canopy. As well, a number of understorey species normally associated with sand environments are present.

Distribution within Werakata NP

Small pockets of the scrub variant (5a) of this vegetation type occur in the Neath and Bishops Hill portions of the Park, normally associated with Kurri Sand Swamp Woodland (Unit 4). The forest variant (5b) occurs only in the Neath portion. 183 ha of sub-unit 5a, and 80 ha of sub-unit 5b, currently lie within the Park.

Outside Werakata NP

NPWS (2000) have not identified this vegetation type, but indicate that 2195 ha of their Kurri Sand Swamp Woodland (MU 35) remains in the region, with only 46 ha in reserve (i.e. Werakata NP). It is possible that this vegetation type includes the Kurri Sand Melaleuca Scrub-Forest, and it is probably also restricted to the Kurri–Cessnock–Maitland area.

Determining factors

Kurri Sand Melaleuca Scrub-Forest occurs on poorly drained clay deposits associated with the Kurri Sands. In most cases, these deposits comprise compacted clay soil with some laterite, which influences local floristic composition. Other smaller areas occur on shallow drainage lines with similar soil conditions.

Mapping reliability and included units

Mapped from aerial photographic interpretation and field reconnaissance, and is considered accurate.

Conservation significance

Local: Poor (Werakata NP). Regional: Poor (no reservation known). National: Poor (no reservation known).

Threats:

No threats have been identified for this community.

Other comments

In the extreme northern part of the Bishops Hill portion, emergent *Eucalyptus crebra* is found in this community, and understorey diversity is generally also higher. The forest variant (5b) described for the Neath portion may represent a distinct community, but further sampling and analysis is required. In their regional study, NPWS (2000) do not identify Kurri Sand Melaleuca Scrub-Forest, although there are strong similarities to similar *Melaleuca nodosa* thickets from the Wyong sub-coastal plain.

Riparian Melaleuca Thicket (Unit 6)

REMS Classification: ? Central Hunter Riparian Forest (MU 13)

Description No of Plots: [none]

Along some drainage lines on Permian clays where drainage is impeded, narrow bands of *Melaleuca linariifolia* occur, forming dense thickets. Other species present in the small tree layer include *Melaleuca styphelioides* and occasionally *Callistemon salignus*. Emergent trees may include *Eucalyptus tereticornis*, *Angophora floribunda* or *Eucalyptus canaliculata*. Understorey vegetation is generally limited to sedges such as *Carex appressa* and occasional grasses.

Structure

Trees: 15–25 m, 10–25% cover. Small tree: 5–12 m, 80–100% cover. Ground: < 0.8m, 80–100% cover.

Floristics

Trees: *Eucalyptus tereticornis*, *Angophora floribunda*, *Eucalyptus canaliculata*.

Small trees: *Melaleuca linariifolia*, *Melaleuca styphelioides*.

Vines: *Parsonia straminea*.

Graminoids: *Carex appressa*, *Entolasia marginata*.

Rare or Threatened Species

None recorded.

Relationship to other communities

Riparian Melaleuca Thicket is generally quite distinct and should not be confused with any other community. The dominance of dense stands of *Melaleuca linariifolia* are characteristic, and these are best developed in poorly drained areas where runoff collects after rain events. Characteristics of Central Hunter Riparian Forest (Unit 2) are similar, but that community can be distinguished on a structural (forest) and floristic (higher species diversity) basis.

Distribution within Werakata NP

This vegetation type occurs intermittently along drainage lines throughout the Park, where drainage is poor. Best development is in the Abermain portion near the disused dump site. Less than 5 ha of this vegetation type is likely to occur within the Park.

Outside Werakata NP

This vegetation type does not readily align with any of the REMS vegetation communities. However, it is likely to form part of the Central Hunter Riparian Forest (MU13), of which NPWS (2000) have mapped 1187 ha remaining in the region.

Determining factors

This vegetation type occurs only on impeded clay soils, with areas of standing water after rain events.

Mapping reliability and included units

Riparian Melaleuca Thicket has not been mapped individually due to the small size of stands and the difficulty of detecting these on the available aerial photographs. Consequently, this unit is included in the mapping of Central Hunter Riparian Forest (Unit 2). Mapping of known stands may be carried out in the future.

Conservation significance

Local: Poor (Werakata NP). Regional: Poor (no reservation known). National: Poor (no reservation known).

Threats

No threats have been identified for this community.

Other comments

Detailed survey is yet to be undertaken for this vegetation type, and the information presented here is based on brief field notes. It is possible that this community forms a variant of the Central Hunter Riparian Forest (Unit 2) occurring on impeded clay soils, but is recognised here as distinct due to its characteristic and unmistakable composition.