# The Natural Vegetation of Maitland Local Government Area

**Report Prepared for Maitland City Council**

**September 2003**


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Front cover shows view from Winders Hill looking north-east with Hunter River in foreground; *Pittosporum undulatum* (top left) and *Hakea sericea* (bottom left) in flower. Photos by T. Peake.

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# Executive Summary


Systematic vegetation survey was carried out in Maitland LGA to provide Maitland Council with detailed information on natural vegetation for strategic planning purposes. Flora was sampled at 55 field sites (plots) and extensive field reconnaissance was carried out across the LGA. Agglomerative cluster analysis of plot data delineated eleven vegetation communities and an additional two communities were described by previous work in the LGA work (NPWS 2000). A total of 8,305 ha of extant vegetation was mapped in Maitland LGA using aerial photograph interpretation (API) at 1:25,000 scale. This included thirteen vegetation communities and areas of scattered trees and regeneration that did not constitute intact communities. Much of the vegetation in the LGA has affiliation with vegetation in the central, lower and mid Hunter valley, with areas in the south-east of the LGA more related to coastal vegetation in the lower Hunter-Central Coast Region.

Review of vegetation studies carried out in the lower Hunter-Central Coast Region and the Mid to Upper Hunter valley indicated that of the thirteen vegetation communities described in Maitland, nine have a low to very low level of reservation in the region and six are estimated to have over 70% of their pre-1750 extent cleared. Three communities in Maitland LGA are listed as Endangered Ecological Communities (EEC) on the NSW *Threatened Species Conservation Act 1995* (TSC Act), including Kurri Sand Swamp Woodland and two variants of Hunter Lowlands Redgum Forest. Of the remaining 10 communities, eight are considered to meet the criteria for listing.

In Maitland LGA, 561 vascular plant taxa were recorded, occurring in over 100 plant families. Three species of state or national conservation significance were recorded, including one listed as Vulnerable on the TSC Act and Commonwealth EPBC Act and three on the rare or threatened Australian plants (ROTAP) database. An additional seven species of state or national significance that have been recorded near to the study area may also occur in the LGA. Four species recorded in Maitland LGA represent extensions of known range, including the first record for one species in the North Coast floristic subdivision and three local range extensions. A total of 92 taxa recorded in Maitland LGA are considered to be regionally significant because they are rare, uncommon, under threat, endemic or at the limit of their natural distribution in the Hunter region.

Ecological assessment of extant vegetation in Maitland LGA was carried out to provide Council with indicative, relative conservation priorities in the LGA. Criteria used in the ecological assessment were based on attributes that could be measured remotely. Ecological assessment was carried out at two levels: the Community-level and Landscape-level. The Community-level assessment incorporated five measurements of vegetation community value, including the presence of a listed EEC, significant community, important ecosystem (wetlands, riparian vegetation), poorly reserved community and/or largely cleared community (over 70%). The Landscape-level assessment incorporated three measurements of vegetation-remnant value, including remnant size, connection to a wildlife corridor and/or diversity (number of vegetation communities). For assessment at both the Community-level and Landscape-level, the different measures were combined to create categories of ecological value. Four categories of ecological value were created in the Community-level assessment (A, B, C and D), and three categories were created in the Landscape-level assessment (a, b and c). Results of the Community-level assessment found the following areas of each category (from highest to lowest value): A=14.6% (1,211.3ha), B= 40.7% (3,383.1ha); C=27.3% (2,265.3ha) and D=9.4% (782.8ha) of extant vegetation. The remaining 8% consisted of scattered trees or regeneration that could not be described as a particular vegetation community. Similarly, results of the Landscape-level assessment found: a=80.0% (6715.5ha), b=9.6% (798.8ha) and c=9.5% (790ha).

Vegetation in Maitland LGA has been significantly reduced in extent by clearing (estimated over 90% removed). The remaining vegetation is predominantly of high significance and is under threat from a range of process. One of the greatest threats to vegetation in Maitland LGA is the lack of formal protection as neither formal reserves nor voluntary protection by way of covenants exist. Wherever possible, strategies should be employed by Council to conserve and manage what little vegetation remains, with particular focus on maintaining intact, larger tracts of natural vegetation and areas of significant vegetation.

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## Abbreviations used in report

| | |
|---|---|
| API | aerial photograph interpretation |
| ASL | above sea level |
| cm | centimetres |
| CSIRO | Commonwealth Scientific Industrial Research Organisation |
| Council | Maitland City Council |
| EEC | Endangered Ecological Community |
| EPBC Act | Environment Protection and Biodiversity Conservation Act, 1999 |
| ha | hectares |
| HCMT | Hunter Catchment Management Trust |
| HNVR | Hunter Regional Vegetation Committee |
| km | kilometres |
| LGA | local government area |
| LHCC | lower Hunter and Central Coast |
| LHCCREMS | Lower Hunter and Central Coast Regional Environmental Management Strategy |
| m | metres |
| Ma | million years ago |
| mm | millimetres |
| MU | Map Unit |
| NPWS | New South Wales National Parks and Wildlife Service |
| NSW | New South Wales |
| PATN | Statistical analysis package produced by the CSIRO (Belbin 1995a & b) |
| RBCS | Regional Biodiversity Conservation Strategy |
| REMS | Regional Environmental Management Strategy |
| ROTAP | Rare or Threatened Australian Plant |
| subsp. | subspecies |
| TSC Act | Threatened Species Conservation Act, 1995 |
| var. | variety |
| v. | very |

# Chapter 1 Introduction

## 1.1 Background

Maitland City Council (the Council) commissioned vegetation survey and mapping in 2002 of the natural vegetation in Maitland Local Government Area (LGA) for strategic planning purposes. Previous vegetation survey and mapping in the LGA was carried out by Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS) as part of a region-wide study incorporating seven different local government areas and Councils (NPWS 2000). Evaluation of the LHCCREMS work carried out by CSIRO found that the vegetation map produced was adequate at a regional scale and recommended further survey work for planning at a local level (Nicholls *et al* 2002).

In February 2002 Maitland Council, through community consultation, developed the Maitland Greening Plan which sets objectives for the conservation of natural vegetation in the LGA. Maitland Greening Plan provides a strategic framework for future management of vegetation in the LGA by focusing on extant vegetation and revegetation (Maitland City Council 2002). The Council required vegetation mapping at a local level to support the Local Greening Plan.

The study described herein (the current work) is based on field survey carried out in summer 2003 and previous work by NPWS (2000) carried out between March and June 1999.

## 1.2 Aim and Objectives

The aim of the study was to provide the Council with description and mapping of vegetation communities and assess the local conservation value of vegetation remnants in Maitland LGA.

Project objectives stated by Maitland Council were:

- Preparation of more detailed mapping of Maitland's vegetation communities to assist in the implementation of the Maitland Greening Plan
- Determination of local conservation priorities in the Maitland LGA based on pre-determined generic conservation assessment criteria

## 1.3 Acknowledgments

This work was funded by Maitland City Council and supervised by the Strategic Planning Department. Maitland City Council provided GIS and other data for the project. Lisa Redmond of LREnviro GIS carried out digitising of the Vegetation Map and other related GIS work. The Department of Infrastructure Planning & Natural Resources provide a loan of aerial photographs for mapping vegetation. Plot data in and adjacent to Maitland LGA was provided by LHCCREMS and the Hunter Catchment Management Trust. Review of the final report was provided by Maitland Council, Trish Poulos and Travis Peake of the Hunter Catchment Management Trust. The NSW National Herbarium Sydney carried out botanical identification of cryptic and significant specimens. Terry Tame, formerly of the Hunter Region Botanic Gardens, provided expert identification of *Acacia* specimens.

# Chapter 2 Study Area

## 2.1 Location

Maitland LGA is located in New South Wales about 130 km north of Sydney and 30 km north-west of Newcastle. It covers about 39,200 hectares (392 square km) of land at the junction of the Paterson and Hunter rivers in the lower Hunter Valley. Port Stephens LGA bounds it to the east, Dungog LGA to the north, Singleton LGA to the west, and the cities of Cessnock and Newcastle to the south (see *Figure 2.1*). It has a population of 53,716 persons (2001 Census). The major urban centres are Maitland, Thornton, Woodberry, East Maitland, Ashtonfield, Metford, Rutherford, Lorn, Largs, Lochinvar, Morpeth and Telarah.

## 2.2 Climate

The prevailing climate of the lower Hunter is warm-temperate with a maritime influence, with warm to hot and humid summers and cool to mild winters (Matthei 1995). Climate data for the closest weather stations were obtained from the Bureau of Meteorology (*www.bom.gov.au/climate)*. Average annual rainfall is 913 mm at Paterson and 850 mm at Maitland west; average monthly temperatures at Paterson are 29$^{o}$C in December and January; average minimum monthly temperatures are 4$^{o}$C in July at Maitland. Frost hazard and low temperatures may restrict plant growth in the winter, with around 6.5 frost days per year (Tweedie 1963). Adequate soil moisture is available year-round, however during late autumn and winter water storage capacity of soils is often exceeded, resulting in prolonged runoff (Edwards 1979). Maitland typically has 91 rain days per year (Tweedie 1963). The prevailing winds are from the west in winter, while summer winds are from the east and south-east (Matthei 1995).

## 2.3 Biogeographic Location

New South Wales is divided into five major floristic divisions that strongly reflect the distribution of flora species (Anderson 1961). These are further divided into north, central and southern climatic subdivisions, except for the two western divisions. Subdivisions broadly reflect differences in average temperature and rainfall, with the north and south experiencing a summer and winter rainfall pattern, respectively. Rainfall in the central subdivisions is distributed more evenly between the seasons (Harden 1990). The elevated tableland country divides eastern (coastal) and western (inland) divisions.

The study area occurs wholly within the North Coast botanical subdivision in the lower Hunter Valley. Harden (1990) describes this subdivision as being characterised by relatively rich, loamy soils supporting tall eucalypt forests, with stretches of poor sandy or stony soils and tidal flats with stunted forest. Maitland LGA contains a range of deep, rich alluvial soils through to stony soils and clayey soils.

According to the interim biogeographic regionalisation of Australia (IBRA) system of Thackway and Cresswell (1995) and Cummings and Hardy (2000), the study area bridges the southern extremity of the NSW North Coast biogeographic region and the north-eastern extent of the Sydney Basin biogeographic region.

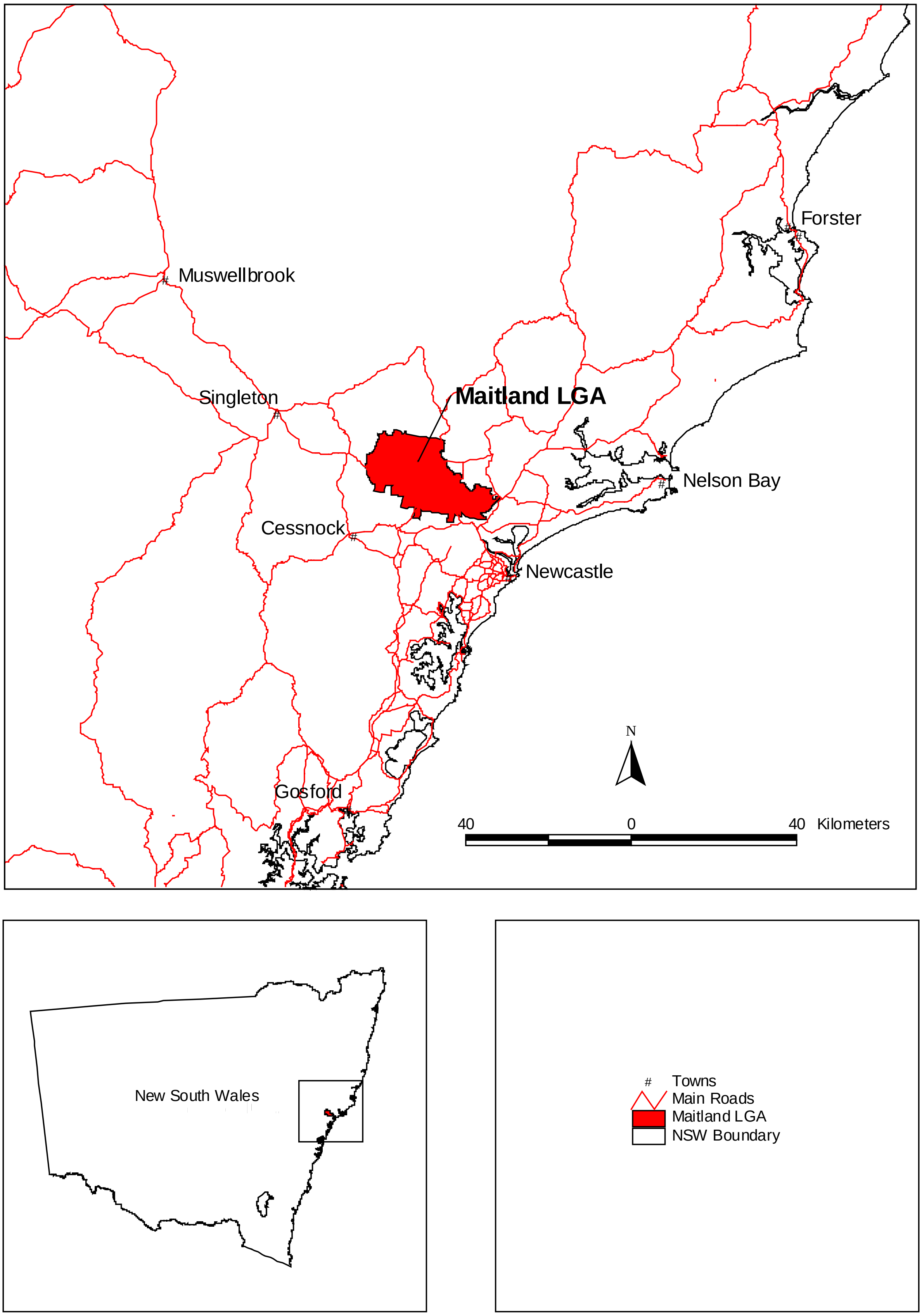


Figure 2.1: Location of the Study Area

Thackway and Cresswell (1995) describe the two biogeographic regions that the study area falls within, as follows:

- NSW North Coast: humid, hills, coastal plains and sand dunes – *Eucalyptus* open forests and woodlands, rainforest often with *Araucaria cunninghamii* (complex notophyll and microphyll vine forest), *Melaleuca quinquenervia* wetlands and heaths.
- Sydney Basin – Mesozoic sandstones and shales, dissected plateaus; forests, woodlands and heaths; skeletal soils, sands and podzolics.

As a result of its location at the junction of biogeographic regions and botanical subdivisions, a high proportion of the plant species occurring within the Hunter Valley are at or close to their distributional limits (Peake and Curran in prep.). The relatively low level of the Great Dividing Range at the western extremity of the Hunter Valley that separates the coastal vegetation from inland vegetation, encourages the exchange of plant species between coastal and inland districts. This exchange cannot occur as easily in other parts of NSW because of the presence of the Great Escarpment, which parallels the Great Dividing Range, and because of extensive tablelands separating coastal and western slopes districts (eg. the New England Tablelands and the Southern Highlands). Maitland LGA is situated near the eastern end of the Hunter Valley, but still supports a number of plants species that are typically western. The study area is also located in an area that is a barrier to plant species exchange between northern coastal NSW and central coastal NSW. This barrier is the relatively dry, expansive eastern end of the Hunter Valley itself, which supports an environment that is largely dissimilar to the coastal lagoons, moist forests and escarpments of the adjoining lower North Coast and the Central Coast (Peake and Curran in prep.).

## 2.4 Geology

The geology of Maitland is dominated by three broad underlying strata - those of Carboniferous, Permian and Quaternary ages. In broad terms, Carboniferous rocks occupy the majority of the north-western LGA, Permian rocks dominate the central-west, central-north and south-east of the LGA, and Quaternary alluvium makes up the remainder of the LGA. (see *Figure 2.2*).

### *2.4.1 Geological Provinces and History*

Maitland LGA lies on the junction of the north-eastern margin of the Sydney Basin and the south-eastern margin of the New England Fold Belt. The junction of these two geological provinces is marked by the presence of the Hunter Thrust System, which bounds most of the north-eastern side of the Hunter Valley floor. The Hunter Thrust is a series of faults along which Carboniferous rocks have been pushed towards the south-west and in some cases have moved over Permian rocks (Branagan and Packham 2000). The most eastern expression of the thrust is in hills near Gosforth (Branagan and Packham 2000), in the north-west of the study area.

The New England Fold Belt is a large geological province stretching from the Hunter Valley to the Queensland border, comprising most of the New England Tablelands. It developed over a long period of time, stretching from late Devonian (369 million years ago (Ma)) period through to early Triassic (241 Ma) period. In the vicinity of the lower Hunter Valley it has been extensively deformed into a series of north to north-west trending folds adjacent to the Hunter Thrust (Matthei 1995). In Maitland LGA, the New England Fold belt primarily consists of rocks of Carboniferous age.

The Sydney Basin is part of the much larger Sydney-Gunnedah-Bowen Basin, stretching 1,500 km from the south coast of NSW well into the central Queensland coast (Hawley and Brunton 1995). It contains a thick Permian - Triassic succession of rocks that was formed by rifting in the early Permian and developed as a foreland basin in front of the deforming New England Fold Belt (Branagan and Packham 2000). Most of the sedimentary strata in this portion of the Sydney Basin were derived from erosion of the New England Fold Belt, followed by a final terrestrial fluvial sedimentation expressed in the Triassic rocks of the nearby Sugarloaf Range (Roy and Boyd 1996). Within Maitland LGA the rocks of the Sydney Basin are of Permian age (251-298 Ma).

### *2.4.2 Carboniferous Strata*

The Carboniferous rocks in Maitland LGA are 298-354 Ma in age. They include a diverse array of rocks, such as volcanics (including lava and tuff), and sedimentary rocks (sandstone, mudstone and conglomerates). They are strongly resistant to erosion, and have formed steep-sided hills and valleys with moderate relief. Extensive folding has occurred in this region as a result of a series of faults associated with the Hunter Thrust System.

### *2.4.3 Permian Strata*

Maitland LGA lies at the north-eastern boundary of the Sydney Basin. The Sydney Basin comprises sedimentary rocks of predominantly Permian-Triassic age (205-298 Ma), although in the upper Hunter around Cassilis rocks of Jurassic age (141-205) are present. In Maitland LGA all rocks in the Sydney Basin are of Permian age (251-298 Ma). Typically they form low, undulating hills since these rocks weather readily (Galloway 1963) and do not form sheer-sided valleys typical of Triassic sandstone that occurs to the south and south-west of Maitland. Towards the end of the early Permian period sedimentation changed from dominantly marine to mostly non-marine coal measures deposition, forming the extensive coal measures that the lower Hunter is renowned for (Branagan and Packham 2000). Most Permian rocks in Maitland LGA are composed of sandstones, shale, mudstones, siltstones and conglomerates, with coal measures interbedded.

### *2.4.4 Quaternary Deposits*

The floodplains of the Hunter and Paterson rivers consist of unconsolidated Quaternary age (<1.8 Ma) sediment which occupy a bedrock palaeovalley (Matthei 1995). This sediment is made up of fluvial, estuarine and coastal-marine sediments of various ages that were deposited during much of the last one million years in a large estuary. This estuary once extended inland from the coast to a distance of about 35 km to just west of present-day Maitland (Roy and Boyd 1996). The dominant sediments are floodplain alluvium and channel sands (Matthei 1995). During the last several thousand years the Hunter River has continued to erode its catchment, with the rate of erosion increasing since the time of European settlement due to extensive thinning and clearing of natural vegetation (Tame 1992).

## 2.5 Physiography

Regionally, Maitland LGA lies close to the eastern extremity of the Hunter River catchment. This catchment is a broad, deep incision into the typically rugged escarpment and tablelands that characterise much of the remainder of the NSW sub-coastal hinterland. The study area includes floodplains and terraces typical of the major streams of the Hunter catchment, rugged hills and mountains that characterise the Hunter Thrust fault, and low, gently rolling hills of the Permian sedimentary landscape. There are no major mountain ranges, lakes or reservoirs within the study area.

The landforms of Maitland LGA are largely characteristic of the three main geological substrates on which they occur. In the north-western and south-western portion of the LGA, the landscape is dominated by rolling hills, low mountains, and both steep and gentle slopes. In these areas the Carboniferous New England Fold Belt dominates the geology. Where it joins with the Permian sediments surrounding the Hunter River, extensive uplifting and folding has occurred in an area termed the Hunter Thrust fault. Maximum elevation here is at Mount Hudson, at 302 m above sea level (ASL). Rolling low hills occur to the south of the Hunter River in the Lochinvar and Greta district.

These are formed on residual Carboniferous geology, which include Winders Hill, Harpers Hill and Jacobs Hill, the latter reaching a maximum of 225 m ASL.

The areas surrounding the Paterson and Hunter rivers and Wallis and Fishery creeks are characterised by floodplains and river terraces, formed by the deposition of silt over millennia. Relief is extremely low in these areas, with the lower and upper limits being between 2 m ASL along the Hunter River near Woodberry, and tens of metres ASL on some river terraces. Several large wetlands occur in this landscape, including Wentworth, Tenambit and Woodberry swamps. A large number of swamps, billabongs and overflow channels have been filled in during the two centuries since European settlement. The lower reaches of the Hunter River within the study area (around Morpeth) are under tidal influence and provide estuarine habitat.

The remainder of Maitland LGA is characterised by the low, undulating hills formed on Permian sediments in the central (Rutherford), northern (Tocal) and south-central (Ashtonfield) parts. Relief is relatively low, with the highest elevation in the Tocal district where it reaches about 200 m ASL.

The elevation of the study area ranges from 2 m along the lower Hunter River up to 302 m ASL at Mount Hudson in the north-west of Maitland LGA. The main drainage channels are the Hunter and Paterson rivers, with smaller tributaries including Fishery (Swamp), Wallis, Four Mile and Scotch Dairy creeks, which all enter the Hunter River from the south.

## 2.6 Land Systems

Land systems are areas with their *own characteristic combination of land forms, soils and vegetation, and consequently* [their] *own potential and own reaction under any given set of conditions* (Christian and Stewart 1953). Story *et al.* (1963a) describes the climate, landforms, geology, geomorphology, soils and vegetation of the Hunter Valley. Although most of these features have since been studied in more detail (such as soils and vegetation). Storey *et al.* (1963a) remains the only comprehensive snapshot of the geomorphology of the Hunter Valley and it still provides the only complete study of the landforms of the Hunter.

Within Maitland LGA Story *et al.* (1963b) mapped 11 land systems, summarised in *Table 2.1*.

**Table 2.1: Land Systems in Maitland LGA (from Storey *et al.* 1963a)**

| Land System Name | Code | Description |
|---|---|---|
| Apis | Ap | Rocky hills; clayey skeletal soils and often stony cracking clays; savannah woodland of box and gum, with ironbark in the south, mostly thinned or cleared, good ground cover of Queensland blue grass. |
| Beresfield | Bf | Undulating lowlands; podzolic soils; dry sclerophyll forest, including blackbutt, red bloodwood and smooth-barked apple, with shrubs and good ground cover of herbs and leafy grasses, cleared area *Paspalum* dominant. |
| Cranky Corner | Cc | Rugged, massive mountains and hills; skeletal soils and rock outcrop, with some shallow cracking clays and solonetzic and podzolic soils; tall mixed woodland, some thinned or cleared, of gums, stringybarks, and ironbarks, with rain forest in sheltered places. |
| Elrington | E | Rounded hills and open valleys; podzolic soils with some skeletal soils and earths; dry sclerophyll forest 13 m of gums, ironbarks, stringybarks, and blackbutt, with shrubs, herbs, and leafy grasses. |
| Glendower | Gd | Rounded hills and open valleys; solonetzic and podzolic soils, earths, skeletal soils, some cracking clays and degraded black earths; savannah woodland of box, gum and ironbark, mostly thinned or cleared, with wire grass, *Chloris*, Queensland blue grass, corkscrew grass and wallaby grass. |

**Table 2.1: Land Systems in Maitland LGA (from Storey *et al.* 1963a)**

| Land System Name | Code | Description |
|---|---|---|
| Hexham | H | Freshwater and brackish swamps; dark heavy and sometimes peaty acid swamp soils and meadow soils, some recent clays; fen (swamp) vegetation, wet areas under paper-bark, drier areas often cleared and under couch grass and *Paspalum*. |
| Hunter | Hu | Alluvial terraces; wide range of soils, cracking clays, chernozemic, solonetzic, and podzolic soils, and regosols; cleared and under cultivation or pioneer grasses. |
| Killarney | K | Undulating lowlands; mostly podzolic and solonetzic soils, smaller patches of shallow earths, skeletal soils, cracking clays, and degraded black earths; savannah woodland of box, gum and ironbark, mostly thinned or cleared, wiry grasses. |
| Moonibung | Mn | Rocky hills and plateaux; shallow podzolic soils, skeletal soils, and some shallow cracking clays; tall mixed woodland 17 m, mainly gums and ironbarks, mostly thinned or cleared, with dense leafy grasses. |
| Parkville | Pv | Undulating lowlands; complex of deep cracking clays, solonetzic soils, and degraded black earths; savannah woodland of box, gum and ironbark, mostly cleared, Queensland blue grass dominant, with scattered eucalypts, mostly white box. |
| Vacy | V | Undulating lowlands; mostly deep, brown podzolic soils; cleared ground under *Dichanthium*, *Paspalum* and other leafy grasses, uncleared ground under 17 m tall mixed woodland of spotted gum and cabbage gum. |

## 2.7 Soil Landscapes

Maitland LGA is covered by two soil landscape maps which were developed at different scales: the Singleton 1:250,000 sheet (west LGA) and the Newcastle 1:100,000 sheet (East LGA). Kovac and Lawrie (1991) and Matthei (1995) delineated 35 soil landscapes within Maitland LGA. Matthei (1995) explains that soil landscapes differ from soil associations in that more emphasis is placed on describing topography. They also differ from land systems in that less emphasis is placed on describing vegetation. Soil landscapes mapped in Maitland LGA are summarised in *Table 2.2*.

Soil landscapes are grouped into larger systems (termed Soil Landscape groups) which are named after environments where soil formation is influenced by certain current and recent processes (Matthei 1995; Martens & Associates 1999). Five soil landscape groups occur in the study area, listed below. *Figure 2.2* shows the distribution of these soil landscape groups in Maitland LGA.

- Residual Soil Landscapes
- Erosional Soil Landscapes
- Alluvial Soil Landscapes
- Estuarine Soil Landscapes
- Disturbed Soil Landscapes

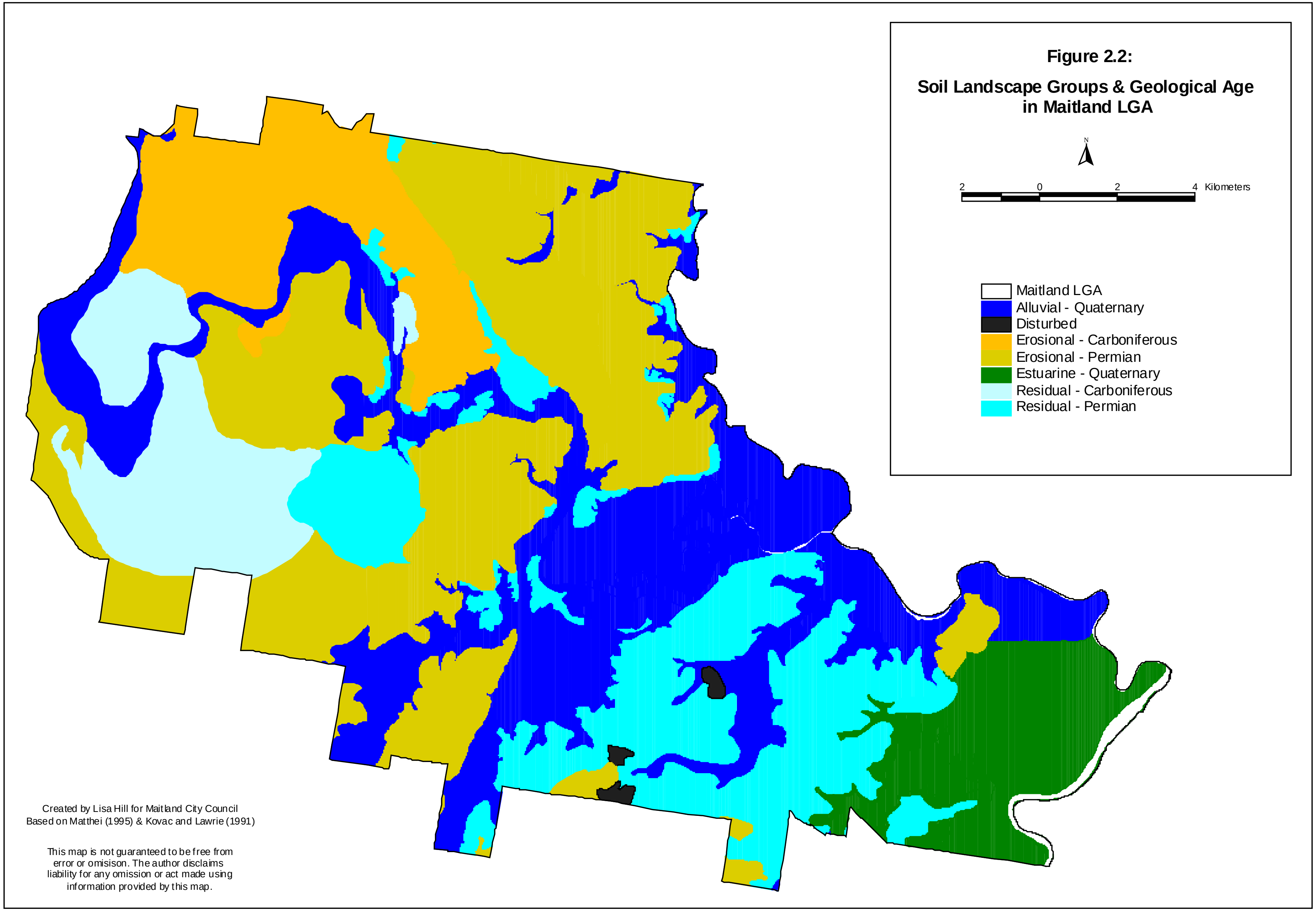


**Figure 2.2:**

**Soil Landscape Groups & Geological Age in Maitland LGA**

**Table 2.2: Soil landscapes in Maitland LGA**

| Soil Landscape Group * | Area (ha) | Soil Landscape Name | Geology and Lithology | Fertility/Suitability for Plant Growth | Description of Soils Present |
|---|---|---|---|---|---|
| Alluvial | 194.7 | Wallis Creek (wc) | Quaternary alluvium: sandy, minor clay from Triassic sandstone. | Low, topsoil v. high in organic matter but profile has v. low nutrient retention capacity. | Brownish, black, greasy, clay-loam; brown, loose loamy-sand; pale loose clayey sand. |
| Alluvial | 46.8 | Paterson River (pa) | Quaternary sediments: gravel, sand, silt, clay. | Moderate to low; very low in organic matter. | Weakly pedal loamy-sand to sandy-loam; loose brown sand. |
| Alluvial | 6.0 | Hunter (variant b oxbows, recent overbank deposits, crevasse splays and broad levees) (hub) | Quaternary alluvium: clay, silt, sand. | High to moderate (some minor soils low). Moderate to v. high organic matter. | Friable, brown, pedal loam; brownish-black well-structured clay; weakly-structured brown sandy-clay-loam; pedal brownish, black silty-clay to medium clay; brown, well-structured loam. |
| Alluvial * | 5.7 | Neath (SCnh) | Permian sediments: siltstone, silty pebbly sandstone, minor coal. | Low | Grey solodics; yellow solodics. |
| Disturbed | 29.6 | Disturbed (xx) | Quaternary, Tertiary and Permian. | Low | Most of original soil removed, buried or greatly disturbed. |
| Erosional * (some alluvial) | 606.4 | Stanhope (BPst) | Carboniferous sediments: acid lava with interbedded conglomerate, ignimbrite, tuff, sandstone, shale, mudstone, tillite, granodiorite. | Low | Brown podzolics; yellow podzolics, red solodics; non calcic brown soils. |
| Erosional * | 287.2 | Moonabung (SLmb) | Carboniferous sediments: acid lava flows; conglomerate; ignimbrite, tuff, sandstone, shale, tillite, mudstone. | Moderate | Red podzolic soils. |
| Erosional | 166.7 | Welshmans Creek (variant a: steep slopes) (wea) | Carboniferous sediments and ignimbrite: sandstone, siltstone, conglomerate, ignimbrite, tuff. | Moderate to low; topsoil high in organic matter. | Brown, weakly pedal sandy loam; bleached sandy-clay-loam; brown plastic clay; bright brown gritty earthy-clay. |
| Erosional | 103.1 | Welshmans Creek (we) | Carboniferous sediments and ignimbrite: sandstone, siltstone, conglomerate, ignimbrite, tuff. | Moderate to low; topsoil high in organic matter. | Brown, weakly pedal sandy-loam; bleached sandy-clay loam; brown plastic clay; bright brown gritty earthy-clay. |

## Table 2.2: Soil landscapes in Maitland LGA

| Soil Landscape Group * | Area (ha) | Soil Landscape Name | Geology and Lithology | Fertility/Suitability for Plant Growth | Description of Soils Present |
|---|---|---|---|---|---|
| Erosional | 98.1 | Seaham (se) | Carboniferous sediment: tillite, shale, tuff, sandstone, conglomerate. | Low. Topsoils low to very low in organic matter. | Brown-black weakly pedal loam; hardsetting, bleached sandy-clay-loam; yellowish brown pedal clay. |
| Erosional | 71.1 | Seaham (variant a: steep slopes with narrow rock benches) (sea) | Carboniferous sediment: tillite, shale, tuff, sandstone, conglomerate. | Low. Topsoils low to very low in organic matter. | Brown-black weakly pedal loam; hardsetting bleached sandy-clay-loam; yellowish brown pedal clay. |
| Erosional * | 29.1 | Lambs Valley (SHlb) | Carboniferous sediments: conglomerate, tuff, sandstone, shale. | Low | Yellow soloths; brown soloths; brown earths. |
| Vestigial | 7.5 | George Trig (gt) | Carboniferous volcanics: ignimbrites, oligoclase, orthoclase, quartz, hornblends, minor sandstone. | Very low to moderate. | Black organic pedal loam; brown earthy-sandy-loam. |
| Colluvial | 5.5 | Hungry Hill (hh) | Carboniferous volcanics: ignimbrite; tuff, sandstone and conglomerate. | Moderate to low; very low in loams; moderate in chocolate soils. | Weakly pedal gravelly loam; bleached earthy-sandy-clay-loam; pedal brown mottled clay. |
| Erosional | 1058.1 | Bolwarra Heights (bh) | Permian sediments: sandstone, siltstone, conglomerate, erratics, siltstone, shale, splitting coal seams, mudstone. | Moderate; topsoil very high in organic matter. | Brownish black gravelly loam; earthy gravelly sandy-clay-loam; yellowish brown pedal clay. |
| Erosional * (some residual) | 943.1 | Branxton (Ypbx) | Permian sediments: sandstone, mudstone, siltstone, shale, tuff, coal, conglomerate, limestone. | Low | Yellow podzolics, red podzolics; yellow soloths; alluvial sands; siliceous sands. |
| Erosional | 403.2 | Middlehope (mi) | Permian conglomerate: sandstone, siltstone, mudstone, shale. | Low; very low to low topsoils; low in organic matter in profile. | Gravelly brown loam; bleached dull brown clayed sand; mottled dull yellowish brown clay. |
| Erosional * (some alluvial) | 326.8 | Rothbury (Rpro) | Permian sediments: sandstone, siltstone, shale, tuff, conglomerate, mudstone, limestone, coal. | Low to moderate. | Red podzolic soils; yellow podzolic soils; yellow solodic soils; brown soloths; prairie soils. |
| Erosional | 153.9 | North Eelah (ne) | Permian sediments: sandstone, siltstone, shale, tuff, basalt, erratics, conglomerate. | High, moderate & low depending on soil; mostly high to moderate. | Black clay; dark brown clay; brown pedal clay loam; bleached clay loam; pedal yellowish brown clay; dark red brown clay; black clay. |

## Table 2.2: Soil landscapes in Maitland LGA

| Soil Landscape Group * | Area (ha) | Soil Landscape Name | Geology and Lithology | Fertility/Suitability for Plant Growth | Description of Soils Present |
|---|---|---|---|---|---|
| Erosional | 133.7 | Shamrock Hill (sh) | Permian sediments: shale, mudstone, sandstone, coal, tuff, clay. | Moderate to low; profile has low to very low nutrient storage. | Brownish black friable loam; bleached, hardsetting sandy-clay-loam; pedal bright reddish-brown mottled clay; mottled grey puggy clay. |
| Erosional | 6.4 | Bolwarra Heights (variant a: shallow) (bha) | Permian sediments: sandstone, siltstone, conglomerate, erratics, siltstone, shale, splitting coal seams, mudstone. | Moderate; topsoil very high in organic matter. | Brownish-black gravelly loam; earthy gravelly sandy-clay-loam; yellowish brown pedal clay. |
| Swamp | 441.9 | Hexham Swamp (hs) | Quaternary estuarine backplains/ lacustrine sediments: silts and clays. | | Black pedal silty-clay-loam; Gleyed sticky plastic clay. |
| Estuarine | 106.9 | Millers Forest (mf) | Quaternary Holocene alluvium: clay, silt, sand. | High to low; profile moderate to high suitability to plant growth. | Well-structured brownish black silty-clay-loam; well-structured brown silty clay. |
| Estuarine | 5.7 | Fullerton Cove (fc) | Holocene sediments: estuarine mud, silt, clay. | Waterlogged and saline soils limits vegetation. | Black organic rich peat; saturated saline organic mud. |
| Alluvial | 468.1 | Hunter (variant a: swampy backplains) (hua) | Quaternary alluvium: clay, silt, sand. | High to moderate (some minor soils low); moderate to very high in organic matter. | Friable brown pedal loam; brownish black well-structured clay; weakly-structured brown sandy-clay-loam; pedal brownish black silty-clay to medium clay; brown well-structured loam. |
| Alluvial | 313.1 | Hunter (hu) | Quaternary alluvium: clay, silt, sand. | High to moderate (some minor soils low). Moderate to very high in organic matter. | Friable brown pedal loam; brownish black well-structured clay; weakly-structured brown sandy-clay-loam; pedal brownish black silty-clay to medium clay; brown well-structured loam. |
| Alluvial * | 196.8 | Hunter (Ahu) | Quaternary alluvium: clay, silt, sand. | High to moderate (some minor soils low); moderate to very high in organic matter. | Friable brown pedal loam; brownish black well-structured clay; weakly-structured brown sandy-clay-loam; pedal brownish black silty-clay to medium clay; brown well-structured loam. |
| Alluvial | 170.6 | Cockle Creek (cc) | Quaternary alluvium: sandstone, siltstone, conglomerate, shale, tuff. | Moderate to low; topsoil very high in organic matter. | Brownish black sandy loam; hardsetting bleached sandy-clay-loam; yellowish brown pedal clay; earthy mottled sandy-clay. |
| Erosional & Alluvial* | 242.1 | Lochinvar (NKlv) | Carboniferous sediments: siltstone, sandstone, basalt, tuff. | Moderate to Low. | Non calcic brown soils; brown podzolics; yellow solodics. |
| Erosional * | 14.5 | Mount View (CSmv) | Carboniferous sediments: basalt, acid volcanics, trachyandesite, ignimbrite, granodiorite. | High | Chocolate soils; euchrozems. |

**Table 2.2: Soil landscapes in Maitland LGA**

| Soil Landscape Group * | Area (ha) | Soil Landscape Name | Geology and Lithology | Fertility/Suitability for Plant Growth | Description of Soils Present |
|---|---|---|---|---|---|
| Residual | 0.6 | Brecon (br) | Carboniferous sediments & ignimbrites: sandstone, siltstone; conglomerate, ignimbrite. | Moderate to low; topsoil has high organic matter; profile fertility low in shallow soils and moderate in deep soils. | Brown weakly pedal sandy loam; bleached sandy-clay-loam; brown strongly pedal sticky plastic clay. |
| Residual | 1662.2 | Beresfield (be) | Permian sediments: shale, mudstone, sandstone, coal, tuff, clay, siltstone, limestone. | Moderate to low; topsoil moderate in organic matter. | Black loam; hardsetting dull yellowish brown sandy loam; pedal brown plastic mottled clay; reddish brown plastic pedal clay; gleyed "puggy" silty clay. |
| Residual | 49.6 | Wallalong (variant a: alluvial fans and drainage plains) (wga) | Permian sediments: sandstone, mudstone, siltstone; shale; tuff; basalt; erratics. | Moderate to low; topsoil high in organic matter. | Weakly pedal brown loam; hardsetting bleached sandy clay loam; brown harsh sticky clay. |
| Residual | 32.6 | Rivermead (ri) | Quaternary or Tertiary alluvium: sand, silt and clay. | Moderate to low; topsoil high in organic matter. | Earthy brow black sandy clay loam; brown earthy loamy sand to fine sandy clay loam; crumbly sandy clay loam; massive hardsetting sandy clay loam; brown sandy clay loam to sandy clay; cracking brown plastic pedal clay; pedal plastic clay. |
| Residual | 1.2 | Wallalong (wg) | Permian sediments: sandstone, mudstone, siltstone; shale; tuff; basalt; erratics. | Moderate to low; topsoil high in organic matter. | Weakly pedal brown loam; hardsetting bleached sandy clay loam; brown harsh sticky clay. |

**Notes:** Soil Landscape Groups marked with and asterisk (*) are based on Martens and Associates (1999). All other information is from Kovac and Lawrie (1991) and Matthei (1995).

## 2.8 Land Use

### *2.8.1 1813 – present*

Europeans first settled in the Maitland district in the early 1800s. From 1813 Europeans were first officially permitted to occupy land at Paterson's Plains, comprising the rich river flats along the north side of the Hunter River between Bolwarra and Phoenix Park and around the lower reaches of the Paterson River (Wood 1972).

Initially, the primary economic returns from the area were gained from cedar-getting and cropping after forests and brush were cleared. Morpeth became an important trading port and early on was the major urban centre in the Maitland district. After much of the area had been cleared, forestry was no longer viable and both cropping and dairying became the main agricultural pursuits.

Most of the natural vegetation of Maitland LGA has been cleared, with the Maitland Greening Plan (Maitland City Council 2002) stating that over 90 percent of pre-1750 vegetation has been removed. The high level of clearing in the LGA has resulted from a number of factors, including early settlement in the colonial period, the location of Morpeth (and later Maitland) on important transport networks and the district's agricultural potential for large-scale clearing. Most clearing has occurred on the fertile floodplains that were suitable for cropping and grazing. These areas probably supported mostly tall open woodland and pockets of lowland rainforest. Even in the heavily timbered lowland rainforests along the major rivers, where tree density was very high, the agricultural potential was considered high enough to undertake clearing. Clearing of drier forest and woodland types was initially less extensive, but in recent decades has become much more prevalent. While mining and agriculture were the former drivers for vegetation clearance, residential and light industrial developments are the key reasons for continued pressure.

### *2.8.2 Current*

Today Maitland LGA supports a population of some people 53,716 (2001 Census). However, the largest proportion of land is under rural use. Morpeth is no longer an important trading port, and Maitland is now the leading urban centre. Most agriculture is focussed on cropping (including lucerne, maize and vegetables), limited dairying and beef cattle grazing, and turf farming.

# Chapter 3 Previous Botanical Work

## 3.1 Introduction

Several previous reports are relevant to the study of vegetation in Maitland LGA. In addition, some other reports provide information on similar vegetation types in nearby areas or in areas with similar environments. The following sections provide a brief summary of reports relevant to the current work.

## 3.2 Maitland Greening Plan (Maitland City Council 2002)

The Maitland Greening Plan was developed by Maitland Council with support from Bushcare (The Natural Heritage Trust). The Plan followed two consultant reports for Stage 1: a bushland inventory (Manidis Roberts 1996) and Stage 2A: conservation and management options (Pittendrigh, Shinkfield and Bruce Landscape Architects *et al.* 1998). After attaining broad community support for the Greening Plan process, the Greening Plan Coordinating Group was established, comprising representatives from Council, community, and relevant government and non-government organisations. With input and advice from the Coordinating Group, Maitland Council developed the Maitland Greening Plan Stage 2B that was adopted by Maitland Council in February 2002 (Maitland City Council 2002).

Maitland City Council (2002) states that the Greening *plan is essentially a collection of information about vegetation and related environmental issues in the Maitland Local Government Area and a framework for the management of that vegetation towards increased sustainability in the long term.* The Greening Plan makes 13 recommendations to Maitland Council, which are currently being worked towards by Council.

As a consequence of the Greening Plan, in March 2002 Council resolved to commission more detailed mapping of native vegetation communities in Maitland City. This report results directly from that resolution and is intended to assist Council in the achievement of the recommendations in the Maitland Greening Plan.

## 3.3 Lower Hunter and Central Coast Vegetation Survey and Mapping (NPWS 2000)

The Lower Hunter and Central Coast Regional Environment Management Strategy (LHCCREMS) is an initiative of seven local councils (Maitland, Cessnock, Port Stephens, Newcastle, Lake Macquarie, Wyong and Gosford) to improve consistency in the management of natural resource and environmental issues at a regional scale. LHCCREMS developed a Regional Biodiversity Conservation Strategy (RBCS) in partnership with State agencies and community networks, which has the following objectives:

- be guided by comprehensive baseline mapping of the biodiversity values in the landscape
- identify the conservation status and significance of all land in the study area
- provide input into future planning and development strategies for the region
- seek to identify and facilitate implementation of an innovative mix of approaches to conservation of natural areas of significance outside the formal reserve system

NPWS was commissioned by LHCCREMS to undertake additional vegetation survey and mapping necessary to fill in data gaps and to upgrade existing information to a suitable level. The outcomes of the study, reported in NPWS (2000) include:

- a detailed cross tenure map of the distribution of the vascular plant communities in the lower Hunter and Central Coast region
- estimates of the distribution of those plant communities prior to European arrival (pre-1750), based on complex modelling and vegetation mapping
- descriptions of each of the vegetation communities mapped and modelled

LHCCREMS (2003) provides information on the reservation status, percentage cleared and rarity of vegetation communities in the lower Hunter and Central Coast, based on analysis of vegetation data and mapping from NPWS (2000) and application of stated conservation criteria.

### 3.4 Hunter Remnant Vegetation Project (Peake 1999, Peake 2000 and Peake in prep.)

Sampling and mapping of remnant vegetation in the central Hunter Valley floor was carried out by the Hunter Catchment Management Trust (HCMT) in 1997-2001 (Peake 1999, Peake 2000 and Peake in prep.). Vegetation mapping from Peake (in prep.) covers 3,200 square kilometres on the central Hunter Valley floor and includes parts of the Scone, Muswellbrook and Singleton LGAs. The study area borders with Maitland LGA where it meets Singleton LGA in the Luskintyre-Dalwood-Lambs Valley district. The Hunter Remnant Vegetation Project has mapped vegetation at 1:25,000, with extensive map validation, and sampled flora in about 150 plots. At the time of writing this report, the HCMT was undertaking detailed statistical analysis of all data collected in this work. Results will be reported in the near future (Peake pers. comm.).

Two reports (Peake 1999 & 2000) summarise some of the key preliminary findings of the project, which include:

- about 20% of the study area has forest or woodland cover, indicating that the decline since European settlement is about 80%
- the typical remnant size is in the order of two hectares
- the vegetation has been highly fragmented, and edge effects are contributing to remnant decline through weed invasion, tree dieback and lack of regeneration
- approximately 50 vegetation communities are anticipated to be delineated in the study area (at the time of writing this report, these were being defined), of which possibly 25% are likely to be considered to be threatened and poorly reserved
- currently, two TSC Act listed Endangered Ecological Communities occur in the study area, being Warkworth Sands Woodland and Grassy White Box Woodland, although it is likely that Hunter Lowlands Redgum Forest occurs in the study area
- most vegetation occurs on private land, and only a very small fraction is protected in reserves (Peake in prep.)

Several field survey plots from Peake (in prep.) located adjacent to Maitland LGA at Greta (in Cessnock LGA) and Lambs valley (Singleton LGA), were used in the current work for comparative purposes.

### 3.5 Vegetation Assessment for the Thornton North Master Plan (Bell 2003)

Vegetation in a 900 ha site of the Thornton North area of Maitland LGA was mapped and assessed for conservation value as part of the Thornton North Master Plan. Three vegetation communities were mapped, including an intergrade of Lower Hunter Spotted Gum Ironbark Forest and Seaham Spotted Gum Ironbark Forest, Hunter Lowlands Redgum Forest and Freshwater Wetland Complex. Mapping was based on two plots that were carried out as part of the current work and general field reconnaissance. Results found a high degree of modification of vegetation in about 70% of the 900 ha area. Areas of relatively intact vegetation were recommended for retention. No threatened or otherwise significant species were described and one Endangered Ecological Community (EEC) was mapped.

Overall, mapping by Bell (2003) is consistent with the current work, although areas mapped by Bell as Hunter Lowlands Redgum Forest have been mapped in the current work as a variant of that community, Hunter Lowlands Redgum Moist Forest (Unit 10). Dissimilarity between these studies is the result of different methods used, disturbance of the vegetation and size of the study areas.

### 3.6 Vegetation of Werakata National Park (Bell 2001 & Hill in prep.)

Werakata National Park (also known as Lower Hunter National Park) occurs in several portions in and around Kurri Kurri, Cessnock and Kitchener. The reserve occupies land that was formerly Aberdare and Cessnock state forests. Bell (2001) reports on vegetation in the part of the reserve first gazetted, covering some 2,145 ha. Hill (in prep.) reports on vegetation in a 500 ha addition to the existing reserve, near Sawyers Gully. In general, the reserve comprises heavily logged but important stands of Lower Hunter Spotted Gum Ironbark Forest and Kurri Sand Swamp Woodland, both of which occur in Maitland LGA. Also, smaller areas of Central Hunter Riparian Forest occur in the reserve. A number of significant flora species were recorded, some of which are relevant to this report.

### 3.7 Register of Regionally Significant Plant Species, Populations and Communities Within the Hunter Region (Bell *et al.* 2003)

This working register of regionally significant plant species, populations and communities has been developed to meet a need in the Hunter for scientific assessment of significance at a regional scale. The register will be updated as new assessments are made, and is available on the Hunter Region Botanic Gardens web site. The assessment method developed for this register has been formulated based on contemporary scientific knowledge. Assessment of regional significance of plant species and communities in Maitland LGA presented in *Sections 6.1.4* and *6.3.1* has generally followed methods used by Bell *et al.* (2003).

# Chapter 4 Methods

## 4.1 Introduction

Methods developed for this study followed standard techniques used by most government agencies in NSW that undertake ecological survey, including the National Parks and Wildlife Service, Department of Infrastructure Planning & Natural Resources, and Royal Botanic Gardens Sydney. The project consisted of plot-based sampling of vegetation and vegetation mapping using aerial photograph interpretation (API) and field reconnaissance. Vegetation sampling techniques used were compatible with the LHCCREMS project, carried out by NSW National Parks and Wildlife Service (NPWS 2000). This ensured that data collected in the LHCCREMS survey could be incorporated into the current work, thereby maximising the size of the final data set used in delineation of vegetation communities. Use of standard techniques also allows data collected in the current work to be used in future systematic survey.

The survey consisted of the following steps, which are described in subsequent sections.

- preliminary vegetation mapping
- existing data audit
- stratification of study area and selection of new sites
- field survey – plot-based sampling and field reconnaissance
- data analysis
- final vegetation mapping
- vegetation map validation ('ground truthing')

## 4.2 Preliminary Vegetation Mapping

Aerial photograph interpretation (API) was undertaken using stereoscopic pairs of 1:25,000 colour photographs taken in 2000 and 2001. Second and third edition topographic maps prepared by Land and Property Information NSW in 2001 at a scale of 1:25,000 were used for referencing photographs to the ground surface. Details of aerial photographs and topographic maps used are provided in *Table 4.1* and *Table 4.2*.

**Table 4.1: Aerial Photographs Used for Vegetation Mapping**

| Run Name | Run Number | Photograph Numbers | Date |
|---|---|---|---|
| Cessnock | 3 | 121-125 | 23-7-2000 |
| Cessnock | 4 | 76-81 | 23-7-2000 |
| Cessnock | 5 | 69-75 | 23-7-2000 |
| Cessnock | 6 | 26-32 | 23-7-2000 |
| Cessnock | 7 | 19-25 | 23-7-2000 |
| Cessnock | 8 | 192-193 | 23-7-2000 |
| Newcastle | 3 | 2-5 | 03-1-2001 |
| Newcastle | 4 | 165-172 | 03-1-2001 |
| Newcastle | 5 | 100-106 | 03-1-2001 |
| Newcastle | 6 | 87-97 | 03-1-2001 |

**Table 4.1: Aerial Photographs Used for Vegetation Mapping**

| Run Name | Run Number | Photograph Numbers | Date |
|---|---|---|---|
| Newcastle | 7 | 32-43 | 03-1-2001 |
| Newcastle | 8 | 19-28 | 03-1-2001 |
| Newcastle | 9 | 203-205 | 03-1-2001 |

**Table 4.2: Topographic & Orthophoto Maps Use for Vegetation Mapping**

| Name | Code | Edition | Year |
|---|---|---|---|
| Clarence Town | 9232-1N | Third Edition | 2001 |
| Beresfield | 9232-3N | Third Edition | 2001 |
| Paterson | 9232-4N | Third Edition | 2001 |
| Elderslie | 9132-1N | Second Edition | 2001 |
| Greta | 9132-1S | Second Edition | 2001 |
| Cessnock | 9132-2N | Third Edition | 2001 |

Preliminary vegetation units were mapped onto topographic map overlays using LHCCREMS 1:10,000 extant vegetation mapping (Eco Logical 2002a) as a base layer for boundaries of remnant vegetation. LHCCREMS mapping was used as it provided linework at a larger scale than was possible using API of 1:25,000 photos and it facilitated comparison with regional mapping.

Each preliminary vegetation unit was labelled with a code representing features of: (1) vegetation type (eg. alluvial, non-alluvial, rainforest, wetland, regeneration, etc); (2) vegetation form (eg. closed forest, open forest, woodland, etc); and (3) vegetation height. Details of these codes are provided in *Appendix A*.

In addition to vegetation typing, API was used to label each vegetation remnant with three additional features, with the third one used as part of the local ecological assessment process (see *Section 4.9*): (1) Adjacent land use; (2) Modification level; and (3) Connectivity of remnant. Details of these codes are provided in *Appendix A*. A remnant was defined as an area of contiguous woody vegetation dominated by native flora.

The minimum mappable size of vegetation units was generally one hectare in area (approximately 16 square millimetres on the topographic map) and 50 metres in width (approximately two millimetres on the topographic map) due to limitations of the mapping and subsequent digitising processes. The minimum tree crown number for remnants was five, so that remnants with less than five tree crowns visible on aerial photos were not mapped. Consequently, linear vegetation units such as some riparian vegetation and very small vegetation remnants may not have been mapped.

The preliminary vegetation map was used to select additional sites for field survey (see *Section 4.4*) and as a base map for the final vegetation community map (see *Section 4.8.1*).

## 4.3 Data Audit

To maximise the floristic dataset for this project, existing vegetation surveys available for Maitland LGA were reviewed to identify suitable data that could be incorporated into the study. Existing surveys included several studies carried out for developments in the study area and systematic vegetation survey carried out by NPWS (2000) for the LHCCREMS study. Methods used for these studies were reviewed to identify high quality data that could be incorporated into data analysis for the current work. High quality data was defined as data collect by studies that used scientifically sound quantitative sampling and qualified field botanists. NPWS (2000) was considered to be the only available study in Maitland that provided high quality data. Other studies with data unsuitable for quantitative analysis provided useful information about vegetation patterns without incorporation into data analysis. *Table 4.3* shows results of the data audit.

**Table 4.3: Results of Data Audit of Available Vegetation Studies in Maitland LGA**

| Survey | Suitable for Data Analysis | Field Survey Method | Reference |
|---|---|---|---|
| LHCCREMS | yes | Plot-based | NPWS (2000) |
| Anambah View Estate, Rutherford | no | Random Meander | HLA Envirosciences (2000) |
| Statement of Effect on threatened flora and fauna, for proposed rezoning at East Maitland | no | Random Meander | Woodhouse & Worth (2001) |
| Flora & fauna assessment, for proposed rezoning at Ashtonfield | no | Random Meander ? | Ecotone Ecological Consultants (1998) |
| Thornton North Master Plan | no | Reconnaissance | Bell (2003) |
| Flora & Conservation Assessment, for proposed rezoning at Avalon Forest State, Thornton | no | Random Meander / Reconnaissance | SWC Consultancy (1995) |

## 4.4 Stratification of Study Area and Site Selection

Vegetation in the study area was sampled using a stratification method, which allows replicated sampling of environmental variables that influence vegetation patterns. Extant vegetation in the study area was stratified using the following environmental variables.

- soil landscape group
- topographic position
- aspect

### *4.4.1 Soil Landscape Groups*

For the purpose of stratification, the 35 soil landscapes mapped in the Maitland LGA by Kovac and Lawrie (1991) and Matthei (1995) (see *Section 2.7*) were placed into four groups, shown below. Limitations in time and resources did not allow further separation of these groups.

- Erosional
- Residual
- Alluvial
- Estuarine

### *4.4.2 Topographic Position*

The landscape is generally divided into seven positions with respect to the local topography. These include the crest, upper slope, mid slope, lower slope, gully/open depression, closed depression (wetland) and flat.

However, due to limitations in time and resources available for the project, these positions were grouped. In general, these groups were based on the reasoning that slope positions are more influential on vegetation in areas of low to high relief (relief of over 30 m) and moderately inclined to very steep slopes (10% slope or more). In areas of very low relief (relief less than 30 m) and level to gently inclined slopes (0-10% slope), effect of slope position on vegetation was considered less significant since incident sunlight is more or less similar across the landscape. Areas of high to low relief and moderately inclined to very steep slopes were divided into crest/upper slope (U), lower slope (L), flat (F) and gully/open depression (G). Areas of very low relief and level to gently inclined slopes were divided into slope/flat/river terraces (L) and gully/open depression (G).

These topographic positions were related to soil landscape groups in the study area. Alluvial and estuarine soil landscapes typically have very low relief and level to gentle slopes in the Maitland area, while residual and erosional soil landscapes typically have low to high relief and moderate to very steep slopes. *Figure 4.1* illustrates the topographic positions used in the stratification process and their relationship to soil landscape groups.

Wetlands (closed depressions) were not sampled as part of this project since Council hopes to undertake a survey specifically targeting wetlands in the future. This will allow the complex wetland ecosystems in the LGA to be sampled at a more intense level than resources available for the current work would have allowed.

### *4.4.3 Aspect*

Aspect was applied to areas where modal slopes (most common slope) are moderately inclined to very steep (10% or greater). Aspect was not considered a significant influence on vegetation in areas dominated by level to gently inclined slopes (less than 10% modal slope). Therefore alluvial and estuarine soil landscapes were not stratified for aspect. Residual and erosional soil landscapes were stratified for the four points of the compass: north, east, south and west. The following aspect classes were used for the survey, described by the points of the compass shown.

- north 337.6-67.5 degrees
- east 67.6-157.5 degrees
- south 157.6-247.5 degrees
- west 247.6-337.5 degrees

### *4.4.4 Stratification Classes*

Stratification classes were formed by the combination of the environmental variables that occur within the study area. *Table 4.4* shows the stratification classes used in the study area. Using the stratified sampling approach the number of replicates surveyed in each stratification class should be in proportion to their occurrence within the study areas.

Based on the stratification classes that are shown in *Table 4.4*, a minimum of 87 field sites/plots (29 stratification classes by three replicates) were required to adequately sample these environmental variables in the study area. This number is reduced by the removal of stratification classes that no longer have extant vegetation or where so little extant vegetation remains that replication is not possible. For example, very little vegetation remains on the estuarine and alluvial plains in Maitland LGA, so that opportunities for replicating field sites were reduced.

Existing field sites with high quality data were placed into the stratification classes shown in *Table 4.4*. The locations of additional sites were then selected to fill gaps in the stratification matrix. Time and resources allowed for an additional 35 plots to be sampled in the study area. Due to limited resources and time not all stratification classes were adequately sampled.

**Table 4.4: Stratification Classes Existing in the Study Area: Soil Landscape Group *by* Topographic Position *by* Aspect**

| Soil Landscape Group (Aspect shown in capitals) | Topographic Position: Upper slope/ Crest (low-high relief & moderate to V. steep slopes) | Lower slope (low-high relief & moderate to V. steep slopes) | Gully/ Open depression/ River | Flat | Slope/Plain/ River terraces (V. low relief & level-gentle slopes) |
|---|---|---|---|---|---|
| **Erosional** | N E S W | N E S W | N E S W | - | - |
| **Residual** | N E S W | N E S W | N E S W | nil aspect | - |
| **Estuarine** | - | - | nil aspect | - | nil aspect |
| **Alluvial** | - | - | nil aspect | - | nil aspect |

Note: N = north aspect; E = east aspect, S = south aspect, W = west aspect.
A dash (-) indicates the stratification class does not exist in the study area. See *Section 4.4* for an explanation.

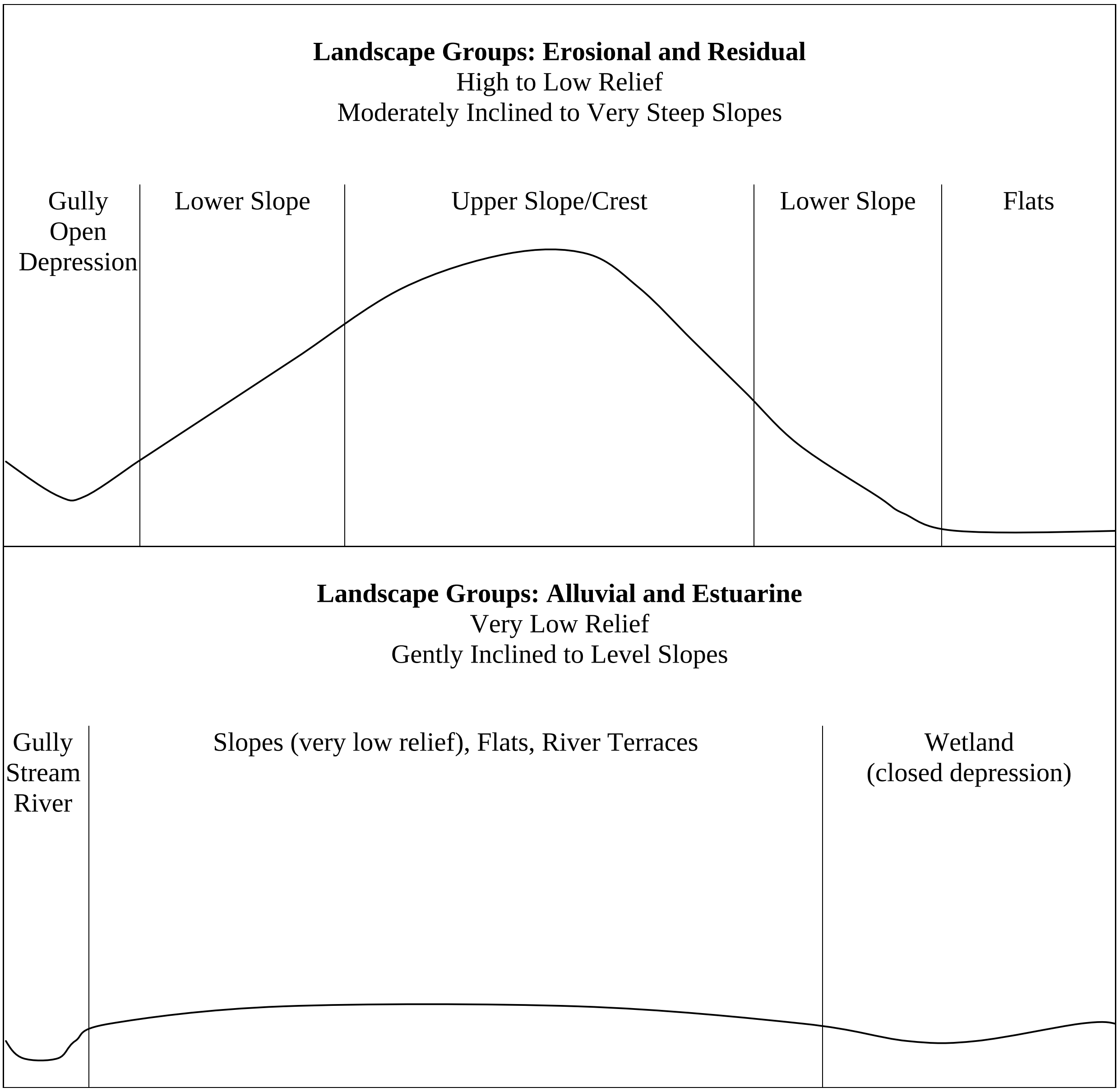


**Figure 4.1: Topographic Positions for Stratification of Study Area**

### 4.5 Floristic Sampling

Vegetation was sampled in 55 field sites of 400 square metres each (typically 20 by 20 metre plots). This number included 20 plots provided by NPWS (2000) and 35 plots sampled for the current work. Locations of field plots are shown on *Figure 4.2*. *Table 4.5* indicates sampling intensity in relation to the stratification classes shown in *Table 4.4*. In addition to sampling carried out in 55 plots, field reconnaissance and 'ground truthing' of vegetation was carried out at numerous locations across the study area during a total of 10 person days. At these locations, observations on dominant canopy species and vegetation structure were made to improve accuracy of the final vegetation community map and to provide additional information for description of community variations in the study area.

**Table 4.5: Total Number of Field Sites Sampled in Each Stratification Class**

| | | **Topographic Positions** | | | | | |
|---|---|---|---|---|---|---|---|
| **Soil Landscape Group** | **Aspect** | Upper slope/ Crest | Lower slope | Gully/ Open depression/ River | Flat | Slope/ Plain/ River terraces | **Total** |
| Erosional | N | 4 | 3 | 3 | - | - | 10 |
| | E | 1 | 2 | 2 | - | - | 5 |
| | S | 6 | 2 | 3 | - | - | 11 |
| | W | 2 | 2 | 2 | - | - | 6 |
| **Subtotal** | | **13** | **9** | **10** | **-** | **-** | **32** |
| Residual | N | 1 | 1 | 0 | - | - | 2 |
| | E | 1 | 1 | 2 | - | - | 4 |
| | S | 2 | 0 | 1 | - | - | 3 |
| | W | 3 | 0 | 0 | - | - | 3 |
| | nil | - | - | - | 6 | - | 6 |
| **Subtotal** | | **7** | **2** | **3** | **6** | **-** | **18** |
| Alluvial | nil | - | - | 2 | - | 0 | 2 |
| Estuarine | nil | - | - | 2 | - | 1 | 3 |
| **Total** | | **20** | **11** | **17** | **6** | **1** | **55** |

Note: A dash (-) indicates stratification class does not exist in the study area.

Field sampling for the current work was carried out between January and March 2003. Field sampling by NPWS (2000) incorporated into the dataset for the current work was carried out between March and June 1999.

Vegetation species occurring within each field site were recorded and given a score for cover abundance using a six-point modified Braun-Blanquet system (Poore 1955; Austin *et al.* 2000): 1 = <5% cover, few individuals; 2 = <5% cover, many individuals; 3 = 5-20% cover; 4 = 20-50% cover; 5 = 50-75% cover; 6 = 75-100% cover. Information on vegetation structural formation and biophysical attributes of each site was also recorded, including aspect, slope, elevation, azimuths, landform element and morphology, disturbance history, soil colour, soil texture, soil depth and soil drainage. Photographic records were also taken.

Flora nomenclature used in the current work follows Harden (1990, 1992, 1993, 2002), Harden & Murray (2000) and Wheeler *et al.* (2002). PlantNet (2003) was referred to for changes in nomenclature since these publications. Common names used follow Harden (1990, 1992, 1993 & 2002) and Harden & Murray (2000) where available, and draw on other sources such as local names where these references did not provide a common name. Plant voucher specimens were collected for confirmation of identification and lodgement with the National Herbarium of NSW.

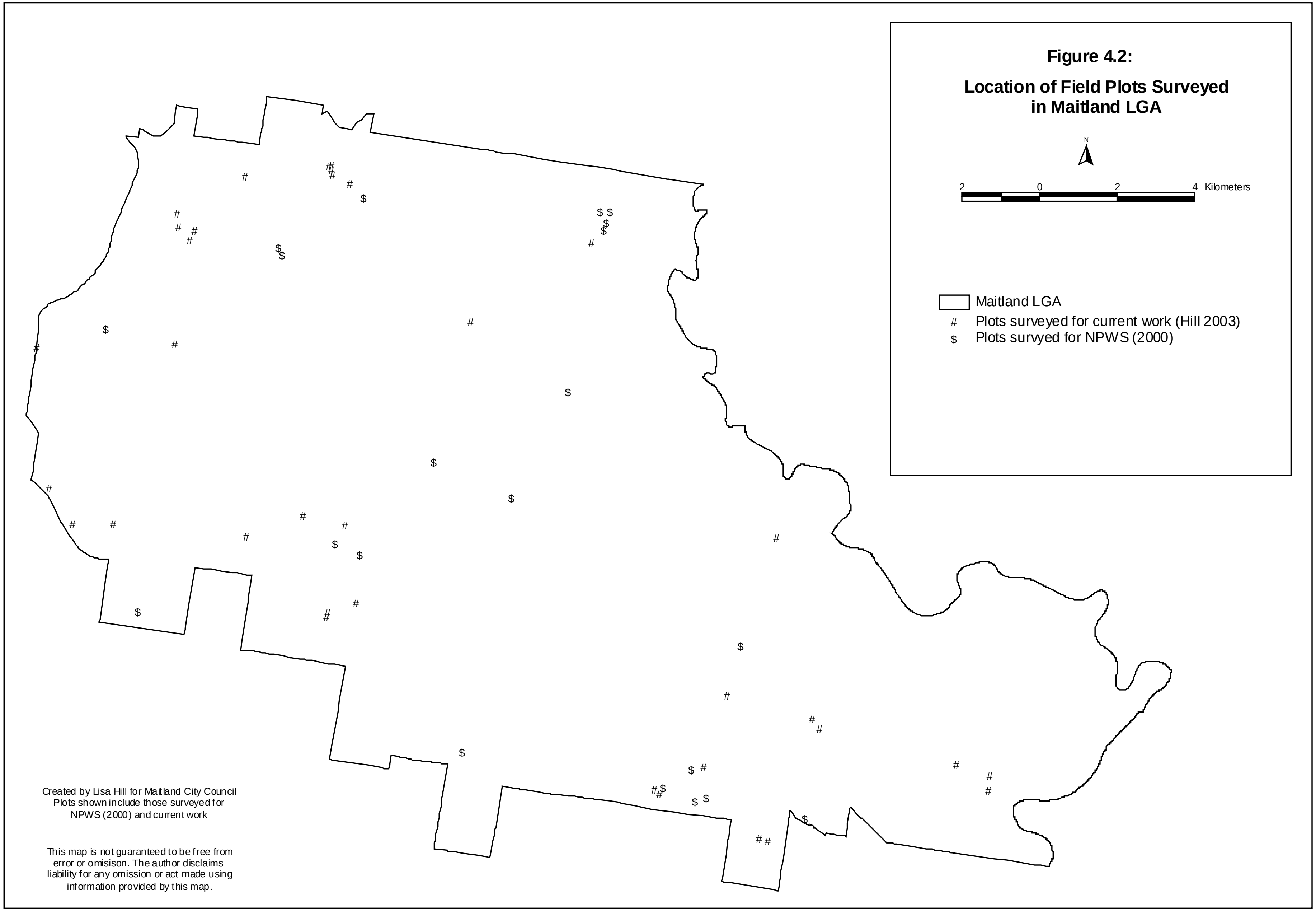


**Figure 4.2:**

**Location of Field Plots Surveyed in Maitland LGA**

## 4.6 Taxonomic Review

A taxonomic review of the data set was carried out to ensure all species followed the same botanical nomenclature and to correct several other factors that can interfere with data analysis. Taxonomic review was necessary as data used in the analysis was sourced from different observers and surveys carried out in different years and seasons. Names revised since Harden (1990, 1992, 1993 & 2002) and Harden & Murray (2000) are listed in *Table 4.6.*

The taxonomic review resulted in 330 taxa being included in analysis. Outcomes of the taxonomic review included:

- taxonomy was updated to be consistent with more recent literature.
- exotic species were excluded from the analysis.
- species most likely to have been incorrectly identified were corrected. This included data entry errors and mis-identification. Where mis-identification was likely, renaming to the most likely species was carried out for important species (high cover abundances) otherwise species were excluded from analysis.
- taxa identified to genus level only (eg. *Oxalis* sp.) were excluded from the analysis or allocated a species name if obvious.
- hybrids and their constituent species were allocated a common name if hybrids were know to occur widely. For example, *Eucalyptus canaliculata* X *punctata*, *E. canaliculata* and *E. punctata* were named *E. punctata* for analysis.
- taxa inconsistently named to subspecies or varieties were allocated a common name. For example, *Dianella caerulea* var. *caerulea, D. caerulea* and *D. caerulea* var. *producta* were all named *D. caerulea* for analysis.

**Table 4.6: Revisions to Botanical Nomenclature Recognised in this Report**

| Species/Group Revised | Reference |
|---|---|
| *Adiantum* revision | Bostock (1998) |
| *Agrostis revision* and instatement of *Lachnagrostis* | Jacobs (2001) |
| *Asparagus* revision | Fellingham & Meyer (1995) |
| *Bursaria* revision | Cayzer *et al.* (1999) |
| Revision of *Citriobatus* and *Pittosporum* | Cayzer *et al.* (2000) |
| *Conyza* revision | Walker (1971) |
| *Danthonia*/*Austrodanthonia*/*Notodanthonia* revisions (includes *Chionochloa*) | Linder & Verboom (1996); Linder (1997) |
| *Gnaphalium* revision and transferral to *Euchiton* and *Gamochaeta* | Anderberg (1991) |
| *Lastreopsis microsora* revision | Jones (1998) |
| *Marsdenia* revision | Forster (1996) |
| *Olea europea* subsp. *cuspidata* reinstatement | Ciferri *et al.* (1942) |
| *Pandorea pandorana* revision | Green (1990) |
| *Parsonsia* revision | Williams (1996) |
| *Picris* revision | Holzapfel (1994) |
| *Senna* revision | Randell & Barlow (1998) |
| *Solanum brownii* revision | Bean (2002) |
| *Sporobolus* revision | Simon & Jacobs (1999) |
| *Stipa*/*Austrostipa* revision | Jacobs & Everett (1996) |
| *Verbena* revisions | Michael (1997a & 1997b); Munir (2002) |

## 4.7 Data Analysis

Agglomerative cluster analysis of floristic data assisted in the delineation of vegetation communities in the study area. Analysis was undertaken using PATN (Belbin 1995a & b), a statistical analysis package that has been widely used in previous vegetation surveys in the local region (eg. NPWS 2000; Peake in prep.; Bell 2001). Vegetation data from a total of 55 field plots available for the study area was analysed following taxonomic review (see *Section 4.6*) using the Two-Step procedure and Bray Curtis association measure applied to species-site data (Belbin 1995a). Belbin (1995a & b) provide detailed information about the PATN analysis process for bio-survey data.

Analysis was undertaken for grouping of survey sites into floristic communities based on similarities in plant species recorded. As part of the analysis process, species and survey sites are placed into groups using hierarchical polythetic agglomerative clustering. Central to PATN analysis is assessment of the association between data pairs, such as between pairs of sites. PATN provides several association-measures applicable to different types of data. In the current work, results of analysis using the Bray-Curtis and Kulczynski association measures were explored, with similar results obtained. The Bray-Curtis measure was ultimately used as it provided relatively clearer delineation.

Dendrograms were used to show results of the hierarchical classification as they provide a useful tool in showing the relationships between all sites and between all species (Belbin 1991). A two-way table of species-groups to survey-site-groups was used to summarise the results of analysis as a useful interpretive tool.

## 4.8 Vegetation Community Delineation

### *4.8.1 Vegetation Community Mapping*

Vegetation communities identified through field survey and PATN analyses were mapped using a combination of API of 1:25,000 colour aerial photographs and field reconnaissance. Preliminary mapping described in *Section 4.2* was used as a base layer for this mapping. Line work was then digitised using GIS. Remnants dominated by exotic species were removed from the final vegetation community map.

Validation of the final vegetation community map was undertaken through field reconnaissance. Each polygon making up the final vegetation map was allocated a reliability code, as follows, ordered from the highest to the lowest reliability:

A  Vegetation mapping is validated by one or more field survey site(s) being carried out in the remnant. Some areas of the remnant may remain unsampled, particularly in larger remnants.

B  Vegetation mapping is validated by field reconnaissance, which comprises viewing vegetation from a nearby position, such as an adjacent road, or walking through the remnant. Some areas of the remnant may remain unseen, particularly in larger remnants.

C  Vegetation was mapped using only API, without mapping validation.

### *4.8.2 Vegetation Community Description*

Descriptions of each vegetation community were based on results of field survey and data analysis. Vegetation community profiles provided in *Appendix B* summarise key species, floristic structure and other important attributes for each community. Development of community profiles follows procedures used in previous work by NSW National Parks and Wildlife Service and in the Hunter region (eg. NPWS 2000; Hill *et al.* 2001).

In the current work, methods for assessing *key diagnostic species* developed by Keith and Bedward (1999) were broadly followed to compile a list of key species for each community. This method applies a set of user-defined rules for assessing diagnostic species based on the fidelity of a species to a particular community. This process was used to highlight species that are dominant and/or characteristic to each vegetation community. *Table 4.7* shows the calculations used to calculate fidelity in the current work.

Key diagnostic species provided in each community profile include all positive diagnostic species and a selection of uninformative diagnostic species that were considered by the author to be important dominant or characteristic species in the target community. As shown in *Table 4.7*, positive diagnostic species are those that occur at higher frequency and/or median cover abundance in the target community, relative to other communities. Uninformative species are not unique to the target community although may still be important components of the community. Negative diagnostic species are not recorded in the target community.

**Table 4.7: Calculations for Diagnostic Species**

| | | **Occurrence of Species in other Vegetation Communities:** | | |
|---|---|---|---|---|
| | | **Frequency>=50% AND C/A>=2** | **Frequency <50% OR C/A<2** | **Frequency=0** |
| **Occurrence of species in Target Vegetation Community:** | **Frequency>=35% AND C/A>=2** | Uninformative | Positive Diagnostic | Positive Diagnostic |
| | **Frequency <35% OR C/A<2** | Uninformative | Uninformative | Positive Diagnostic |
| | **Frequency=0** | Negative Diagnostic | Uninformative | |

## 4.9 Ecological Assessment

### *4.9.1 Assessment Criteria*

An assessment of the ecological significance of native vegetation communities and remnants in the study area was carried out to assist Council in determining relative conservation priorities in the LGA. This assessment is predominantly based on intuitive evaluation and does not provide a quantitative measure of ecological value. It should be used only as a broad indication of relative ecological value within the study area.

Criteria for this assessment was developed with consideration of practical issues in their measurement, through consultation with Maitland Council and through review of similar work in the region (eg. LHCCREMS 2003), and relevant research undertaken by various workers. Discussion of the criteria used in the ecological assessment is provided in *Section 6.6*. As this assessment was essentially a desktop exercise, only criteria that could be assessed remotely were selected. Attributes that could not be measured for each and every remnant were omitted to maximise consistency in assessment across the entire study area. Site-specific attributes such as condition/health of vegetation, weed infestation and fauna habitat could not be assessed for remnants that were not inspected in field survey (see *Table 4.9*). Consequently, criteria of site- or remnant-condition were not included in this assessment.

Ecological assessment integrated attributes of vegetation in the LGA that have been identified through survey, mapping and conservation significance assessment carried out for the current work. Assessment attributes were divided into two levels to assess ecological value of each vegetation community and each remnant: the **Community-level** and the **Landscape-level**. Community-level attributes were applicable to vegetation communities (polygons in the map). Landscape-level attributes were applicable to remnants, which can include one or more vegetation communities/polygons. For the purposes of this assessment, a remnant was classified as an area of contiguous woody vegetation dominated by native flora. Attributes used in the ecological assessment are listed below and in *Table 4.8*.

**Community-level (applied to vegetation communities):**

- Presence of a currently listed Endangered Ecological Community (EEC) listed under the TSC Act.
- Presence of significant vegetation community
- Presence of important ecosystem/vegetation type/s
- Reservation status of vegetation community
- Percentage of extant vegetation community remaining (compared to pre-1750 cover)

**Landscape-level (applied to vegetation remnants):**

- Size of remnant (see below for more information)
- Connectivity of remnant
- Diversity of remnant

Community-level criteria used in the ecological assessment generally relate to assessment of vegetation community significance described in *Section 6.3*. Details of the ecological assessment method for each attribute is provided in *Table 4.8,* with further explanation provided below for the Landscape-level attribute, *Size of remnant*.

Remnant size was assessed using the cumulative size of proximate remnants, as measured in hectares. This was achieved through the buffering function of the ArcView Geographic Information System. Using this function, remnants 30 m or less apart were effectively considered as a single, connected remnant with the sum of their sizes on the final vegetation map used to determine their size-class. The 30 m distance was selected to ensure that small breaks in the canopy caused by minor clearings such as telephone lines and narrow gravel roads and other small clearings did not result in the breaking-up of remnants that had adequate connection to be measured together. The distance of 30 m was chosen based on field observation of the average size of one to two eucalypt crowns. It was considered that a gap of this size would generally be passable by most fauna, particularly with the presence of understorey vegetation, such as gliders, koalas, possums, most inspects and small birds, as well as larger, more mobile fauna. It should be noted that the character of the gap between remnants would effect the passage of fauna. For example, *permeable* (McIntyre and Barrett 1992) gaps such as areas of scrubland, pasture or scattered timber may provide less of a barrier to movement than bitumen roads or paved or slashed areas (McIntyre and Barrett 1992). Due to the nature and scale of this work, however, all gaps up to 30 m have been treated equally and have been assumed to be more or less passable.

**Table 4.8: Ecological Assessment Criteria & Method**

| Attribute | Method for Assessment | Assessment Classes |
|---|---|---|
| **Community-level** | | |
| Presence of a currently listed EEC on the TSC Act | Presence determined by comparison of vegetation community descriptions to TSC Act. See *Table 6.7* in *Section 6.3.1* for assessment. | (a) Present<br>(b) Absent |
| Presence of significant vegetation community, defined as a vegetation community likely to meet the criteria for listing as threatened under the TSC Act or EPBC Act | Presence determined by application of Landsberg (2000). See *Section 6.3.2* for assessment. | (a) *Critically Endangered* 1(C) or *Endangered* 1(E)<br>(b) *Vulnerable* 1(V), *Restricted* 2(R) or *Limited* 2(L)<br>(c) none of above |
| Presence of important ecosystem/vegetation type, including riparian vegetation and/or a naturally occurring wetland. | Presence determined by the occurrence of the following within a remnant:<br>(a) Major river or tributary: includes Units 3 & 5 described by current work (see *Section 5.3*).<br>(b) Wetland: includes Unit 13 described by current work (see *Section 5.3*). | (a) Present<br>(b) Absent |
| Reservation level of vegetation community at regional level. | Estimated using information available in relevant literature and liaison with relevant workers in the ecological field. See *Table 6.14* in *Section 6.3.2* for assessment. | (a) Very Low or Low<br>(b) Moderate-Low or better |
| Percentage of pre-1750 vegetation community remaining in region | Intuitive assessment based on comparison of the final vegetation community map to equivalent or near-equivalent vegetation described in available literature (eg. NPWS 2000, Peake in prep.). See *Table 6.15* for assessment. | (a) Over 30%<br>(b) 30% or less |
| **Landscape-level** | | |
| Size of remnant | Measured in hectares. Determined using GIS calculation functions applied to the remnants in the final vegetation map. See *Section 4.9.1* for more information. Size classes used were:<br>(a) Very Large: 100+ Ha<br>(b) Large: 40-100 Ha<br>(c) Medium: 10-40 Ha<br>(d) Small: <10 Ha | (a) Very Large<br>(b) Large<br>(c) Medium<br>(d) Small |

**Table 4.8: Ecological Assessment Criteria & Method**

| Attribute | Method for Assessment | Assessment Classes |
| --- | --- | --- |
| Connectivity of remnant | Remnant connectivity was assessed by API using the following criteria:<br>(a) Regional connectivity: part of regional corridor, defined as occurring within 100 m of a bushland corridor that extends across whole or part of the study area and into large tracts of vegetation outside of the study area.<br>(b) Local connectivity: part of a local corridor, defined as occurring within 100 m of two or more remnants of similar or larger size.<br>(c) Isolated: remnant is greater than 100 m from nearest neighbouring remnant and does not fit any of the above criteria. | (a) Regional<br>(b) Local<br>(c) Isolated |
| Remnant diversity (the number of vegetation communities within a remnant) | Remnant diversity was assessed using the final vegetation map and the calculation functions of ArcView GIS. Categories of diversity were defined as follows:<br>(a) High: 4 or more communities<br>(b) Medium: 2-3 communities<br>(c) Low: 1 community | (a) High<br>(b) Medium<br>(c) Low |

**Supplementary Ecological Assessment Criteria**

Site-specific ecological attributes not used in the ecological assessment are relevant in the assessment of a remnant's ecological value. However, these could not be applied to the entire study area due to lack of survey data. Assessment of site-specific attributes would require survey of all remnants in the study area, which was beyond the scope of the current work and would require significant outlay of resources in time and funds.

Site-specific attributes considered most relevant to ecological functioning (see *Table 4.9*) were measured for the current work at 55 field sites, including plot locations and ground-truthing sites. Results of these on-site assessments have been provided to Council in hard copy for future reference and may be relevant to the Council if funds become available for a citywide survey.

**Table 4.9: Supplementary Criteria of Remnant Ecological Assessment (for on-site assessment)**

| Criteria | Details |
|---|---|
| Disturbance Present | Exotic species in upper stratum<br>Exotic species in mid strata<br>Exotic species in ground stratum<br>Tracks by people and/or domestic stock<br>Rubbish Dumping<br>Mistletoe infestation<br>Fire<br>Logging<br>Grazing by domestic or feral animals |
| Floristic diversity | Number of native species present compared to the number expected |
| Habitat diversity | Diversity of tree ages<br>Presence of hollow-bearing trees<br>Presence of fallen timber, rocks and other habitat |
| Structural diversity | Number of strata present compared to the number expected |
| Natural regeneration | Regeneration of native trees, woody shrubs |
| Threats active | Stock access (unfenced)<br>Clearing/removal of upper stratum<br>Clearing/removal of mid strata<br>Clearing/removal of ground strata<br>Bush rock removal |

### *4.9.2 Assessment Categories*

For practical purposes, categories of ecological value were created based on the Community- and Landscape-level. The Community-level refers to individual polygons that delineate vegetation communities, while the Landscape-level refers to remnants that may contain more than one vegetation communities/polygons on the map. These categories should be used with caution, as they are only intended to be useful at a broad (small) scale of planning, such as planning the location of a potential wildlife corridor across the LGA or placing future site-specific survey into context. The ecological assessment provided here is not intended to reduce or replace the requirement for site-specific survey and investigation of individual locations, which is essential for making informed planning decisions at the development level.

Categories of Ecological Assessment at a Community- and Landscape-level are presented in *Table 4.10. Section 4.9.1* describes the assessment criteria used.

It is important to note that the difference between ‘A’, ‘B’ & ‘C’ at the Community-level assessment is largely based on legal status. Each of these three categories includes communities that are likely to meet the criteria for listing as EECs on the TSC Act. Category ‘A’ includes communities that are already listed as an EEC, while categories ‘B’ and ‘C’ include communities that, although they meet the criteria for listing, have not been listed as yet. Several communities in the ‘B’ and ‘C’ categories have reportedly been nominated to the TSC Act for listing as EECs. Listing of a community that is ranked as ‘B’ or ‘C’ would afford it the ‘A’ ranking, regardless of it’s distribution or level of reservation.

**Table 4.10: Ecological Assessment Categories Applied in Maitland LGA Using a Community- and Landscape-Level**

| Category | Details |
|---|---|
| **Community-level (Features of Vegetation Communities/Polygons):** | |
| A | Listed EEC |
| B | Landsberg Criteria Critically Endangered 1(C) AND Pre-1750 Extent Remaining <30%, *OR*<br>Landsberg Criteria Endangered 1(E) AND Pre-1750 Extent Remaining <30%, *OR*<br>Landsberg Criteria Vulnerable 1(V) AND Pre-1750 Extent Remaining <30%, *OR*<br>Landsberg Criteria 2(VR) AND Reservation Level Very Low, *OR*<br>Landsberg Criteria 2(R) AND Reservation Level Very Low, *OR*<br>Landberg Criteria 2(L) AND Reservation Level Very Low |
| C | Landsberg Criteria Restricted 2(R) AND Reservation Level Low or better, *OR*<br>Landsberg Criteria Limited 2(L) AND Reservation Level Low or better, *OR*<br>Important Ecosystem/Vegetation Type Present |
| D | Landsberg Criteria nil |
| **Landscape-Level (Features of Remnants):** | |
| a | Very Large Size, *OR*<br>Regionally Connected |
| b | Large Size, *OR*<br>Medium Size AND Locally Connected, *OR*<br>Medium Size AND Isolated AND Medium-High Diversity, *OR*<br>Small Size AND Locally Connected AND Medium-High Diversity |
| c | Small Size AND Isolated, *OR*<br>Small Size AND Locally Connected AND Low Diversity, *OR*<br>Medium Size AND Isolated AND Low Diversity |

# Chapter 5 Results

## 5.1 Floristic Survey

In total 55 plots were sampled in the study area during the current work and previous surveys (NPWS 2000). Twenty of those plots were sampled by NPWS (2000), while the remaining 35 were sampled for the current work. Details of the plots are provided in *Appendix C*.

As a result of field survey for the current work and NPWS (2000), 474 vascular plant taxa were identified within the study area, including 101 plant families and 271 genera, shown in *Table 5.1*. *Table 5.2* lists the ten most populous plant families and the most populous genus within each. A further 37 taxa were tentatively identified but require further samples to be certain of identification. Another 87 taxa were recorded by previous work in the study area (see *Section 4.3*). A complete list of flora species recorded to date in the study area is provided in *Appendix D*. Recent synonyms are also listed for cross-referencing purposes.

**Table 5.1: Composition of Plant Classes and Families Recorded in Maitland LGA**

| Plant Class | Sub-class | No. of Families | No. of Taxa |
|---|---|---|---|
| Filicopsida (ferns) | - | 8 | 19 |
| Cycadopsida (cycads) | - | 1 | 1 |
| Magnoliopsida (flowering plants) | Magnoliidae (dicots) | 77 | 336 |
| Magnoliopsida (flowering plants) | Liliidae (monocots) | 15 | 118 |
| **Totals (all plants)** | | **101** | **474** |

**Table 5.2: Ten Most Populous Plant Families and Most Populous Genus Therein, Recorded in Maitland LGA**

| Family | No. Species | Genus | No. Species |
|---|---|---|---|
| Poaceae (grasses) | 59 | *Aristida* (wire grasses) | 5 |
| Fabaceae (peas, wattles, etc) | 41 | *Acacia* (wattles) | 10 |
| Myrtaceae (myrtles) | 40 | *Eucalyptus* (eucalypts) | 17 |
| Asteraceae (daisies) | 34 | *Cassinia* (cough-bushes) | 3 |
| Cyperaceae (sedges) | 15 | *Cyperus* (sedges) | 7 |
| Euphorbiaceae (euphorbs) | 12 | *Phyllanthus* (spurges) | 2 |
| Solanaceae (tomatoes) | 11 | *Solanum* (nightshades) | 7 |
| Pittosporaceae | 9 | *Pittosporum* (pittosporums) | 3 |
| Rubiaceae | 9 | *Opercularia* (stinkweeds) | 3 |
| Lomandraceae (mat-rushes) | 8 | *Lomandra* (mat-rushes) | 8 |

Due to seasonal and time limitations of the floristic survey, it is likely that certain taxa have been under-represented. For example, as a result of survey timing and drought conditions, only one orchid was identified during survey for both the current work and NPWS (2000) that could not be identified to species (*Pterostylis* sp.). It is likely that Maitland LGA supports a reasonable diversity of orchid species, but these would need to be sampled during late winter and early spring to record a higher number of species.

Of the vascular flora taxa positively identified, 84 (17.7%) non-native taxa were present. All of these were taxa not native to Australia, except for the silky oak (*Grevillea robusta*) which is an Australian native that is not native to the Hunter Valley.

## 5.2 Data Analysis

The dendrogram derived by the Bray-Curtis association and cluster analysis is shown in *Figure 5.1*. Analysis identified eleven plant communities based on dissimilarity measures between 0.6-0.9. Two additional communities that occur in the study area were not sampled in the current work, therefore do not appear in the dendrogram (Kurri Sand Swamp Woodland and Freshwater Wetland Complex). Vegetation communities mapped in Maitland LGA are briefly described in *Section 5.3*. Detailed descriptions of communities can be found in the Vegetation Community Profiles (*Appendix B*).

Analysis was affected by survey and observer bias, which is often encountered when data from more than one survey or observer is used. Data is affected by seasonal and climatic influences acting at the time of each survey, and observer bias affects taxa naming and estimations of cover abundances. A common effect is the grouping of sites carried out by an observer and/or as part of the same survey that may not represent the same community, and/or the separation of sites that represent the same community. The effect of observer/survey bias on analysis can be seen in *Figure 5.1*. Fidelity of sites carried out by different observers/surveys was evident in the full dendrogram. In particular, groups two and 13 (Hunter Lowlands Redgum Forest Variant) and three and five (Lower Hunter Spotted Gum Ironbark Forest) were separated by PATN due to survey bias. Additionally, group two included a mix of sites from several communities. These misplaced sites were reallocated to the correct communities based on knowledge of the study area and familiarity with the site data.

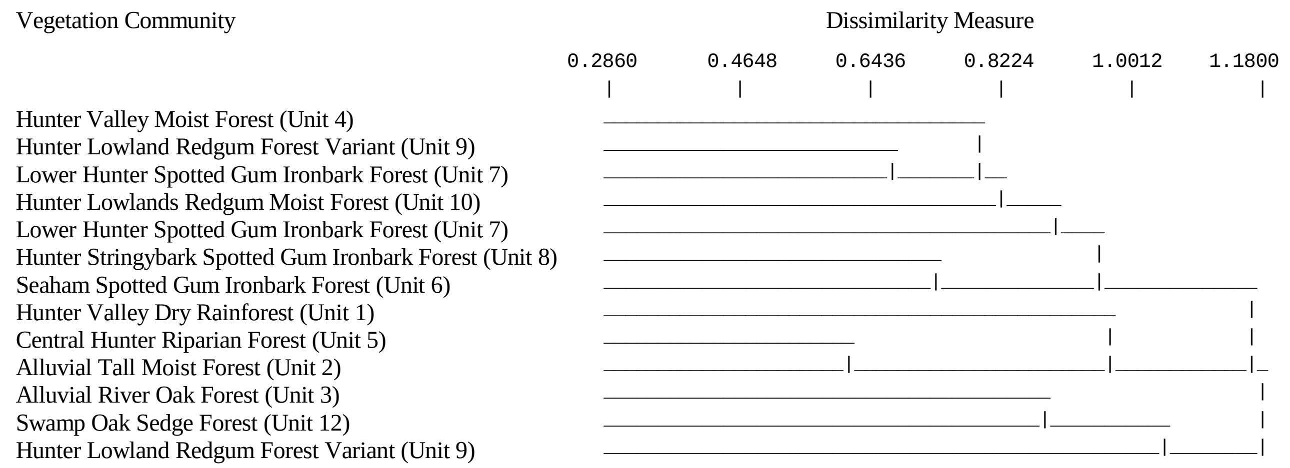


**Figure 5.1 Dendrogram (abbreviated) showing plant communities and dissimilarity values**

## 5.3 Vegetation Mapping & Community Description

A total of 8,305 ha of natural vegetation were mapped in Maitland LGA in the current work. This included 7,643 ha described as one of the 13 vegetation communities in the study area, and 124.5 ha and 537.5 ha of regeneration and scattered trees, respectively, that did not represent an intact vegetation community.

Thirteen vegetation communities have been described in Maitland LGA, which include 11 sampled by field survey in the study area and two described by NPWS (2000). Description of the 11 communities sampled in the study area is predominantly based on field survey in Maitland LGA, with supplementary information drawn from NPWS (2000). Mapping and description of the two additional communities that were not sampled the study area is based on NPWS (2000), with field reconnaissance in the current work providing supplementary information. These are Kurri Sand Swamp Woodland (Map Unit 35 in NPWS 2000) and Freshwater Wetland Complex (Map Unit 46 in NPWS 2000).

Description of all thirteen vegetation communities is detailed in the Vegetation Community Profiles in *Appendix B*. A brief outline of each community is provided below. The final vegetation community map for Maitland LGA is shown in *Figure 5.2*.

**Hunter Valley Dry Rainforest (Unit 1)**

Hunter Valley Dry Rainforest occurs throughout Maitland LGA on sheltered slopes and gullies, usually with south and east aspects. It typically develops on steep slopes and scree in richer soils derived from basalt intrusions into Carboniferous sediment and alluvium.

This unit is a low to mid-high forest with a closed canopy dominated by two to three dry rainforest species, including whalebone tree (*Streblus brunonianus*) and red kamala (*Mallotus philippensis*). Emergent trees are scattered and often relate to adjacent communities. Rusty fig (*Ficus rubiginosa*) is also a common emergent of the rainforest. Rainforest trees generally form two to three strata in the forest, with shrubs and ground cover sparse to absent due to the dense canopy. Breaks in the canopy allow the development of a denser shrub layer. Common shrubs include native rosella (*Hibiscus heterophyllus* subsp. *heterophyllus*), native cascarilla (*Croton verreauxii*) and brush wilga (*Geijera salicifolia*). In some areas, lantana (**Lantana camara*) and African olive (**Olea europaea* var. *cuspidata*) are invading the rainforest understorey. Vines are common and include wonga wonga vine (*Pandorea pandorana* subsp. *pandorana*), slender grape (*Cayratia clematidea*), gum vine (*Aphanopetalum resinosum*) and scrambling lily (*Geitonoplesium cymosum*). Dry rainforest on rocky scree shows more understorey development with common maidenhair (*Adiantum aethiopicum*) and the mint bush *Plectranthus parviflorus* common.

**Alluvial Tall Moist Forest (Unit 2)**

Alluvial Tall Moist Forest occurs in stream channels in the south-east of Maitland LGA in areas with coastal influence, higher rainfall and some alluvium. Main areas of occurrence are tributaries of Four Mile Creek and Scotch Dairy Creek in the Ashtonfield and Thornton areas.

Alluvial Tall Moist Forest is characterised by a tall to very tall canopy dominated by Sydney blue gum (*Eucalyptus saligna*), with flooded gum (*E. grandis*) also present and most likely an intergrade between both species (*E. saligna* X *grandis*). Coastal influences in the flora include smooth-barked apple (*Angophora costata*), blackbutt (*E. pilularis*) and turpentine (*Syncarpia glomulifera* subsp. *glomulifera*) as common canopy trees. A dense mid stratum dominated by dry rainforest species is typical, including lilly pilly (*Acmena smithii)*, hairy-leaved doughwood (*Melicope micrococca*), cheese tree (*Glochidion ferdinandi* var. *ferdinandi*) and creek sandpaper fig (*Ficus coronata*). The mid-dense shrub layer includes elderberry panax (*Polyscias sambucifolia* subsp. A) and brush muttonwood (*Rapanea howittiana*). Vines are an important component of the community with wonga wonga vine (*Pandorea pandorana* subsp. *pandorana*), *Glycine clandestina*, scrambling lily (*Geitonoplesium cymosum*) and snake vine (*Stephania japonica* var. *discolor*) frequent. The ground cover includes a range of ferns reflecting soil moisture.

**Alluvial River Oak Forest (Unit 3)**

Alluvial River Oak Forest occurs on riverbanks and backwaters of major rivers including the Hunter River, Paterson River and several of their major tributaries. The riparian forest is dominated and characterised by river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) over a sparse understorey. Alluvial River Oak Forest may also contain this hybrid, *C. cunninghamiana* X *glauca*, particularly in more saline soils. Other native tree species recorded in the community include forest red gum (*Eucalyptus tereticornis*), grey gums (*E. punctata*, *E. canaliculata* and/or their hybrid *E. punctata* X *canaliculata*), river red gum (*E. camaldulensis*) and rough-barked apple (*Angophora floribunda*).

Canopy density is influenced by the degree of modification and land use, ranging from a dense canopy in less disturbed sites, to a sparse canopy in sites disturbed by cattle access, bank erosion and/or bank slumping. Regeneration of *C. cunninghamiana* subsp. *cunninghamiana* on disturbed riverbanks is common and the community is modified throughout most of its range. As a result, the understorey is typically dominated by exotic species. The extent of grazing by domestic stock, bank erosion, bank slumping and change to flood regimes affects the floristic composition and structure.

The allelopathic qualities of *C. cunninghamiana* subsp. *cunninghamiana* and soil disturbance generally result in a sparse low tree and shrub layer, although dense patches of grasses and herbs can occur below openings in the canopy. Native species recorded in the understorey include fern-leaved wattle (*Acacia filicifolia*), native wandering dew (*Commelina cyanea*), spiny-headed mat-rush (*Lomandra longifolia*), and the vines native raspberry (*Rubus parvifolius*) and *Calystegia sepium*.

It is likely that areas of Alluvial River Oak Forest (Unit 3) have regenerated in sites that once supported Lowland Rainforest on Floodplain, a listed EEC that has been cleared from Maitland LGA. Historic records (eg. Albrecht 2000; Brayshaw 1986; Cunningham 1827; Giles 1995; Knott *et al.* 1998; Wood 1972) and presence of remnant rainforest trees in the river oak community, such as hard quandong (*Elaeocarpus obovatus*) and whalebone tree (*Streblus brunonianus*) supports this premise. Although searches were made of the study area, no intact remnants of this community were located. The closest known remnant occurs at Tocal about 2km from the Maitland – Dungog LGA border. The lowland rainforest would probably have included emergent trees of *C. cunninghamiana* subsp. *cunninghamiana*.

**Hunter Valley Moist Forest (Unit 4)**

Hunter Valley Moist Forest occurs throughout Maitland LGA in open depressions, gullies and slopes with sheltered aspects. It generally develops in areas of moderate to high relief and/or with poorer soils derived from basalt and Carboniferous geologies. It is most common in the Erosional landscape of the study area. The community is a tall open forest usually dominated by grey gum (*Eucalyptus punctata*), large-fruited grey gum (*E. canaliculata*), and/or their hybrid *E. punctata* X *canaliculata*. Forest red gum (*E. tereticornis*) and rough-barked apple (*Angophora floribunda*) may co-dominate with *E. punctata* X *canaliculata* typically in more sheltered locations with better soils, such as open depressions on lower slopes and flats. Spotted gum (*Corymbia maculata*) and narrow-leaved ironbark (*E. crebra*) commonly occur with *E. punctata* X *canaliculata* in locations with relatively poorer soils such as higher-energy gullies and open depressions located on mid to upper slopes and sites on sheltered slopes away from drainage depressions.

Soil conditions and shelter provided by the adjacent landscape influence the diversity and dominant species in the understorey. A mid-dense understorey characterised by mesic species develops in sites with greater soil moisture and fertility. Vines are often common in these locations, including wonga wonga vine (*Pandorea pandorana* subsp. *pandorana*), gum vine (*Aphanopetalum resinosum*), grape vine (*Cayratia clematidea*), giant water vine (*Cissus hypoglauca*) and wombat berry (*Eustrephus latifolius*). Shrubs and low trees present in moister sites include hairy clerodendrum (*Clerodendrum tomentosa*), hairy pittosporum (*Pittosporum revolutum*), native rosella (*Hibiscus heterophyllus* subsp. *heterophyllus*) and narrow-leaved orangebark (*Maytenus silvestris*). In drier sites, more xeric shrubs and low trees occur, which can include coffee bush (*Breynia oblongifolia*), *Leucopogon juniperinus*, sticky cassinia (*Cassinia uncata*) and native blackthorn (*Bursaria spinosa*). The forest is often distinguished by its dense, mesic ground cover comprising a diversity of species including stinking pennywort (*Hydrocotyle laxiflora*), ivy leaved violet (*Viola hederacea*), whiteroot (*Pratia purpurascens*), kidney weed (*Dichondra repens*), native wandering jew (*Commelina cyanea*) and the grass *Oplismenus aemulus*.

**Central Hunter Riparian Forest (Unit 5)**

Central Hunter Riparian Forest occurs on minor streams of low gradient generally in Permian sediments from Greta to Tocal. Only one plot was sampled in this unit within Maitland LGA. Additional information about the unit has been drawn from NPWS (2000) and Williams (1993).

Central Hunter Riparian Forest is a mid-high to tall forest characterised by swamp oak (*Casuarina glauca*) typically as a dense/closed forest in more or less pure stands along minor streams. The hybrid between *C. glauca* and river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) has also been recorded in this community (*C. glauca* X *cunninghamiana*). The community develops in streams with Permian sediments of marine origin, which are generally saline. The salt tolerance and colonising ability of *C. glauca* gives it advantages in sites affected by salinity and past disturbance. Some locations of this community with dense regrowth of *C. glauca* and low species diversity are probably indicative of past disturbance of areas with saline soils. Other occasional and scattered tree species include forest red gum (*Eucalyptus tereticornis*), narrow-leaved ironbark (*E. crebra*), grey box (*E moluccana*), spotted gum (*Corymbia maculata*), hard quandong (*Elaeocarpus obovatus*) and Moreton Bay fig (*Ficus macrophylla* subsp. *macrophylla*). *Melaleuca linariifolia* and prickly-leaved tea tree (*M. styphelioides*) are also present in scattered clumps throughout the community.

Locations of this community that have been disturbed may lack a mid-storey. Shrubs recorded in more sheltered sites and sites with lower levels of disturbance include creek sandpaper fig (*Ficus coronata*), hairy clerodendrum (*Clerodendrum tomentosum*) and coffee bush (*Breynia oblongifolia*). The weed African olive (**Olea europaea* subsp. *cuspidata*) has also been recorded in the community. Common vines present include pearl vine (*Sarcopetalum harveyanum*), *Clematis aristata*, slender grapevine (*Cayratia clematidea*) and common silkpod (*Parsonsia straminea*). A dense ground layer of grasses and forbs is typical, with diversity and density higher along streambeds in patches of higher soil moisture

**Seaham Spotted Gum Ironbark Forest (Unit 6)**

Seaham Spotted Gum Ironbark Forest is widespread in the north-western quarter of the LGA on slopes and ridges. The unit is closely related to Lower Hunter Spotted Gum Ironbark Forest (Unit 7). The change from the Seaham unit to the Lower Hunter Spotted Gum Ironbark Forest occurs over a wide area in Maitland LGA, so that an intergrade of the two units is common within the study area. Mapped boundaries of both units are estimates based on survey and field reconnaissance.

Seaham Spotted Gum Ironbark Forest tends to show greater dominance of narrow-leaved ironbark (*Eucalyptus crebra*) than the lower Hunter unit. Spotted gum (*Corymbia maculata*) usually co-dominates. The community forms a mid-high to tall, dry open forest on exposed slopes and hills in the Erosional-Carboniferous landscape. Other tree species that may occur as sub-dominants include blue-leaved stringybark (*Eucalyptus agglomerata*), thin-leaved stringybark (*E. eugenioides*) and the grey *gums E. punctata* and *E. canaliculata*, which also form the hybrid *E. punctata* X *canaliculata*. Kurrajong (*Brachychiton populneus* subsp. *populneus*) is occasionally present.

The understorey is typically mid-dense with frequent low-trees being sweet pittosporum (*Pittosporum undulatum*), native cherry (*Exocarpos cupressiformis*), dogwood (*Jacksonia scoparia*) and native rosella (*Hibiscus heterophyllus* subsp. *heterophyllus*). Common shrubs include *Cassinia* species D, *Acacia falcata*, *Dodonaea viscosa* subsp. *angustifolia*, elderberry panax (*Polyscias sambucifolia* subsp. A), *Swainsona luteola* and hickory wattle (*Acacia implexa*). Frequent vines in the mid-stratum are *Glycine tomentella* and false sarsaparilla (*Hardenbergia violacea*). The ground cover is usually mid-dense and comprises a diversity of native grasses and forbs, including *Goodenia hederacea* subsp. *hederacea*, *Plectranthus graveolens*, tufted bluebell (*Wahlenbergia communis*), and the grasses *Aristida queenslandica* var. *queenslandica* and kangaroo grass (*Themeda australis*).

**Lower Hunter Spotted Gum Ironbark Forest (Unit 7)**

Lower Hunter Spotted Gum Ironbark Forest occurs on slopes and ridges throughout most of Maitland LGA, predominantly on Permian sediments in the Residual landscape. It is one of the most widespread vegetation communities in the study area. The unit is dominated by several species, with the most characteristic being spotted gum (*Corymbia maculata*) and broad-leaved ironbark (*Eucalyptus fibrosa*). A range of other tree species develop patches of dominance including grey gums (*E. punctata*, *E. canaliculata* and/or their hybrid *E. punctata* X *canaliculata*), grey box (*E. moluccana*), forest red gum (*E. tereticornis*) and narrow-leaved ironbark (*E. crebra*). More coastal affiliated species occur in the south-east of the study area, including red bloodwood (*Corymbia gummifera*), white mahogany (*E. acmenoides*) and white stringybark (*E. globoidea*). The lower tree stratum includes scattered, dense patches of *Melaleuca nodosa* particularly in the south-east of the study area. The community is closely related to Seaham Spotted Gum Ironbark Forest (Unit 6) and the distributions of both units meet in Maitland LGA. Consequently, vegetation in the LGA tends to show characteristics of both communities. Lower Hunter Spotted Gum Ironbark Forest is generally distinguished by a higher dominance of *E. fibrosa*, which is replaced by *E. crebra* in the Seaham unit.

A dry, mid-dense to sparse low tree and shrub strata and ground cover is typical, comprising mostly xeric species. Common shrubs/low trees recorded include gorse bitter pea (*Daviesia ulicifolia*), *Leucopogon juniperinus*, native blackthorn (*Bursaria spinosa*), *Acacia falcata* and *Dillwynia phylicoides*. Ground species include the forbs *Vernonia cinerea* var. *cinerea*, *Goodenia hederacea* subsp. *hederacea*, *Lagenifera stipitata*, hairy stinkweed (*Opercularia hispida*), *Pomax umbellata*, the rock fern *Cheilanthes sieberi* subsp. *sieberi* and many-flowered mat-rush (*Lomandra multiflora* subsp. *multiflora*). Common grasses are wiry panic (*Entolasia stricta*), *Aristida vagans*, barbed wire grass (*Cymbopogon refractus*), kangaroo grass (*Themeda australis*) and *Microlaena stipoides* var. *stipoides*. False sarsaparilla (*Hardenbergia violacea*), *Glycine clandestina* and *Cassytha pubescens* are frequent vines in the ground and mid strata.

**Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8)**

Hunter Stringybark Spotted Gum Ironbark Forest occurs in well-drained soils on steep to moderately inclined slopes in the Erosional landscape in the north-west of the study area. The unit is an open forest characterised by blue-leaved stringybark (*Eucalyptus agglomerata*) and spotted gum (*Corymbia maculata*). Grey gums (*E. punctata*, *E. canaliculata* and their hybrid *E. punctata* X *canaliculata*) are also common sub-dominant canopy species. Other common trees are grey box (*E. moluccana*) and narrow-leaved ironbark (*E. crebra*). Tree canopy species develop mosaic dominance patterns. *E. agglomerata* is most dominant on well drained, steep slopes and *E. crebra* is more common on moderate slopes. *E. punctata* X *canaliculata* becomes more common in sheltered sites with higher soil moisture. A sparse mid-tree layer is typical and includes dogwood (*Jacksonia scoparia*), large mock olive (*Notelaea longifolia* forma *intermedia*) and sweet pittosporum (*Pittosporum undulatum*).

A sparse understorey is typical, although areas of dense shrub and/or ground cover occur in patches that reflect changes in soil drainage. Pockets of higher soil moisture in more sheltered locations such as gully heads have more mesic species such as *Pittosporum revolutum* and gum vine (*Aphanopetalum resinosum*). Common shrubs include *Leucopogon juniperinus*, coffee bush (*Breynia oblongifolia*), hickory wattle (*Acacia implexa*) and narrow-leaved geebung (*Persoonia linearis*). The most common climbers are wonga wonga vine (*Pandorea pandorana* subsp. *pandorana*), wombat berry (*Eustrephus latifolius*), large tick-trefoil (*Desmodium brachypodum*) and slender tick-trefoil (*Desmodium varians*).

**Hunter Lowlands Redgum Forest Variant (Unit 9)**

Occurrences of Hunter Lowlands Redgum Forest (MU19 in NPWS 2000) in Maitland LGA represent the northern extent of this community. Consequently, the redgum forest in Maitland LGA shows some variation to the vegetation unit described by NPWS (2000). These variations have been described in the current work as Hunter Lowlands Redgum Forest Variant (Unit 9) and Hunter Lowlands Redgum Moist Forest (Unit 10), both of which are considered to be equivalent to the NPWS (2000) redgum forest. These differences are also partly due to the extent of survey by NPWS (2000). NPWS (2000) delineated and described Hunter Lowlands Redgum Forest (MU19) using plot-based survey carried out across the LHCCREMS region (Central Coast to Port Stephens, Cessnock and Maitland), many of which were outside of Maitland LGA. NPWS (2000) describe variations in the community across the region, whilst the current work describes only the variations of this unit that occurs in Maitland LGA.

In the study area, the unit extends from Greta and Rutherford to the north-east of the LGA around Tocal and Bolwarra Heights. It is most common on low-lying hills and open depressions on the Permian landscape and to a lesser extent on the Residual, Carboniferous landscape. The community shows variation across these environmental locations which have not been adequately sampled to allow separate mapping and description.

Throughout much of the study area, particularly in the more western areas, Hunter Lowlands Redgum Forest Variant is influenced by western flora more typical further up the Hunter valley. Grey box (*E. moluccana*) is common and the understorey is often sparser and drier than Hunter Lowlands Redgum Forest (MU19) described by NPWS (2000). Occurrences of redgum forest in open sites in the residual landscape from Rutherford to Greta, show affiliation with Central Hunter Ironbark-Spotted Gum-Grey Box Forest (MU18 in NPWS 2000). In these areas, the canopy is characterised predominantly by forest redgum (*Eucalyptus tereticornis*) with grey box (*E. moluccana*), narrow-leaved ironbark (*E. crebra*) and spotted gum (*Corymbia maculata*) present in varying patterns of dominance. The understorey changes from sparse to mid-dense depending on disturbance history and is typically dominated by xeric shrubs, herbs and grasses.

Locations of the lowland redgum forest in more sheltered sites such as south-facing lower slopes and stream channels with more fertile and moister soils generally fit better into the description of Hunter Lowlands Redgum Forest (MU19) provided by NPWS (2000). In these locations grey gums (*E. punctata*, *E. canaliculata* and/or their hybrid *E. punctata* X *canaliculata*) and rough-barked apple (*Angophora floribunda*) become more common with *E. tereticornis*, and the ground cover density and mesic nature increases with improved soil moisture and fertility. Examples are found around Tocal to Bolwarra Heights in Maitland LGA. The *E. tereticornis – E. moluccana* dominance pattern is often found on stream flats and lower slopes with better soils. The ground cover in these areas is often denser and more mesic.

Hunter Lowlands Redgum Forest Variant (Unit 9) typically has a sparse mid-stratum that is often absent in disturbed sites. Shrubs recorded include *Leucopogon juniperinus* and *Cassinia cunninghamii*. The ground cover is characteristically dense, comprising a variety of forbs and grasses. Common grass species include barbed wire grass (*Cymbopogon refractus*), small-flowered finger grass (*Digitaria parviflora*), *Enteropogon acicularis*, wallaby grass (*Austrodanthonia fulva*) and weeping grass (*Microlaena stipoides* var. *stipoides*). Some frequent forbs recorded are berry saltbush (*Einadia nutans* subsp. *linifolia*), Austral bugle (*Ajuga australis*), amulla (*Eremophila debilis*) and kidney weed (*Dichondra repens*).

**Hunter Lowlands Redgum Moist Forest (Unit 10)**

Occurrences of Hunter Lowlands Redgum Forest (MU19) described by NPWS (2000) in Maitland LGA represent the northern extent of this community. Consequently, the redgum forest in Maitland LGA shows some variation to the vegetation unit described by NPWS (2000). These variations have been described in the current work as Hunter Lowlands Redgum Forest Variant (Unit 9) and Hunter Lowlands Redgum Moist Forest (Unit 10), both of which are considered to be equivalent to the NPWS (2000) redgum forest. These differences are also partly due to the extent of survey by NPWS (2000).

NPWS (2000) delineated and described Hunter Lowlands Redgum Forest (MU19) using plot-based survey carried out across the LHCCREMS region (Central Coast to Port Stephens, Cessnock and Maitland), many of which were outside of Maitland LGA. NPWS (2000) describe variations in the community across the region, whilst the current work describes only the variations of this unit that occurs in Maitland LGA.

Hunter Lowlands Redgum Moist Forest (Unit 10) occurs in the south-east of the LGA, in the Thornton-Metford area in open depressions on the margins of the alluvial plain. It is typical of level to very gently inclined stream channels in deep loams of Permian and Quaternary age. Fragments of the community also exist as scattered *E. tereticornis* trees over pasture on streams, adjacent lower slopes and stream flats in these areas. This community merges into Hunter Lowlands Redgum Forest Variant (Unit 9) towards Maitland and Bolwarra Heights, with an intergrade of both units probably occurring along open depressions in these areas.

Hunter Lowlands Redgum Moist Forest is a tall to very tall open forest dominated by forest red gum (*Eucalyptus tereticornis*) over a mesic understorey. Coastal influence in this community is reflected by the occurrence of blackbutt (*E. pilularis*), white mahogany (*E. acmenoides*) and smooth-barked apple (*Angophora costata*). Narrow-leaved ironbark (*E. crebra*) is also a common canopy species. A sparse low-tree stratum develops in less disturbed locations, with cheese tree (*Glochidion ferdinandi* var. *ferdinandi*) and seedlings of the canopy species recorded. The shrub stratum is well developed in less disturbed sites and includes gorse bitter pea (*Daviesia ulicifolia*), silver-stemmed wattle (*Acacia parvipinnula*), sticky cassinia (*Cassinia uncata*), native blackthorn (*Bursaria spinosa*), sour currant bush (*Leptomeria acida*) and *Leptospermum polygalifolium* subsp. *cismontanum*. The ground cover is typically dense and disturbance by clay quarrying and residential development has led to sedimentation in some areas and infestation of exotic species such as the grass paspalum (*Paspalum dilatatum*) and cobbler's pegs (*Bidens pilosa*).

**Kurri Sand Swamp Woodland (Unit 11)**

Description of Kurri Sand Swamp Woodland is based on NPWS (2000), with no plots surveyed in Maitland LGA. NPWS (2000) describe the community as occurring on waterlogged Tertiary sand deposits overlying Permian sediments in the Kurri Kurri area. The unit is mapped in Maitland LGA in a small area adjacent to Wentworth Swamp near the Cessnock LGA boundary. Several unsampled patches of vegetation in Metford and in forested land south of Ashtonfield may be isolated patches of this community. In the absence of plot work in these sites, they have been mapped as part of Lower Hunter Spotted Gum Ironbark Forest. It is recommended that searches for and sampling of these sites be undertaken if land use in these areas is likely to change. NPWS (2000) indicate it is likely that mapping of this community has been underestimated, with difficulties related to lack of available soil mapping.

Kurri Sand Swamp Woodland is listed as an Endangered Ecological Community (EEC) on the TSC Act. Due to the importance of this community, it is recommended that a targeted field survey be carried out to accurately map its distribution in Maitland LGA.

NPWS (2000) describe Kurri Sand Swamp Woodland as a low woodland dominated by Parramatta redgum (*Eucalyptus parramattensis* subsp. *decadens*) and narrow-leaved apple (*Angophora bakeri*). Other common canopy tree species recorded by NPWS (2000) include scribbly gum (*E. signata*) and narrow-leaved stringybark (*E. sparsifolia*). The understorey is described as a mid-dense to dense shrub/low-tree continuum comprising *Melaleuca nodosa*, *Banksia spinulosa*, dogwood (*Jacksonia scoparia*), *Hakea laevipes* subsp. *laevipes* (syn *H. dactyloides*), prickly Moses (*Acacia ulicifolia*) and mountain devil (*Lambertia formosa*). The ground cover ranges from sparse to dense comprising low shrubs and grasses including wiry panic (*Entolasia stricta*), *Pimelea linifolia*, *Dillwynia retorta*, peach heath (*Lissanthe strigosa*) and thyme-leaved paperbark (*Melaleuca thymifolia*).

**Swamp Oak Alluvial Forest (Unit 12)**

Swamp Oak Alluvial Forest occurs on alluvial flats of Quaternary deposits mainly in the south-east and east of the study area. The unit is a structurally simple, mid high to tall open forest, with areas of dense growth forming a closed forest. The canopy is typically dominated by swamp oak (*Casuarina glauca*) often in monospecific stands over large areas of the alluvial flats, with some areas dominated by low trees of prickly-leaved paperbark (*Melaleuca styphelioides*).

Swamp Oak Alluvial Forest occasionally has a sparse, low tree stratum that includes *M. styphelioides*, *Guioa semiglauca* and whalebone tree (*Streblus brunonianus*). More disturbed sites often lack a mid-strata. The ground cover is usually dense and modified by grazing, changes to flood regime, pasture improvement, sedimentation and other human activities. As a result, the ground cover typically comprises exotic and pasture species. Common ground forb species include *Oxalis perennans*, water pepper (*Persicaria hydropiper*), **Phyla nodiflora* var. *nodiflora*, **Verbena quadrangularis*, pennywort (*Centella asiatica*), lamb's tongue (**Plantago lanceolata*) and native wandering jew (*Commelina cyanea*). Grasses recorded include panic veldtgrass (**Ehrharta erecta*) and common couch (*Cynodon dactylon*). Sedges and rushes are a distinctive component of the ground species, with umbrella sedge (**Cyperus eragrostis*), *Carex appressa*, common rush (*Juncus usitatus*) and spiny-headed mat-rush (*Lomandra longifolia*) recorded. Vines are also common with common silkpod (*Parsonsia straminea*), cockspur thorn (*Maclura cochinchinensis*) and common milk vine (*Marsdenia rostrata*) recorded.

Swamp Oak Alluvial Forest has probably colonised areas on the floodplain that once supported Lowland Rainforest on Floodplain, a listed EEC community that is essentially extinct from the Maitland area. This is supported by records of rainforest trees in Swamp Oak Alluvial Forest that may be relicts of the floodplain rainforest. Historic records indicate that the floodplain in the Maitland-Morpeth-Raymond Terrace district once supported this rainforest community (Albrecht 2000; Brayshaw 1986; Cunningham 1827; Giles 1995; Knott *et al.* 1998; Wood 1972). *C. glauca* was probably scattered throughout this rainforest and is also likely to have grown in dense stands on the floodplain within and adjacent to the lowland rainforest

**Freshwater Wetland Complex (Unit 13)**

Freshwater Wetland Complex was not sampled by the current work since it was considered to require targeted, more intense survey for adequate sampling to occur, which was beyond the scope of this project. Therefore, description and mapping of this unit is based on NPWS (2000). NPWS (2000) describes this unit as a complex, which has the potential to be further divided into more communities that relate to local conditions. It has been significantly modified across most of its range by human activities such as stock grazing, changes to flood regime, introduction of exotic species, sedimentation and wetland reclamation/drainage and infilling.

The wetlands occur on the alluvial and estuarine floodplain in closed depressions. NPWS (2000) describe Freshwater Wetland Complex as occurring in low-lying areas that are permanently or periodically inundated by water. The unit comprises areas of open water, closed sedgeland and scattered trees and tree clumps. Sedgeland develops along margins of wetlands and areas that are only periodically inundated. Variation is evident across its distribution with dominant species changing between locations. A dense ground cover of sedges, grasses, rushes and aquatic plants is characteristic. The most common species recorded are *Ludwigia peploides* subsp. *montevidensis*, *Eleocharis sphaecelata*, common rush (*Juncus usitatus*) and the water couch *Paspalum distichum*. Scattered trees and tree clumps of prickly-leaved paperbark (*Melaleuca styphelioides*), *M. linariifolia*, and swamp oak (*Casuarina glauca*) occur as emergent trees particularly in response to improved water drainage.

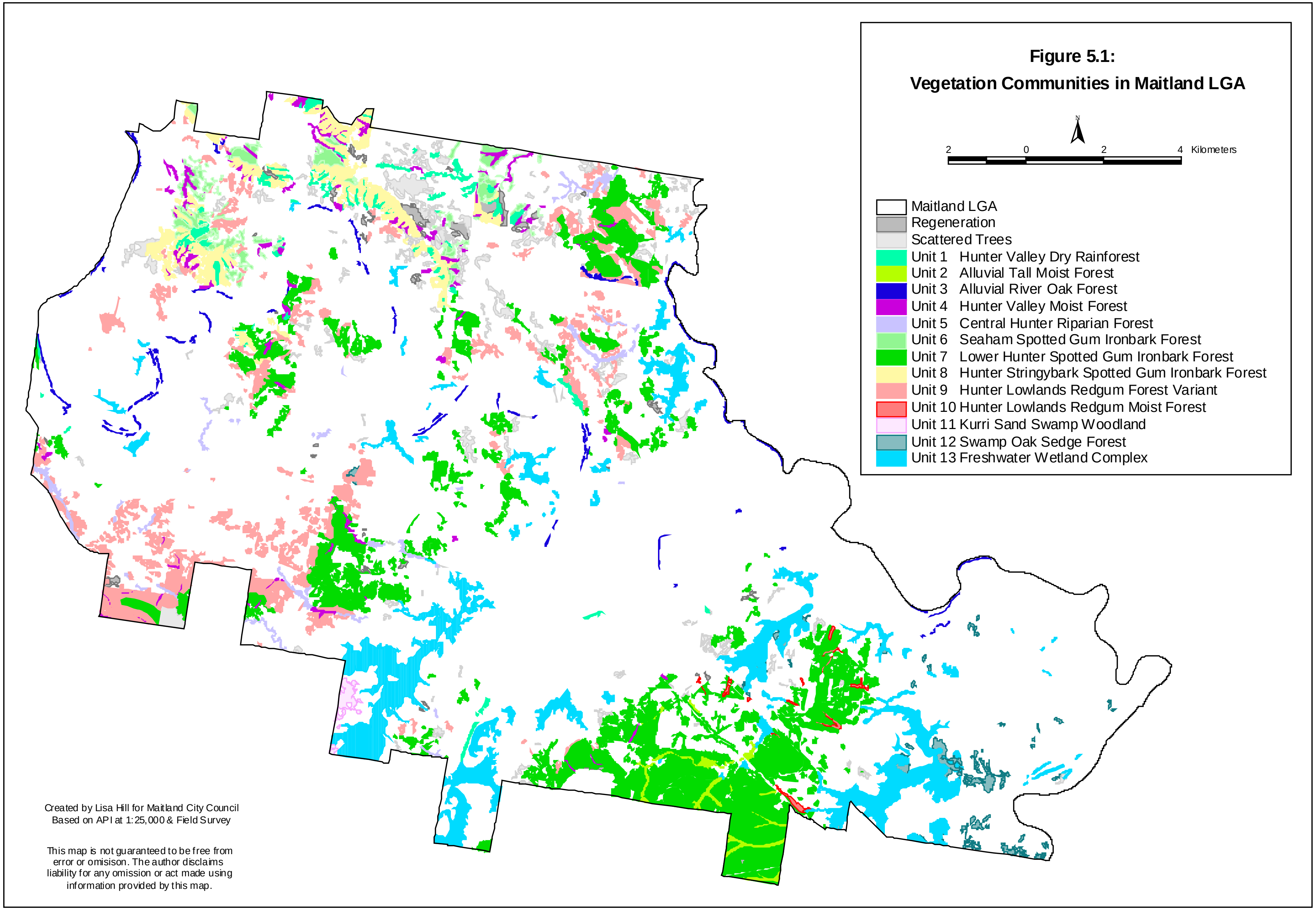


**Figure 5.1:**
**Vegetation Communities in Maitland LGA**

## 5.4 Ecological Assessment

Results of the ecological assessment in Maitland LGA are presented in two parts: at the Community-level and Landscape-level. Ecological assessment at the Community-level assigned each polygon in the final vegetation map to one of four categories of **relative** ecological value. Ordered from highest to lowest relative-value, these are A, B, C and D. The fifth category of not applicable (n/a) was assigned to vegetation that did not constitute a viable vegetation community (scattered trees and regeneration). *Table 5.3* shows the area of each assessment category at the Community-level mapped in Maitland LGA. Only 14.6% of vegetation in the study area was assessed to be of the highest value, which included vegetation communities listed as EECs. Category B had the largest area of occurrence with 40.7% of vegetation in the study area. The results of assessment at the Community-level are presented spatially in *Figure 5.3*.

Users of this ecological assessment should understand that at the Community-level, distinction between categories A, B & C is largely based on present-day legal status, which can change in the future. All three categories (A, B & C) include communities that are threatened. The difference is that category A includes communities that are already listed as EECs, and categories B and C include communities that meet the criteria for listing. Additionally, several communities that are ranked as B and C have reportedly been nominated to the TSC Act for listing as EECs. If and when these communities are listed, they would fall within category A regardless of their distribution or level of reservation.

Ecological assessment at the Landscape-level assigned each remnant of vegetation in the final vegetation map to one of three categories of **relative** ecological value. Ordered from highest to lowest relative-value, these are a, b and c. *Table 5.4* shows the area of each category at the Landscape-level mapped in the LGA. 80.9 % of remnants in the study area were assessed as having the highest value at the Landscape-level, as they were part of a regional corridor or very large in size (over 100ha). The results of assessment at the Landscape-level are presented spatially in *Figure 5.4*.

Relative valuation or ranking of categories is not straightforward when considering both the Community- and Landscape-level assessments together. For example, it would be a subjective and possibly erroneous judgement to rank a very large-sized remnant that supports non-threatened communities (eg. D & a) above a small remnant that supports an EEC (eg. A & c), or visa versa. It is recommended that Council refer to assessments at both the Community- and Landscape-level but generally consider them as separate entities.

**Table 5.3: Results of Ecological Assessment: Community-level**

| Category with broad description | | No. Polygons | Total Area (ha) | % Area (% of total ha) |
|---|---|---|---|---|
| A | Listed EECs | 425 | 1,211.3 | 14.6% |
| B | Communities meet criteria for listing as EECs, are of limited extent (<30% pre-1750) or have very low reservation. | 715 | 3,383.1 | 40.7% |
| C | Communities meet criteria for listing as EECs, have low or better reservation and are of less limited extent than ‘B’ (>30% pre-1750). | 265 | 2,265.3 | 27.3% |
| D | Communities don’t meet criteria for listing and are of less limited extent than ‘C’ (>30% pre-1750). | 254 | 782.8 | 9.4% |
| n/a (scattered trees & regeneration) | | 217 | 661.9 | 8.0% |

Note: see *Section 4.9* for explanation of categories

**Table 5.4: Results of Ecological Assessment: Landscape-level**

| | Category with broad description# | No. Remnants | % Remnants | Total Area (ha) | % Area (% of total ha) |
|---|---|---|---|---|---|
| a | Very Large remnants and/or regionally connected remnants. | 498 | 47.3 % | 6715.5 | 80.9 % |
| b | Large remnants or medium-small remnants that are part of local corridors and/or have a higher diversity than 'c' remnants. | 115 | 10.9 % | 798.8 | 9.6 % |
| c | Small remnants that are isolated and/or of low diversity or medium-sized remnants that are isolated and of low diversity. | 439 | 41.7 % | 790.2 | 9.5% |

Note: see *Section 4.9* for explanation of categories

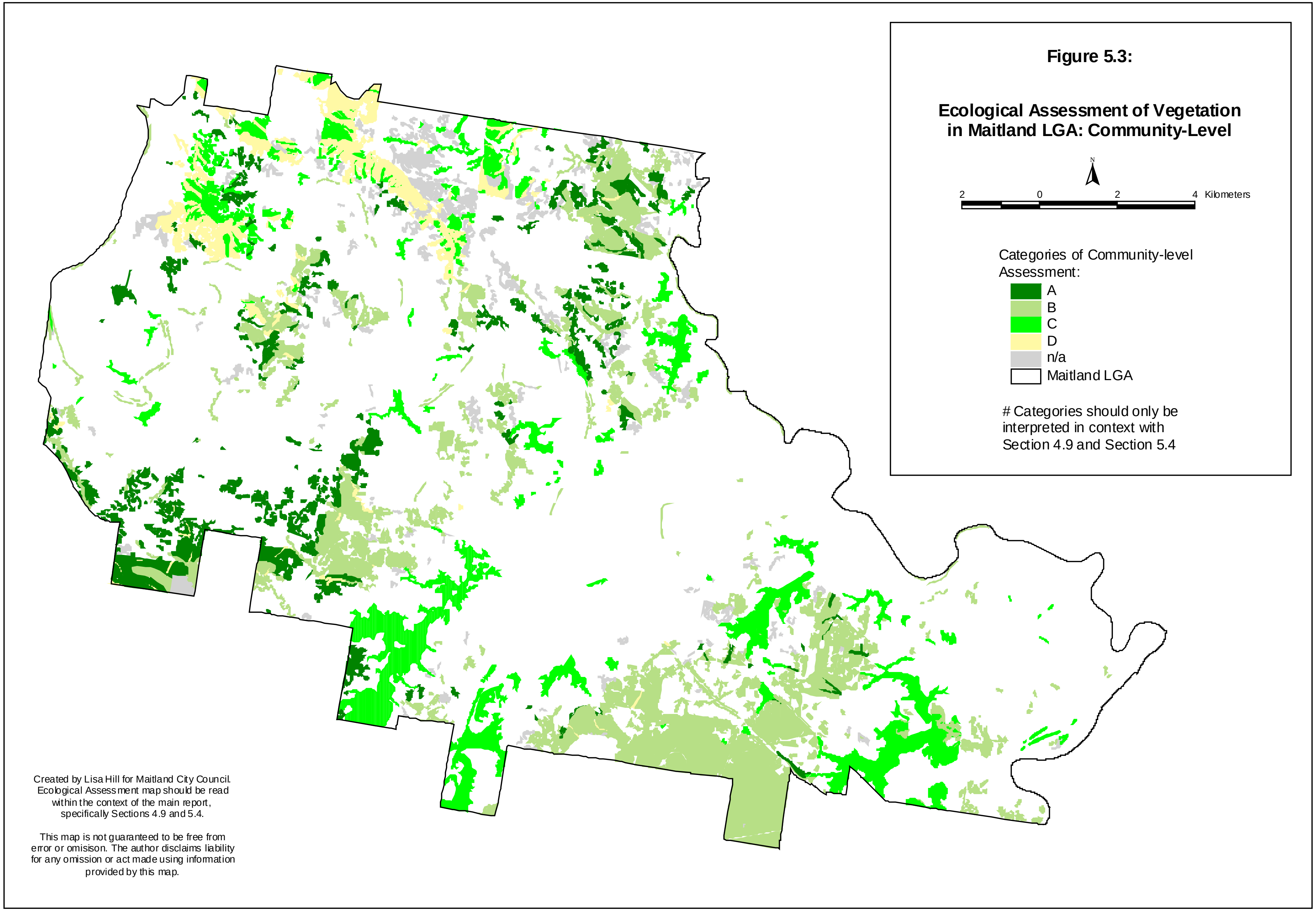


**Figure 5.3:**

**Ecological Assessment of Vegetation in Maitland LGA: Community-Level**

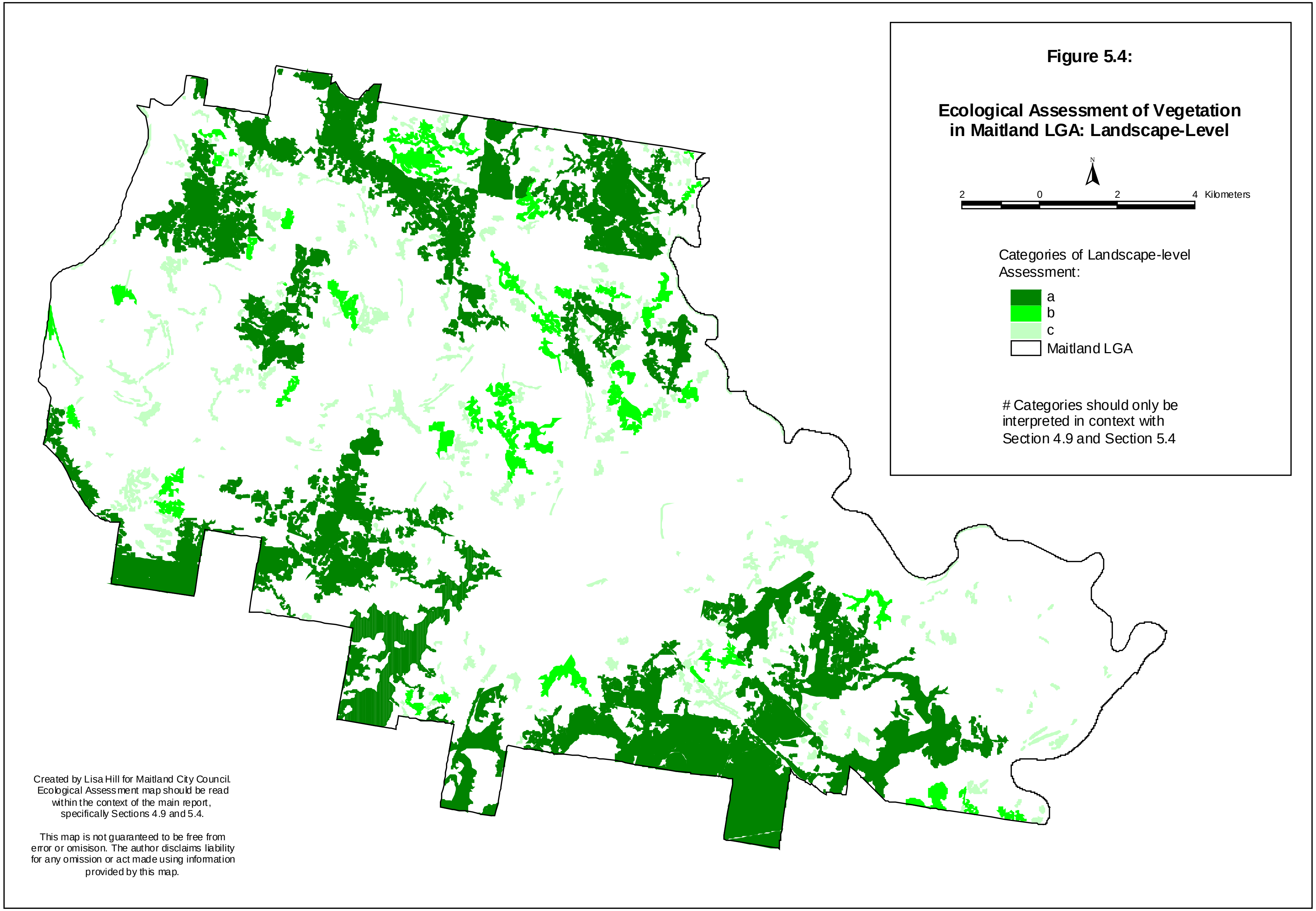
Figure 5.4:
Ecological Assessment of Vegetation in Maitland LGA: Landscape-Level
N
2 0 2 4 Kilometers
Categories of Landscape-level Assessment:
a
b
c
Maitland LGA
# Categories should only be interpreted in context with Section 4.9 and Section 5.4
Created by Lisa Hill for Maitland City Council. Ecological Assessment map should be read within the context of the main report, specifically Sections 4.9 and 5.4.
This map is not guaranteed to be free from error or omisison. The author disclaims liability for any omission or act made using information provided by this map.

# Chapter 6 Discussion

## 6.1 Species Conservation

### *6.1.1 Overview*

Individual species were assessed according to their conservation status at the state and national levels. The July 2003 version of Schedules 1 and 2 of the NSW *Threatened Species Conservation Act* 1995 was consulted for assessment at the state level. The August 2003 version of the threatened species list of the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999, as well as the rare or threatened Australian plants (ROTAP) database (Briggs and Leigh 1996) were consulted for assessment at the national level. In addition to taxa recorded by this survey, those recorded by LHCCREMS (NPWS 2000), other relevant local surveys and the NPWS Wildlife Atlas (September 2002) were assessed.

Three taxa of state or national conservation significance have been recorded in Maitland LGA by survey carried out for the current work. None were recorded by other sources (NPWS 2000 and NPWS Wildlife Atlas September 2002). *Bothriochloa biloba* is listed on the TSC Act, EPBC Act and ROTAP lists. *Grevillea montana* and *Macrozamia flexuosa* are both listed on the ROTAP database.

Seven additional species of significance are known to have been recorded in similar environments within 20 kilometres of Maitland LGA. *Table 6.1* summarises records of these species.

**Table 6.1: Rare or Threatened Flora Species Recorded in or Near to Maitland LGA**

| Scientific Name | Significance [a] ROTAP (national) | EPBC Act | TSC Act | Record Location | No. Plots | Source [b] |
|---|---|---|---|---|---|---|
| **Taxa Recorded in Maitland LGA:** | | | | | | |
| *Bothriochloa biloba* | 3V | V | V | Jacobs Hill | 1 | 1 |
| *Grevillea montana* | 2KC- | - | - | Bishops Bridge & Rosebrook Ridge | 2 | 1 |
| *Macrozamia flexuosa* | 2K | - | - | Ashtonfield - Four Mile Creek | 2 | 1 |
| **Taxa Recorded around Maitland LGA in Similar Environments:** | | | | | | |
| *Callistemon linearifolius* | 2Rci | - | V | Werakata NP - Cessnock | - | 4 |
| *Eucalyptus fergusonii* subsp. *fergusonii* | 3KC- | - | - | North Rothbury | - | 3 |
| *Eucalyptus glaucina* | 3Vca | - | V | Belford district, Glendon Brook, Paterson | - | 2 |
| *Eucalyptus parramattensis* subsp. *decadens* | 2V | V | V | Kurri Kurri district, Werakata NP - Cessnock | - | 4, 5 |
| *Grevillea parviflora* subsp. *parviflora* | - | V | V | Werakata NP - Cessnock | - | 4 |
| *Persoonia pauciflora* | - | - | E | North Rothbury | - | 3 |
| *Tetratheca juncea* | 3Vca | - | V | Buttai, Mt Sugarloaf, sub-coastal Newcastle, Lake Macquarie & upper Central Coast | - | 3 |

Notes: a. Significance Code (no entry indicates species is not listed):
ROTAP Code (refer to Briggs and Leigh 1996, for definitions of codes)
TSC Act 1995 & EPBC Act 1999 E = Endangered; V = Vulnerable
b. Source of Record:
1. Current study 2. NPWS Wildlife Atlas 5. Hill (in prep.)
3. Personal observations by the author 4. Bell (2001)

### *6.1.2 Rare or Threatened Plants*

### *a. Plants Recorded in Maitland LGA*

Three rare or threatened plants have been recorded in Maitland LGA, and are described below.

***Bothriochloa biloba* S. T. Blake (a redgrass)**
**Conservation Status**: TSC **V**; EPBC **V**; ROTAP **3V**. Nationally vulnerable, at risk over 20-50 years of disappearing from the wild through continued depletion, and with a geographic range greater than 100 km (Briggs and Leigh 1996). *B. biloba* is listed as Vulnerable on the TSC Act 1995 and on the EPBC Act 1999.
**Description**: Erect or decumbent caespitose perennial grass to 1 m high; culms often branching from the node. Leaves are keeled and glabrous, with ligule 1-2 mm long and ciliolate, the blade 3-5 mm wide. The lower lemma is ovate and ciliolate; the awn being 16-20 mm long (Jacobs and Wall 1993).
**Fire Response**: Unknown.
**Distribution in Maitland LGA**: *B. biloba* was recorded at Jacobs Hill.
**Comments**: *B. biloba* grows in woodland on poorer soils (Jacobs and Wall 1993). Bean (1999) notes that on the Liverpool Plains *B. biloba* shows a distinct preference for heavier-textured soils formed from volcanic geology above lighter-textured soils formed from scree. The species has been recorded across much of the mid and upper Hunter Valley, with relatively few records in the lower Hunter (Peake in prep.). The taxon is probably close to its eastern limit in Maitland LGA.

***Grevillea montana* R. Br.**
**Conservation Status**: ROTAP **3KC-**. Nationally poorly known, suspected of being Rare or Vulnerable, but with limited field distribution information. Its geographic range is greater than 100 km with an unknown number of plants known to occur within a conservation reserve(s) (Briggs and Leigh 1996). *G. montana* is not listed on TSC Act 1995 or the EPBC Act 1999.
**Description**: A spreading shrub 0.5-1.5 m high. Leaves narrow-elliptic to oblanceolate, 1.5-3 cm long and 1.5-6.5 mm wide, margins entire, recurved to revolute. Flowers mainly in September, with green and red individual flowers in groups of 1-4 (Makinson 2002).
**Fire Response**: Unknown.
**Distribution in Maitland LGA**: *G. montana* was recorded near Bishops Bridge and on Rosebrook Ridge.
**Comments**: *G. montana* grows in open forest in sandy soils over mixed sedimentary substrates, in the southern part of the Hunter Valley from Denman to Kurri Kurri (Makinson 2002). *G. montana* is at the extreme eastern limit of its distribution in Maitland LGA, particularly north-eastern limit at Rosebrook Ridge and may be a local extension of range.

***Macrozamia flexuosa* C. Moore (a burrawang)**
**Conservation Status**: ROTAP **2K**. Nationally poorly known, suspected of being Rare or Vulnerable, but with limited field distribution information. Its geographic range is greater than 100 km (Briggs and Leigh 1996). *M flexuosa* is not listed on TSC Act 1995 or the EPBC Act 1999.
**Description**: Dioecious shrub with a subterranean stem, 8-20 cm diameter. Leaves 1-6 in crown, 45-100 cm long, with rachis strongly spirally twisted; pinnae 80-150. Male cones 15 cm long and female cones 10-16 cm long (Murray 2000).
**Fire Response**: Unknown
**Distribution in Maitland LGA**: *M. flexuosa* was recorded near Ashtonfield in the Four Mile Creek catchment in a site likely to be cleared in the near future for residential development. It is likely that this taxon may occur in scattered in the Ashtonfield and Four Mile Creek area.
**Comments**: *M. flexuosa* is a recently-described burrawang, scattered in sclerophyll forests on siliceous soils from Bulahdelah to Lake Macquarie (Murray 2000). It is known to hybridise with *M. communis*

(Murray 2000). It is likely that due to increasing finds of this taxa by recent vegetation survey work (current survey; Bell 2001; Hill in prep.) its conservation status should be revised to 2R to reflect that the species is abundant in some areas, but occupies a relatively small range.

### *b. Plants Recorded Outside Maitland LGA*

Seven rare or threatened plants have been recorded outside of the study area, within 20 km of Maitland LGA boundary, occurring in similar environments to those found in the study area.

***Callistemon linearifolius* (Link) DC. (a bottlebrush)**
**Conservation Status**: TSC **V**; ROTAP **2RCi**. Nationally rare but does not have any identifiable threat. Its geographic range is less than 100 km with less than 1,000 plants known to be present within a conservation reserve(s) (Briggs and Leigh 1996). *C. linearifolius* is listed as Vulnerable on the TSC Act 1995. It is not listed on the EPBC Act 1999.
**Description**: A shrub 3-4 m high. Leaves are linear to linear-lanceolate, mostly 8-10 cm long and 5-7 mm wide, rarely to 14 cm long and 12 mm wide. Flower spikes usually 9-10 cm long, c. 50 mm diameter, flowers red (Spencer and Lumley 2002).
**Fire Response**: Unknown.
**Distribution near Maitland LGA**: *C. linearifolius* has been recorded in the former Aberdare and Cessnock State Forests, which are now part of Werakata National Park (Bell 2001).
**Comments**: *C. linearifolius* grows in dry sclerophyll forest on the coast and adjacent ranges (Spencer and Lumley 2002). It is considered unlikely that this taxon would occur in Maitland LGA.

***Eucalyptus fergusonii* R. T. Baker** subsp. ***fergusonii* (an ironbark)**
**Conservation Status**: ROTAP **3KC-**. Nationally poorly known, suspected of being Rare or Vulnerable, but with limited field distribution information. Its geographic range is greater than 100 km with an unknown number of plants known to occur within a conservation reserve(s) (Briggs and Leigh 1996). *E. fergusonii* subsp. *fergusonii* is not listed on the TSC Act 1995 or the EPBC Act 1999.
**Description**: A tree to 25 m high; bark persistent throughout, dark grey 'ironbark'. Juvenile leaves are disjunct, lanceolate, dull green. Adult leaves are disjunct, lanceolate, 8-15 cm long, 1.5-3 cm wide, green, dull, strongly discolorous. Umbellasters are 3-7-flowered. The fruit is obconical to ovoid, 7-13 mm long and 5-7 mm diameter. Disc depressed or flat, with valves enclosed (Hill 2002).
**Fire Response**: Unknown.
**Distribution near Maitland LGA**: *E. fergusonii* subsp. *fergusonii* is known to occur broadly between Bulahdelah and Morisset and west to the Widden district (west of Denman). The closest population known to the author is at North Rothbury, south of Branxton. There is a moderate likelihood that this taxon would occur in Maitland LGA, most likely in drier parts of Lower Hunter Spotted Gum Ironbark Forests (Unit 7) around Ashtonfield or Bishops Bridge.
**Comments**: *E. fergusonii* subsp. *fergusonii* occurs sporadically and scattered through wet sclerophyll forest or woodland on sandy soils (Hill 2002).

***Eucalyptus glaucina* Blakely (slaty red gum)**
**Conservation Status**: TSC **V;** ROTAP **3VCa**. Nationally vulnerable, at risk over 20-50 years of disappearing from the wild through continued depletion. 1,000 plants or more are known to occur within a conservation reserve. Its geographic range is greater than 100 km (Briggs and Leigh 1996). *E. glaucina* is listed a Vulnerable on the TSC Act 1995. It is not listed on the EPBC Act 1999.
**Description**: A tree to 30 m high; bark smooth, white or grey, shedding in large plates or flakes. Juvenile leaves are disjunct, ovate and glaucous. Adult leaves are disjunct, lanceolate, 12-18 cm long, 2-3 cm wide, green or grey-green, dull, concolorous. Umbellasters are 7-flowered. The fruit is globose or ovoid, 7-10 mm long and 7-10 mm diameter. Disc is raised, with valves exserted (Hill 2002).
**Fire Response**: Unknown.

**Distribution near Maitland LGA**: *E. glaucina* is known to occur in the Belford-Pokolbin district, Glendon Brook and Dungog-Paterson districts, only about 5 km from Maitland LGA. There is a high probability that this species might occur in Maitland LGA, most likely in the Tocal district.
**Comments**: *E. glaucina* is locally frequent but very sporadic, in grassy woodland on deep, moderately fertile and well-watered soils (Hill 2002).

***Eucalyptus parramattensis* C. Hall** subsp. ***decadens* L.A.S. Johnson & Blaxell (Parramatta red gum)**
**Conservation Status**: EPBC **V**; TSC **V**; ROTAP **2V**. Nationally vulnerable, at risk over 20-50 years of disappearing from the wild through continued depletion. Its geographic range is less than 100 km (Briggs and Leigh 1996). *E. parramattensis* subsp. *decadens* is listed a Vulnerable on the EPBC Act 1999 and on the TSC Act 1995.
**Description**: A tree to 15 m high; bark smooth (not shedding cleanly), white or grey, shedding in large plates or flakes. Juvenile leaves are disjunct, narrow-lanceolate to lanceolate, dull green. Adult leaves are disjunct, narrow-lanceolate or lanceolate, 7-20 cm long, 1-3.5 cm wide, green, dull, concolorous. Umbellasters are 7-flowered. The fruit is hemispherical or globose, 4-9 mm long and 5-9 mm diameter. Disc is flat or raised (slightly), with valves exserted (Hill 2002).
**Fire Response**: Unknown.
**Distribution near Maitland LGA**: *E. parramattensis* subsp. *decadens* is known to occur in the Kurri Kurri to Cessnock district, and was recorded as part of the Kurri Sand Swamp Woodland Endangered Ecological Community less than one kilometre from Maitland LGA boundary. It is likely that this species occurs in Maitland LGA near Wentworth Swamp where this community has been mapped.
**Comments**: *E. parramattensis* subsp. *decadens* is locally frequent, in dry sclerophyll woodland on sandy soils in low, often wet sites (Hill 2002).

***Grevillea parviflora* R. Br.** subsp. ***parviflora* (a grevillea)**
**Conservation Status**: EPBC **V**; TSC **V**.*G. parviflora* subsp. *parviflora* is listed as Vulnerable on the EPBC Act 1999 and on the TSC Act 1995. It is not listed on the ROTAP database.
**Description**: Low, spreading, dense to erect shrub usually 1 m high. Leaves linear or very slightly oblanceolate, mostly 1.5-3.5 cm long and 0.8-2 mm wide. Flowers white (Makinson 2002).
**Fire Response**: Killed by fire, sometimes regenerates from rhizomes (Benson and McDougall 2000).
**Distribution near Maitland LGA**: *G. parviflora* subsp. *parviflora* has been recorded in the southern portion of Werakata National Park near Kitchener (Bell 2001). There is a low probability that *G. parviflora* subsp. *parviflora* would occur in Maitland LGA.
**Comments**: *G. parviflora* subsp. *parviflora* grows in heath or shrubby woodland, in sandy or light clay soils usually over thin shales (Makinson 2002).

***Persoonia pauciflora* P.H. Weston (a geebung)**
**Conservation Status**: TSC **E**. *P. pauciflora* is listed as Endangered on the TSC Act 1995. It is not listed on the EPBC Act 1999 or as a ROTAP. Weston (1999) suggests a ROTAP code of 2E, indicating the species' restricted geographic distribution and endangered status, as well as its lack of conservation.
**Description**: A spreading shrub with young branchlets moderately hairy. Leaves terete, 1.7-3.5 cm long, 0.6-0.8 mm wide, usually incurved, smooth, sparsely hairy to glabrescent when adult. Inflorescence growing on into a leafy shoot, ovary glabrous (Weston 2002).
**Fire Response**: Unknown.
**Distribution near Maitland LGA**: *P. pauciflora* is only known to occur in one population of about 200 plants in three main sub-populations immediately south of North Rothbury, about 5 km south of Branxton (Patrick 1999). Systematic surveys in 1999 failed to find any more plants beyond 2 km and within a 5 km radius of the type specimen (Patrick 1999). The species was only discovered in 1997 (Weston, 1999). It is considered unlikely that this species would occur in Maitland LGA.

**Comments**: *P. pauciflora* grows in dry sclerophyll forest or woodland on clay soils at North Rothbury (Weston 2002).

***Tetratheca juncea*** **Smith (black-eyed Susan)**
**Conservation Status**: TSC **V**; ROTAP **3VCa**. Nationally vulnerable, at risk over 20-50 years of disappearing in the wild through continued depletion. Its geographic range is greater than 100 km with over 1,000 plants being known to occur within a conservation reserve(s) (Briggs and Leigh 1996). *T. juncea* is listed as Vulnerable on the TSC Act 1995. It is not listed on the EPBC Act 1999.
**Description**: A prostrate shrub with stems to 1 m long. Stems with 2 or 3 wings, glabrous with minute tubercles. Leaves alternate, usually reduced to narrow triangular scales, to 3 mm long. Flowers solitary or paired. Petals 7-11 mm long, deep lilac-pink (Gardner and Murray 1992).
**Fire Response**: Unknown.
**Distribution near Maitland LGA**: *T. juncea* has been recorded extensively on clay-based soils between Newcastle and Munmorah State Recreation Area. Records near Maitland include Mount Sugarloaf and at Buttai (pers. obs.). There is a low probability that *T. juncea* would occur in Maitland LGA. If it does occur in Maitland LGA, it is likely to be south of the New England Highway in the Ashtonfield district.
**Comments**: *T. juncea* grows in sandy, occasionally swampy heath and in dry sclerophyll forest; chiefly in coastal districts from Bulahdelah to Lake Macquarie (Gardner and Murray 1992).

### *6.1.3 Range Extensions*

The vine *Calystegia sepium* was recorded at Duckenfield on the banks of Saltwater Gully. This represents the first record for the North Coast botanical subdivision of this species. A voucher specimen lodged with the NSW National Herbarium confirms this record. *C. sepium* has previously only been recorded south from the Sydney region.

Another three taxa have been recorded by this survey as local extensions of range. Verification of these records by the National Herbarium of NSW is needed for formal inclusion into herbarium records.

The shrub *Grevillea montana* was recorded at Bishops Bridge and Rosebrook Ridge, the latter of which is probably the extreme north-eastern limit of its range.

The vine *Jasminum volubile* has previously been collected from the North Coast botanical subdivision at Gloucester and near North Rothbury, south of Branxton (P. Hind pers. comm.). The new record for this species at Maitland (at Rosebrook Ridge and Jacobs Hill) represents a small range extension and the south-eastern known distributional limit of the species.

The grass tree, *Xanthorrhoea johnsonii*, is at its extreme southern limit in Maitland LGA. Its record at Mount Hudson represents a local range extension. NSW National Herbarium give the previous most southern record in the North Coast botanical subdivision at Mt Richardson near Dungog ( P. Hind pers. comm.). *Table 6.2* lists extensions of range.

**Table 6.2: Extensions of Range**

| Botanical Name | Notes (see below) |
|---|---|
| *Calystegia sepium* | confirmed RE to NC |
| *Grevillea montana* | probable LRE within NC (mostly south & west of Maitland) |
| *Jasminum volubile* | LRE within NC (typically north & west from Singleton & Branxton) |
| *Xanthorrhoea johnsonii* | LRE within NC (typically north from Howes Valley) |

Notes: NC = North Coast botanical subdivision, RE = range extension (to new botanical subdivision),
LRE = local range extension (within existing botanical subdivision)

### *6.1.4 Taxa of Regional Conservation Significance*

The regional significance of taxa recorded in Maitland LGA has been assessed using the *Register of Regionally Significant Plant Species, Populations and Vegetation Communities* developed by Bell *et al.* (2003) for the Hunter Rare Plants Committee of the Hunter Region Botanic Gardens. The register is based on previously published and unpublished documents listing significant species, together with the field knowledge of regional botanists. As this is a working register, many taxa that are likely to be regionally significant in the Hunter have not yet been formally assessed for listing. Therefore, several regionally significant species recorded in Maitland LGA may not be listed on the register.

Many species on the register are listed because they are at the limit of their known distribution at some location in the Hunter Region. Accordingly, a number of species recorded in Maitland LGA are considered to be regionally significant, even though they are not at the limit of their range in or near to the study area.

Regional significance is based on one or more of the following criteria in the context of the Hunter Region:

- rare
- uncommon
- under threat
- endemic
- at the eastern, northern, southern or western limit of their distribution
- a disjunct population (a distinct outlier from core occurrence)

Regionally significant taxa recorded in Maitland LGA are listed in *Table 6.3.* A total of 73 taxa are at or near to their known distributional limit in the Hunter Region. A further 10 taxa are possibly at their distributional limit in the region. Most of these are not at their distributional limit in the study area, but elsewhere in the Hunter Region. Other taxa are of regional significance for the reasons shown in *Table 6.3*. A summary of taxa regional significance is provided in *Table 6.4*.

**Table 6.3: Taxa of Regional Significance**

| Botanical Name | Signif. | Botanical Name | Signif. |
|---|---|---|---|
| *Acacia falcata* | W | *Eucalyptus punctata* | W |
| *Acacia leiocalyx* | N | *Eucalyptus saligna* | W |
| *Acacia parramattensis* | N | *Eustrephus latifolius* | W |
| *Acacia parvipinnula* | N W | *Geijera salicifolia* | S? W? |
| *Acronychia oblongifolia* | W | *Goodenia rotundifolia* | S |
| *Adiantum hispidulum* var. *hispidulum* | N | *Grevillea montana* | L? |
| *Alchornea ilicifolia* | W | *Hibbertia empetrifolia* | L? |
| *Alectryon subcinereus* | W | *Hybanthus stellarioides* | D W |
| *Alectryon tomentosus* | S | *Hymenosporum flavum* | W |
| *Alphitonia excelsa* | S? | *Imperata cylindrica* var. *major* | W? |
| *Amyema congener* subsp. *congener* | W | *Jasminum volubile* | S |
| *Aneilema acuminatum* | W | *Legnephora moorei* | W |
| *Angophora bakeri* | D N W | *Leptospermum polygalifolium* ssp *cismontanum* | S |
| *Aristida ramosa* | W? | *Lissanthe strigosa* | U |
| *Babingtonia similis* | S | *Logania albiflora* | U |
| *Backhousia myrtifolia* | W | *Lomandra confertifolia* subsp. *rubiginosa* | N |
| *Boerhavia dominii* | U | *Lomandra glauca* | N |
| *Bossiaea scortechinii* | S? | *Maclura cochinchinensis* | D W |

**Table 6.3: Taxa of Regional Significance**

| Botanical Name | Signif. | Botanical Name | Signif. |
|---|---|---|---|
| *Bothriochloa biloba* | E? | *Macrozamia flexuosa* | L |
| *Calystegia sepium* | D N | *Mallotus philippensis* | S |
| *Capparis arborea* | S W | *Marsdenia rostrata* | W |
| *Carex longebrachiata* | W | *Maytenus silvestris* | U |
| *Cassine australis* var. *australis* | W | *Melaleuca decora* | D W |
| *Cassinia cunninghamii* | N E | *Melaleuca styphelioides* | W |
| *Cassinia* species D | N | *Melia azedarach* | W |
| *Celastrus australis* | W | *Melicope micrococca* | W |
| *Chorizema parviflorum* | W | *Morinda jasminoides* | W |
| *Cissus antarctica* | W | *Notelaea longifolia* forma *intermedia* | W S U |
| *Cissus opaca* | S | *Olea paniculata* | S |
| *Clerodendrum tomentosum* | W | *Ottochloa gracillima* | S |
| *Corymbia maculata* | W | *Pararchidendron pruinosum* var. *pruinosum* | W |
| *Cyperus laevis* | W | *Parsonsia lanceolata* | S |
| *Cyperus tetraphyllus* | W | *Parsonsia straminea* | W? |
| *Daviesia corymbosa* | N | *Pimelea linifolia* | N? |
| *Daviesia squarrosa* | N | *Pittosporum revolutum* | W |
| *Dianella caerulea* var. *caerulea* | W | *Planchonella australis* | W |
| *Dianella caerulea* var. *cinerascens* | W | *Podolobium ilicifolium* | W? |
| *Dodonaea triquetra* | W | *Rhodomyrtus psidioides* | S D |
| *Ehretia acuminata* var. *acuminata* | W | *Sarcopetalum harveyanum* | W |
| *Elaeocarpus obovatus* | D S W? | *Senna septemtrionalis* | W |
| *Eucalyptus agglomerata* | W | *Solanum brownii* | W E |
| *Eucalyptus camaldulensis* | E R D? | *Sorghum leiocladum* | R |
| *Eucalyptus carnea* | S | *Tetrastigma nitens* | S D |
| *Eucalyptus eugenioides* | W? | *Tylophora barbata* | N W? |
| *Eucalyptus globoidea* | W | *Xanthorrhoea johnsonii* | S |
| *Eucalyptus grandis* | S | *Zieria smithii* subsp. *smithii* | W |

Notes: D = disjunct occurrence; E = eastern limit of distribution
L = endemic to the Hunter Region; N = northern limit of distribution
S = southern limit of distribution; U = uncommon
W = western limit of distribution; ? = code is uncertain

**Table 6.4: Summary of Taxa Regional Significance**

| Regional Significance | Number of Taxa |
|---|---|
| Distributional limit - total | 73 |
| Possible distributional limit | 10 |
| Northern distributional limit | 12 |
| Eastern distributional limit | 3 |
| Southern distributional limit | 17 |
| Western distributional limit | 45 |
| Disjunct in the Hunter Valley[1] | 7 |
| Endemic | 1 |
| Possibly endemic | 2 |
| Uncommon | 5 |
| Rare[2] | 2 |

Notes:
1. Indicates that the taxon mostly occurs outside the Hunter Valley, but an outlying population or occurrence exists in the Hunter.
2. Potentially a number of other taxa on this list are likely to be rare, but have not yet been assessed as such by the Hunter Rare Plants Committee (Bell *et al.* 2003).

Two species listed on the *Register of Regionally Significant Plant Species, Populations and Vegetation Communities* (Bell *et al.* 2003) are currently considered to be regionally rare. Information on those species is provided below. Several other species occurring in Maitland LGA that are not currently listed by Bell *et al.* (2003) are likely to be regionally rare.

***Eucalyptus camaldulensis* Dehnh. (river red gum)**

**Conservation Status**: HRPC: **R**. *E. camaldulensis* is regionally rare because it occurs in very few populations, in low or very low numbers, and suffers significant threat in the Hunter Valley. *E. camaldulensis* is not listed on TSC Act 1995, the EPBC Act 1999 or the ROTAP database.

**Description**: Erect tree to 30 m high, occasionally higher, with smooth bark, white, grey to red-brown, shedding in short ribbons or flakes. Juvenile leaves are disjunct, broad-lanceolate to ovate, dull grey-green. Adult leaves are disjunct, narrow-lanceolate or lanceolate, 8-30 cm long, 1-2.5 cm wide, green or grey-green, dull, concolorous. Umbellasters 7-11 flowered, buds ovoid 6-11 mm long, scar present, calyptra hemispherical and rostrate, longer than hypanthium, fruit globose or ovoid, 5-7 mm long and wide, disc raised, valves exserted (Hill 2002).

**Fire Response**: Unknown.

**Distribution near Maitland LGA**: *E. camaldulensis* is known to occur on the Hunter River at Nulla Nulla Lane, Hinton within Port Stephens LGA (adjacent to the Maitland LGA boundary); on the Hunter River at Aberglasslyn lane, Aberglasslyn; a probable record exists at Gosforth, near to the sand mining operation. In each of these cases only one individual tree remains. Single trees may also occur along the Hunter River between Greta and Bolwarra.

**Distribution outside Maitland LGA**: *E. camaldulensis* occurs throughout inland NSW, Queensland, Victoria, South Australia, Western Australia and the Northern Territory. It is probably the most widely distributed eucalypt in Australia. *E. camaldulensis* populations in the Hunter are possibly genetically distinct from inland NSW populations and represent the most eastern distribution of the species. *E. camaldulensis* occurs in remnant floodplain stands extending west from Hinton as far as Bylong and north to Scone (Peake in prep.).

**Comments**: *E. camaldulensis* is a community dominant species, growing in grassy woodland or forest on deep rich alluvial soils adjacent to large permanent water bodies (Hill 2002). In the Hunter it appears to grow in sub-optimal conditions, and presumably once often shared that environment with *E. tereticornis*, *E. melliodora* and *Angophora floribunda* (Peake in prep.). It has been extensively cleared in the Hunter, it is not protected in any conservation reserves and it is under extreme threat.

***Sorghum leiocladum* (Hack.) C.E. Hubb. (wild sorghum)**

**Conservation Status**: HRPC: **R**. *S. leiocladum* is regionally rare because it has been recorded in low numbers in relatively few populations within the Hunter Valley. *S. leiocladum* is not listed on TSC Act 1995, the EPBC Act 1999 or the ROTAP database.

**Description**: A tufted perennial grass to 1 m high, with an open inflorescence, 7-15 cm long, to 3 cm wide. Glumes 6-7 mm long, awnless, margins ciliate, palaea absent or reduced. (Jacobs and McClay 1993).

**Fire Response**: Unknown. Probably killed.

**Distribution in Maitland LGA**: *S. leiocladum* was recorded in five plots in Maitland LGA. In three of those plots it was recorded as abundant, with a percentage cover of between 5 and 25. Plots were located at Mount Hudson and Rosebrook Ridge in the north-western part of the LGA, all on private land on which the grazing intensity was very low.

**Distribution outside Maitland LGA**: *S. leiocladum* occurs throughout eastern NSW and in Queensland, Victoria and the Northern Territory. Within the Hunter Valley it has only been recorded at a relatively small number of sites, especially on roadsides where stock grazing is infrequent or absent.

**Comments**: *S. leiocladum* is recorded in woodland on poorer soils (Jacobs and McClay 1993). Records of *S. leiocladum* are mostly restricted to open forest or woodland and roadside verges in locations that are lightly grazed or ungrazed (T. Peake pers. comm.). These records suggest *S. leiocladum* is sensitive to stock grazing (C. Huxtable pers. comm.). It is likely that this species has declined significantly in abundance and distribution in the Hunter Valley as a result of stock grazing, clearings and urban development.

### *6.1.5 Taxa of Local Conservation Significance*

Fifteen species recorded in Maitland LGA are locally significant because they reach their distributional limit in the local area, shown in *Table 6.5.*

The core distributions of most of the taxa in *Table 6.5* occur north or west of the Maitland district, with many occurring north from the Hunter River and into Queensland. Populations of these species in Maitland LGA may be genetically distinct to populations in their respective core distributions, due to their location at the edge of their range. This would give them a higher conservation value since individual, isolated populations may contain genetically unique characteristics that are worthy of conservation (Daniels and Sheil 1999).

**Table 6.5: Taxa of Local Conservation Significance**

| Species | Local Significance |
|---|---|
| *Babingtonia similis* | north from near Newcastle |
| *Bothriochloa biloba* | Maitland is probably near eastern limit |
| *Capparis arborea* | north from the Hunter Valley, mainly on the coast |
| *Cissus opaca* | north from the Hunter |
| *Eucalyptus camaldulensis* | west from Hinton |
| *Eucalyptus carnea* | north from the Hunter River |
| *Eucalyptus grandis* | north from Minmi |
| *Geijera salicifolia* (var. *salicifolia*) | north from the Hunter River |
| *Grevillea montana* | at extreme eastern distribution in Maitland LGA |
| *Goodenia rotundifolia* | north from the Hunter Valley |
| *Jasminum volubile* | new record is at extreme south-eastern limit |
| *Mallotus philippensis* | chiefly north from the Hunter River |
| *Olea paniculata* | north from the Hunter Valley |
| *Solanum brownii* | Maitland is probably near eastern limit |
| *Xanthorrhoea johnsonii* | north from Howes Valley and Maitland |

## 6.2 Noxious Weeds and Weeds of National Significance

Six species recorded in the study area are listed as noxious weeds in the NSW Government Gazette No. 13 (10 January 2003). One of these is also a weed of national significance (WONS), listed in the Commonwealth Government's National Weeds Strategy 1997. One other species not listed as noxious is a WONS. *Table 6.6* lists these species. Of the 84 exotic taxa recorded in the LGA, 7.1% are listed as noxious, which represents 1.3% of the entire vascular flora recorded in the study area.

**Table 6.6: Noxious Weeds Recorded in Maitland LGA**

| Family | Scientific Name | Common Name | Action Category | Weed of National Significance |
|---|---|---|---|---|
| Asteraceae | **Ageratina adenophora* | crofton weed | W2 | - |
| | **Ageratina riparia* | mist flower | W2 | - |
| *Cactaceae | **Opuntia aurantiaca* | tiger pear | W4f | - |
| | **Opuntia stricta* var. *stricta* | prickly pear | W4f | - |
| *Salicaceae | **Salix* X *sepulcralis* var. *chrysocoma* | golden weeping willow | W4g | yes |
| Solanaceae | **Lycium ferocissimum* | African boxthorn | W2 | - |
| Verbenaceae | **Lantana camara* | lantana | - | yes |

Notes: W2=must be fully and continuously suppressed and destroyed; W4f= must not be sold, propagated or knowingly distributed. Any biological control or other control program directed by a Local Control Authority must be implemented; W4g=Species must not be sold, propagated or knowingly distributed.

## 6.3 Vegetation Community Conservation Significance

### *6.3.1 Background*

#### *a. Introduction*

There are several accepted systems for the assessment of vegetation community conservation significance. The following sections provide an overview of the assessment systems used by the legislation and literature listed below, and place vegetation communities described in Maitland LGA into the context of each:

- *Threatened Species Conservation Act* 1995 (TSC Act) and *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) which set out criteria for listing a vegetation community as Endangered under State and Commonwealth legislation
- NPWS Forest Ecosystem Assessment (NPWS 1999a) which applies the JANIS criteria (JANIS 1997)
- LHCCREMS (NPWS 2000) which applies the draft criteria of Landsberg (2000)
- Hunter Region Botanic Gardens register of regional significance (Bell *et al.* 2003) which applies criteria developed by the Hunter Rare Plants Committee (HRPC)
- Benson (1989) which provides an assessment of vegetation associations across NSW
- Hager and Benson (1994) which provides an assessment of vegetation associations in north-east NSW
- Specht *et al.* (1995) which provides an assessment of vegetation communities in Australia.

The conservation assessment of vegetation communities described in Maitland LGA by the current work considers each of the above systems. The results of this assessment are provided in *Section 6.3.2*.

#### *b. TSC Act 1995 & EPBC Act 1999*

Three vegetation communities mapped within Maitland LGA are currently listed as Endangered Ecological Communities (EECs) on the NSW *Threatened Species Conservation Act* 1995, while none are listed on the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999. Three other vegetation communities in Maitland LGA had reportedly been nominated to the NSW Scientific Committee for consideration for listing as EECs at the time of writing this report. *Table 6.7* lists these communities.

**Table 6.7: Legislative Status of Vegetation Communities in Maitland LGA**

| Vegetation Community (this report) | Listed EEC | TSC Act Status | EPBC Act Status |
|---|---|---|---|
| Hunter Valley Dry Rainforest (Unit 1) | - | Nominated | not listed |
| Alluvial Tall Moist Forest (Unit 2) | - | Nominated | not listed |
| Lower Hunter Spotted Gum - Ironbark Forest (Unit 7) | - | Nominated | not listed |
| Hunter Lowlands Redgum Forest Variant (Unit 9) | Hunter Lowland Redgum Forest | EEC | not listed |
| Hunter Lowlands Redgum Moist Forest (Unit 10) | Hunter Lowland Redgum Forest | EEC | not listed |
| Kurri Sand Swamp Woodland (Unit 11) | Kurri Sand Swamp Woodland in the Sydney Basin Bioregion | EEC | not listed |

**Table 6.7: Legislative Status of Vegetation Communities in Maitland LGA**

| Vegetation Community (this report) | Listed EEC | TSC Act Status | EPBC Act Status |
|---|---|---|---|
| Lowland Rainforest on Floodplain (probably extinct in Maitland LGA) | Lowland Rainforest on Floodplain | EEC | not listed |

Note: EEC = Endangered Ecological Community
TSC Act Status – the shown communities have reportedly been nominated, although at the time of writing this report no preliminary determination had been made.

Based on vegetation communities described by the current work for Maitland LGA, three Endangered Ecological Communities (EECs) exist within Maitland LGA and one is locally extinct in Maitland LGA.

Kurri Sand Swamp Woodland (Unit 11), a listed EEC, occurs in the south-central portion of the LGA, on the southern margins of Wentworth Swamp close to Heddon Greta and Kurri Kurri Aluminium Smelter.

Hunter Lowlands Redgum Forest was mapped by NPWS (2000) in a number of areas within Maitland LGA. The current work has mapped two variants of this community that are less widespread. Despite the differences, the variants are generally equivalent to the NPWS (2000) community. Based on this equivalence, and in the absence of more detailed survey, Hunter Lowlands Redgum Forest Variant (Unit 9) and Hunter Lowlands Redgum Moist Forest (Unit 10) should be considered as the listed EEC. Plot-based survey for the current work was limited to Maitland LGA, compared to NPWS (2000) which sampled vegetation across the lower Hunter-Central Coast region. Additionally, analysis in the current work did not include data from areas outside of the study area. These factors are largely responsible for the variations to the NPWS (2000) redgum communities that are described by the current work. Description of these communities is provided in *Section 5.3* and *Appendix B.*

The listed EEC, Lowland Rainforest on Floodplain was probably once widespread on the Hunter and Paterson river floodplains in Maitland LGA (Knott *et al.* 1998). Searches of the study area undertaken for the current work did not find any intact remnants of this community, therefore it has not been described in this report. Description of this community would require survey to be carried out in known nearby remnants, such as the relatively intact 2.5 hectare remnant at CB Alexander Agricultural College in Dungog LGA, near the border with Maitland LGA. Elements of Lowland Rainforest on Floodplain exist in some locations in the study area, mainly as relict trees that have been described as part of Alluvial River Oak Forest (Unit 3) and Swamp Oak Alluvial Forest (Unit 12). Both of these communities exist on the floodplain in Maitland LGA and have probably developed in areas that previously supported Lowland Rainforest on Floodplain. An example occurs on the Hunter River floodplain in Saltwater Gully at Duckenfield, where the occurrence of remnant trees in Alluvial River Oak Forest (Unit 3) such as *Streblus brunonianus* and *Elaeocarpus obovatus* indicate the likely historical occurrence of Lowland Rainforest on Floodplain. Further discussion of these communities is provided in *Section 5.3* and *Appendix B.*

### *c. NPWS Forest Ecosystem Assessment (NPWS 1999a)*

As part of the Upper and Lower North-East Regional Forest Agreement (RFA), broad-scale vegetation mapping and floristic survey was undertaken in the region extending from the New England Highway in the Hunter Valley to the Queensland border (NPWS 1999a). A similar process was undertaken for the Hunter sub-region, which covers the entire Hunter Valley, except for the Barrington Tops region, and the Central Coast (NPWS 1999b).

Vegetation mapping in these studies creates *Broad Canopy Classification - Forest Types* that described groups of canopy species. The resulting floristic group is termed a *forest ecosystem*, which is defined as *an indigenous ecosystem with an overstorey of trees that are greater than 20% canopy cover*…[they] *should normally be discriminated at a resolution requiring a map-standard scale of 1:100,000*…[and] *be defined in terms of floristic composition in combination with substrate and position within the landscape* (NPWS 1999b).

A draft key to forest ecosystems (NPWS 2002) has been used to attempt to place each vegetation community in Maitland into a forest ecosystem of the Upper and Lower North East RFA. The results, shown in *Table 6.8a*, are not conclusive for most vegetation communities. This is partly due to the scale at which forest ecosystems were modelled (1:100,000) and because the lower Hunter lies at the southern extremity of the Upper and Lower North East RFA. Some communities have been tentatively assigned to a forest ecosystem using the limited information available. These are assigned with [?] in *Table 6.8a*.

At the time of writing this report, the Hunter Regional Vegetation Committee (through its Expert Panel) had considered the RFA assessments of forest ecosystems for vegetation in the Hunter Native Vegetation Region and included them on their draft list of High Conservation Value vegetation. *Table 6.8b* shows the results of applying the NPWS Forest Ecosystem Assessment to vegetation communities in Maitland LGA. This assessment includes the ranking of forest ecosystems based on significance, shown in *Table 6.8b* as *NPWS Rank*. Using this ranking system, most forest ecosystems present in Maitland LGA have a *very high* significance, indicating they are either endangered, rare, vulnerable, largely endemic, severely depleted or highly inadequately conserved. Although the data does not allow a rigorous assessment of each vegetation community, it indicates that forest ecosystems occurring in Maitland LGA are likely to be of high ecological significance. Conclusive analysis is not possible until forest ecosystem modelling for the lower Hunter and Central Coast areas is available.

Despite the limitations of this analysis, it is important to note that five of the 13 vegetation communities mapped in Maitland LGA have 90% or more of their pre-1750 distribution cleared within the Hunter.

**Table 6.8a NPWS Forest Ecosystems Equivalent to Vegetation Communities in Maitland LGA**

| Community Name (Map Unit) in Current Work | Likely Equivalent Forest Ecosystem |
|---|---|
| Hunter Valley Dry Rainforest (Unit 1) | [none] |
| Alluvial Tall Moist Forest (Unit 2) | 137 Southern Wet Sydney Bluegum |
| Alluvial River Oak Forest (Unit 3) | 120 River Oak |
| Hunter Valley Moist Forest (Unit 4) | [none] |
| Central Hunter Riparian Forest (Unit 5) | 120 River Oak [?] |
| Seaham Spotted Gum Ironbark Forest (Unit 6) | 207 Hunter Spotted Gum - Ironbark |
| Lower Hunter Spotted Gum Ironbark Forest (Unit 7) | 207 Hunter Spotted Gum - Ironbark |
| Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) | 54 Grey Box - Red Gum - Grey Ironbark [?] |
| Hunter Lowlands Redgum Forest Variant (Unit 9) | 208 Hunter Rough-barked Apple - Red Gum [?] |
| Hunter Lowlands Redgum Moist Forest (Unit 10) | 208 Hunter Rough-barked Apple - Red Gum [?] |
| Kurri Sand Swamp Woodland (Unit 11) | [none] |
| Swamp Oak Alluvial Forest (Unit 12) | 143 Swamp Oak |
| Freshwater Wetland Complex (Unit 13) | [none] |

**Table 6.8b NPWS Forest Ecosystem Assessment Applied to Maitland Vegetation Communities**

| Community Name (Map Unit) in Current Work | Forest Ecosystems Assessments | | | | | |
|---|---|---|---|---|---|---|
| | FE Extant (Hunter) (ha) | FE Pre-1750 (Hunter) (ha) | % Cleared (Hunter) | % FE in Hunter | NPWS Category | NPWS Rank |
| Hunter Valley Dry Rainforest (Unit 1) | - | - | - | - | - | - |
| Alluvial Tall Moist Forest (Unit 2) | 12,845 | 17,559 | 27 | 31% | - | - |
| Alluvial River Oak Forest (Unit 3) | 19 | 377 | 95 | 2% | 1, 2b, 6 | * |
| Hunter Lowlands Redgum Moist Forest (Unit 10) | 4,780 | 58,473 | 92 | 54% | 2, 3, 4, 7 | Very high |
| Hunter Valley Moist Forest (Unit 4) | - | - | - | - | - | - |
| Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) | 17,243 | 87,496 | 80 | 87% | 2a, 2b, 4, 6 | Very high |
| Central Hunter Riparian Forest (Unit 5) | 19 | 377 | 95 | 2% | 1, 2b, 6 | * |
| Seaham Spotted Gum Ironbark Forest (Unit 6) | 25,586 | 67,107 | 62 | 99% | 3, 5,6 | Very high |
| Lower Hunter Spotted Gum Ironbark Forest (Unit 7) | 25,586 | 67,107 | 62 | 99% | 3, 5, 6 | Very high |
| Hunter Lowlands Redgum Forest Variant (Unit 9) | 4,780 | 58,473 | 92 | 54% | 2, 3, 4, 7 | Very high |
| Kurri Sand Swamp Woodland (Unit 11) | - | - | - | - | - | - |
| Swamp Oak Alluvial Forest (Unit 12) | 150 | 4,676 | 97 | 2% | 2, 4, 7 | Very high |
| Freshwater Wetland Complex (Unit 13) | - | - | - | - | - | - |

Notes: **NPWS Conservation Value Rankings:**

1 = Rare or endangered
2 = Severely depleted (>70% cleared)
3 = Highly inadequately reserved (<40% of target met)
4 = Vulnerable
5 = Predominantly endemic
6 = Private land priority (reservation could not be met on public land)

* No ranking was attributed to this forest ecosystem as only a small amount occurred in the Hunter (according to the model) and it was considered too small to be reliable

Forest ecosystems with no ranking are considered to meet none of the above conservation rankings of ecological significance.

**Forest Ecosystem Criteria (Hunter Regional Vegetation Committee):**

| | |
|---|---|
| Endangered | Distribution <10% of former range or total area <10% of former area, or 90% of area in small patches, and reservation target was not met |
| Rare | Distribution less than 10,000 ha, or total area less than 1,000 ha, or patch sizes less than 100 ha, and reservation target was not met |
| Vulnerable | One approaching reduction in areal extent of 70%, and reservation target was not met |
| Severely Depleted | Forest Ecosystems more than 70% cleared |
| Endemic | 100% of Forest Ecosystem occurs in the HNVR |
| Predominantly Endemic | 75-99% of Forest Ecosystem occurs in the HNVR |
| Highly Inadequately Reserved | <40% of reservation target was met in RFA |
| Private Land Priority | Ecosystems with a high proportion on private land that could not be adequately reserved using only public land |

### *d. LHCCREMS Assessment*

The Lower Hunter Central Coast Regional Environment Management Strategy (LHCCREMS) conservation assessment of vegetation communities in the lower Hunter-Central Coast region described by NPWS (2000) utilised the Landsberg (2000) draft criteria (LHCCREMS 2003). Also considered by LHCCREMS in their conservation assessment was vegetation clearance since mapping, area of land approved for development and habitat of regional significance. Three regional significance codes for vegetation communities were established (vulnerable, specialised and at risk). Additionally, regionally significant habitat and habitat linkages were identified. Results of the LHCCREMS conservation assessment of vegetation communities in Maitland LGA are provided in *Table 6.9*.

LHCCREMS (2003) considers that seven vegetation communities described by NPWS (2000) for Maitland LGA meet the criteria for listing as EECs because they satisfy Landsberg draft criteria (Landsberg 2000). These are equivalent to eight vegetation communities described by the current work, as shown in *Table 6.9*.

LHCCREMS (2003) indicates that two communities meet Criterion 1(V) of Landsberg (2000), which indicates a vulnerable status with the community having a substantial decline in geographic distribution (70-90%). These are equivalent to Alluvial Tall Moist Forest (Unit 2), Hunter Lowlands Redgum Forest Variant (Unit 9) and Hunter Lowlands Redgum Moist Forest (Unit 10) in the current work.

LHCCREMS (2003) indicates that one community meets Criterion 2(VR) of Landsberg (2000), which indicates the unit is very restricted, has a total area of less than 1,000 ha, a total extent of occurrence of less than 10,000 ha, or patch sizes generally of less than 10 ha. This community is equivalent to Swamp Oak Alluvial Forest (unit 12) that is described by the current work.

Four vegetation communities described by NPWS (2000) meet Criterion 2(R) of Landsberg (2000), which indicates a restricted status, with a small geographic distribution and demonstrable threat. Their total extent of occurrence is less than 100,000 ha or patch sizes are generally less than 100 ha. These are equivalent to Hunter Valley Dry Rainforest (Unit 1), Central Hunter Riparian Forest (Unit 5), Seaham Spotted Gum Ironbark Forest (Unit 6) and Lower Hunter Spotted Gum Ironbark Forest (Unit 7) that are described by the current work.

LHCCREMS (2003) indicates that Kurri Sand Swamp Woodland (Unit 11) does not meet criteria provided by Landsberg (2000). This is probably because vegetation community modelling carried out for LHCCREMS by NPWS (2000) estimated that only 45% of the unit has been cleared. Therefore, it does not meet the Landsberg (2000) *demonstrable threat* criterion (LHCCREMS 2003) that requires a reduction of original distribution by 50% (LHCCREMS 2003, page 8). However, this community is a listed EEC, therefore is identified as SSV (state significant vegetation).

**Table 6.9 LHCCREMS Conservation Significance Assessment Applied to Maitland Vegetation Communities**

| **Community Description** | | **LHCCREMS Assessments** | | |
|---|---|---|---|---|
| **Community Name (this report)** | **LHCCREMS Community Name (equivalent to NPWS 2000)** | **Extant Area (%)** | **Landsberg Criteria** | **Regional Significance** |
| Hunter Valley Dry Rainforest (Unit 1) | Hunter Valley Dry Rainforest (MU3) | 35 | 2 (R) | RSV-V, RSV-S |
| Alluvial Tall Moist Forest (Unit 2) | Alluvial Tall Moist Forest (MU5) | 19 | 1 (V) | RSV-V |
| Alluvial River Oak Forest (Unit 3) | [none] | n/a | n/a | n/a |
| Hunter Valley Moist Forest (Unit 4) | Hunter Valley Moist Forest (MU12) | 68 | - | - |

**Table 6.9 LHCCREMS Conservation Significance Assessment Applied to Maitland Vegetation Communities**

| Community Description<br>Community Name (this report) | LHCCREMS Community Name (equivalent to NPWS 2000) | LHCCREMS Assessments<br>Extant Area (%) | Landsberg Criteria | Regional Significance |
|---|---|---|---|---|
| Central Hunter Riparian Forest (Unit 5) | Central Hunter Riparian Forest (MU13) | 47 | 2 (R)* | RSV-V, RSV-S |
| Seaham Spotted Gum Ironbark Forest (Unit 6) | Seaham Spotted Gum Ironbark Forest (MU16) | 45 | 2 (R) | RSV-R |
| Lower Hunter Spotted Gum Ironbark Forest (Unit 7) | Lower Hunter Spotted Gum Ironbark Forest (MU17) | 41 | 2 (R) | RSV-R |
| Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) | [none] | n/a | n/a | n/a |
| Hunter Lowlands Redgum Forest Variant (Unit 9) | Hunter Lowlands Redgum Forest (MU19) | 28 | 1 (V) | SSV[#] |
| Hunter Lowlands Redgum Moist Forest (Unit 10) | Hunter Lowlands Redgum Forest (MU19) | 28 | 1 (V) | SSV[#] |
| Kurri Sand Swamp Woodland (Unit 11) | Kurri Sand Swamp Woodland (MU35) | 55 | - | SSV, RSV-S |
| Swamp Oak Alluvial Forest (Unit 12) | Swamp Oak Sedge Forest (MU41) | 40 | 2 (VR) | RSV-V |
| Freshwater Wetland Complex (Unit 13) | Freshwater Wetland Complex (MU46) | 74 | - | RSV-S |

Notes: Based on LHCCREMS (2003)

**REMS Conservation Codes**:
RSV-V = extant distribution in REMS area of <30% original distribution or less than 1,000 ha
RSV-S = communities that play a critical role in ecosystem processes or provide specialised habitat
RSV-R = extant distribution 30-45% of original distribution

# these units also meet criteria for significance coding RSV-V, since their extant distribution is <30% of pre-1750 extent.

**Landsberg (2000) Criteria**:
1 (V) = vulnerable, substantial decline of 70-90% of original distribution
2 (VR) = very restricted, total area of occupancy <1,000 ha or total extent of occurrence <10,000 ha or patch sizes generally <10 ha.
2 (R) = restricted, total area of occupancy is <10,000 ha or total extent is <100,000 ha or patch sizes generally <100 ha
* this unit meets criteria for 2 (VR) as it's extant area provided by LHCCREMS (2003) is less than 1,000 ha.

LHCCREMS (2003) identified two *high priority lands* that include Maitland LGA as a result of the assessment of national, state and regionally significant vegetation, and regionally significant habitat and habitat corridors. The first, termed the *Allandale - Molly Morgan Range*, is shared with Cessnock LGA. This area is located immediately south of Greta in the vicinity of Camp, Allandale and Lovedale roads, which straddles the boundary between Maitland and Cessnock LGAs. The *Allandale - Molly Morgan Range* high priority land is listed by LHCCREMS (2003) due to significant vegetation communities and a large diversity of ecosystems present, and its occurrence in an important lower Hunter corridor. It is possible that the recently-discovered, endangered shrub *Persoonia pauciflora* may also occur in this location (see *Section 6.1.2*) even though searches of the Molly Morgan Range failed to detect it (Patrick 1999).

The second *high priority land* described by LHCCREMS (2003) includes Winders Hill, Rosebrook Range and Tocal Dam that occur in Maitland LGA. LHCCREMS (2003) note that three vegetation communities of conservation significance occur here and the area is important for connectivity beyond the LHCC region.

### e. *Regional Significance of Vegetation Communities (Bell* **et al.** *2003)*

An assessment of plant populations and vegetation communities in the Hunter and Central Coast regions was being undertaken at the time of writing this report, by the Hunter Region Botanic Gardens – Rare Plants Committee, for listing on a register of regional significance (Bell *et al.* 2003). The list of vegetation communities on the register was therefore incomplete at the time of writing this report. However, the register is likely to expand, as more information on vegetation communities across the region becomes available. Assessment of regional significance uses a combination of Landsberg (2000) and intuitive assessment of clearing levels, protection and threats to vegetation communities in the region.

Several vegetation communities in Maitland LGA probably meet the criteria (Bell *et al.* 2003) for listing as *Regionally Significant* on the register but had not been formally assessed at the time of writing this report (T. Peake pers. com.). The results of a regional assessment of communities in Maitland LGA are shown in *Table 6.10*.

**Table 6.10: Regional Significance of Vegetation Communities in Maitland LGA**

| Community Name (this report) | HRPC Regional Significance |
|---|---|
| Hunter Valley Dry Rainforest (Unit 1) | R |
| Alluvial Tall Moist Forest (Unit 2) | R? |
| Alluvial River Oak Forest (Unit 3) | R? |
| Hunter Valley Moist Forest (Unit 4) | - |
| Central Hunter Riparian Forest (Unit 5) | R? |
| Seaham Spotted Gum Ironbark Forest (Unit 6) | R? |
| Lower Hunter Spotted Gum Ironbark Forest (Unit 7) | R? |
| Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) | - |
| Hunter Lowlands Redgum Forest Variant (Unit 9) | R |
| Hunter Lowlands Redgum Moist Forest (Unit 10) | R |
| Kurri Sand Swamp Woodland (Unit 11) | R |
| Swamp Oak Alluvial Forest (Unit 12) | R? |
| Freshwater Wetland Complex (Unit 13) | R? |

Notes: R = regionally significant in the Hunter and Central Coast region
? = probably meets criteria for listing, but community has not been formally assessed and placed on the Register.

### f. *Other State & National Assessments (Benson 1989, Hager & Benson 1994, & Specht* **et al.** *1995)*

Several authors have carried out conservation assessments of the status of and threats to vegetation units at macro-regional, state or national levels. Benson (1989) provides an assessment of the conservation status of plant associations across NSW. Broad vegetation associations are listed with information on their reservation level and threats to future viability. Hager and Benson (1994) provide an assessment of the reservation level of vegetation associations in north-east NSW, which they divide into three discrete sections. Finally, Specht *et al.* (1995) provides an assessment of the conservation adequacy for plant communities across Australia, with communities based on a statistical analysis of available data. While Specht *et al.* (1995) is a useful resource, the resulting assessment is limited by the lack of data for many communities and by the wide variation in scale of data used in community description.

The outcomes of these assessments applied to vegetation in Maitland LGA are shown in *Tables 6.11-13*. Outcomes should only be viewed as broadly indicative, since communities in Maitland LGA are not adequately represented in these assessments due to the age of the publications, the location of study areas and the scale at which they were assessed. Several vegetation communities in Maitland LGA could not be adequately equated to vegetation units described by these authors and other communities were tentatively equated to them. In general, Alluvial Tall Moist Forest (Unit 2) appears to be adequately conserved and not highly threatened. Central Hunter Riparian Forest (Unit 5) and Hunter Lowlands Redgum Forest Variant (Unit 9) appear to be generally inadequately reserved and under threat across the range in which these units occur.

**Table 6.11: Benson (1989) Conservation Significance Assessment Applied to Maitland Vegetation Communities**

| Community Name (this report) | Likely Equivalent Benson (1989) Association | Benson (1989) Risk and Conservation Levels |
|---|---|---|
| Hunter Valley Dry Rainforest (Unit 1) | *Ficus* spp - *Streblus brunonianus* - *Cassine australis* | Vulnerable, likely to become endangered in a few decades, inadequately conserved |
| Alluvial Tall Moist Forest (Unit 2) | *Eucalyptus saligna* | Not threatened in foreseeable future, adequately conserved |
| Alluvial River Oak Forest (Unit 3) | *Casuarina cunninghamiana* | Not threatened in foreseeable future, inadequately conserved |
| Hunter Valley Moist Forest (Unit 4) | [none] | - |
| Central Hunter Riparian Forest (Unit 5) | *Casuarina cunninghamiana* - *Eucalyptus camaldulensis* | Vulnerable, likely to become endangered in a few decades, inadequately conserved |
| Seaham Spotted Gum Ironbark Forest (Unit 6) | [none] | - |
| Lower Hunter Spotted Gum Ironbark Forest (Unit 7) | *Eucalyptus maculata* - *E. siderophloia* | Not threatened in foreseeable future, not conserved |
| Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) | [none] | - |
| Hunter Lowlands Redgum Forest Variant (Unit 9) | *Eucalyptus moluccana* - *E. tereticornis* | Endangered, likely to become extinct in a few decades, not conserved |
| Hunter Lowlands Redgum Moist Forest (Unit 10) | *Eucalyptus tereticornis* | Not threatened in foreseeable future, inadequately conserved |
| Kurri Sand Swamp Woodland (Unit 11) | *Eucalyptus parramattensis* | Vulnerable, likely to become endangered in a few decades, not conserved |
| Swamp Oak Alluvial Forest (Unit 12) | *Allocasuarina glauca* - *Juncus* spp. | Vulnerable, likely to become endangered in a few decades, inadequately conserved |
| Freshwater Wetland Complex (Unit 13) | *Melaleuca styphelioides* - *M. linariifolia* | Vulnerable, likely to become endangered in a few decades, inadequately conserved |

**Table 6.12: Hager & Benson (1994) Conservation Significance Assessment Applied to Maitland Vegetation Communities**

| Community Name (this report) | Likely Equivalent Hager and Benson (1994) Association | Hager and Benson (1994) Conservation Levels |
|---|---|---|
| Hunter Valley Dry Rainforest (Unit 1) | RF202 *Ficus* spp. - S*treblus brunonianus* - *Dendrocnide excelsa* - *Cassine australis* | Adequately conserved |
| Alluvial Tall Moist Forest (Unit 2) | EF146h *Eucalyptus pilularis* - *Angophora costata* | Adequately conserved |
| Alluvial River Oak Forest (Unit 3) | [none] | - |
| Hunter Valley Moist Forest (Unit 4) | EF095d *Eucalyptus acmenioides* - *E. tereticornis* - *Allocasuarina torulosa* | Inadequately conserved over all of its range |

**Table 6.12: Hager & Benson (1994) Conservation Significance Assessment Applied to Maitland Vegetation Communities**

| Community Name (this report) | Likely Equivalent Hager and Benson (1994) Association | Hager and Benson (1994) Conservation Levels |
|---|---|---|
| Central Hunter Riparian Forest (Unit 5) | OF100a *Casuarina cunninghamiana* | Inadequately conserved over all of its range |
| Seaham Spotted Gum Ironbark Forest (Unit 6) | EF040e *Eucalyptus maculata - E. fibrosa* | Inadequately conserved over all of its range |
| Lower Hunter Spotted Gum Ironbark Forest (Unit 7) | EF040e *Eucalyptus maculata - E. fibrosa* | Inadequately conserved over all of its range |
| Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) | EF040d *Eucalyptus maculata - E. propinqua* | Very poorly conserved |
| Hunter Lowlands Redgum Forest Variant (Unit 9) | EF710b *Eucalyptus moluccana - E. tereticornis* | Inadequately conserved over all of its range |
| Hunter Lowlands Redgum Moist Forest (Unit 10) | [none] | - |
| Kurri Sand Swamp Woodland (Unit 11) | [none] | - |
| Swamp Oak Alluvial Forest (Unit 12) | WTF001b *Casuarina glauca - Juncus* spp. | Adequately conserved |
| Freshwater Wetland Complex (Unit 13) | [none] | - |

**Table 6.13: Specht *et al.* (1995) Conservation Significance Assessment Applied to Maitland Vegetation Communities**

| Community Name (this report) | Likely Equivalent Specht *et al.* (1995) Community | Specht *et al.* (1995) Conservation Status |
|---|---|---|
| Hunter Valley Dry Rainforest (Unit 1) | [none] | - |
| Alluvial Tall Moist Forest (Unit 2) | T710 *Eucalyptus acmenoides - E. pilularis - E. microcorys - Syncarpia glomulifera* | Adequate |
| Alluvial River Oak Forest (Unit 3) | [none] | - |
| Hunter Valley Moist Forest (Unit 4) | [none] | - |
| Central Hunter Riparian Forest (Unit 5) | T190 *Casuarina cunninghamiana* | Reasonable |
| Seaham Spotted Gum Ironbark Forest (Unit 6) | [none] | - |
| Lower Hunter Spotted Gum Ironbark Forest (Unit 7) | [none] | - |
| Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) | [none] | - |
| Hunter Lowlands Redgum Forest Variant (Unit 9) | T176b *Eucalyptus moluccana* (+/- *E. tereticornis*) | Reasonable-adequate |
| Hunter Lowlands Redgum Moist Forest (Unit 10) | [none] | - |
| Kurri Sand Swamp Woodland (Unit 11) | Eucparr *Eucalyptus parramattensis (?)* | Adequate (?) |
| Swamp Oak Alluvial Forest (Unit 12) | [none] | - |
| Freshwater Wetland Complex (Unit 13) | [none] | - |

### 6.3.2 Conservation Assessment of Maitland Vegetation Communities

#### a. Summary of Conservation Assessment

The assessment of the conservation status of vegetation communities in the study area has been undertaken using the established criteria provided by Landsberg (2000). This has required an intuitive approach to determining distribution, extant area, threat status and level of reservation of each vegetation community since adequate spatial information about the natural vegetation of the Hunter Region is currently unavailable. Although LHCCREMS (2003) provides information about vegetation in the Central Coast and lower Hunter, vegetation of Maitland LGA also has strong affinities with the vegetation in the central Hunter, upper Hunter Valley and Dungog LGA, for which adequate vegetation data is not currently available. This is particularly true for vegetation on private land in the Hunter Region as it has not been the subject of comprehensive reporting to date. A forthcoming report on the vegetation of the central Hunter Valley (Peake in prep.) and work underway for the Integrated Catchment Plan for the Hunter Catchment (Hunter Catchment Management Trust 2003) will provide information to allow more accurate conservation assessment of vegetation in the study area.

The assessment of the distribution, extant area, threat status and reservation status of each vegetation community in the study area was undertaken using the author's knowledge, personal communications with other workers and review of LHCCREMS (2003) and other relevant vegetation studies (eg. Bell 2001; Bell and Murray 2001; Biosis Research 2001; Chalmers and Turner 1994; ERM Mitchell McCotter 1998a & 1998b; Floyd 1983; Giles 1995; Greenwood 1999; Peake in prep.; Tame 1984; Thomas 1998; Rodd and Clements 1994; Turner 1976; Turner and Vernon 1990 & 1994; Vernon 1985; Vernon 1987).

The results of the conservation assessment of vegetation communities described and mapped in Maitland LGA by the current work are provided in *Table 6.14*.

*Table 6.15* shows the estimated area of each vegetation community that remains compared to its pre-1750 extent. LHCCREMS (2003) has been referred to for those communities described by the current work that are equivalent to units described for LHCCREMS by NPWS (2000). For communities where such equivalents could not be found and for communities that are expected to extend outside of the lower Hunter-Central Coast region, other studies (noted above) have been referred to and estimations made of pre-European extent, shown in *Table 6.15*. It is estimated that six vegetation communities have had 70% or more of their original extent cleared. These include Alluvial Tall Moist Forest (Unit 2), Alluvial River Oak Forest (Unit 3), Central Hunter Riparian Forest (Unit 5), Hunter Lowlands Redgum Forest Variant (Unit 9), Hunter Lowlands Redgum Moist Forest (Unit 10) and Swamp Oak Alluvial Forest (Unit 12).

As shown in *Table 6.14*, application of the Landsberg (2000) draft criteria to the 13 vegetation communities described in Maitland LGA suggests that 11 probably meet the criteria for listing on the Commonwealth EPBC Act or the NSW TSC Act. Two communities not currently warranting listing (Unit 4 and Unit 8) are presently poorly reserved and occur mostly on private land so are threatened by changes in landaus or zoning. The conservation status of each vegetation community is described in more detail in the following sections.

**Table 6.14: Conservation Assessment of Vegetation Communities in Maitland LGA**

| Community Name (this report) | Intuitive Regional Distribution | Regional Amt. Cleared | Regional Reservation | Regional Threat | Landsberg Criteria | Significance Rank |
|---|---|---|---|---|---|---|
| Hunter Valley Dry Rainforest (Unit 1) | Sheltered slopes & gullies in Maitland-Cessnock district | Moderate-high | Moderate | Moderate-low | 2 (R) | C |
| Alluvial Tall Moist Forest (Unit 2) | Deep alluvial soils in Maitland, Newcastle and Port Stephens, also probably Dungog, with coastal influence | High | Very Low | Very High | 1 (V) | B |
| Alluvial River Oak Forest (Unit 3) | West Maitland LGA to central and upper Hunter Valley, Murrurundi | Very high | Very low (possibly nil) | Very high | 1 (E) | B |
| Hunter Valley Moist Forest (Unit 4) | Cessnock, Newcastle, Maitland, Dungog, Singleton LGAs | Low | Moderate-low | Moderate-low | - | D |
| Central Hunter Riparian Forest (Unit 5) | Maitland west to Muswellbrook district | Very high | Very low (possibly nil) | Very high | 1 (E) | B |
| Seaham Spotted Gum Ironbark Forest (Unit 6) | North of Hunter River north-east to Wallaroo SF | Moderate-high | Low | High | 2 (R) | C |
| Lower Hunter Spotted Gum Ironbark Forest (Unit 7) | Beresfield-Cessnock-Singleton | Moderate-high | Very low | High-very high | 2 (R) | B |
| Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) | Rosebrook Ridge, Moonabung Range; north Maitland, south-west Dungog & east Singleton LGA | Moderate-low | Low | Moderate-low | - | D |
| Hunter Lowlands Redgum Forest Variant (Unit 9) | Maitland to Singleton districts | High | Very low | Very high | 1 (V) | A |
| Hunter Lowlands Redgum Moist Forest (Unit 10) | East Maitland LGA, Dungog | High | Very low | Very high | 1 (V) | A |
| Kurri Sand Swamp Woodland (Unit 11) | Cessnock-Kurri-Heddon-Greta districts | Moderate-high | Very low | Very high | 2 (R) | A |
| Swamp Oak Alluvial Forest (Unit 12) | Lower Hunter, coastal valleys | Moderate-high | Very low | High | 2 (R) | B |
| Freshwater Wetland Complex (Unit 13) | Lower Hunter & Central Coast | Moderate | Moderate | Moderate | 2 (R) | C |

Notes: **Landsberg Criteria:**
1 (C) = critically endangered, very severe decline of 95% or more of original distribution
1 (E) = endangered, severe decline of 90-95% of original distribution
1 (V) = vulnerable, substantial decline of 70-90% of original distribution
2 (VR) = very restricted, total area of occupancy is <1,000 ha or total extent is <10,000 ha or patches generally <10 ha
2 (R) = restricted, total area of occupancy is <10,000 ha or total extent is <100,000 ha or patches generally <100 ha
2 (L) = limited, total area of occupancy <100,000 ha or total extent of occurrence <1,000,000 ha
**Significance Rank:** see *Section 4.9.2* for explanation.

**Table 6.15 Estimated Percentage of Pre-1750 Extent Remaining for Each Vegetation Community in Maitland LGA**

| Community Name | % Extant Pre-1750* | Discussion |
|---|---|---|
| Hunter Valley Dry Rainforest (Unit 1) | 40%* | LHCCREMS (2003) indicates a 35% extant area of this community and Peake (in prep.) suggests that most Hunter Valley Dry Rainforest occurring in the central and upper Hunter Valley would be only partly cleared. |
| Alluvial Tall Moist Forest (Unit 2) | 19% | LHCCREMS (2003) estimate that 19% of this unit remains. This unit would be mainly found in the LHCC region. |
| Alluvial River Oak Forest (Unit 3) | 10%* | This community mostly occurs along river banks from Maitland west to the upper Hunter Valley, in a landscape that has been extensively cleared with less than 30% woody vegetation cover in total (HCMT 2003) |
| Hunter Valley Moist Forest (Unit 4) | 68% | LHCCREMS (2003) estimates that 68% of this vegetation unit remains. |
| Central Hunter Riparian Forest (Unit 5) | 10%* | LHCCREMS (2003) indicate about 53% cleared, however the majority of this community would occur in the central & upper Hunter, and Peake (in prep.) suggests that this community is largely cleared |
| Seaham Spotted Gum Ironbark Forest (Unit 6) | 45% | LHCCREMS (2003) estimates that 45% of this vegetation unit remains. |
| Lower Hunter Spotted Gum Ironbark Forest (Unit 7) | 41% | LHCCREMS (2003) estimates that 41% of this vegetation unit remains. |
| Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) | 60%* | It is likely that a high proportion of this community still remains since it mostly occurs on steep slopes, which have been historically cleared only to low levels. |
| Hunter Lowlands Redgum Forest Variant (Unit 9) | 25%* | LHCCREMS (2003) indicate about 72% of the equivalent community, Hunter Lowlands Redgum Forest (MU19) is cleared. A reasonable proportion of this community probably occurs in the central Hunter and Peake (in prep.) suggests that this community is probably >70% cleared. |
| Hunter Lowlands Redgum Moist Forest (Unit 10) | 20%* | LHCCREMS (2003) indicate about 72% of the equivalent community, Hunter Lowlands Redgum Forest (MU19) is cleared. This variant mostly occurs on or near floodplains in the Maitland district, in a landscape extensively cleared with less than 30% woody vegetation cover in total (HCMT 2003). |
| Kurri Sand Swamp Woodland (Unit 11) | 55% | LHCCREMS (2003) estimates that 55% of this vegetation unit remains. |
| Swamp Oak Alluvial Forest (Unit 12) | 35%* | Although LHCCREMS (2003) estimate that 40% of a similar unit (Swamp Oak Sedge Forest - MU41) remains compared to pre-1750, where this community occurs on the floodplain of the central to lower Hunter valley, vegetation has been extensively cleared with less than 30% woody vegetation cover in total (HCMT 2003). Therefore an estimate of 35% has been made for this unit. |
| Freshwater Wetland Complex (Unit 13) | 74% | LHCCREMS (2003) estimate that 74% of this unit remains. Where this community occurs on the floodplain of the central to lower Hunter valley vegetation has been extensively modified with less than 30% woody vegetation cover in total (HCMT 2003). Although this vegetation community is typically not dominated by woody vegetation, wetland reclamation and extensive modification to the flora and fauna by grazing, changes to the flood regime, sedimentation, enrichment and other impacts are likely to have reduced the area of this unit that remains in or close to it’s original state. |

Note: % Extant of pre-1750 extent that are marked with an asterix (*) have been estimated with reference to LHCCREMS (2003), Peake (in prep.) and other relevant studies. LHCCREMS (2003) extant figure has not been solely relied on since some communities are considered to extend beyond LHCC region or a fully equivalent unit has not been described in the LHCC region by NPWS (2000). % Extant not marked with an asterix are based on LHCCREMS (2003).

### *b. Discussion*

Maitland is situated in a location where flora from western and coastal botanical regions meet and mix. As a result of this, although no vegetation communities are restricted to Maitland LGA, the mix of vegetation communities within the lower Hunter, including the study area, is unique. Flora in the study area represents both inland and coastal origins, with numerous north and central coast species co-occurring.

Vegetation mapping carried out for this work mapped about 8,305 ha of natural woody vegetation in Maitland LGA, which comprises 7,643 ha described as one of the 13 vegetation communities in the study area. The balance was mapped as scattered trees (537.5 ha) and regeneration (124.5 ha) that did not constitute intact communities. The total figure of 8,305 ha is comparable to mapping undertaken for LHCCREMS (Eco Logical 2002a) that was used in the current work as a base layer for mapping remnant boundaries. Earlier work for LHCCREMS mapped a significantly lower figure of 2,677 ha (Maitland City Council 2002) in Maitland LGA. The increase in vegetation area from earlier mapping compared to recent work is attributable mainly to the larger scale of recent mapping (1:10,000 compared to 1:25,000). Additional vegetation mapped occurs predominantly in smaller, more fragmented remnants that the higher detail of 1:10,000 mapping was able to perceive.

A number of ecologically significant vegetation communities are present in Maitland LGA, with 11 of the thirteen vegetation communities in Maitland LGA most likely meeting the criteria for nomination to the NSW TSC Act.

Probably the most significant factor that will contribute towards the continued decline of the native vegetation of Maitland LGA is the lack of formal protection of any vegetation in the study area. Neither formal reserves nor voluntary protection by way of covenants exist in the study area. The absence of any legal requirement to protect and sustain the vegetation in the LGA is most likely the single largest threat to its future viability.

The following sections discuss the conservation assessment of each vegetation community described in Maitland LGA by the current work and provide the reasoning behind each assessment, with reference to background assessments presented in *Section 6.3.1* and threatening processes discussed in *Section 6.4*.

#### *i. Hunter Valley Dry Rainforest (Unit 1)*

Hunter Valley Dry Rainforest is restricted, moderately extensively cleared and mostly inadequately reserved according to most assessments presented in *Section 6.3.1*. LHCCREMS (2003) suggests that the unit meets the Landsberg (2000) draft criterion of a *Restricted* community with a *small geographic distribution coupled with demonstrable threat*. Results of the current work support this assessment. LHCCREMS (2003) also suggest that the unit is regionally significant because it is regionally restricted and provides specialised habitat for a species or plays a critical role in ecosystem processes. Bell *et al.* (2003) regard the community as regionally threatened. Hunter Valley Dry Rainforest is particularly threatened by weed invasion, altered fire regimes and fragmentation. At the time of writing this report, the unit had reportedly been nominated for inclusion on the TSC Act as an EEC.

#### *ii. Alluvial Tall Moist Forest (Unit 2)*

Alluvial Tall Moist Forest is adequately conserved according to most macro-regional assessments presented in *Section 6.3.1*, including the assessment of forest ecosystems being undertaken for the Hunter Regional Vegetation Committee which suggests the unit is not a forest ecosystem of ecological significance. However, assessment at the regional level by LHCCREMS (2003) considers this community to be vulnerable with significant decline in its pre-European extent (70-90% cleared) and to be regionally significant. Alluvial Tall Moist Forest may be one of the most threatened vegetation communities in Maitland LGA, with development, fire, weed invasion and rubbish dumping threatening its existence (see *Section 6.4*). It is probably poorly represented in regional conservation reserves. Application of Landsberg (2000) indicates this unit is probably *Vulnerable*. At the time of writing this report, the unit had reportedly been nominated for inclusion on the TSC Act as an EEC.

*iii. Alluvial River Oak Forest (Unit 3)*

Alluvial River Oak Forest is one of the most threatened, highly cleared and poorly reserved communities in Maitland LGA. It occurs almost exclusively on private land along major streams and rivers that have been heavily cleared for grazing and cropping. There is weak equivalence between this and other communities described in *Section 6.3.1*, including those of LHCCREMS (2003) and NPWS (2000). Application of the Landsberg (2000) draft criteria indicates that Alluvial River Oak Forest is *Endangered* and therefore meets criteria for listing as an EEC. This community is highly threatened by fragmentation, grazing, erosion, pollution and erosion/sedimentation (see *Section 6.4*).

*iv. Hunter Valley Moist Forest (Unit 4)*

Hunter Valley Moist Forest is probably in a lower ecological risk category than most other vegetation communities in Maitland LGA. LHCCREMS (2003) suggest that about 30% of its pre-1750 extent has been cleared, while Hager and Benson (1994) suggest that an equivalent association is highly inadequately conserved over all of its range. It does not have any equivalents in any other classifications. Application of Landsberg (2000) indicates that Hunter Valley Moist Forest is not significantly threatened.

*v. Central Hunter Riparian Forest (Unit 6)*

Central Hunter Riparian Forest has been heavily cleared in the study area and elsewhere, and is threatened by various processes. LHCCREMS (2003) considers this unit to meet criteria for nomination as an EEC due to a *small geographic distribution coupled with demonstrable threat* and also as a vegetation community of regional significance. Other assessments described in *Section 6.3.1* indicate that Central Hunter Riparian Forest is vulnerable and inadequately reserved, except for the forest ecosystem assessment that discounts this unit due to its small representation in the Hunter Region. The community has been altered in structure and flora by human activity and has been significantly reduced from its former distribution (Williams 1993). Additionally, all known stands of the community occur on private land, so are threatened by changes to land use and zoning. Consideration of these factors and application of Landsberg (2000) indicates that Central Hunter Riparian Forest is *Endangered*. Central Hunter Riparian Forest is ranked as the second most threatened community in the study area (see *Section 6.4*).

*vi. Seaham Spotted Gum Ironbark Forest (Unit 6)*

This community is closely related to Lower Hunter Spotted Gum Ironbark Forest (Unit 7) so that both units fit into the same forest ecosystems. The assessment of both units outlined in *Section 6.3.1* indicates that they are highly inadequately reserved and predominantly endemic. Consequently, both are highly significant forest ecosystems. LHCCREMS (2003) considers Seaham Spotted Gum Ironbark Forest as warranting nomination as an EEC because of a *small geographic distribution coupled with demonstrable threat* as a result of its restricted occurrence, and also regards it as regionally significant. Hager and Benson (1994) consider an equivalent to Seaham Spotted Gum Ironbark Forest to be inadequately conserved over all of its range. Seaham Spotted Gum Ironbark Forest is relatively highly threatened, poorly reserved and has been cleared to a moderately high level. Assessment using Landsberg (2000) indicates the unit is *Restricted*.

*vii. Lower Hunter Spotted Gum Ironbark Forest (Unit 7)*

As discussed above under Unit 6, Seaham Spotted Gum Ironbark Forest and Lower Hunter Spotted Gum Ironbark Forest are closely related. As outlined in *Section 6.3.1*, both units are probably part of Forest Ecosystem 207 Hunter Spotted Gum – Ironbark (NPWS 1999a), which is highly inadequately reserved and predominantly endemic, and is therefore a very highly significant forest ecosystem. LHCCREMS (2003) suggest this community meets the Landsberg (2000) draft criteria for listing as an EEC because of its *Restricted* extent, and also considers the community as regionally significant. Assessment using Benson (1989) and Hager and Benson (1994) also indicate that Lower Hunter Spotted Gum Ironbark Forest is probably inadequately conserved. This unit has a *small geographic distribution coupled with demonstrable threat* (Landsberg 2000), and results of the current work support the LHCCREMS (2003) suggestion that the community meets the *Restricted* category under the Landsberg draft criteria definition. At the time of writing this report, Lower Hunter Spotted Gum Ironbark Forest had reportedly been nominated to the TSC Act as an EEC.

*viii. Hunter Valley Stringybark Spotted Gum Ironbark Forest (Unit 8)*

Hunter Valley Stringybark Spotted Gum Ironbark Forest is partially equivalent to Forest Ecosystem 54 (NPWS 1999a), which is, at the time of writing, considered to be very highly significant by the Expert Panel of the Hunter Regional Vegetation Committee. Hager and Benson (1994) is the only other document outlined in *Section 6.3.1* that finds a similar classification, which indicates the unit is very poorly conserved. No equivalent community was described for LHCCREMS by NPWS (2000). Application of Landsberg (2000) to this community indicates that it is very poorly conserved. However it is considered not heavily cleared and is under relatively low threat (see *Section 6.4*). Weed invasion is probably the most important threat to this community, as lantana (**Lantana camara*) is present and dominant in some places. Considering these assessments, Hunter Valley Stringybark Spotted Gum Ironbark Forest is probably not a threatened community.

*ix. Hunter Lowlands Redgum Forest Variant (Unit 9)*

Hunter Lowlands Redgum Forest (Map Unit 19 in NPWS 2000) is listed as an EEC on the TSC Act. As a variant of the NPWS (2000) unit, Hunter Lowlands Redgum Forest Variant (Unit 9) has sufficient equivalence to the listed community to be considered as a listed EEC. Further field survey and floristic data for the Maitland variant would help clarify the relationship between the NPWS (2000) unit and that of the current work. There is no clear equivalence with a specific forest ecosystem (NPWS 1999a), although Forest Ecosystem 208 provides a reasonable fit. Assessment outlined in *Section 6.3.1* indicates that the unit is probably poorly reserved (Benson 1989; Hager and Benson 1994) and regionally significant (Bell *et al.* 2003). Assessment according to Landsberg (2000) indicates this unit is *Vulnerable* with a decline in area of between 70% and 90% of its pre-European extent.

*x. Hunter Lowlands Redgum Moist Forest (Unit 10)*

Hunter Lowlands Redgum Moist Forest is described by the current work as a variant of Hunter Lowlands Redgum Forest (Map Unit 19 in NPWS 2000), a listed EEC. As discussed above for Unit 9, being a variant of the NPWS (2000) unit, Hunter Lowlands Redgum Moist Forest has sufficient equivalence to the listed community to be considered as the listed EEC. The unit is not readily equivalent to many other classifications outlined in *Section 6.3.1*, except broadly Forest Ecosystem 208 (NPWS 1999a) and Benson's (1989) *Eucalyptus tereticornis* association. Benson (1989) regards the *E. tereticornis* association as not threatened and inadequately reserved, while the Forest Ecosystem assessment regards it as vulnerable, severely depleted and highly inadequately reserved. Hunter Lowlands Redgum Moist Forest has probably been extensively cleared in the study area and it is considered to be very poorly reserved and subject to significant threats (see *Section 6.4*). With consideration to these assessments, Hunter Lowlands Redgum Moist Forest is assessed as *Vulnerable* using Landsberg (2000).

### *xi. Kurri Sand Swamp Woodland (Unit 11)*

Kurri Sand Swamp Woodland in Maitland LGA has been mapped in a small patch in the south near Wentworth Swamp by NPWS (2000) and field reconnaissance in the current work found the unit occurring in nearby, connected forest in Cessnock LGA. This community is listed on the TSC Act as an EEC. Assessment outlined in *Section 6.3.1* indicates that LHCCREMS (2003) and Bell *et al.* (2003) consider the unit to be regionally significant. The unit is *Restricted* (Landsberg 2000) and not conserved according to Benson (1989). Since Benson (1989), small areas of the community have been protected in Werakata National Park. Results from the current work support the listing of this unit as an EEC, as it has a *small geographic distribution coupled with demonstrable threat*. The unit's total extant area is less than 100 square km and a substantial proportion of its former extent has been cleared. This community is considered to be moderately threatened (see *Section 6.4*).

### *xii. Swamp Oak Alluvial Forest (Unit 12)*

Swamp Oak Alluvial Forest is equivalent to Forest Ecosystem 143 (NPWS 1999a), which is regarded as severely depleted and vulnerable in the forest ecosystem assessment, which is likely to be adopted by the Expert Panel of the Hunter Region Vegetation Committee. LHCCREMS (2003) consider this community to be regionally significant because it plays a critical role in ecosystem processes or specialised habitat. Assessment using Landsberg (2000) indicates that Swamp Oak Alluvial Forest may meet the requirements for listing as an EEC, since it is *Restricted* (Landsberg 2000). It is also regarded as moderately threatened (see *Section 6.4*).

### *xiii. Freshwater Wetland Complex (Unit 13)*

Freshwater Wetland Complex has few equivalents largely because it comprises a complex of several vegetation communities mapped together in the absence of additional field data. Assessments in *Section 6.3.1* indicates that the unit broadly fits the Benson (1989) unit *Melaleuca styphelioides - M. linariifolia*, which is considered to be vulnerable and inadequately conserved. LHCCREMS (2003) consider the community is regionally significant because it plays a critical role in ecosystem processes or specialised habitat. Application of Landsberg (2000) to results of the current work indicate that Freshwater Wetland Complex is *Restricted*, having a *small geographic distribution coupled with demonstrable threat* and occurring in remnants less than one square km. Therefore, it may meet the requirements for listing as an EEC. However, further field studies of this unit are first required to adequately describe discreet vegetation communities present. It is also regarded as being under a high level of threat (see *Section 6.4*).

### *xiv. Lowland Rainforest on Floodplain*

A number of authors (eg. Albrecht 2000; Brayshaw 1986; Cunningham 1827; Giles 1995; Knott *et al.* 1998; Wood 1972) note that there was once a sizeable sub-tropical rainforest covering much of the floodplain environments in the Maitland-Morpeth-Raymond Terrace district. Very few intact remnants of this vegetation community remain in the Hunter Valley, with one of the few located on Webbers Creek on the grounds of CB Alexander Agricultural College, Tocal. This vegetation type has been listed as an EEC and described as *Lowland Rainforest on Floodplain*, which occurs on floodplains between the Hunter Valley and the Queensland border.

Knott *et al.* (1998 p.357) writes that the subtropical rainforest *occurred from Kanwarry Hill* [near Nelsons Plains] *to well above Maitland on the Hunter River*. Knott *et al.* (1998) describes that in many places large eucalypts (probably flooded gum, *Eucalyptus grandis*, forest red gum, *E. tereticornis*, and swamp mahogany, *E. robusta*) towered above the rainforest canopy, as did large figs (probably Moreton Bay fig, *Ficus macrophylla* subsp. *macrophylla*). Today, some of those figs remain in the Morpeth - Tocal district. However, one of the dominant tree species of the rainforest, red cedar (*Toona ciliata*), is now absent from the area. Historical accounts by many authors from the early 1800's support the fact that this vegetation type occurred on the floodplain, indicating that the scale of removal of the subtropical rainforest was extensive.

No remnants of this community have been mapped on the Hunter Valley floor by the current work or NPWS (2000). Further sampling of this community outside of the study area, such as the Tocal remnant, would allow modelling of pre-1750 distribution of this community. This could assist in identifying areas of extant vegetation that may potentially support remnants of the unit, which could provide regeneration opportunities. Remnant rainforest species that have alliances with Lowland Rainforest on Floodplain were recorded in the current work in Alluvial River Oak Forest (Unit 3) and Swamp Oak Alluvial Forest (Unit 12). These records may indicate past distribution of the lowland rainforest. The NSW Scientific Committee (2003), in their TSC Act EEC nomination form, note that an EEC can potentially be extinct from an area. Given that the observed rainforest elements could provide a basis for revegetation and/or re-establishment of the community, it is possible that the areas supporting these rainforest elements could in fact be part of the EEC listing. Further field survey of such elements and comparison with intact community remnants, such as the remnant at Tocal, is needed to investigate this possibility. Depending on the results of these studies, protection of such sites should occur in recognition of their important value in the Hunter, which is the southern limit of this vegetation community.

## 6.4 Threatening Processes

### *6.4.1 Summary*

Benson (1999) lists threatening processes that are characteristic of each of the biogeographic regions, and notes that the following are directly relevant to the two biogeographic regions in which Maitland LGA exists:

- Sydney Basin - urbanisation and subdivision, pollution, fire, weeds, resource extraction; and
- NSW North Coast - subdivision and urbanisation, weed invasion, water pollution and wetland drainage, fire, total grazing pressure, inappropriate logging.

These and other threatening processes affect the viability of vegetation communities in Maitland LGA. Main threats are briefly outlined below.

- ***Fragmentation***: clearing of vegetation piecemeal without a strategic approach, commonly leaves remnants of vegetation isolated and with a high edge to area ratio. Such effects can create and magnify a wide range of threatening processes, such as weed invasion, pollution, tree dieback and risk from disease and catastrophic events such as fire. Many are encompassed by the term 'edge effects' that refer to the impacts of threatening processes which are magnified by a larger edge to area ratio.
- ***Development***: much of the remaining vegetation in Maitland LGA is subject to high development pressure, particularly for residential, rural residential and industrial purposes. These can threaten vegetation directly, through clearing, and indirectly through processes such as nutrient enrichment from runoff, sedimentation caused by erosion of disturbed soil, exotic species introduction and 'garden escapees'.
- ***Tree dieback***: this affects a large amount of highly fragmented vegetation across Maitland LGA, particularly in extensively cleared rural areas. It is related to fragmentation, nutrient enrichment and grazing.

- ***Weeds***: several serious environmental weeds are present and problematic in Maitland LGA, particularly African olive (**Olea europaea* subsp. *cuspidata*) and lantana (**Lantana camara*). Weeds can affect native vegetation in a range of ways such as competition with native flora, through competition for resources (water, nutrients, sunlight, etc), native fauna pollinators, and space. Weeds can also significantly modify natural ecosystems and native plant species.
- ***Rubbish dumping & pollution***: the dumping of domestic or industrial waste into remnant bushland can threaten vegetation and plant species through physical damage, chemical pollution or introduction of weed species or pathogens. Rubbish dumping can have particularly severe consequences in riparian or wetland remnants. Rubbish dumping occurs in many remnants in Maitland LGA, particularly those adjacent to residential and industrial areas.
- ***Fire***: altered fire regimes (frequency, severity and season) can pose a serious threat to the integrity of ecosystems since many Australian native plants are adapted to and sometimes dependent on particular fire regimes. For example, high frequency fires and/or fires in cooler seasons can lead to depletion of the seed bank of fire sensitive species.
- ***Grazing/mowing***: grazing and mowing can significantly modify the floristic and structural make-up of a vegetation community through the selection of grazing-tolerant species over those which are sensitive to grazing. Grazing can also harm an ecosystem through damage by hard hooves and rubbing of trees by stock, nutrient-enrichment of the soils and through the introduction of weed species. Pasture improvement for grazing often significantly modifies the ground cover. Grazing occurs in many vegetation remnants throughout Maitland LGA.
- ***Erosion/sedimentation***: the impact of significant erosion or sedimentation (above natural levels) can include suppression of plant growth, introduction of weed species, removal of topsoil, soil instability and burial of low plants and seedlings.

*Table 6.16* lists the main threatening processes which currently impact the viability of the native vegetation of Maitland LGA. Threat-levels for each threatening process provided in the table are qualitative and relative to other threatening processes. Assessment of the threat-levels is based on observations during field survey. The final row and column sum the threat-levels in each category, providing a simple method for relative comparison of threatening processes active in each community.

**Table 6.16 Threatening Processes to Vegetation in Maitland LGA**

| **Community Name** | **Fragmentation** | **Development** | **Tree Dieback** | **Weeds** | **Rubbish Dumping** | **Fire** | **Grazing/mowing** | **Pollution** | **Erosion/sedimentation** | **Total Threat-Level** |
|---|---|---|---|---|---|---|---|---|---|---|
| Hunter Valley Dry Rainforest (Unit 1) | 2 | 1 | 0 | 1 | 1 | 2 | 2 | 1 | 1 | **11** |
| Alluvial Tall Moist Forest (Unit 2) | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | **22** |
| Alluvial River Oak Forest (Unit 3) | 3 | 1 | 2 | 3 | 2 | 1 | 3 | 3 | 3 | **21** |
| Hunter Valley Moist Forest (Unit 4) | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | **13** |
| Central Hunter Riparian Forest (Unit 5) | 3 | 1 | 2 | 3 | 2 | 1 | 3 | 3 | 2 | **20** |
| Seaham Spotted Gum Ironbark Forest (Unit 6) | 2 | 2 | 3 | 2 | 1 | 2 | 3 | 1 | 1 | **17** |
| Lower Hunter Spotted Gum Ironbark Forest (Unit 7) | 2 | 3 | 3 | 2 | 1 | 2 | 3 | 1 | 1 | **18** |
| Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 0 | **11** |
| Hunter Lowlands Redgum Forest Variant (Unit 9) | 3 | 1 | 2 | 2 | 1 | 2 | 3 | 1 | 1 | **16** |
| Hunter Lowlands Redgum Moist Forest (Unit 10) | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | **18** |

**Table 6.16 Threatening Processes to Vegetation in Maitland LGA**

| Community Name | Fragmentation | Development | Tree Dieback | Weeds | Rubbish Dumping | Fire | Grazing/mowing | Pollution | Erosion/sedimentation | Total Threat-Level |
|---|---|---|---|---|---|---|---|---|---|---|
| Kurri Sand Swamp Woodland (Unit 11) | 2 | 3 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | **15** |
| Swamp Oak Alluvial Forest (Unit 12) | 3 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | **16** |
| Freshwater Wetland Complex (Unit 13) | 2 | 3 | 0 | 2 | 3 | 0 | 2 | 3 | 3 | **18** |
| **Total Threat Level** | **29** | **25** | **20** | **28** | **22** | **21** | **30** | **21** | **20** | **-** |

Notes: Threat-levels: 0 = No or minuscule threat 2 = Moderate threat
1 = Low threat 3 = High threat

Analysis of the table indicates that the most threatened communities are those which occur on or near floodplains, including Alluvial Tall Moist Forest (Unit 2), Alluvial River Oak Forest (Unit 3), Central Hunter Riparian Forest (Unit 5), Hunter Lowlands Redgum Moist Forest (Unit 10) and Freshwater Wetland Complex (Unit 13). Communities that are subject to residential or industrial development also have a higher threat level, including Hunter Valley Moist Forest (Unit 4) Seaham Spotted Gum Ironbark Forest (Unit 6) and Lower Hunter Spotted Gum Ironbark Forest (Unit 7).

The threatening processes likely to impact vegetation communities in Maitland LGA to the highest degree are grazing, fragmentation, weeds and development.

In addition to the local threatening processes identified in *Table 6.15*, a number of Key Threatening Processes (KTPs) are listed on the EPBC Act and/or the TSC Act, which are relevant to the management of remnant native vegetation in Maitland LGA. Development applications are required to assess whether or not the proposed form of development is a listed KTP.

Listed KTPs possibly relevant in Maitland LGA are:

**KTPs listed under EPBC Act *1999:***

- Land clearance
- Continued net loss of native hollow-bearing trees and coarse woody debris due to firewood harvesting practices (Nomination under consideration at time of writing this report)

**KTPs listed under TSC Act *1995:***

- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands
- Bushrock removal
- Clearing of native vegetation
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition
- Invasion of native plant communities by exotic perennial grasses

**KTPs listed under TSC Act (Preliminary Determinations at time of writing this report):**

- Removal of dead wood, dead trees and logs

### *6.4.2 Specific Threats*

In addition to the threatening processes listed in *Section 6.4.1*, a number of specific threats exist which warrant discussion due to their severity in the study area.

#### *a. African Olive and Lantana*

Field survey carried out for the current work found that African olive (*Olea europaea* subsp. *cuspidata*) and lantana (*Lantana camara*) are significantly impacting on the ecology of natural vegetation in Maitland LGA.

African olive is well established in many parts of Maitland LGA, however observations suggest that it is yet to occupy its full habitat potential (pers. obs.) and the distribution of the species is likely to continue to expand. The primary concern with African olive is its ability to dominate and significantly alter the ecosystem in which it establishes. Olives are generally able to survive low winter temperatures, hot, dry conditions, and harsh, exposed locations and may live for several hundred years (Muyt 2001) or even up to two thousand years (Blood 2001).

*Olea europaea* has been cultivated in the Mediterranean Basin since early human civilisation and was probably introduced to the Sydney region in the eighteen hundreds (Reichelt and Burr 1997). African olive was probably introduced to the lower Hunter Valley soon after this. It was introduced to South Australia in 1900 and is now established as a major environmental weed in that state where it poses a serious threat to native vegetation communities (Crossman 2002). Similarly, in the Hunter Valley *O. europaea* subsp. *cuspidata* particularly poses significant threat to the integrity of the vegetation communities it invades. Crossman (2002) argues that the reduction in light infiltration caused by the dense canopy of *O. europaea* prevents regeneration of native species and found that gaps in eucalypt canopies could be attributed to the suppression of seedling growth by *O. europaea*.

A similar situation has been observed in Maitland LGA, where significant areas of native remnants have been invaded and structurally and floristically altered by African olive (pers. obs.). The main communities affected include Hunter Valley Dry Rainforest (Unit 1), Seaham Spotted Gum Ironbark Forest (Unit 6), Lower Hunter Spotted Gum Ironbark Forest (Unit 7), Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) and Hunter Lowlands Redgum Forest Variant (Unit 9). *O. europaea* is now also a significant component of roadside vegetation throughout the study area (pers. obs.). Crossman (2002) found that the floristic simplification and modification of eucalypt woodland following *O. europaea* invasion threatens its ecological integrity and thereby reduced the conservation value of the community.

At present African olive probably occupies perhaps less than half of its potential habitat and so could threaten much more of the remnant native vegetation in Maitland LGA in the near future. However, because it is not listed as a noxious weed under the NSW *Noxious Weeds Act* 1997 there is no obligation for Council or landholders to remove or control the species' spread. No biological control exists, therefore the only effective way to remove it involves stem poisoning (drill-fill method is probably best) and physical removal (Muyt 2001). Olives rapidly resprout from their roots or base after cutting (Blood 2001), so continued suppression is essential. Vectors of olives, including native and introduced birds and mammals (eg. common starlings (*Sturnus vulgaris*) and foxes (*Vulpes vulpes*)), readily distribute seeds widely, so control methods need to be extensive and thorough.

Lantana is a shrub originating from Central and South America. It is one of the most invasive weeds in tropical, subtropical and warm-temperate regions of the world (Muyt 2001). Lantana physically crowds or shades indigenous vegetation and prevents regeneration occurring, and will alter the soil chemistry and nutrient cycle (Muyt 2001). The species is well established as a significant weed of natural ecosystems in Maitland LGA. Vegetation communities particularly threatened by it include all but Kurri Sand Swamp Woodland (Unit 11), Swamp Oak Alluvial Forest (Unit 12) and Freshwater Wetland Complex (Unit 13). Hunter Stringybark Spotted Gum Ironbark Forest (Unit 8) and Hunter Valley Dry Rainforest (Unit 1) are particularly threatened by lantana invasion and currently support extensive populations of the weed in many locations. Like African olive, lantana is not listed as a noxious weed under the NSW *Noxious Weeds Act* 1997, so there is no obligation for Council or landholders to remove or control it. Likewise, no biological control exists for this species. The only effective way to remove it involves stem poisoning and physical removal in a manner that allows native plants and birds to re-colonise gradually.

### *b. Development and Subdivision*

Maitland LGA is subject to continued pressure for residential and industrial growth and some of that growth is occurring on forested land, which now covers only a very small proportion of the LGA. Most vegetation communities are already significantly reduced from their pre-1750 extent and are very fragmented. Continued fragmentation will lead to further weed problems, declines in indigenous species and exacerbated tree dieback. Rubbish dumping and increased levels of predation of native fauna by domestic cats and dogs will also contribute to the decline of urban remnants.

It is likely that much of the remaining vegetation communities in Maitland LGA qualifies for listing on the TSC Act, and so are of high conservation significance. Future development should be directed towards sites where native ecosystems have already been removed, and where sensible development can provide real ecological benefits through appropriate vegetation re-establishment and land management initiatives. Likewise, sensible rural subdivision should be allowed for where it provides real gains to the natural environment.

### *c. Tree Dieback*

Tree dieback has been well studied in some parts of Australia (eg. the New England Tablelands, see for example Ford 1985; Nadolny 1984), but poorly documented in many other regions, such as the Hunter Valley. In recent times the Hunter Catchment Management Trust has sought to increase the knowledge base of tree dieback causes and processes in the Hunter catchment and is currently preparing a report into the results of tree dieback monitoring it has undertaken (Staheyeff and Peake in prep.).

Tree dieback is one component of the more general problem of rural tree decline. The term tree decline refers to progressive loss of trees from landscapes through five main processes (from Nadolny 1995):

- natural death through ageing
- removal of trees (such as through logging, clearing, etc)
- lack of natural regeneration
- wind-throw
- premature death (dieback) resulting from a number of factors

Tree dieback is widespread across the current rural landscape as a result of landscape simplification since European settlement (Landsberg 1988; Reid and Landsberg 2000). During the past 200 years extensive clearing has taken place and trees which were formerly components of extensive forests and woodland are now isolated individuals in extensive pastures.

Symptoms of tree dieback can result from any of the following factors (Nadolny 1995; Russell 1993):

- changes in water chemistry and hydrology
- changes in soil depth, organic matter and nutrient levels
- loss of native biodiversity
- general loss of tree cover – making single trees more susceptible to extremes in weather and/or insect attack
- insect plagues
- pasture improvement
- stock damage such as bark chewing, rubbing and soil compaction
- root rot fungi - such as the *Phytophthora cinnamomi* fungus
- mistletoe infestation
- spray drift
- dryland salinity

Drought, flood, fire, frost and hail may also cause dieback in extremes. Also cited as a cause is airborne pollution from coal-fired power stations and other industry (Nadolny 1995; Russell 1993).

Tree dieback is a very complex process and despite years of research the problem remains poorly understood (Wylie and Landsberg 1989). Insect outbreaks, cattle rubbing or mistletoe infestation are not simply the cause of tree dieback, but rather symptoms of the problem. For example, in Sydney blue gum (*Eucalyptus saligna*) forests, the aggressive bell miner (*Manorina melanophrys*) invades the forest and disperses other bird species, which feed on lerps that eat the tree foliage. In this situation, modification of the habitat, particularly vegetation clearance and/or thinning, encourages the passage of bell miners, with the result being progressive loss of vigour and death of Sydney blue gums (G. Price pers. comm.). These circumstances can be seen in Alluvial Tall Moist Forest (Unit 2) and are most evident to the north of the New England Highway where it crosses Four Mile Creek near Ashtonfield.

In 1993 the Hunter Catchment Management Trust broadly mapped the distribution and incidence of tree dieback in the Hunter catchment (Russell 1993). In 2000, Staheyeff and Peake (in prep.) re-visited Russell's sites and studied new sites to establish a monitoring program for tree dieback over time.

The main tree species found to be affected by dieback during the 1993 study were rough-barked apple (*Angophora floribunda*), yellow box (*Eucalyptus melliodora*), narrow-leaved ironbark (*Eucalyptus crebra*), forest red gum (*Eucalyptus tereticornis*), grey gum (*Eucalyptus punctata*), spotted gum (*Corymbia maculata*) and kurrajong (*Brachychiton populneus* subsp. *populneus*), all of which occur in Maitland LGA.

Staheyeff and Peake (in prep.) found that *C. maculata* dieback in the Maitland district is widespread and severe. Numerous trees have been prematurely lost in the district, with isolated farm trees and small stands with limited native understorey being the most affected. Evidence of tree dieback in *E. tereticornis* is also seen in the study area. Example sites include the Aberglasslyn and Tocal districts.

It is an urgent requirement to undertake a detailed study of tree dieback in Maitland LGA, and to implement means to halt and reverse tree dieback. As a high proportion of Maitland LGA is currently devoid of forest or woodland, the survival of remnants and isolated farm trees is crucial to the on-going viability of the vegetation communities in Maitland LGA.

### *d. Lack of Regeneration*

In many parts of rural Maitland, rural tree decline (see Nadolny 1995) has resulted in a suite of older, dying trees with very few young trees establishing and replacing them. The effects of tree dieback and lack of regeneration has resulted in the development of senescent remnant vegetation across much of the rural area. Many of the original individual trees that grew in the native forest and woodland prior to European settlement are now dead or dying and are not being replaced. This is partly due to inappropriate grazing regimes, but also probably related to the lack of suitable incentives for farmers to retain native vegetation and encourage strategic regeneration.

In an extensive review of literature relating to the value of regrowth vegetation, Doherty (1998) states that it can be strongly argued that any patch of regrowth vegetation will have some conservation value, it is a matter of whether the value is of local, regional or national significance. Doherty (1998) indicates that the conservation value of regrowth vegetation can be assessed at three levels:

- compositional importance, eg. as individual species within a vegetation type including threatened species
- as a vegetation type
- structural importance eg. as fauna habitat
- functional importance eg. as a functioning native ecosystem

Given the general paucity of native vegetation in Maitland LGA, it is likely that most regrowth vegetation across the LGA is of significance. Despite their relative isolation and often senescent state, isolated paddock trees still perform important functions including provision of fauna habitat, salinity and erosion mitigation, nutrient recycling, stock shade and visual aesthetics (Gibbons and Boak 2000).

### *e. Lack of Public Ownership Land Tenure*

One of the primary threats to vegetation in the study area is change in land use, as a result of the overall lack of public ownership of land that supports native vegetation. Almost all of the remaining vegetation in the LGA is in private ownership.

Retention of the maximum area of extant vegetation is central to most vegetation management plans and publicly owned land can provide opportunities for retention. Due to low public ownership of vegetated land in Maitland LGA, efforts should be undertaken to either increase public ownership or to foster public participation and co-operation in the ecological management of significant tracts of vegetation, such as through management agreements. Investigation into management options is highly recommended. A package including a range of options should be promoted to landholders on a strategic basis, perhaps with lower-level measures promoted to owners of lower-quality vegetation while the highest level measures would be reserved for the very best sites.

## 6.5 Limitations to Sampling & Mapping Procedures

Users of vegetation survey data and maps must be aware of the procedures used for collection and interpretation of data, and the limitations inherent in such procedures. Consideration should be made of all methods used, in particular scale of work, sampling and mapping methods and procedure used for classification of vegetation communities.

Sampling of vegetation followed a stratified method (see *Section 4.4*) in an attempt to sample variations across environmental variables that are generally important determinants of vegetation patterns. Substrate was sampled using soil landscape mapping at 1:100,000, outlined in *Section 4.4.1*.

Scale and limited extent of field sampling for development of this soil landscape mapping means that inaccuracies are likely. Additionally, soil landscapes were grouped to simplify the stratification process, which further reduces the accuracy of this stratification element used in the sampling procedures for the current work. Topographic positions recognised in the landscape were also grouped as a result of limited time and resources available for the field survey (see *Section 4.4.2*). Additionally, not all stratification-classes were adequately sampled. As a result of sampling procedures, vegetation variation in the study area was not fully sampled due to limitations in time and resources. Therefore description of vegetation in this report, including flora species, populations and communities, does not encompass all variation that exists in the study area, but instead represents it with the most accuracy that is reasonably possible within limitations of available time and resources.

Mapping of vegetation was carried out using API of aerial photos of 1:25,000 scale. The map of extant vegetation produced for LHCCREMS by Eco Logical (2002a) was used as a base-layer for mapping in the current work, to provide some consistency between these studies. Human error in API and digitising, both in the current work and Eco Logical (2002a), can lead to various inaccuracies in the final vegetation maps. For example, the boundary between vegetation communities can be misplaced due to interpretational errors during API and limitations associated with aerial photographs, such as distortion and poor resolution. Different vegetation units may also appear very similar on aerial photographs, which makes accurate mapping of their extent difficult to achieve. Disturbance of the vegetation such as clearing, weed invasion and other changes to the floristics and structure, often compounds interpretation. This was particularly true in the study area, with high levels of disturbance present in many areas and at varying levels across the landscape. Additionally, very small and/or narrow remnants (see *Section 4.2*) and those with a high representation of exotic species were generally omitted from mapping.

Delineation and description of vegetation units (termed *vegetation communities* in the current work) utilised field data collected by the current and previous work (NPWS 2000) with the assistance of data analysis. The quality and amount of data used inherently limits this process. Incomplete sampling of stratification-classes (*Section 4.4*) and survey and surveyor bias (see *Section 5.2*) affects the data quality and therefore data analysis. Disturbance and resultant modification of vegetation found in the study area compounds analysis due to its affect on the raw data. As a result of these effects, some sites were placed by agglomerative analysis into inappropriate vegetation groups. These sites were reallocated to the most suitable group based on intuition. The extent of sampling also affects delineation of vegetation communities. For example, the units Hunter Lowlands Redgum Forest Variant (Unit 9) and Hunter Valley Moist Forest (Unit 4) show variations across the study area that were not adequately sampled to allow separate description and mapping of each variant. Several other units were also undersampled, in particular: Alluvial River Oak Forest (Unit 3), with only one site sampled; Central Hunter Riparian Forest (Unit 5), with only one site sampled; Seaham Spotted Gum Ironbark Forest (Unit 6), with only three sites sampled; Hunter Lowlands Redgum Moist Forest (Unit 10), with only three sites sampled; and Swamp Oak Alluvial Forest (Unit 12), with only three sites sampled. In addition, Kurri Sand Swamp Woodland (Unit 11) and Freshwater Wetland Complex (Unit 13) were not sampled in the study area. Description of these latter two units has been based on NPWS (2000), which utilises data from outside of the study area.

Validation of the final vegetation map was undertaken through field reconnaissance. Each remnant was allocated one of three levels of validation. The first indicates that vegetation was sampled in the remnant using plot-based survey. The second indicates that vegetation was ground tuthed by field reconnaissance. The third level indicates that map validation has not been carried out. The first and second levels do not indicate that mapping is definitely accurate, since in many cases validation was only carried out in part of the remnant, particularly if the remnant is large in size.

## 6.6 Ecological Assessment

Ecological assessment herein is intended to provide indication of the relative ecological value of remnants in Maitland LGA. As such, vegetation ranked as being of low relative-value does not indicate it is of low ecological value. In fact, the large extent of vegetation clearance that has occurred in Maitland LGA and the high proportion of significant vegetation units represented means that nearly all of the remaining vegetation in the LGA is highly valuable.

The procedures used for this assessment (see *Section 4.9*) do not constitute an exhaustive assessment and are essentially only qualitative. Several measures used in this assessment are also intuitive, such as reservation status of vegetation communities, due to the limited data available for assessments. As a result, this assessment should only be used at a broad (small) scale in strategic planning. The ecological assessment provided here is intended to assist Council with planning for future land use using a strategic approach. The assessment will help highlight opportunities for creation, enhancement and management of ecological values in the LGA.

Criteria for ecological assessment were developed through review of relevant literature and consultation with Maitland Council. As outlined in *Section 4.9.1*, assessment excluded attributes that could not be measured for every remnant, such as site-specific attributes (eg. internal condition of remnant and fauna habitat). The criteria selected for this assessment are widely recognised as important to the ecological functioning or value of vegetation. The following sections provide background information about each criterion used in the ecological assessment carried out for the current work.

### *a. Presence of a listed EEC*

The presence of an Endangered Ecological Community (EEC) is commonly used as a measure of conservation significance. The legal status that listing on the TSC Act provides, establishes the need to consider the potential impact of a major proposed development on any EECs present.

### *b. Presence of significant vegetation community*

The presence of a potentially threatened community and/or regionally significant vegetation type is commonly used to measure conservation significance. For example, LHCCREMS (Eco Logical 2002b) applies Landsberg (2000) to identify critically endangered communities within the Central Coast and Lower Hunter Region. The Hunter Remnant Vegetation Project (Peake in prep.) uses both listing under the TSC Act and regional significance to identify significant vegetation types.

This criteria is also consistent with draft criteria being considered by the Hunter Regional Vegetation Committee at the time of writing this report. The Inverell-Yallaroi Regional Vegetation Committee (Curran 2002) has also considered very similar criteria.

Work carried out by various other local councils in NSW have also adopted similar criteria (eg. Kingston *et al.*, 1999; Landmark Ecological Services *et al.* 1999). At the bioregional level, other authors have developed various criteria for assessing the threat and reservation status of vegetation communities. Recent examples include Sattler and Williams (1999), English and Blyth (1999) and Landsberg (2000). Relevant components of these works have been considered in the development of criteria for the current work.

Criteria currently being developed for listing of a *Vulnerable Ecological* Community under the TSC Act, which is likely to become enacted towards the end of 2003, should also be considered in future by Council.

Criteria for listing Endangered Ecological Communities under the TSC and EPBC Acts include the assessment of the degree of reduction in distribution from an ecological community's former range. The percentage of pre-European vegetation communities remaining has been estimated by comparison of the final vegetation community map to equivalent or near-equivalent vegetation communities modelled by NPWS (2000) for LHCCREMS (2003) and with reference to other relevant works (eg. Peake in prep.). Information about the distribution of vegetation communities beyond the lower Hunter-Central Coast region is generally lacking.

### *c. Presence of important ecosystem type*

Riparian and wetland vegetation is widely recognised as important vegetation types having specific ecological values and roles (eg. Fisher and Goldney 1997; Pressey and Harris 1998; Raine and Gardiner 1995). Wetlands provide important ecosystem functions such as flood mitigation, sediment and nutrient control, water quality control, and regulation and recharge of groundwater. Wetlands have an important place in conservation (Brock and Jarman 2000), and provide unique habitat for a variety of aquatic and terrestrial organisms, ranging from fish and aquatic invertebrates to birds. Council's Greening Plan (Maitland City Council 2002) highlights the importance of wetland ecosystems, and State Legislation and international treaties also recognise the role of wetlands through tools such as State Environment Planning Policy 14 (SEPP 14), the Japan Australia Migratory Bird Agreement (JAMBA) and China Australia Migratory Bird Agreement (CAMPB).

Riparian vegetation also has an important role in sediment, nutrient and water quality control through acting as a buffer between terrestrial and aquatic systems (Raine and Gardiner 1995). Riparian vegetation provides essential habitat and food for aquatic organisms, shelter, temperature control, and protection from stream bank and bed erosion. Riparian vegetation also provides important links for flora and fauna between remnants where surrounding lands are predominantly cleared of vegetation. Riparian vegetation can have a higher diversity of species than non-riparian systems and provide keystone habitats for many species (Raine and Gardiner 1995). Riparian zones are protected through a variety of state legislation including the *Soil Conservation Act* 1938, *Rivers and Foreshores Improvement Act* 1948, and the *Native Vegetation Conservation Act* 1997.

### *d. Reservation status of vegetation type/s*

In any assessment of the conservation status of vegetation communities, it is important to consider the degree to which vegetation is protected within formal conservation reserves. Formal conservation reserves offer relative protection to terrestrial vegetation communities. They include nature reserves, national parks, flora reserves, state conservation areas, regional parks, karst conservation areas and aboriginal areas. The NSW National Parks and Wildlife Service manage all of these except flora reserves and regional parks. Flora reserves that are managed by State Forests of New South Wales are sites within state forests for which the highest conservation zoning is afforded. The Department of Sport and Recreation now manage regional parks, formerly managed by NPWS.

Several authors provide assessments of the formal reservation levels of vegetation communities. These include English and Blyth (1999), Sattler and Williams (1999), Hager and Benson (1994), Specht *et al.* (1995) and Benson and Ashby (2000). The latter three were referred to in the current work for estimating the level of reservation of vegetation communities that occur in the study area.

### *e. Percentage of extant vegetation type remaining, compared to pre-1750 cover*

The degree to which native vegetation has been cleared is integral to assessing the conservation status of vegetation for any area. Extent of clearing affects the future viability of vegetation and other biota at the regional level, since plants form the basis and structure upon which most ecosystem functions take place.

Smith and Sivertsen (2001) suggest that at the landscape level the decline of vegetation cover has two critical thresholds beyond which further decline leads to massive loss of biodiversity. These are 40% and 70% clearing of original (pre-European) extent. They indicate that once 40% of a landscape's vegetation is removed, a significant loss in biodiversity will follow. Below the 40% threshold, biodiversity levels continue to drop gradually with further clearing, until the point at which about 70% of the landscape is cleared, where once again a massive loss of biodiversity follows (Smith and Sivertsen 2001). The two points at which biodiversity declines relatively rapidly will be vary in dissimilar ecosystems - in some cases the declines will be rapid, while in others it may take decades or longer to be realised.

A high level of clearing in a landscape, such as in Maitland LGA, has major implications for biodiversity. Remaining vegetation is usually very fragmented in highly cleared landscapes, patches are usually small and very isolated. This has a variety of negative effects on biodiversity (see for example Burgess 1988; Hobbs 2001; Murcia 1995; Saunders *et al.* 1991).

Comparison between extant and pre-European vegetation cover is typically made on an intuitive basis due to the general lack of information on pre-European vegetation extent and character. However, advances in computer modelling in recent years and the availability of increasingly accurate environmental data (such as that for climate, terrain, soil types etc) have allowed the development of models which predict the likely extent and distribution of vegetation communities prior to disturbance by Europeans. Such maps are usually termed *pre-1750* to highlight that they display modelled vegetation extent prior to European contact with eastern mainland Australia. The pre-1750 map produced by NPWS (2000) for the lower Hunter Central Coast Region is an example, which was referred to in the current work for relevant vegetation communities. The pre-European extent of vegetation communities that had no clear equivalent unit in NPWS (2000) or that extended outside of the lower Hunter-Central Coast region could only be estimated. These estimates were based mainly on intuition due to the general absence of data for flora in the mid Hunter and Dungog LGA, into which many vegetation communities in Maitland LGA extend.

### *f. Size of remnant*

The conservation value of any particular remnant is often directly related to its size, depending on the diversity of vegetation and habitat types present. Following on from the theory of island biogeography (MacArthur and Wilson 1967), species richness in habitat fragments is expected to be a function of island sizes and degree of isolation (Debinski and Holt 2000). As applied to terrestrial situations, smaller, more isolated fragments are expected to retain fewer species than larger, less isolated tracts (eg. Diamond 1975; Wilson and Willis 1975; Terborg 1976). Some studies have shown larger remnants generally have a higher diversity of habitats and consequently a greater number flora and fauna species and populations. However, smaller tracts of habitat can have surprisingly high species richness and diversity of habitats (Simberloff 1993).

In general, the scientific literature supports the theory that the larger a remnant, the less the likelihood of a single event such as fire or disease causing local extinction of a species or population from that area. Small, isolated populations of plants are likely to suffer from the impacts of stochastic events, such as extreme weather or wildfire (Keith 2002).

The minimisation of disturbances, including those caused by people, is critical to ensure the minimisation of threats. This is generally achieved more effectively through the protection of larger tracts of vegetation, rather than preserving smaller, more isolated tracts of protected vegetation while fragmentation increases in adjacent land.

Fragmentation usually leads to decreased remnant size and increased edge to area ratio. Impacts related to an increase in edge to area ratio are often included under the term *edge effects*. The impacts from surrounding land uses are most apparent at the edge of remnants, such as dieback and weed infestation (Murcia 1995; Curran 2002). Small remnants that have a relatively high edge length to area ratio are more susceptible to the impacts of surrounding land uses. It is now well understood that edge effects are detrimental to a wide range of native flora and fauna (eg. Janzen 1986; Lovejoy *et al.* 1986; Laurance 1991, 2000; Saunders *et al.* 1991; Murcia 1995).

### *g. Connectivity of remnant*

As discussed in previous sections, ecosystem fragmentation reduces the overall integrity of vegetation communities at regional and local scales. As vegetation becomes increasingly fragmented, species richness and natural habitat diversity decreases. Smith and Sivertson (2001) identified two critical levels at which biodiversity declines outpace the loss of vegetation cover, at 40% and 70% regional vegetation loss. An integral component of habitat fragmentation is the level of connectivity of remnant patches.

Connection between remnants typically decreases as fragmentation increases, with remnants increasingly isolated from one another. As the size of the gap between remnants increases, typically fewer and fewer fauna species can move between remnants (Saunders *et al.* 1991). Restricted faunal mobility can lead to isolation of gene pools, inbreeding depression and eventual local extinction through limited gene pools or lack of habitat resources (Saunders *et al.* 1991). Similarly, the ease of movement of plant pollinators and seed vectors between remnants reduces with fragmentation. Retention and construction of corridors of adequate dimensions, composition and health can improve the ecosystem functioning in fragmented landscapes. However, corridors are only partly compensatory for degradation of the landscape through vegetation clearance and modification (Soule and Gilpin 1991).

### *h. Diversity of remnant*

The diversity of habitats or vegetation communities within a remnant patch can be important in determining the richness of species present within the remnant. Diverse remnants will typically provide habitat for a wider range of species, both flora and fauna, depending on the remnant’s location, connectivity to other remnants, edge to area ratio and internal health. Large remnants will typically provide a more diverse range of habitats than small remnants because they usually include more landscape units. Simberloff (1993) argues, however, that small sites with the right habitats can have a high species diversity, while large sites with the wrong habitats can have low diversity. To account for this, remnant size has not been used in isolation to assess the value of a remnant in the current work. Diversity of vegetation communities has been included to allow a more integrated assessment.

# Chapter 7 References


Albrecht, G. (2000)
*Rediscovering the Coquun: Towards an Environmental History of the Hunter River*. Pp. 4-26 in *Our River: Our Future*. Proceedings of the 2000 Water Forum. Hunter Catchment Management Trust, Tocal.

Anderberg, A.A. (1991)
The taxonomy and phylogeny of the tribe Gnaphaliae (Asteraceae). *Opera Botanica* 104:1-195.

Anderson, R.H. (1961)
Introduction. *Contributions from the New South Wales National Herbarium Flora Series* 1-18: 1-15.

Austin, M.P., Cawsey, E.M., Baker, B.L., Yialeloglou, M.M., Grice, D.G. and Briggs, S.V. (2000)
*Predicted Vegetation Cover in the Central Lachlan Region*. Final report of the Natural Heritage Trust project AA 1368.97. CSIRO, Canberra.

Bean, A. R. (2002)
A revision of *Solanum brownii* Dunal (Solanaceae) and its allies. *Telopea* 9 (3): 639-661.

Bean, J.M. (1999)
*Bothriochloa biloba* (Poaceae) in natural grasslands on slopes of the Liverpool Plains, New South Wales. *Cunninghamia* 6 (2): 383-387.

Belbin, L. (1991)
The Analysis of Pattern in Bio-survey Data. Pp. 176 - 190 in C. Margules and M. Austin (eds) *Nature Conservation: Cost Effective Biological Surveys and Data Analysis.* CSIRO, Canberra.

Belbin, L. (1995a)
*PATN Pattern Analyyis Package: Users Guide.* CSIRO, Canberra.

Belbin, L. (1995b)
*PATN Pattern Analysis Package: Reference Manual* CSIRO, Canberra.

Bell, S.A.J. (2001)
*The Vegetation of Werakata (Lower Hunter) National Park, Hunter Valley, New South Wales*. Final draft report to National Parks and Wildlife Service.

Bell, S.A.J. (2003)
*Vegetation Assessment for the Thornton North Master Plan, Maitland LGA*. Report to Parsons Brinckerhoff Australia Pty Ltd and Maitland City Council.

Bell, S. and Murray, M. (2001)
*The Ecological Significance of Bow Wow Creek Gorge, Mulbring, Hunter Valley, New South Wales. A Nationally Significant Site*. Report to Cessnock City Council.

Bell, S.A.J., Peake, T., Tame, T., Simpson, J., & Curran, T. (2003).
*Regionally Significant Vegetation of the Hunter Valley and Central Coast, New South Wales: A Working Register. Version 1.* Hunter Rare Plants Committee, Hunter Region Botanic Gardens. January 2003.

Benson, D. and McDougall, L. (2000)
Ecology of Sydney plant species part 7b: Dicotyledon families Proteaceae to Rubiaceae. *Cunninghamia* 6 (4): 1017-1202.

Benson, J. (1989)
Establishing Priorities for the Conservation of Rare or Threatened Plants and Plant Associations in New South Wales. Pp. 17-82 in M. Hicks and P. Eiser (eds) *The Conservation of Threatened Species and Their Habitats*. Proceedings of a National Conference Held in Sydney in March 1987.

Benson, J. (1999)
*Setting the Scene. The Native Vegetation of New South Wales. A Background Paper of the Native Vegetation Advisory Council of New South Wales*. Native Vegetation Advisory Council, Sydney.

Benson, J.S. and Ashby, E.M. (2000)
Vegetation of the Guyra 1:100 000 map sheet New England Bioregion, New South Wales. *Cunninghamia* 6 (3): 747-872.

Biosis Research (2001)
*Kurri Sand Swamp Woodland Recovery Assessment*. Biosis Research, Sydney.

Blood, K. (2001)
*Environmental Weeds. A Field Guide for South-east Australia*. C.H. Jerram and Associates, Victoria.

Bostock, P.D. (1998)
Adiantaceae. Pp. 248-286 in A. Orchard (ed) Flora of Australia. *Volume 48: Ferns, Gymnosperms and Allied Groups*. CSIRO, Melbourne.

Branagan, D.F. and Packham, G.H. (2000)
*Field Geology of New South Wales*. Third edition. New South Wales Department of Mineral Resources, Sydney.

Brayshaw, H. (1986)
*Aborigines of the Hunter Valley*. Scone and Upper Hunter Historical Society, Scone.

Briggs, J.D. and Leigh, J.H. (1996)
*Rare or Threatened Australian Plants*. CSIRO, Canberra.

Brock, M.A. and Jarman, P.J. (2000)
Wetland Use and Conservation in the Agricultural Environment: Managing Processes for the Components. Pp. 259-268 in J. Craig, N. Mitchell and D. Saunders (eds) *Nature Conservation 5: Nature Conservation in Production Environments: Managing the Matrix*. Surrey Beatty and Sons, Sydney.

Burgess, R.L. (1988)
Community organization: effects of landscape fragmentation. *Canadian Journal of Botany* 66: 2687-2690.

Cayzer, L.W., Crisp, M.D. and Telford, I.R.H. (1999)
*Bursaria* (Pittosporaceae): A morphometric analysis and revision. *Australian Systematic Botany* 12: 117-143.

Cayzer, L.W., Crisp, M.D. and Telford, I.R.H. (2000)
Revision of *Pittosporum* (Pittosporaceae) in Australia. *Australian Systematic Botany* 13: 845-902.

Chalmers, A.C. and Turner, J.C. (1994)
Climbing plants in relation to their supports in a stand of dry rainforest in the Hunter Valley, New South Wales. *Proceedings of the Linnean Society of New South Wales* 114 (2): 73-90.

Christian, C.S. and Stewart, G.A. (1953)
*General Report on Survey of Katherine-Darwin Region, 1946. Land Research Series No. 1.* CSIRO, Melbourne.

Ciferri, R., Marinucci, M. and Morettini, A. (1942)
Dat preliminari per una sistemazione delle razze di olivo in coltura. *L. 'Olivicoltore* 19: 96.

Crossman, N.D. (2002)
The impact of the European olive (*Olea europaea* L. subsp. *europaea*) on grey box (*Eucalyptus microcarpa* Maiden) woodland in South Australia. *Plant Protection Quarterly* 17 (4): 140-46.

Cummings, B. and Hardy, A. (2000)
*Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1*. Environment Australia, Canberra.

Cunningham, P.M. (1827)
*Two Years in New South Wales: A Series of Letters*…. Henry Coburn, London.

Curran, T.J. (2002)
*Inverell-Yallaroi Regional Vegetation Committee Discussion Paper: Criteria for Assessing the Threat Status of Ecological Communities*. Unpublished report.

Daniels, R.E. and Sheil, J. (1999)
Genetic pollution: concepts, concerns and transgenic crops. Pp. 65-72 in *'Gene Flow and Agriculture: Relevance to Transgenic Crops*.'BCPC Symposion proceedings No. 72.

Debinski, D.M. and Holt, R.D. (2000)
A survey and overview of habitat fragmentation experiments. *Conservation Biology* 14 (2): 342-355.

Diamond, J.M. (1975)
The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. *Biological Conservation* 7: 129-146.

Doherty, M. (1998)
*The Conservation Value of Regrowth Native Plant Communities: A Review*. Final report. Prepared for the New South Wales Scientific Committee. CSIRO, Canberra.

Eco Logical Australia Pty Ltd (2002a)
*Lower Hunter & Central Coast Regional Biodiversity Conservation Strategy Techical Report: Digital Aerial Photo Interpretation and Updated Extant Vegetation Community Map.* Report for the Lower Hunter and Central Coast Regional Environment Strategy prepared by Ecological Australia Pty Ltd, Sutherland. May 2003

Eco Logical Australia Pty Ltd (2002b)
*Lower Hunter & Central Coast Regional Biodiversity Conservation Strategy Techical Report: Conservation Assessment Scenarios*. Report for the Lower Hunter and Central Coast Regional Environment Strategy prepared by Ecological Australia Pty Ltd, Sutherland.

Ecotone Ecological Consultants (1995)
*Flora and Fauna Study, Proposed Avalon Rural Residential Estate, Avalon Drive, Thornton*.

Ecotone Ecological Consultants (1998)
*Flora and Fauna Survey and Assessment for the Proposed Rezoning of Land at Ashtonfield to Support Residential Development*. Final Report. Prepared for Hilltop Planners Pty Ltd.

Edwards, K. (1979)
*Rainfall in New South Wales, with Special Reference to Soil Erosion*. Soil Conservation Service Technical Handbook No. 3.

English, V. and Blyth, J. (1999)
Development and application of procedures to identify and conserve threatened ecological communities in the south-west botanical province of Western Australia. *Pacific Conservation Biology* 5 (2): 124-138.

ERM Mitchell McCotter (1998a)
*Dungog Biological Diversity Study. Clarence Town Planning District*. Prepared for Dungog Shire Council.

ERM Mitchell McCotter (1998b)
*Dungog Biological Diversity Study. Paterson Planning District*. Prepared for Dungog Shire Council.

Fellingham, A.C. and Meyer, N.L. (1995)
New combinations and a complete list of *Asparagus* species in southern Africa (Asparagaceae). *Bothalia* 25 (2): 205-209.

Fisher, A.M. and Goldney, D.C. (1997)
Use by birds of riparian vegetation in an extensively fragmented landscape. *Pacific Conservation Biology* 3 (3): 275-288.

Floyd, A. (1983)
*Dry Rainforest Outliers, Dungog – Maitland*. Unpublished report.

Floyd, A.G. (1990)
*Australian Rainforests in New South Wales. Volume 2*. Surrey Beatty and Sons, Sydney.

Ford, H.A. (1985)
The Bird Community in Eucalypt Woodland and Eucalypt Dieback in the Northern Tablelands of New South Wales. Pp. 333-40 in A. Keast, H. Recher, H. Ford and D. Saunders (eds) *Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management*. Surrey Beatty and Sons, Sydney.

Forster, P.I. (1996)
Asclepiadaceae. Pp. 197-283 in A.E. Orchard (ed) *Flora of Australia. Volume 28. Gentianales*. CSIRO, Melbourne.

Galloway, R.W. (1963)
Geology of the Hunter Valley. Pp. 81-89 in R. Story, R. Galloway, R. van de Graaf and A. Tweedie (eds) *General Report on the Lands of the Hunter Valley. Land Research Series No. 8.* CSIRO, Melbourne.

Gardner, C. and Murray, L. (1992)
Tremandraceae. Pp. 74-78 in G. Harden (ed) *Flora of New South Wales. Volume 3*. Royal Botanic Gardens Sydney and University of New South Wales Press, Sydney.

Gibbons, P. and Boak, M. (2000)
*The Importance of Paddock Trees for Regional Conservation in Agricultural Landscapes. A Discussion Paper for Consideration by the Riverina Highlands Regional Vegetation Committee*. NSW National Parks and Wildlife Service, Queenbeyan.

Giles, G. (1995)
*The Vegetation of the Paterson River Valley. A Survey of the Current Distribution of Canopy Species, A Reconstruction of the Original Distribution, and Proposals for Revegetation and Rehabilitation*. Thesis for Master of Environmental Studies, University of Newcastle.

Green, P.H. (1990)
Notes relating to the floras of Norfolk and Lord Howe islands: 3. *Kew Bulletin* 45 (2): 235-255.

Greenwood, M.E. (1999)
*Dungog Vegetation and Biodiversity Study*. Prepared on behalf of Dungog Shire Council.

Hager, T.C. and Benson, J.S. (1994)
*Review of the Conservation Status of Vegetation Communities in New South Wales. Part 3. Assessment of the Conservation Status of Forest Plant Communities in North Eastern NSW. Final Report*. Report to the Australian Heritage Commission.

Harden, G.J. and Murray, L.J. (2000)
*Supplement to Flora of New South Wales Volume 1*. Royal Botanic Gardens Sydney and New South Wales University Press, Sydney.

Harden, G.J. editor (1990)
*Flora of New South Wales. Volume 1*. Royal Botanic Gardens Sydney and New South Wales University Press, Sydney.

Harden, G.J. editor (1992)
*Flora of New South Wales. Volume 3*. Royal Botanic Gardens Sydney and New South Wales University Press, Sydney.

Harden, G.J. editor (1993)
*Flora of New South Wales. Volume 4*. Royal Botanic Gardens Sydney and New South Wales University Press, Sydney.

Harden, G.J. editor (2002)
*Flora of New South Wales. Volume 24*. Revised edition. Royal Botanic Gardens Sydney and New South Wales University Press, Sydney.

Harden, G.J. and Murray, L.J. (2000)
*Supplement to Flora of New South Wales Volume 1*. Royal Botanic Gardens Sydney and New South Wales University Press, Sydney.

Hawley, S.P. and Brunton, J.S. (1995)
*The Newcastle Coalfield. Notes to Accompany the 1:100 000 Newcastle Coalfield Regional Geology Map*. Geological survey report GS1995/256. Department of Mineral Resources, Sydney.

Hill, K.D. (2002)
*Eucalyptus*. Pp. 96-164 in G. Harden (ed) *Flora of New South Wales. Volume 2*. Revised edition. Royal Botanic Gardens Sydney and University of New South Wales Press, Sydney.

Hill, L.M. (1999)
*Goulburn River National Park and Munghorn Gap Nature Reserve: Vegetation Survey for Fire Management Purposes. Volume 2 Community Profiles*. Unpublished report prepared for NSW National Parks and Wildlife Service, Upper Hunter District, Muswellbrook.

Hill, L.M. (2000)
*Goulburn River National Park and Munghorn Gap Nature Reserve: Vegetation Survey for Fire Management Purposes. Volume 1 Main Report*. Unpublished report prepared for NSW National Parks and Wildlife Service, Upper Hunter District, Muswellbrook.

Hill, L. (in prep.)
*Vegetation of Native Dog Hill addition to Werakata NP*. Unpublished report prepared for NSW National Parks and Wildlife Service, Hunter Range Area, Bulga.

Hill, L.M. and Peake, T. (2000)
*Towarri National Park Vegetation Survey for Fire Management Purposes*. Unpublished draft report prepared for NSW National Parks and Wildlife Service, Hunter District.

HLA-Envirosciences (2000)
*Assessment of Impact to Flora and Fauna by Proposed Subdivision "Anambah View Estate" at Rutherford*. Prepared for Anambah Homes Pty Ltd.

Hobbs, R.J. (2001)
Synergisms among habitat fragmentation, livestock grazing, and biotic invasions in southwestern Australia. *Conservation Biology* 15 (6): 1522-1528.

Holzapfel, S. (1994)
A revision of the genus *Picris* (Asteraceae, Lactuceae) *s.l.* in Australia. *Willdenowia* 24. 97-218

Hunter Catchment Management Trust (2003)
*Integrated Catchment Management Plan for the Hunter Catchment 2002*. NSW Department of Land and Water Conservation, Sydney.

Jacobs, S.W.L. (2001)
The genus *Lachnagrostis* (Gramineae) in Australia. *Telopea* 9 (3): 439-448.

Jacobs, S.W.L. and Everett, J. (1996)
*Austrostipa*, a new genus, and new names for Australasian species formerly included in *Stipa* (Gramineae). *Telopea* 6 (4): 579-595.

Jacobs, S.W.L. and McClay, K.L. (1993)
*Sorghum*. Pp. 435-437 in G. Harden (ed) *Flora of New South Wales. Volume 4*. Royal Botanic Gardens Sydney and New South Wales University Press, Sydney.

Jacobs, S.W.L. and Wall, C.A. (1993)
*Bothriochloa*. Pp. 439-441 in G. Harden (ed) *Flora of New South Wales. Volume 4*. Royal Botanic Gardens Sydney and New South Wales University Press, Sydney.

JANIS - see Joint ANZECC/MCFFA National Forestry Policy Statement Implementation Sub-committee (1997)

Janzen, D.H. (1986)
The Eternal External Threat. Pp. 286-303 in M. Soule (ed.) *Conservation Biology: The Science of Scarcity and Diversity*. Sinauer Associates, Massachusetts.

Joint ANZECC/MCFFA National Forestry Policy Statement Implementation Sub-committee (1997)
*Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia*. Commonwealth of Australia, Canberra.

Jones, D.L. (1998)
Dryopteridaceae. Pp. 393-418 in A. Orchard (ed) Flora of Australia. *Volume 48: Ferns, Gymnosperms and Allied Groups*. CSIRO, Melbourne.

Keith, D.A. (2002)
Population dynamics of an endangered heathland shrub, *Epacris stuartii* (Epacridaceae): recruitment, establishment and survival. *Austral Ecology* 27 (1): 67-76.

Keith, D. & Bedward, M. (1999)
Native vegetation of the South East Forest region, Eden, New South Wales. *Cunninghamia* 6(1): 1-219.

Kingston, M.B., Turnbull, J.W., Hall, P.W., Boulton, S.C. and Storey, R.J. (1999)
*Tweed Vegetation Management Plan 1999. Volume 1*. Prepared for Tweed Shire Council by Ecograph, Murwillumbah.

Knott, T., Lunney, D., Coburn, D. and Callaghan, J. (1998)
An ecological history of koala habitat in Port Stephens Shire and the lower Hunter on the Central Coast of New South Wales, 1801-1998. *Pacific Conservation Biology* 4 (4): 354-368.

Kovac, M. and Lawrie, J.W. (1991)
*Soil Landscapes of the Singleton 1:250 000* Sheet. Soil Conservation Service of New South Wales, Sydney.

Landmark Ecological Services Pty Ltd, Ecograph and Terrafocus Pty Ltd (1999)
*Byron Flora and Fauna Study 1999*. Prepared for Byron Shire Council.

Landsberg, J. (1988)
Dieback of rural trees in Australia. *GeoJournal* 17.2: 231-237.

Landsberg, J. (2000)
*Criteria for Assessing the Level of Threat to Ecological Communities. Regulations*. Unpublished report for Environment Australia.

Laurance, W.F. (1991)
Edge effects in tropical forest fragments: application of a model for the design of nature reserves. *Biological Conservation* 57: 205-219.

Laurance, W.F. (2000)
Do edge effects occur over large spatial scales? *Trends in Ecology and Evolution* 15: 134-135.

LHCCREMS (2003) - see Lower Hunter and Central Coast Regional Biodiversity Conservation Strategy (2003)

Linder, H.P. (1997)
Nomenclatural corrections in the *Rytidosperma* complex (Danthonieae, Poaceae). *Telopea* 7 (3): 269-274.

Linder, H.P. and Verboom, G.A. (1996)
Generic limits in the *Rytidosperma* (Danthoniae, Poaceae) complex. *Telopea* 6 (4): 597-627.

Lovejoy, T.E., Bierregaard, R.O., Rylands, A.B., Malcolm, J.R., Quintela, C.E., Harper, L.H., Brown, K.S., Powell, A.H., Powell, G.V.N., Schubart, H.O.R. and Hays, M.B. (1986)
Edge and Other Effects of Isolation on Amazon Forest Fragments. Pp. 257-285 in M. Soule (ed) *Conservation Biology. The Science and Scarcity of Diversity*. Sinauer Associates, Massachusetts.

Lower Hunter and Central Coast Regional Biodiversity Conservation Strategy (2003)
*Briefing Notes - Results of Regional Conservation Assessment for the Lower Hunter and Central Coast*. Lower Hunter and Central Coast Regional Environment Management Strategy, Newcastle. August 2003.

MacArthur, R.H. and Wilson, E.O. (1967)
*The Theory of Island Biogeography*. Princeton University Press, Princeton.

Maitland City Council (2002)
*The Maitland Greening Plan. Stage 2 Part B.* Maitland City Council, Maitland.

Makinson, R.O. (2002)
*Grevillea*. Pp. 32-66 in G. Harden (ed) *Flora of New South Wales. Volume 2*. Revised edition. Royal Botanic Gardens Sydney and University of New South Wales Press, Sydney.

Manidis Roberts Consulting (1996)
*Maitland Linkages Study*. Prepared for Maitland City Council.

Martens and Associates (1999)
*Broad Scale Study for Outside Effluent Disposal Suitability Maitland Local Government Area*. Report for Maitland City Council from Martens and Associates, Newtown.

Matthei, L.E. (1995)
*Soil Landscapes of the Newcastle 1:100 000 Sheet (Allworth, Stockton, Maitland, Paterson).* Department of Land and Water Conservation, Sydney.

McIntyre, S. and Barrett, G.W. (1992)
Habitat variegation, an alternative to fragmentation. *Conservation Biology* 6 (1): 142-143.

Michael, P.W. (1997a)
Notes on *Verbena officinalis sensu stricto* and *V. macrostachya* (Verbenaceae) with new combinations in two closely related taxa. *Telopea* 7 (3): 293-297.

Michael, P.W. (1997b)
A putative hybrid in *Verbena* (Verbenaceae) and the application of the name *V. brasiliensis*. *Telopea* 7 (3): 299-300.

Munir, A.A. (2002)
A taxonomic revision of the genus *Verbena* L. (Verbenaceae) in Australia. *Journal of the Adelaide Botanic Gardens* 20 (1): 21-103.

Murcia, C. (1995)
Edge effects in fragmented forests: implications for conservation. *Trends in Ecology and Evolution* 10 (2): 58-62.

Murray, L.J. (2000)
*Macrozamia*. Pp. 12-16 in G. Harden and L. Murray (eds) *Supplement to Flora of New South Wales. Volume 1*. Royal Botanic Gardens Sydney and University of New South Wales Press, Sydney.

Muyt, A. (2001)
*Bush Invaders of South-east Australia. A Guide to the Identification and Control of Environmental Weeds found in South-east Australia*. R.G. and F.J. Richardson, Victoria.

Nadolny, C. (1984)
Eucalypt Dieback on the Northern Tablelands of New South Wales. M. Sc. Thesis, University of New England, Armidale.

Nadolny, C. (1995)
Causes of Tree Decline/Dieback in NSW. Pp.11-18 in A. Kater. (ed) *Redressing Rural Tree Decline in NSW*. Proceedings of the "After Dieback" conference presented by Greening Australia at Orange, May 1995.

Nicholls AO, Doherty MD, Newsome AE. (2002)
*Evaluation of Data, Modelling Techniques and Conservation Assessment Tools for the Lower Hunter and Central Coast Regional Biodiversity Conservation Strategy*. Lower Hunter and Central Coast Regional Environmental Management Strategy, NSW.

NSW National Parks and Wildlife Service (1999a)
*Forest Ecosystem Classification and Mapping for the Upper and Lower North-east*: A project undertaken as part of the NSW Comprehensive Regional Assessments. NPWS, Hurstville.

NSW National Parks and Wildlife Service (1999b)
*Forest Ecosystem Classification and Mapping for the Hunter Sub-region in the Lower North East Comprehensive Regional Assessment*. A project undertaken for the Joint Commonwealth-NSW Regional Forest Agreement Steering Committee as part of the NSW Comprehensive Regional Assessments. Project No. NL 10E/H & NL 02/ EH. CRA Unit, Sydney Zone NPWS. March 1999.

NSW National Parks and Wildlife Service (2000)
*Vegetation Survey, Classification and Mapping: Lower Hunter and Central Coast Region. Version 1.2.* A project undertaken for the Lower Hunter and Central Coast Regional Environment Management Strategy. NPWS, Hurstville.

NSW National Parks and Wildlife Service (2002)
*Final Field Key to Forest Ecosystems on Private Lands in North-east New South Wales. For Assessment of Clearing Applications under the Native Vegetation Conservation Act 1997*. NPWS, Coffs Harbour.

NSW Scientific Committee (2003)
*Nomination for Listing an Endangered Ecological Community*. NPWS website npws.nsw.gov.au

Patrick, G. (1999)
*Initial Flora Survey to Sample Potential Habitat, Abundance and Distribution of the New Plant Species Persoonia 'North Rothbury'*. Prepared for NSW National Parks and Wildlife Service. Ecotone Ecological Consultants, Newcastle.

Peake, T. (1999)
Hunter Remnant Vegetation Project: An Interim Report. Pp. 99-109 in Andrews.Neil (ed) *Synoptic Plan. Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of NSW*. Report prepared for NSW Department of Mineral Resources, Sydney.

Peake, T. (2000)
The Vegetation of the Mid-Hunter Valley: What State is it in Currently? Pp. 4-18 in M. Fallding (ed)

*Vegetation Management and Biodiversity Conservation – Hunter Region*. Proceedings of a workshop held in May 2000 at Singleton. Hunter Environment Lobby, Singleton.

Peake, T.C. (in prep.)
The vegetation of the central Hunter Valley. A report on the findings of the Hunter Remnant Vegetation Project. Hunter Catchment Management Trust, Tocal.

Peake, T.C. and Curran, T.J. (in prep.)
The phytogeographic significance of the Hunter Valley, New South Wales: A test of the barrier/conduit hypothesis.

Pittendrigh, Shinkfield & Bruce Landscape Architects, Urban Bushland Management Consultants and Peter Annand & Associates (1998)
*Maitland Greening Plan Stage 2 Part A*. Prepared for Maitland City Council.

PlantNET (2003) http: //plantnet/rbgsyd.gov.au (Royal Botanic Gardens, Sydney).

Poore, M.E.D. (1955)
The use of phytosociological methods in ecological investigations. I. The Braun-Blanquet system. *Journal of Ecology* 42: 216-224.

Pressey, R.L. and Harris, J.H. (1998)
Wetlands of New South Wales. Pp. 35-57 in A. McComb and P. Lake (eds) *The Conservation of Australian Wetlands*. Surrey Beatty and Sons, Sydney.

Raine, A.W. and Gardiner, J.N. (1995)
*Rivercare, Guidelines for Ecologically Sustainable Management of Rivers and Riparian Vegetation*. LWRRDC Occasional Paper Series No. 03/95.

Randell, B.R. and Barlow, B.A. (1998)
*Senna*. Pp. 89-138 A. Orchard (ed) *Flora of Australia. Volume 12. Mimosaceae (excluding Acacia), Caesalpiniaceae.* Australian Biological Resources Study, Canberra.

Reichelt, K. and Burr, M. (1997)
*Extra Virgin: An Australian Companion to Olives and Olive Oil*. Wakefield Press, Adelaide.

Reid, N. and Landsberg, J. (2000)
Tree Decline in Agricultural landscapes: What We Stand to Lose. Pp. 127-166 in R. Hobbs and C. Yates (eds) *Temperate Eucalypt Woodlands in Australia: Biology. Conservation, Management and Restoration*. Surrey Beatty and Sons, Sydney.

Rodd, A.N. and Clements, A. (1994a)
*Flora Survey of Remnant Bushland Patches in Newcastle Local Government Area*. Prepared for Newcastle City Council.

Roy, P.S. and Boyd, R. (1996)
*Quaternary Geology of Southeast Australia: A Tectonically Stable, Wave-dominated, Sediment-deficient Margin. Field Guide to the Central New South Wales Coast*. International Geological Correlation Program Project 367. New south Wales Geological Survey, Sydney.

Russell, D. (1993)
*Preliminary Survey of Tree Decline (“Dieback”) in the Hunter Valley, NSW*. Report to the Hunter Catchment Management Trust, Maitland NSW.

Sattler, P. and Williams, R. (eds) (1999)
*The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency, Brisbane.

Saunders, D.A., Hobbs, R.J. and Margules, C.R. (1991)
Biological consequences of ecosystem fragmentation: A review. *Conservation Biology* 5 (1): 18-32.

Simberloff, D. (1993)
Fragmentation, Corridors, and the Longleaf Pine Community. Pp. 47-56 in C. Moritz and J. Kikkawa (eds) *Conservation Biology in Australia and Oceania*. Surrey Beatty and Sons, Sydney.

Simon, B.K. and Jacobs, S.W.L. (1999)
Revision of the genus *Sporobolus* (Poaceae, Chloridoideae) in Australia. *Australian Systematic Botany* 12: 375-448.

Smith, P.L. and Sivertsen, D. (2001)
Background Paper. Part A. Landscape Composition for the Maintenance of Biodiversity Values in Production-oriented Landscapes. NSW Department of Land and Water Conservation, Sydney.

Soul□, M.E. and Gilpin, M.E. (1991)
The Theory of Wildlife Corridor Capability. Pp. 3-8 in D. Saunders and R. Hobbs (eds) *Nature Conservation 2: The Role of Corridors*. Surrey Beatty and Sons, Sydney.

Specht, R.L., Specht, A., Whelan, M. and Hegarty, E.E. (1995)
*Conservation Atlas of Plant Communities in Australia*. Southern Cross University Press, Lismore.

Spencer, R.D. and Lumley, P.F. (2002)
*Callistemon*. Pp. 193-198 in G. Harden (ed) *Flora of New South Wales. Volume 2*. Revised edition. Royal Botanic Gardens Sydney and University of New South Wales Press, Sydney.

Staheyeff, N. and Peake, T. (in prep.)
Tree dieback status in the Hunter Catchment. Hunter Catchment Management Trust, Tocal.

Story, R., Galloway, R.W., van de Graaff, R.H.M. and Tweedie, A.D. (1963a)
*General Report on the Lands of the Hunter Valley. Land Research Series No. 8.* CSIRO, Melbourne.

Story, R., Galloway, R.W. and van de Graaff, R.H.M. (1963b)
Land Systems of the Hunter Valley. Pp. 13-61 in R. Story, R. Galloway, R. van de Graaf and A. Tweedie (eds) *General Report on the Lands of the Hunter Valley. Land Research Series No. 8.* CSIRO, Melbourne.

SWC Consultancy (1995)
*Flora and Conservation Assessment for Proposed Rezoning for Avalon Forest Estate, Thornton*. Prepared for Hilltop Planners Pty Ltd.

Tame, T. (1984)
*Vegetation of the Hunter Valley. Volumes 1 & 2*. Unpublished report.

Tame, T. (1992)
Evolution of the Hunter Valley. *Hunter Natural History* 50: 1-7.

Terborg, J. (1976)
Island biogeography and conservation strategy and limitations. *Science* 193:1029-1030.

Thackway, R. and Cresswell, I.D. (1995)
*An Interim Biogeographic Regionalisation for Australia: A Framework for Setting Priorities in the National Reserves System Cooperative Program*. Australian Nature Conservation Agency, Canberra.

Thomas, D. (1998)
*Vegetation Communities of the Singleton Military Area*. Unpublished report to the Department of Defence.

Turner, J.C. (1976)
An altitudinal transect in rain forest in the Barrington Tops area, New South Wales. *Australian Journal of Ecology* 1: 155-174.

Turner, J.C. and Vernon, S.L. (1990)
*Survey of Rainforest Stands between Barrington Tops and the Hunter River. Final Report*. Geography Department, University of Newcastle.

Turner, J.C. and Vernon, S.L. (1994)
Rainforest stands between Barrington Tops and the Hunter River, New South Wales. *Cunninghamia* 3 (3): 465-514.

Tweedie, A.D. (1963)
Climate of the Hunter Valley. Pp. 62-80 in R. Story, R. Galloway, R. van de Graaf and A. Tweedie (eds) *General Report on the Lands of the Hunter Valley. Land Research Series No. 8*. CSIRO, Melbourne.

Vernon, S.L. (1985)
Dry Rainforests of the Hunter Valley: A Comparative Study. Thesis for Bachelor of Arts with Honours, University of Newcastle.

Vernon, S.L. (1987)
*Hunter Valley River Bank Vegetation Research Project. Stage 1*. Report to the Hunter Catchment Management Trust, Maitland.

Vernon, S. (1991)
List of Native Species Recorded Adjacent to Four Mile Creek, Thornton. Attachment to letter dated 1st May 1991.

Walker, E.H. (1971)
Critical taxonomic changes concerning the plants of Okinawa and the southern Ryukyu Islands. *Journal of Japanese Botany* 46 (3): 65-72.

Walker, J. and Hopkins, M.S. (1990)
Vegetation. Pp. 58-86 in R. McDonald, R. Isbell, J. Speight, J. Walker and M. Hopkins (eds) *Australian Soil and Land Survey Field Handbook*. Inkata Press, Sydney.

Weston, P.H. (1999)
*Persoonia pauciflora* (Proteaceae), a new species from the Hunter Valley, New South Wales. *Telopea* 8 (2): 159-164.

Weston, P.H. (2002)
*Persoonia*. Pp. 4-20 in G. Harden (ed) *Flora of New South Wales. Volume 2*. Revised edition. Royal Botanic Gardens Sydney and University of New South Wales Press, Sydney.

Wheeler, D.J.B., Jacobs, S.W.L. and Whalley, R.D.B. (2002)
*Grasses of New South Wales*. 3rd edition. The University of New England, Armidale.

Williams, J. L. (1993)
*Casuarina glauca* (Swamp Oak): Aspects of its Distribution and Ecology in the Hunter Valley. Thesis for the Department of Geography, University of Newcastle.

Williams, J.B. (1996)
*Parsonsia*. Pp. 154-189 in A. Orchard (ed) *Flora of Australia. Volume 28. Gentianales*. Australian Biological Resources Study, Melbourne.

Wilson, E.O. and Willis, E.O. (1975)
Applied Biogeography. Pp. 522-534 in M. Cody and J.Diamond (eds) *Ecology and Evolution of Communities*. Harvard University Press, Cambridge.

Wood, A.W. (1972)
*Dawn in the Valley. The Story of Settlement in the Hunter River Valley to 1833*. Wentworth, Books, Sydney.

Woodhouse, J. and Worth, G. (2001) *Statement of Effect on Threatened Flora and Fauna for a Proposed Rezoning at Lot 1 DP631323, Lot 1 DP200772 and Part Lot 3 DP150052 East Maitland*. Report prepared for Pulver Cooper and Blackley by Wildthing Environmental Consultants, Salt Ash NSW.

Wylie, F.R. and Landsberg, J. (1989)
Rural tree decline in Australia. Extended abstract. *New Zealand Journal of Forestry Science* 19 (2/3): 306-307.

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