Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands

M.G. Tozer, K. Turner, D.A. Keith, D. Tindall[#], C. Pennay[#], C.Simpson, B. MacKenzie, P. Beukers and S. Cox

NSW Department of Environment & Climate Change, Scientific Sevices Division
PO Box 1967 Hurstville 2220 AUSTRALIA
[#]Present address: Qld Department of Natural Resources & Water, Qscape Building, 80 Meiers Rd Indooroopilly 4068

Abstract: Native vegetation of the NSW south coast, escarpment and southeast tablelands was classified into 191 floristic assemblages at a level of detail appropriate for the discrimination of Threatened Ecological Communities and other vegetation units referred to in government legislation. Assemblages were derived by a numerical analysis of 10832 field sample quadrats including 8523 compiled from 63 previous vegetation surveys. Past bias in the distribution of field data towards land under public tenure was corrected by extensive surveys carried out on private land. The classification revises and integrates the units described in recent vegetation studies of Eden, Cumberland Plain and Sydney-south coast into a single, consistent classification.

Relationships between floristic assemblages and climate, terrain, substrate and vegetation structure were used to map the distribution of communities prior to clearing at 1:100 000 scale. The extent of clearing was mapped using interpretations of remote imagery (1991–2001) from previous work, standardised and merged into a single coverage and supplemented with additional work. Profiles for each assemblage, which we term 'communities' or 'map units', describe their species composition, vegetation structure, environmental habitat, the extent of clearing and conservation status. Lists of diagnostic species were defined using a statistical fidelity measure and a procedure for using these for community identification is described.

Approximately 66% of the study area retains a cover of native vegetation, primarily in areas with low fertility soils and dissected topography. Communities subject to over-clearing (>70%) are concentrated in a few large areas characterised by clay/loam soils and flat to undulating terrain. These include the Sydney metropolis, Wingecarribee Plateau, Illawarra Plain, Shoalhaven floodplain, Araluen Valley and Bega Valley, and various smaller river valleys. Forty-one percent of remaining native vegetation is protected within conservation reserves while 31% occurs on private land, 20% in State Forests and 8% on other Crown lands. Forty-five Threatened Ecological Communities (TECs) were recorded in the study area. The majority of TECs are represented by a single map unit, although in some cases a TEC is included within a broader map unit. Twelve TECs are represented by combinations of two or more map units.

The full text, additional appendices and maps are provided on an accompanying CD.

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Introduction

Native vegetation classifications and maps are widely used as a surrogate for biological diversity in landscape-level planning applications in NSW. Recent applications include the development of Regional Planning Strategies by the NSW Department of Planning; revision of Local Environmental Plans by local governments under the *Environmental Planning & Assessment Act 1979*; establishment, planning and management of conservation reserves under the *National Parks and Wildlife Act 1974*; management of water catchments under the *Sydney Water Catchment Management Act 1998*; assessment, listing and recovery of threatened ecological communities under the *Threatened Species Conservation Act* 1995; forestry reforms under the *National Forest Policy Statement 1992*; the setting of catchment-level targets and performance evaluation for vegetation management under the *Catchment Management Authorities Act 2003*; and monitoring, evaluation and reporting against native vegetation targets under the *NSW State Plan*. In addition to these fundamental strategic roles in landscape-scale planning, vegetation classifications and maps can provide useful contextual guidance for site-scale assessment of native vegetation, in tandem with appropriate field inspection.

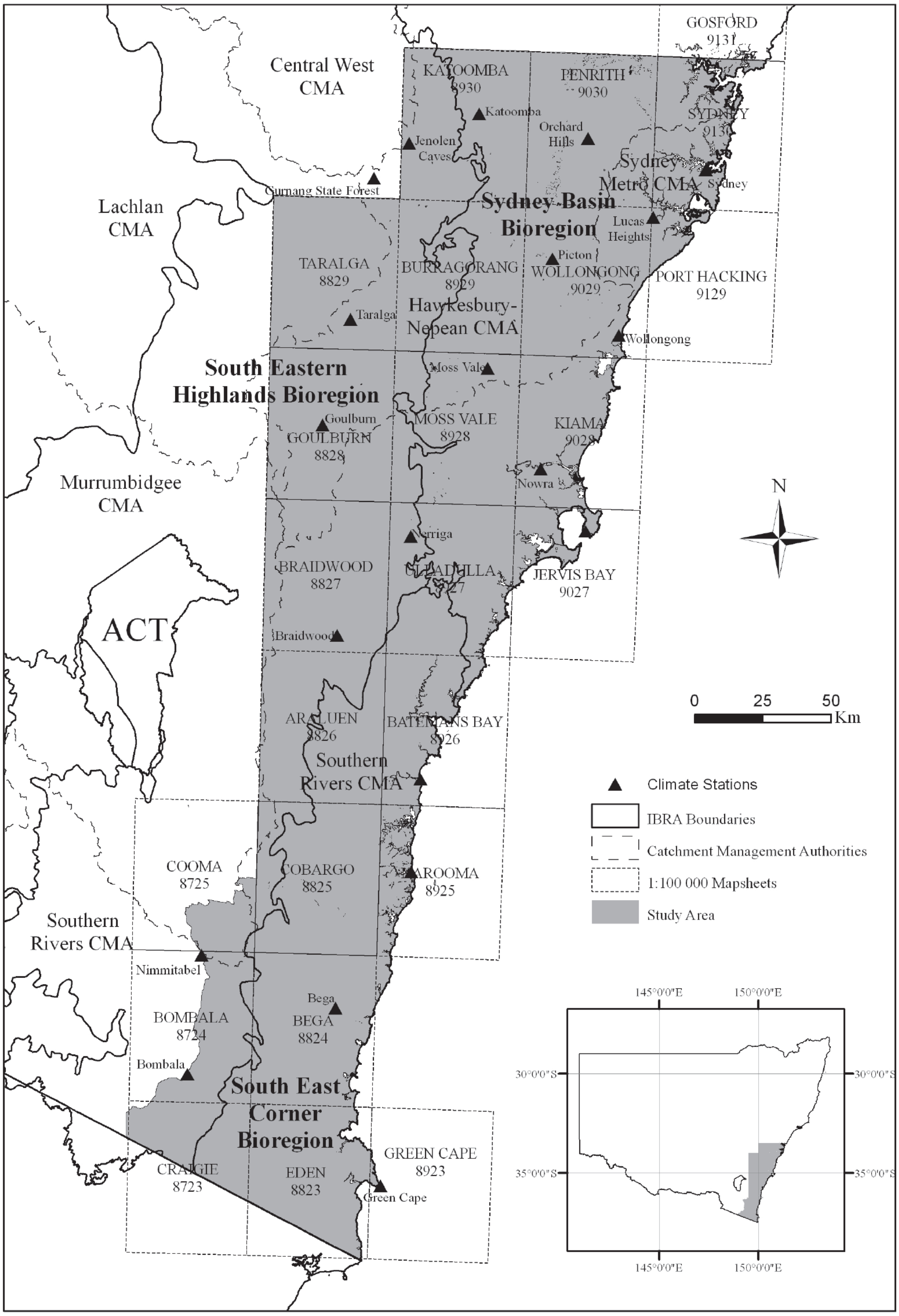


Fig. 1. Map of the study area showing the boundaries of bioregions, Catchment Management Areas, 1:100 000 map sheets and the location of weather stations referred to in Table 1.

If vegetation classifications and maps are to perform their roles effectively, they must closely represent landscape patterns in a regional biota (i.e. they must be realistic surrogates for biodiversity) and be robust to improvements in knowledge. The classifications and maps of vegetation that produce the most robust and informative generalisations about species distributions are those founded on quantitative sampling and analysis of biota (e.g. Rodwell *et al.* 2002) and systematic integration of compositional data with spatial data (e.g. Keith & Bedward 1999). The more comprehensive and more evenly stratified the sampling, the more robust and more representative of ecological patterns the resulting classifications and maps will be (Nicholson *et al*. 2009).

Systematic classification and mapping approaches were first applied to relatively small areas (Myerscough and Carolin 1986; Keith 1994). Surveys of conservation reserves in NSW now routinely involve quantitative sampling and numerical classification of vegetation, although a variety of approaches to the integration of floristic compositional data with spatial data have been used in map production (e.g. Clarke *et al*. 2000; Westbrooke *et al.* 1998; Keith *et al*. 2007) Hunter & Sherringham 2008. Systematic classification and mapping approaches were extended to regional scales in the NSW wheat belt (Sivertsen and Metcalfe 1995) and to forested regions of the coast and tablelands (Keith & Sanders 1990; Keith & Bedward 1999; Gellie 2005) as part of the Regional Forest Agreement process (Commonwealth of Australia 1992). The principles of systematic classification and mapping were subsequently adopted in a state-wide Native Vegetation Mapping Program (NVMP) for NSW (Sivertsen & Smith 2001) and continue to be applied in an expanding range of landscapes within the state (Benson & Ashby 2000; Ismay *et al*. 2004; McNellie *et al.* 2005; Tozer 2003; Peake 2005; Wall 2006).

The work presented here is the third revision of a vegetation classification and map originally produced for the NVMP and previously only available in unpublished form (Tindall *et al.* 2004; Tozer *et al.* 2006). Revision has included integration with the Eden region vegetation classification and map of Keith & Bedward (1999), and inclusion of additional recent field survey and spatial data.

In this paper, we demonstrate the feasibility of applying a systematic approach to classification and mapping of native vegetation across a large, physiographically complex and botanically diverse region extending over 4 million hectares from northern Sydney and the Blue Mountains to the NSW-Victorian border. Our aim was to produce a consistent regional typology and map of native vegetation to support various regional planning functions, which have included the development of biodiversity targets under the *Catchment Management Authorities Act 2003* and the development of Regional Planning Strategies for the Illawarra and South Coast regions. To support these planning functions, mapping of vegetation was required to produce accurate and robust estimates of the current extent and historical reduction in community distributions, although not necessarily a high level of fine-scale accuracy to support highly localised interpretation throughout the 4 million hectares.

To produce a vegetation classification and map, we synthesised a substantial base of floristic sample data and remote image interpretation from previous studies, and carried out additional field sampling and aerial photograph interpretation to fill gaps, enhance spatial resolution and update recent changes in land cover. We analysed the combined floristic data using a suite of numerical methods to produce a unified native vegetation classification for the study area. We then used the classified field samples to quantify the occurrence of each community in relation to combinations of aerial photo-pattern, substrate, topography and climate, and applied these relationships to spatial data layers to map the distribution of communities across southeast NSW. Remote image interpretations of clearing patterns were then used to trim these distributions to their current extent. Finally, we present novel descriptions and assessments of the classification and map to assist users in the diagnosis of plant communities and to understand the suitability of the classification and map for various applications.

Study Area

The study area is located between latitudes 33°30'S and 37°30'S and longitudes 149°00'E and 151°30'E in southeast New South Wales and is bounded by the coast from northern Sydney to the Victorian border and the escarpment and tablelands from the Blue Mountains to Delegate (Fig. 1). It comprises 4 006 650 hectares on twenty-three 1: 100 000 scale map sheets.

The study area covers all of the South Coast Botanical Subdivision as well as parts of the Central Coast (CC), Central Tablelands (CT) and Southern Tablelands (ST) (Harden 1990). The entire South East Corner bioregion in NSW is included, as well as parts of the Sydney Basin and South Eastern Highlands bioregions (Thackway & Cresswell 1995). The study area overlaps seven Catchment Management Authorities (CMAs), including the entire Sydney Metropolitan CMA and significant portions of the Hawkesbury/Nepean, Southern Rivers, and Lachlan CMAs. Minor areas of the Murrumbidgee, Central West and Hunter/Central Rivers CMAs overlap the periphery of the study area.

Topography

The coast of the study area features a narrow and interrupted coastal plain, which is most extensive east of Nowra on the Shoalhaven floodplain. Elsewhere it is confined to narrow strips of low-lying land, such as the Illawarra Plain, and is typically associated with coastal embayments, freshwater lagoons and lakes subject to intermittent tidal flushing. Narrow strips of floodplain extend inland along the lower reaches of larger rivers such as the Clyde, Moruya and Bega rivers.

In the north, the Sydney Basin is the dominant topographic feature, stretching from beyond the northern boundary of the study area, south to the Clyde River with an outer rim largely defined by the extent of the Morton, Woronora, Hornsby and Blue Mountains plateaux. These heavily dissected, elevated plateaux contrast with the Cumberland Plain, an expansive, low-lying coastal plain centrally located within the basin to the west of Sydney. The Blue Mountains Plateau rises steadily west of the Cumberland Plain as far as the Cox and Wollondilly River valleys. On the southeast margin of the basin, the Woronora Plateau rises in a ramp from the Nepean River to form an escarpment running roughly parallel to the coast from Port Hacking to the Budderoo Plateau. South of the Shoalhaven River the coastal hinterland is dominated by the Morton Plateau which extends south to the Clyde River valley. Like the Blue Mountains Plateau, the Morton Plateau is dissected by numerous streams and forms a west-east incline from the upper Shoalhaven River to the coast.

South of the Sydney Basin a coastal range rises to 300 – 600 m above sea level, punctuated by individual peaks up to 900 m (e.g. Mount Dromedary). Further west, an undulating hinterland featuring several rain shadow valleys, including those of the Araluen, Bega and Towamba Rivers, ends abruptly at the foot slopes of a rugged escarpment rising to form a mountain range (700–1000m) that marks the eastern edge of the southern tablelands. These tablelands are a very extensive undulating landscape, punctuated by low hills and exceeding 1300 m elevation on parts of the Great Dividing Range. The southern tablelands extend from west of the Blue Mountains southwards to the Monaro tableland.

Geology

The study area is dominated by the Sydney geological basin in the north and the older Lachlan fold belt in the south and along the western fringe (Branagan & Packham 2000). The Sydney basin comprises horizontal sediments of Triassic and Permian age. The youngest rocks, the Wianamatta shales, are found in the centre of the basin on the Cumberland Plain, with successively older rocks outcropping in a concentric pattern. The Wianamatta group comprises mainly siltstones, mudstones and claystones that yield moderately fertile clay loams. These contrast with very infertile sandy loams derived from the Hawkesbury sandstones found on the elevated plateaux that surround the plain. Further toward the margins of the basin, the Hawkesbury formation is succeeded by underlying rocks of the Triassic Narrabeen group and Permian Shoalhaven group. Both of these groupings comprise massive sandstone strata interbedded with narrower bands of claystone, siltstone and mudstone. These latter rocks weather more rapidly than the sandstones, and undercutting results in

Table 1: Summary of climate statistics for 21 selected weather stations within the study area (Bureau of Meteorology 2004).

Location	Region	Altitude (m)	Mean daily max temp (°C) (Jan)	Mean daily min temp (°C) (July)	Mean annual no days min ≤ 0.0 °C	Lowest mean monthly rainfall (mm)	Highest mean monthly rainfall (mm)	Mean annual rainfall (mm)
1. Sydney (Observatory Hill)	Sydney coastal	39	25.8	8	0	69.2 (Sep)	131.5 (Mar)	1219.8
2. Orchard Hills Treatment Works	Cumberland Plain	93	28.3	5.3	1.1	38.7 (Sep)	110.2 (Feb)	821.6
3. Lucas Heights (ANSTO)	Woronora plateau	140	25.9	6.6	0.1	51.9 (Sep)	117.9 (Mar)	1036.4
4. Katoomba (Narrowneck Rd)	Upper Blue Mountains	1030	23.1	2.5	13.1	72.9 (Sep)	173.7 (Feb)	1402.3
5. Oberon (Jenolan Caves)	Central gorges	730	25.6	0.2	50.4	66.7 (May)	93.8 (Jan)	966.2
6. Gurnang State Forest	Central tableland	1148	22.8	-1.6	98.4	72.7 (Apr)	94.4 (Jun)	991.7
7. Taralga (Post Office)	Central tableland	845	25.7	0.6	50.2	60.8 (Apr)	74.6 (Jun)	806.1
8. Picton (Council Depot)	Cumberland plain	165	29.3	3.2	32.4	44.0 (Sep)	88.8 (Mar)	806.2
9. Wollongong (University)	South coast lowlands	25	25.6	8.4	0	60.5 (Jul)	173.0 (Mar)	1354
10. Moss Vale (Hoskins St)	Southern highlands	675	25.8	1.3	31.1	60.7 (Sep)	99.8 (Jun)	976
11. Goulburn (Progress St)	Southern tableland	702	28.1	1.3	32.8	47.8 (Jul)	64.8 (Jan)	665.7
12. Braidwood (Wallace St)	Southern tableland	643	26	-0.2	59	47.5 (Jul)	71 (Jan)	722.8
13. Nerriga Composite	Southern tableland	630	26.1	0.2	58.5	54.6 (Sep)	76.1 (Mar)	767.8
14. Nowra (RAN Air Station)	South coast lowlands	109	25.8	6.2	0.1	55.7 (Jul)	130.4 (Mar)	1134.7
15. Jervis Bay (Point Perpendicular Lighthouse)	South coast lowlands	85	23.8	9.2	0.2	79.5 (Sep)	134.2 (May)	1245.4
16. Moruya Heads (Pilot Station)	South coast lowlands	17	23.9	5.9	0.1	54.3 (Aug)	109.3 (Mar)	963.2
17. Narooma Royal Volunteer Coastal Patrol	South coast lowlands	25	23.3	6.4	0	49.3 (Jul)	106.7 (Mar)	912.3
18. Nimmitabel (Post Office)	Southern Tablelands	1075	22.8	-1.9	104.1	46.9 (Aug)	68.7 (Jan)	690.6
19. Bombala (Therry St)	Southern Tablelands	705	25.2	-1.2	73.6	40.7 (Aug)	64.9 (Jan)	645.3
20. Bega (Newtown Rd)	Far South Coast	50	27.0	1.4	33.9	51.0 (Aug)	96.5 (Mar)	864.1
21. Green Cape Lighthouse	Far South Coast	20	21.6	8.4	0	45.6 (Aug)	78.2 (Jan)	749.7

the formation of sandstone cliffs that are characteristic of the western Blue Mountains, Illawarra escarpment and Morton plateau.

The Sydney basin unconformably overlies the Lachlan fold belt, which comprises contorted and variously metamorphosed rocks of Devonian, Silurian and Ordovician age (Branagan & Packham 2000). Primarily, these are metamorphosed mudstones, sandstones, conglomerates, slates, cherts, phyllites and quartzites. These rocks yield loamy soils of moderate fertility and outcrop over much of the area from south of the Victorian Border and northwards along the tableland beyond Taralga. The tableland also includes significant areas of acid volcanic rocks such as porphyry, tuff, rhyolite, andesite and felsite, particularly along the gorges of the Wollondilly and Shoalhaven rivers where the soils are relatively infertile loams. Localised outcrops of rhyolite are also found near Deua River, Tathra and to the north-west and south of Eden. Restricted outcrops of limestone occur at Jenolan, Abercrombie, Wombeyan, Bungonia, Wyanbene and Bendethera caves. These rocks weather to clay loams, rich in calcium. The Lachlan fold belt also includes large granite intrusions west of the Blue Mountains and Marulan and Braidwood (Bathurst batholith), and from Moruya south to the Victorian border (Bega batholith). These igneous intrusions include a great variety of granites, leucogranites, adamellites and granodiorites that produce sandy loams of varied nutrient status.

Basic volcanic rocks are relatively restricted, although significant basalt flows are found on the Kiama lowlands, the Robertson plateau, Taralga, Crookwell and the Monaro Tableland. Residual basalt caps occur on various peaks along the escarpment, including Mt Wilson and Mt Tomah in the Blue Mountains and Sassafras on the Morton plateau. The Blue Mountains also contain some highly localised diatremes, which mark the site of volcanic vents now filled with breccia. Further south, localised outcrops of basalt occur at Mt Darragh, Bull Mountain, Brown Mountain and Nethercote. The soils derived from basalts and dolerites are clays rich in a variety of mineral nutrients.

Unconsolidated sediments of Tertiary and Quaternary age occur along the coast and in localised sites on the tableland. The Tertiary deposits are associated with old streams and their floodplains. They comprise low-nutrient gravels, sands and clays and are mainly restricted to small areas on the Cumberland Plain and in the upper Shoalhaven River catchment. The coastline includes several sand plains of marine origin and a few small areas of perched aeolian dunes. Examples include the sand plains around Botany Bay and Port Hacking, Seven Mile Beach, Jervis Bay, Disaster Bay and the mouths of Burrill and Tabourie Lakes. These are sandy soils, whose fertility declines rapidly with age and distance from the salt-laden sea winds. Rich fluvial sediments are associated with the active floodplains of the coastal rivers. The largest areas are associated with the Hawkesbury River between Windsor and Camden, the Shoalhaven River downstream of Nowra, and the Bega and Moruya floodplains, although there are many other occurrences on the floodplains of smaller streams. These floodplains support deep nutrient-rich silts. Small areas of Quaternary alluvium also occur in the headwaters of streams where slopes are sufficiently flat to permit accumulation of sediment. These areas are typically boggy and may develop acid peats, as seen at Wingecarribee Swamp, Hanging Rock Swamp and numerous examples in the Blue Mountains and on the Woronora Plateau. However, the largest areas of alluvium on the tableland are Lake Bathurst, The Morass and the Mulwarree-Breadalbane plains, which have accumulated sediments from their respective closed drainage basins.

Climate

Most of the study area experiences a temperate climate featuring warm summers and cool winters on the coast and mild/warm summers and cold winters on the ranges and tablelands. The coastal lowlands around Sydney are at the southern limit of the north coast subtropical climate zone (Stern, de Hoedt & Ernst, 1999) and experience warmer, more humid summers than coastal areas further south. At the other extreme, areas of high elevation on the Gourock Range and Boyd Plateau fall within a montane cool temperate zone characterised by mild summers and occasional snow in winter. Daily and annual temperature variations are least in coastal areas, which also experience few frost days. Large areas of the tablelands experience on average 30–50 frost days per annum, while the Boyd Plateau experiences approximately 100 frost days per annum. Climate statistics from selected weather stations across the study area (Fig. 1) are presented in Table 1 (Commonwealth Bureau of Meteorology 2004).

Table 2: Cover/abundance scores for 6 and 7 class modified Braun-Blanquet scales.

Cover/abundance score	6 class scale	7 class scale
1	Uncommon and cover < 5%	Rare, one or few individuals present and cover < 5%
2	Common and cover < 5%	Uncommon and cover < 5%
3	5% ≤ cover < 20%	Common and cover < 5%
4	20% ≤ cover <50%	Very abundant and cover < 5%; or 5% ≤ cover < 20%
5	50% ≤ cover <75%	20% ≤ cover <50%
6	75% ≤ cover <100%	50% ≤ cover <75%
7	-	75% ≤ cover <100%

Precipitation varies across the study area in relation to altitude and distance from the coast, with higher rainfall areas found closer to the coast or at higher elevations. On the coastal lowlands, rainfall is generally higher in the north (>1000 mm per annum) than south of Batemans Bay (750 – 900 mm per annum). Orographic effects are particularly marked on the coastal escarpment between Nowra and the Royal National Park, the upper Blue Mountains, the southern escarpment from the Budawang Range to the Victorian border, including the Gourock Range, and isolated peaks on the coastal range. These areas receive on average at least 1100 mm of rainfall per year, with highest mean annual tallies exceeding 2000 mm at Barren Grounds. A number of rain shadow areas, where mean annual precipitation declines below 900mm (Table 1), occur among coastal plateaux and foothills, including the Cumberland Plain and the Araluen, Bega and Towamba valleys. The Monaro tableland in the far south-west of the study area is the driest rain shadow area, where mean annual precipitation falls below 600mm around Numeralla and Bombala. Throughout much of the area, rainfall is typically weakly seasonal with late summer months having higher rainfall, on average, than months from late winter to early spring.

Methods

Evaluation of Floristic Survey Data

Existing vegetation survey data were compiled from literature and databases held by land management agencies (e.g. Councils, Sydney Catchment Authority, State Forests of NSW, Department of Environment and Conservation; see Appendix 4). The following criteria were used to identify suitable quadrat data for analysis: i) the plot location was accurately recorded ($\pm$100m); ii) all vascular plant species were recorded with Braun-Blanquet cover/abundance estimates on either a 6 or 7 class scale (Table 2, Poore 1955, Sivertsen & Smith 2001); and iii) the quadrat area was 0.04 ha. A small number of eligible quadrats with larger dimensions (i.e. 0.1 ha) or without cover/abundance estimates were included in the data set where they sampled areas from which no other data were available.

Sample Stratification and Site Selection

New field sampling was carried out to increase the representation of environmental diversity of the study area. South from Batemans Bay, new sampling was primarily targeted at conservation reserves to verify existing regional vegetation maps (Keith & Bedward 1999, Gellie 2005), whereas further north new sampling covered all tenures and targeted sampling gaps on private land. Environmental diversity was represented in a Geographic Information System (GIS) by seven spatial variables on a 25m grid; terrain class (500m), aspect, slope, minimum temperature of the coldest period, maximum temperature of the warmest period, annual precipitation, and lithology (see Table 4 for explanation of variables). Environments that were under-represented by existing samples were identified by computing p-median scores (Faith & Walker 1996) which calculate the environmental dissimilarity of a point in the landscape compared with the most similar location represented by existing samples. P-median scores were interpolated for the entire study area based on 10 000 randomly selected locations (Ferrier 2002). Areas with the highest p-median values were given priority in the selection of new sample locations. The procedure was repeated iteratively throughout the survey period as new samples were acquired and the field survey plan was adjusted accordingly.

Field Sampling

Fieldwork was carried out from January 2001 until December 2006, with a total of 2309 new samples recorded. A Global Positioning System (GPS) device was used to navigate to chosen sample locations. Where necessary, the location was adjusted to ensure that the site characteristics matched the specified stratification parameters, that the terrain and soils were reasonably uniform across the plot and to avoid cleared areas. Additional sites were sampled if there appeared to be more than one type of vegetation community in the vicinity of the chosen location. Square survey quadrats of 0.04 ha were marked out using tape measures except where a rectangular configuration of the same area was required to ensure homogeneity of terrain and soils across the plot (e.g. along stream banks).

All vascular plant species rooted within or overhanging the quadrat were recorded and assigned a cover/abundance score. For historical reasons, the existing data sets south of Batemans Bay were based primarily on a 6-class Braun – Blanquet cover-abundance scale (Poore 1955, see Table 2), while those further north used a 7-class scale. To maximise compatibility with existing regional data sets, we continued to collect 6- and 7-class cover-abundance estimates in the north and south, respectively. The height range and projected foliage cover were estimated for all structural strata recognisable at the site (e.g. tree, small tree, shrub or forb), and a compass and clinometer were used to measure the aspect and slope at the centre of the quadrat, as well as horizon elevations at compass bearings of 0, 45, 90, 135, 180, 225, 270 and 315°. The location and elevation of the site were determined in the field using 1:25 000 topographic maps and/or a GPS. The soil type was determined by hand-texturing. Evidence of rock out-cropping, erosion, weed invasion, logging, soil disturbance or recent fire was noted.

Plant species that could not be identified in the field were collected for later identification. Where necessary, collections were sent for identification to the National Herbarium of NSW. Specimens that could not be identified to species level were not included in the analysis. Suitable voucher specimens were lodged at the Janet Cosh Herbarium (University of Wollongong) or the National Herbarium of

NSW. Nomenclature was standardised to follow Harden (1990 – 2002) and Flora Online [*plantnet.rbgsyd.nsw.gov.au/floraonline.htm]*. Exotic species were recorded but excluded from classification analysis.

Data Checking and Taxonomic Standardisation

Several data checking procedures were used to identify errors in the species recorded and spatial location of survey sites. Wherever possible, digital survey data were systematically checked against the original field data sheets to correct errors in data entry. The altitude of each survey site was estimated from its grid co-ordinates on a 25m digital elevation model for comparison with the corresponding value read from a map by the field observer. Where a discrepancy of more than 25m existed, or where no field value was recorded then the site location was cross-checked using the text descriptions on the data sheet and/or consultation with the observer. If the location could not be resolved to within 100m then the site was discarded. Grid references were compared among sites to identify and exclude any duplicate entries in the database.

Potential errors in species identification were checked by comparing distributions from the field data with published habitat descriptions and distributions (Harden 1990–2002; NSW DEC 2004a). A Geographic Information System was used to sort the survey sites into NSW botanical sub-regions and a separate species list was compiled for survey data from each observer in each botanical sub-region. Taxa recorded outside their published range were retained in the data provided the identification was reliable (e.g. voucher specimen lodged in a herbarium), the record was ecologically plausible (e.g. habitat matched the known distribution or the new record was not spatially isolated), or if the range extension was consistently recorded by multiple reliable observers. All taxa were checked for synonyms and for consistency in the naming of subspecies among observers. Any anomalies were corrected prior to analysis.

Cluster Analyses and Classification of Plant Communities

The data set compiled for analysis was derived from numerous sources, with different observers typically sampling non-overlapping spatial and physiographic domains. To assess potential observer-related artefacts, a sequence of analyses was carried out in PATN (Belbin 1994), starting with a reliable core of data and expanding to include subsets of additional data. Each iteration comprised a series of checks to identify misclassified sites, outliers and other anomalies. The classification was compiled in two stages. Firstly, a preliminary classification was derived from samples with 7-class cover-abundance estimates (primarily from north of Batemans Bay). Secondly, an expanded classification was derived after these data were standardised to 6-class cover-abundance estimates and combined with a large set of additional data in this latter format (primarily from south of Batemans Bay). Where both cover and abundance estimates were recorded the conversion was as follows (c/a = 1→1; c/a = 2→2; c/a = 3→2; c/a = 4 AND cover < 5% →2; c/a = 4 AND 5% ≤ cover < 20% →3; c/a = 5→4; c/a = 6→5; c/a = 7→6). For survey data in which cover and abundance were not differentiated all scores of c/a = 4 were converted to c/a = 3.For both analyses, dissimilarity among survey sites was computed from unstandardised data using a symmetric form of the Kulczynski coefficient (Faith 1991).

In the preliminary analysis, hierarchical agglomerative clustering was carried out using a flexible unweighted pair group arithmetic averaging strategy with no adjacency constraint and ß=-0.1. Provisional groups of sites were identified from the resulting dendrogram by interpreting lineages in the manner described by Keith & Bedward (1999). Homogeneity analysis (Bedward *et al*. 1992) was used to determine a preliminary level for interpreting lineages. Sister groups were recognised as distinct if there were obvious differences in species composition (Westhoff & van der Maarel 1978) and either spatial distribution or habitat characteristics of the constituent samples.

A non-hierarchical cluster analysis (Belbin 1987) was then carried out on the same data set to identify misclassified samples and search for clusters that may not have been identified in the hierarchical analysis. Centroids were calculated for the provisional groups described above and samples were allocated to centroids on the basis of Kulczynski dissimilarity values. The provisional classification of any given sample was reviewed if the most similar group centroid differed from its provisional allocation, or if the sample lay outside a dissimilarity threshold of 0.8 from any existing group centroid. New groups were added to the provisional classification if they were distinct from existing groups in species composition and either spatial distribution or habitat characteristics. The provisional classification was modified iteratively by including additional datasets from north of Batemans Bay that had been recorded by other observers (non-core data sources).

A supplementary analysis was carried out to assess potential differences among observers in the estimation of cover scores. This analysis compared the provisional classification with an alternative unseeded, non-hierarchical classification (maximum radius of 0.8 and 20 iterations) of the same samples, in which all cover/abundance estimates had been transformed to unity (presence/absence). Provisional groups which were composed primarily of samples from one non-core source, and which dissipated in the alternative classification, were subjected to further analysis of their floristic and physiographic characteristics in order to justify their retention in the classification.

The second stage of the classification followed a similar, iterative process to that described above, with subsets of data from south of Batemans Bay progressively added to the core dataset which, for this second set of analyses, had been transformed to 6-class cover-abundance estimates. This stage included two iterative, non-hierarchical analyses (i.e.

seeds were recalculated following the allocation of samples). In the first, the provisional groups were used as seeds and the stability of these groups was examined following three iterations. In the second, random seeds were used to derive a classification independent of previous classifications, to examine the robustness of the provisional groups. Where samples from different groups in the provisional classification were allocated to a single grouping in the unseeded classification, these units were merged. Conversely, if samples from the same provisional group were allocated to multiple groups in the unseeded classification, then consideration was given to expanding the classification by recognising additional groups.

All potentially outlying samples with centroid dissimilarity values > 0.7 (approximately one standard deviation above the mean) were examined for anomalies in the number of species present, spatial location and data provenance relative to other group members. Samples suspected to be incomplete due to very low species numbers (i.e. less than half the group median), or other anomalies such as doubtful species identifications, were discarded.

Community Descriptions and Field Identification

Final groups of classified sites were used to characterise the properties of the communities. Names given to communities were derived from a composite of location (e.g. south coast, Burragorang, Sydney), landform (e.g. rocky slopes, ridge, lowlands) and vegetation structure (e.g. forest, woodland, heath). If no obvious geographic location could be chosen then a substrate descriptor was used instead (e.g. basalt, coastal sands, sandstone). If the assemblage was distributed over a variety of landforms then a climatic descriptor was used instead (dry, wet, temperate). Where the properties of a final group of classified sites matched the description of a Threatened Ecological Community listed on Schedule 2 of the *NSW Threatened Species Conservation Act* (1995) then the community was given that name.

The alpha-numeric codes used to label map units reflected the origin of each unit. Units corresponding closely with a unit described in either Keith & Bedward (1999) or Tindall *et al.* (2004) retained their original number prefaced by "e" or "p" respectively. New units were prefaced with either an "n" or "m".

Descriptions of vegetation structure were compiled for each community from statistical summaries of estimates of structural variables recorded in the survey data. The height and projected foliage cover for each vertical stratum of vegetation were averaged (±s.d.) across all sample sites assigned to the community (these data were not available for all sites). The frequency with which each stratum was encountered in samples of the community was also calculated.

Lists of diagnostic species were derived for each community to assist with its identification in the field. Positive diagnostic species occurred more frequently within a map unit than in other map units (hypergeometric probability < 0.001). In order to minimize the inclusion of unreliable species, those occurring with frequency < 0.2 (within the community) and coefficient of variation > 0.05 were excluded (Tozer 2003). For each community, an estimate was made of the minimum number of positive diagnostic species expected in any 0.04 ha sample of that map unit (95% confidence interval). Using this estimate, map users may identify (with 95% confidence) an unknown vegetation community by enumerating the number of positive diagnostic species occurring in a randomly selected field sample.

Table 3: Vegetation Structural Categories used to standardise existing API data and carry out new API

Vegetation Structure Code	Vegetation Structural Category
SF1	Tall Wet Sclerophyll Forest
SF2	Low Dry Sclerophyll Forest
SF3	Tall Dry Sclerophyll Forest
SF4	Swamp Sclerophyll Forest
SF5	Tall Intermediate Sclerophyll Forest (Wet/Dry Transition)
MX1	Mixed Woodlands
RF1	Rainforest
RF2	Rainforest with emergent (5–10% CCP) Sclerophyll Forest
RF3	Fig Dry Rainforest
SS1	Littoral Rainforest (Sutherland Shire)
RV1	Riparian Forest
RV2	Riparian Scrub
RV3	Riparian Complex
HH1	Dry Heath (sandy substrates)
HH2	Dry Heath (rocky substrates)
HH3	*Allocasuarina nana* dominated Dry Heath
HH4	Wet Heath (moist substrates)
RO1	Rocky Outcrops
RO2	Rock Pavement Complexes
CS1	Coastal Scrub (rocky substrates)
CS2	Coastal Scrub (sandy substrates)
EB1	Banksia Scrub (Eastern Suburbs)
FP1	Floodplain Forests
MT1	Melaleuca Thickets
FW1	Floodplain Wetlands
SW1	Sand plain Wetlands
MW1	Montane Wetlands
US1	Upland Swamps (hanging swamps etc)
BF1	Bogs/Fens
GL1	Grassland
GL2	Moist Graminoid Complex
GL3	Strand Grasslands
CP1	Cypress Pine
AC1	Acacia Scrub
EV1	Mangroves
EV2	Salt marsh Complexes
EV3	Seagrass
EX3	Pioneering Dry Shrubs/Regrowth

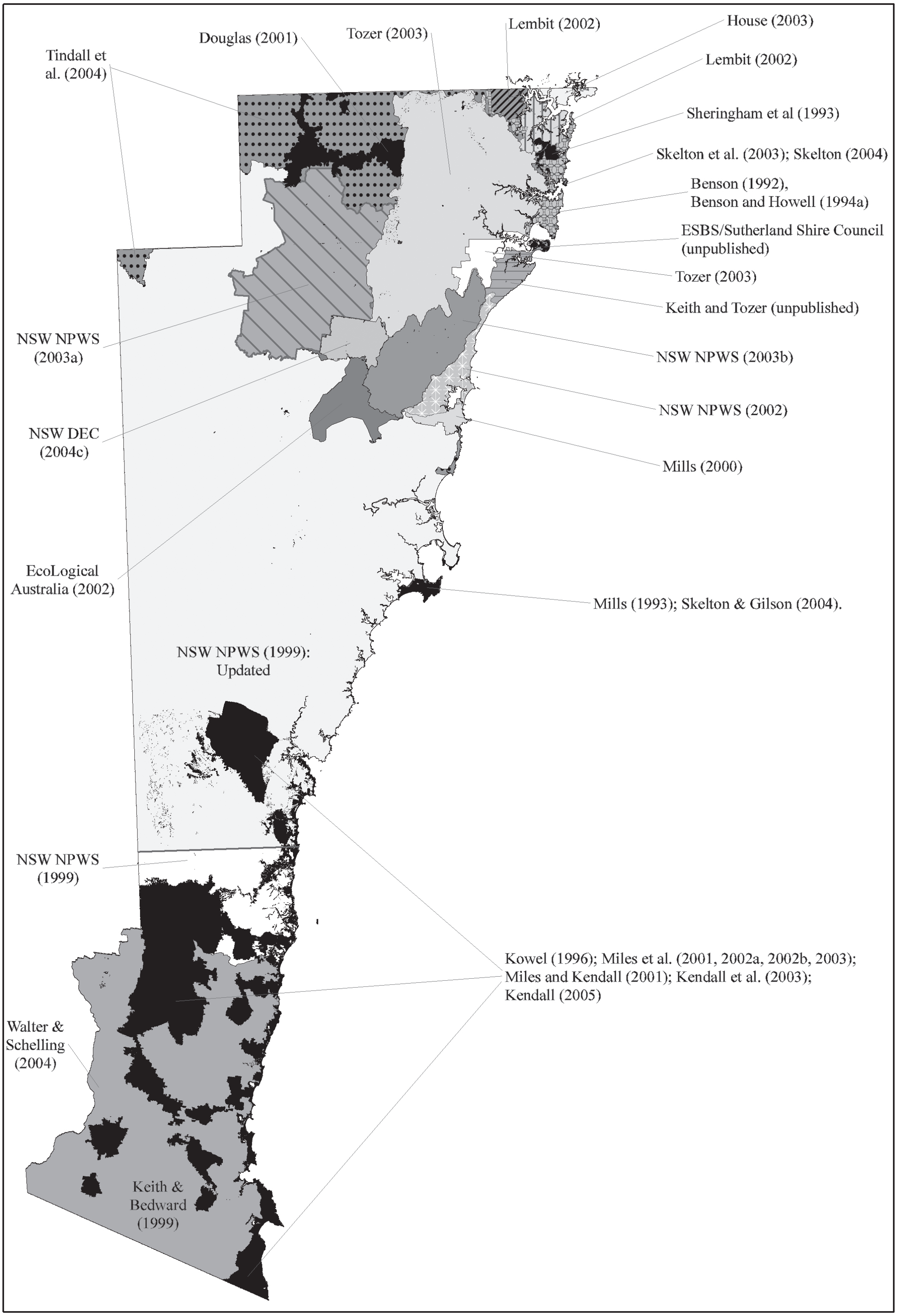


Fig. 2. Sources of API vegetation spatial layers compiled into a seamless coverage for the study area.

Table 4: Spatial data layers used in modeling the distribution of vegetation communities

Spatial Variable	Description
Location	
Easting	Australian Map Grid Easting, Zone 56.
Northing	Australian Map Grid Northing, Zone 56.
Distance to coast	Shortest distance to nearest point of the coastline (metres).
Distance to stream	Shortest distance to stream of any size (metres).
Distance to stream (order ≤4)	Shortest distance to stream of size order 4 or greater (metres).
Terrain	
Elevation	Elevation above sea level (metres).
Wetness index	Continuous index representing the volume of water draining to a given location (after Moore et al. 1993).
Neighbourhood topographic roughness (250 m)	Standard deviation of elevation of cells within a neighbourhood of 250 by 250 metres.
Neighbourhood topographic roughness (500 m)	Standard deviation of elevation of cells within a neighbourhood of 500 by 500 metres.
Neighbourhood topographic roughness (1000 m)	Standard deviation of elevation of cells within a neighbourhood of 1000 by 1000 metres.
Neighbourhood topographic position (250 m)	Difference in elevation between an individual cell and the mean elevation of cells in the surrounding neighbourhood of 250 by 250 metres.
Neighbourhood topographic position (500 m)	Difference in elevation between an individual cell and the mean elevation of cells in the surrounding neighbourhood of 500 by 500 metres.
Neighbourhood topographic position (1000 m)	Difference in elevation between an individual cell and the mean elevation of cells in the surrounding neighbourhood of 1000 by 1000 metres.
Local topographic position	A measure of the position of each grid cell on a continuum between ridge (value = 100) and gully (value = 0) (after Skidmore 1990).
Slope	Inclination from horizontal (degrees).
Solar radiation (June)	Solar radiation received in June and corrected for terrain and rainfall (Megajoules.metres^{-2}.Day^{-1}).
Solar radiation (July)	Solar radiation received in July and corrected for terrain and rainfall (Megajoules.metres^{-2}.Day^{-1}).
Aspect (degrees)	Deviation from grid north of the horizontal component of the slope vector (in degrees).
Aspect index (southness)	Continuous index (0 – 100) calculated as 100 times sine of half of the aspect value (flat sites assigned missing values).
Aspect index (eastness)	Continuous index (0 – 100) calculated as 100 times sine of the aspect value in radians (flat sites assign missing values).
Ordinal Aspect Class (NNE)	Categorical index of aspect measured from NNE.
Ordinal Aspect Class (N)	Categorical index of aspect measured from N.
Substrate	
Soil landscapes	Integrated soil/topography classes from soil landscape maps.
Soil landscape lithology	Derived from soil landscape maps, dominant lithology classified as: high quartz sedimentary; low quartz sedimentary; transitional sedimentary; recent alluvium; inactive alluvium; coastal/marine sands; basaltic; granitic; acid volcanic; limestone; aeolian sediments; and excavated/filled land.
Geological formation	Geological formation responsible for surface soil features from geological/metallogenic maps (111 categories).
Geological group	Major groups of geological formations (12 categories Sydney Basin only).
Geological age	Age of geological formations (18 categories).
Geological lithology	Dominant lithology classified as: high quartz sedimentary; low quartz sedimentary; recent alluvium; inactive alluvium; coastal/ marine sands; basaltic; granitic; acid volcanic; limestone; and aeolian sediments derived from geological/metallogenic maps.
Coastal Quaternary Geology	Areas of coastal Quaternary sediment cover classified into broad classes: beach, dune, dune on rock, estuarine, dune wetland, saline wetland, riverine wetland, other alluvium, or covered by standing water.
Contemporary Vegetation Cover	
Vegetation structure	Vegetation structural categories derived from interpretation of recent remote imagery (see Table 3).
Climate	
Annual Mean Temperature	The mean of all the weekly mean temperatures. Each weekly mean temperature is the mean of that week's maximum and minimum temperature.
Mean Diurnal Range (Mean (period max-min))	The mean of all the weekly diurnal temperature ranges. Each weekly diurnal range is the difference between that week's maximum and minimum temperature.
Isothermality	The mean diurnal range divided by the Annual Temperature Range.
Temperature Seasonality (CV)	The temperature Coefficient of Variation (CV) is the standard deviation of the weekly mean temperatures expressed as a percentage of the mean of those temperatures (i.e. the annual mean). For this calculation, the mean in degrees Kelvin is used. This avoids the possibility of having to divide by zero, but does mean that the values are usually quite small.

Spatial Variable	Description
Max Temperature of Warmest Period	The highest temperature of any weekly maximum temperature.
Min Temperature of Coldest Period	The lowest temperature of any weekly minimum temperature.
Temperature Annual Range	The difference between the Max Temperature of Warmest Period and the Min Temperature of Coldest Period.
Mean Temperature of Wettest Quarter	The wettest quarter of the year is determined (to the nearest week), and the mean temperature of this period is calculated.
Mean Temperature of Driest Quarter	The driest quarter of the year is determined (to the nearest week), and the mean temperature of this period is calculated.
Mean Temperature of Warmest Quarter	The warmest quarter of the year is determined (to the nearest week), and the mean temperature of this period is calculated.
Mean Temperature of Coldest Quarter	The coldest quarter of the year is determined (to the nearest week), and the mean temperature of this period is calculated.
Annual Precipitation	The sum of all the monthly precipitation estimates.
Precipitation of Wettest Period	The precipitation of the wettest week or month, depending on the time step.
Precipitation of Driest Period	The precipitation of the driest week or month
Precipitation Seasonality (CV)	The Coefficient of Variation (CV) is the standard deviation of the weekly precipitation estimates expressed as a percentage of the mean of those estimates (i.e. the annual mean).
Precipitation of Wettest Quarter	The wettest quarter of the year is determined (to the nearest week), and the total precipitation over this period is calculated.
Precipitation of Driest Quarter	The driest quarter of the year is determined (to the nearest week), and the total precipitation over this period is calculated.
Precipitation of Warmest Quarter	The warmest quarter of the year is determined (to the nearest week), and the total precipitation over this period is calculated.
Precipitation of Coldest Quarter	The coldest quarter of the year is determined (to the nearest week), and the total precipitation over this period is calculated.
Annual Mean Radiation	The mean of all the weekly radiation estimates.
Highest Period Radiation	The highest radiation estimate for all weeks.
Lowest Period Radiation	The lowest radiation estimate for all weeks
Radiation Seasonality (CV)	The Coefficient of Variation (CV) is the standard deviation of the weekly radiation estimates expressed as a percentage of the mean of those estimates (i.e. the annual mean).
Radiation of Wettest Quarter	The wettest quarter of the year is determined (to the nearest week), and the average radiation over this period is calculated.
Radiation of Driest Quarter	The driest quarter of the year is determined (to the nearest week), and the average radiation over this period is calculated.
Radiation of Warmest Quarter	The warmest quarter of the year is determined (to the nearest week), and the average radiation over this period is calculated.
Radiation of Coldest Quarter	The coldest quarter of the year is determined (to the nearest week), and the average radiation over this period is calculated.

Threatened Ecological Communities and Threatened Flora

Several Threatened Ecological Communities (TECs) listed under either NSW (*Threatened Species Conservation Act* 1995) or Australian (*Environment Protection and Biodiversity Conservation Act* 1999) government legislation are known to occur within the study area. Some estuarine and marine plant communities may also be Protected Marine Vegetation under the NSW *Fisheries Management Act* 1994. Relationships between communities described in this study and those listed as threatened were investigated by comparing the descriptions of their corresponding properties (i.e. characteristic species, habitat and distribution).

Relationships with other classifications

Relationships between the communities described here and those described in previous classifications were explored by comparing the allocation of samples to units in the respective classifications. Comparisons were restricted to previous classifications that covered appreciable portions of the study area (Fig. 1), incorporated a substantial set of shared samples and were derived from similar numerical clustering methods to those described here. These included surveys of the Southeast forests region (Keith & Bedward 1999), Southern Comprehensive Regional Assessment (Gellie 2005), Illawarra (NSW NPWS 2002) and Warragamba Special Area (NSW NPWS 2003a). Comparisons were made by obtaining the allocations of samples to classification units made by each author and compiling cross-tabulation matrices of sample numbers assigned to each pair-wise combination of units from the respective classifications. Matrices were range-standardised by row and column totals in turn to highlight points of correspondence between classifications. Communities were also assigned to NSW Structural Formations and Vegetation Classes (Keith 2004) on the basis of floristic and structural features as well as distribution.

Remote sensing of contemporary vegetation cover

A map of contemporary vegetation cover was produced by compiling and upgrading remote image interpretation data from 25 previous studies (Fig. 2). The majority of these studies (Appendix 5) were based on traditional aerial photograph interpretation, in which polygons were drawn manually to delineate spatial vegetation features onto acetate overlaying contact prints that were examined with stereoscopic viewers. The linework was subsequently scanned into digital format, ortho-rectified using suitable geo-reference control points and attributed with the interpreted vegetation features. Exceptions included the Monaro tablelands (Walter & Schelling 2004), where native grasslands were mapped by multi-temporal spectral classification of Landsat TM imagery, and the Eden region (Keith & Bedward 1999), in which structural classes were initially delineated by interpreting aerial photos flown in 1963, with clearing boundaries updated using automated classification of Landsat TM captured in 1994, and then enhanced to finer resolution and further updated using colour aerial photography (Appendix 6).

The available remote sensing data sets were evaluated using four criteria based on those described by Keith & Simpson (2006):

i) thematic compatibility (units assignable to common structural categories, Table 3);

ii) accuracy (assessed by overlaying linework on imagery; Keith *et al.* 2000);

iii) precision or resolution (minimum remnant size 1 ha; crown cover 5%); and

iv) currency (imagery captured after 1991).

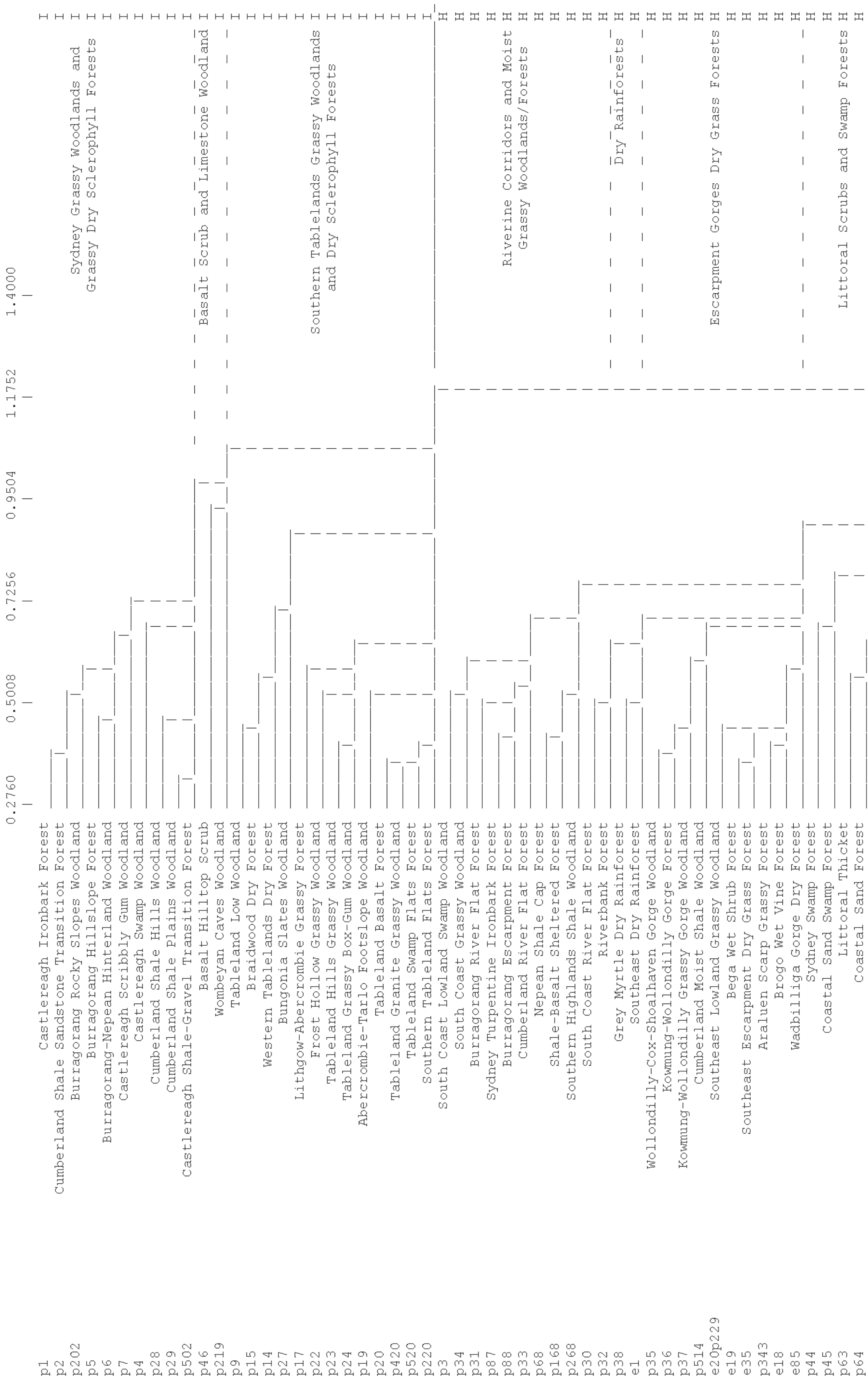
Boundary accuracy (criterion ii) was checked by comparing linework with vegetation boundaries using ortho-rectified aerial photography on a GIS (Keith *et al*. 2000). Linework that varied by more than 20m (average) from the boundary positions on the photographs was considered unreliable and discarded. Where the criterion iii (resolution) could not be met, the best available map was identified and enhanced as required (see below). Maps based on imagery older than 1991 were only considered in areas that were unlikely to have undergone subsequent land clearing (e.g. conservation reserves).

Prior to merging, maps were thematically standardised by assigning all maps units to common structural categories (Table 3). Where adjacent maps matched poorly along their boundaries after standardisation, alternative assignments of their units were examined to resolve conflicts. Maps with poor compatibility were discarded. A seamless coverage of contemporary vegetation cover was compiled from the suitable data sets using a GIS. Where layers overlapped, layers with greater geographic range, a more recent date of interpretation, greater spatial accuracy and greater attribute accuracy were used in preference to layers with lesser attributes. The merged coverage was checked for gaps and consistency where individual coverages were joined.

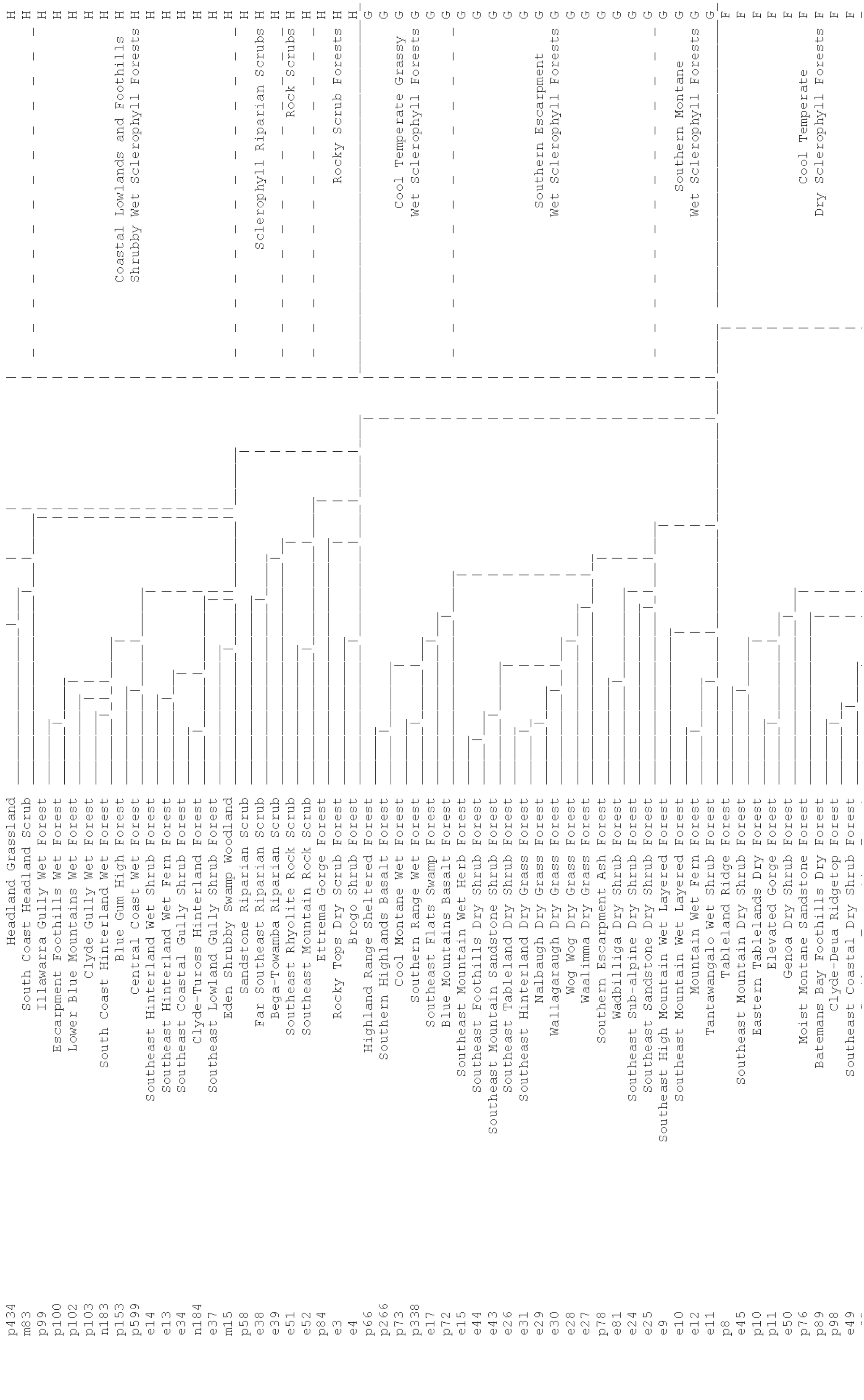
Supplementary aerial photograph interpretation using digital orthophotos and/or stereoscopic pairs was carried out to improve resolution and fill gaps in the map coverage identified during the checking process. Enhancements to existing linework were undertaken, where possible, using the original air photos and hand-marked acetate overlays. Modifications and additions to linework and attributes were done digitally in a GIS using either rectified digital ortho-photo mosaics or recent Landsat 7-TM satellite imagery (small areas of the Taralga and Goulburn map sheets) as a base. Details of imagery used to update existing API layers are provided in Appendix 6. As well as upgrades to resolution of linework, enhancements included delineation of bogs and fens throughout cleared land on the tableland and delineation of native grasslands on coastal headlands, as these features were poorly represented in the existing data sets. In most cases the digital base layers were more recent than the original aerial photography and some differences were detected in the boundaries of the extant vegetation. These boundaries were updated during digitisation. Gaps in the map coverage were filled by interpreting the structural categories directly from colour stereo pairs (Appendix 6). Boundaries were delineated on clear acetate air photo overlays and then digitised in a GIS using rectified digital ortho-photo mosaics as a base.

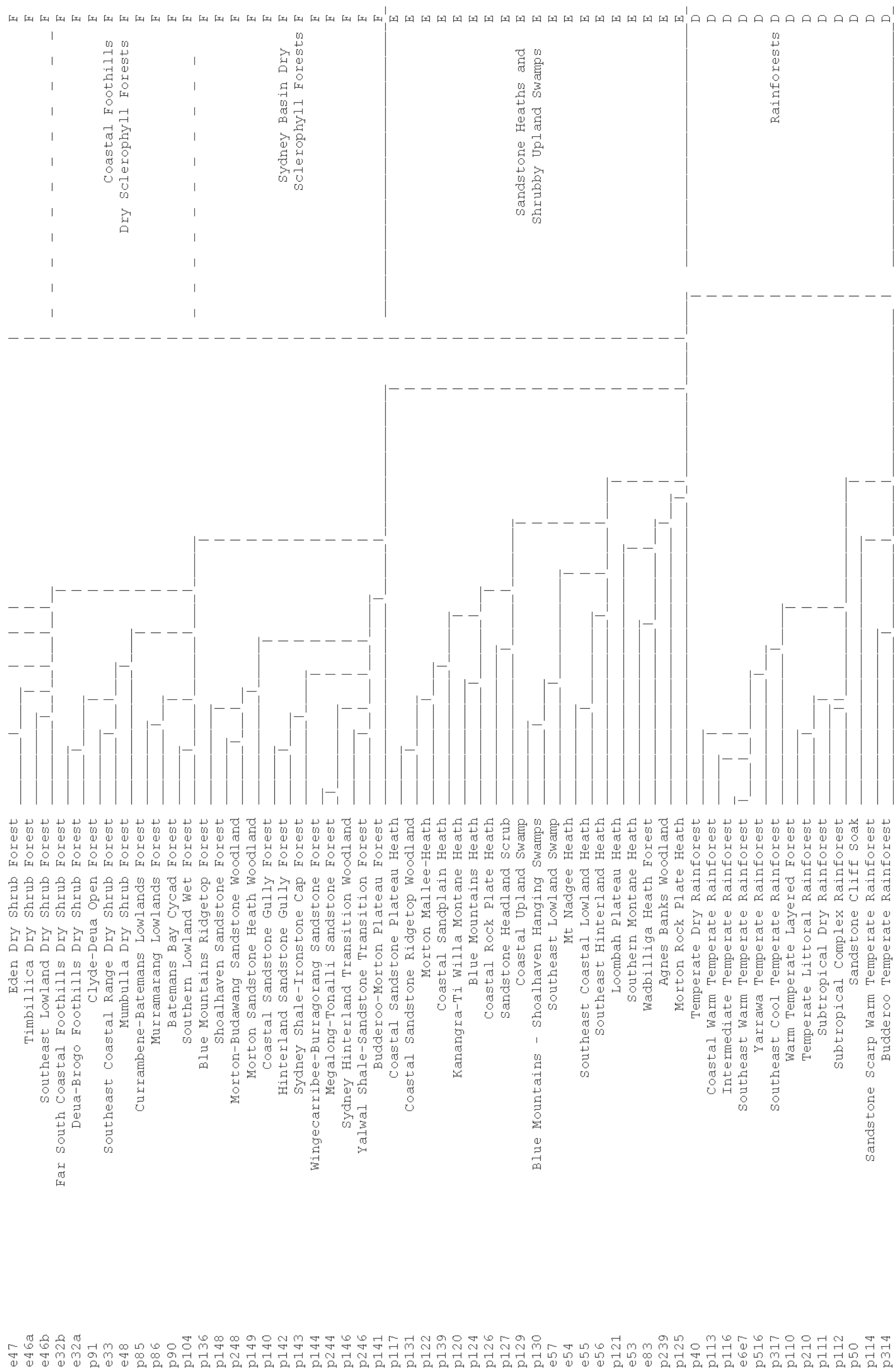
Environmental Data

A set of spatial data layers was created for modelling the distributions of vegetation map units (Table 4). The data layers were derived and manipulated in digital raster format at a grid cell resolution of 25 m in Zone 55 of the Australian Grid Datum 66 using a GIS. Location variables were derived directly from the grid datum and by calculating distance from vectors representing landscape features (Table 4). The terrain variables included a range of indices computed at grid neighbourhoods of varying size (Table 4). Climatic variables representing temperature, precipitation and solar radiation were derived from the digital elevation model and long-term meteorological data using ESOCLIM (Hutchinson 1989). Substrate data layers were compiled from soil landscape (1:100 000) and geological/metallogenic (1:250 000, 1:100 000 or 1:25 000) mapping (Bannerman & Hazelton 1990, Barnes *et al.* 2005, Chapman & Murphy 1989, NSW DLWC 1999 and 2002, NSW DNR 2006, Hazelton 1990 and 1992,



0.2760
0.5008
0.7256
0.9504
1.1752
1.4000
Sydney Grassy Woodlands and Grassy Dry Sclerophyll Forests
Basalt Scrub and Limestone Woodland
Southern Tablelands Grassy Woodlands and Dry Sclerophyll Forests
Riverine Corridors and Moist Grassy Woodlands/Forests
Dry Rainforests
Escarpment Gorges Dry Grass Forests
Littoral Scrubs and Swamp Forests
p1 Castlereagh Ironbark Forest
p2 Cumberland Shale Sandstone Transition Forest
p202 Burragorang Rocky Slopes Woodland
p5 Burragorang Hillslope Forest
p6 Burragorang-Nepean Hinterland Woodland
p7 Castlereagh Scribbly Gum Woodland
p4 Castlereagh Swamp Woodland
p28 Cumberland Shale Hills Woodland
p29 Cumberland Shale Plains Woodland
p502 Castlereagh Shale-Gravel Transition Forest
p46 Basalt Hilltop Scrub
p219 Wombeyan Caves Woodland
p9 Tableland Low Woodland
p15 Braidwood Dry Forest
p14 Western Tablelands Dry Forest
p27 Bungonia Slates Woodland
p17 Lithgow-Abercrombie Grassy Forest
p22 Frost Hollow Grassy Woodland
p23 Tableland Hills Grassy Woodland
p24 Tableland Grassy Box-Gum Woodland
p19 Abercrombie-Tarlo Footslope Woodland
p20 Tableland Basalt Forest
p420 Tableland Granite Grassy Woodland
p520 Tableland Swamp Flats Forest
p220 Southern Tableland Flats Forest
p3 South Coast Lowland Swamp Woodland
p34 South Coast Grassy Woodland
p31 Burragorang River Flat Forest
p87 Sydney Turpentine Ironbark Forest
p88 Burragorang Escarpment Forest
p33 Cumberland River Flat Forest
p68 Nepean Shale Cap Forest
p168 Shale-Basalt Sheltered Forest
p268 Southern Highlands Shale Woodland
p30 South Coast River Flat Forest
p32 Riverbank Forest
p38 Grey Myrtle Dry Rainforest
e1 Southeast Dry Rainforest
p35 Wollondilly-Cox-Shoalhaven Gorge Woodland
p36 Kowmung-Wollondilly Gorge Forest
p37 Kowmung-Wollondilly Grassy Gorge Woodland
p514 Cumberland Moist Shale Woodland
e20p229 Southeast Lowland Grassy Woodland
e19 Bega Wet Shrub Forest
e35 Southeast Escarpment Dry Grass Forest
p343 Araluen Scarp Grassy Forest
e18 Brogo Wet Vine Forest
e85 Wadbilliga Gorge Dry Forest
p44 Sydney Swamp Forest
p45 Coastal Sand Swamp Forest
p63 Littoral Thicket
p64 Coastal Sand Forest


Coastal Lowlands and Foothills
Shrubby Wet Sclerophyll Forests
Sclerophyll Riparian Scrubs
Rock Scrubs
Rocky Scrub Forests
Cool Temperate Grassy
Wet Sclerophyll Forests
Southern Escarpment
Wet Sclerophyll Forests
Southern Montane
Wet Sclerophyll Forests
Cool Temperate
Dry Sclerophyll Forests
p434 Headland Grassland H
m83 South Coast Headland Scrub H
p99 Illawarra Gully Wet Forest H
p100 Escarpment Foothills Wet Forest H
p102 Lower Blue Mountains Wet Forest H
p103 Clyde Gully Wet Forest H
n183 South Coast Hinterland Wet Forest H
p153 Blue Gum High Forest H
p599 Central Coast Wet Forest H
e14 Southeast Hinterland Wet Shrub Forest H
e13 Southeast Hinterland Wet Fern Forest H
e34 Southeast Coastal Gully Shrub Forest H
n184 Clyde-Tuross Hinterland Forest H
e37 Southeast Lowland Gully Shrub Forest H
m15 Eden Shrubby Swamp Woodland H
p58 Sandstone Riparian Scrub H
e38 Far Southeast Riparian Scrub H
e39 Bega-Towamba Riparian Scrub H
e51 Southeast Rhyolite Rock Scrub H
e52 Southeast Mountain Rock Scrub H
p84 Ettrema Gorge Forest H
e3 Rocky Tops Dry Scrub Forest H
e4 Brogo Shrub Forest H
p66 Highland Range Sheltered Forest G
p266 Southern Highlands Basalt Forest G
p73 Cool Montane Wet Forest G
p338 Southern Range Wet Forest G
e17 Southeast Flats Swamp Forest G
p72 Blue Mountains Basalt Forest G
e15 Southeast Mountain Wet Herb Forest G
e44 Southeast Foothills Dry Shrub Forest G
e43 Southeast Mountain Sandstone Shrub Forest G
e26 Southeast Tableland Dry Shrub Forest G
e31 Southeast Hinterland Dry Grass Forest G
e29 Nalbaugh Dry Grass Forest G
e30 Wallagaraugh Dry Grass Forest G
e28 Wog Wog Dry Grass Forest G
e27 Waalimma Dry Grass Forest G
p78 Southern Escarpment Ash Forest G
e81 Wadbilliga Dry Shrub Forest G
e24 Southeast Sub-alpine Dry Shrub Forest G
e25 Southeast Sandstone Dry Shrub Forest G
e9 Southeast High Mountain Wet Layered Forest G
e10 Southeast Mountain Wet Layered Forest G
e12 Mountain Wet Fern Forest G
e11 Tantawangalo Wet Shrub Forest G
p8 Tableland Ridge Forest F
e45 Southeast Mountain Dry Shrub Forest F
p10 Eastern Tablelands Dry Forest F
p11 Elevated Gorge Forest F
e50 Genoa Dry Shrub Forest F
p76 Moist Montane Sandstone Forest F
p89 Batemans Bay Foothills Dry Forest F
p98 Clyde-Deua Ridgetop Forest F
e49 Southeast Coastal Dry Shrub Forest F


Coastal Foothills Dry Sclerophyll Forests
Sydney Basin Dry Sclerophyll Forests
Sandstone Heaths and Shrubby Upland Swamps
Rainforests
e47 Eden Dry Shrub Forest F
e46a Timbillica Dry Shrub Forest F
e46b Southeast Lowland Dry Shrub Forest F
e32b Far South Coastal Foothills Dry Shrub Forest F
e32a Deua-Brogo Foothills Dry Shrub Forest F
p91 Clyde-Deua Open Forest F
e33 Southeast Coastal Range Dry Shrub Forest F
e48 Mumbulla Dry Shrub Forest F
p85 Currambene-Batemans Lowlands Forest F
p86 Murramarang Lowlands Forest F
p90 Batemans Bay Cycad Forest F
p104 Southern Lowland Wet Forest F
p136 Blue Mountains Ridgetop Forest F
p148 Shoalhaven Sandstone Forest F
p248 Morton-Budawang Sandstone Woodland F
p149 Morton Sandstone Heath Woodland F
p140 Coastal Sandstone Gully Forest F
p142 Hinterland Sandstone Gully Forest F
p143 Sydney Shale-Ironstone Cap Forest F
p144 Wingecarribee-Burragorang Sandstone Forest F
p244 Megalong-Tonalli Sandstone Forest F
p146 Sydney Hinterland Transition Woodland F
p246 Yalwal Shale-Sandstone Transition Forest F
p141 Budderoo-Morton Plateau Forest F
p117 Coastal Sandstone Plateau Heath E
p131 Coastal Sandstone Ridgetop Woodland E
p122 Morton Mallee-Heath E
p139 Coastal Sandplain Heath E
p120 Kanangra-Ti Willa Montane Heath E
p124 Blue Mountains Heath E
p126 Coastal Rock Plate Heath E
p127 Sandstone Headland Scrub E
p129 Coastal Upland Swamp E
p130 Blue Mountains - Shoalhaven Hanging Swamps E
e57 Southeast Lowland Swamp E
e54 Mt Nadgee Heath E
e55 Southeast Coastal Lowland Heath E
e56 Southeast Hinterland Heath E
p121 Loombah Plateau Heath E
e53 Southern Montane Heath E
e83 Wadbilliga Heath Forest E
p239 Agnes Banks Woodland E
p125 Morton Rock Plate Heath E
p40 Temperate Dry Rainforest D
p113 Coastal Warm Temperate Rainforest D
p116 Intermediate Temperate Rainforest D
e6e7 Southeast Warm Temperate Rainforest D
p516 Yarrawa Temperate Rainforest D
p317 Southeast Cool Temperate Rainforest D
p110 Warm Temperate Layered Forest D
p210 Temperate Littoral Rainforest D
p111 Subtropical Dry Rainforest D
p112 Subtropical Complex Rainforest D
p50 Sandstone Cliff Soak D
p114 Sandstone Scarp Warm Temperate Rainforest D
p314 Budderoo Temperate Rainforest D

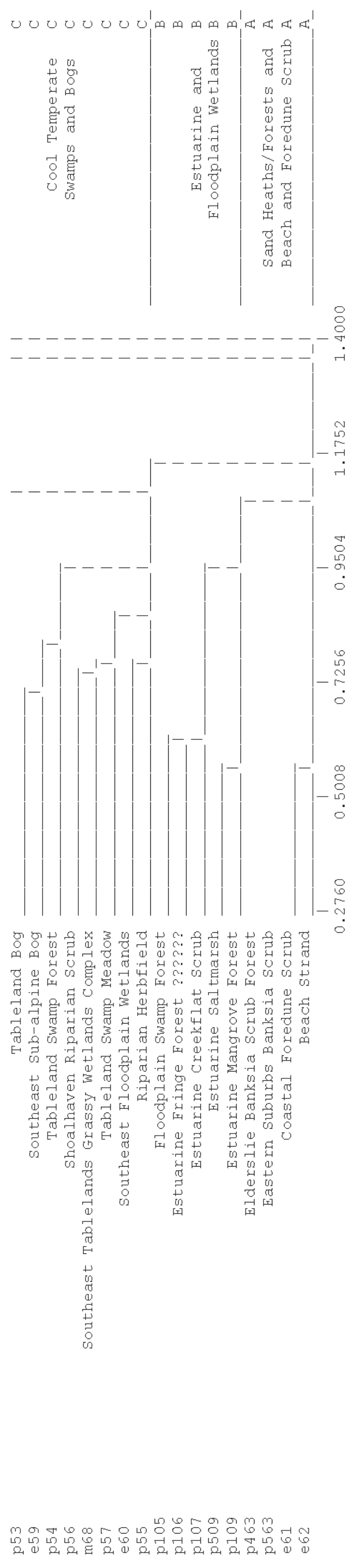


Fig. 3. Dendrogram showing hierarchical relationships between Map Units.

Jenkins 1996, King 1994, Bryan 1966, Rose 1966a and 1966b, Brunker & Offenberg 1970, Best *et al.* 1963, Stevens 1968, Felton 1974, McIlveen 1973, Gilligan 1974, Raymond & Pogson 1998, Pogson & Watkins 1998, Lewis & Glen 1995, Scheibner 1973, Clark & Jones 1991, Wyborn & Owen 1982, Felton & Huleatt 1975). Layers for contemporary native vegetation cover and structural categories were derived from remote sensing as outlined above.

Spatial Modelling of Communities and Map Compilation

A map showing the reconstructed distributions of the communities across the entire landscape was prepared using the geo-referenced field samples assigned to each community and the spatial data layers (Table 4) to interpolate the occurrence of communities across both cleared and vegetated parts of the landscape. This map of reconstructed (pre-clearing) vegetation patterns was then intersected with the map of contemporary native vegetation cover to obtain a map of the extant distributions of communities.

Interpolation was done by first constructing a matrix of field samples, the community to which they had been assigned (dependent variable), and the relevant values of each spatial parameter listed in Table 4 (independent variables) obtained by intersecting sample locations and these spatial data layers. The data matrix was then used to develop decision rules quantifying the occurrence of each community in relation to multi-dimensional envelope(s) defined by the spatial data variables. Finally, the distributions of communities were mapped in a GIS by intersecting and merging the relevant spatial data layers to implement the decision rules.

The decision rules were developed iteratively over several cycles of modelling, evaluation, deconstruction and revision using ALBERO, a hybrid decision tree/expert system with a mapping module that translates the decision rules into a vegetation map using the spatial data layers specified in the rules (Keith & Bedward 1999). This technique uses a divisive strategy in which a sequence of spatial variables is used to progressively split the full set of samples into smaller and smaller groups. Splitting is performed in a dichotomous manner that seeks to maximise discrimination between each pair of daughter groups with respect to the communities represented in their component samples. The splits were determined jointly by the authors, who were familiar with both the data set and the landscape. ALBERO informs the operators' selection of decision rules by providing a list of variables at each node which could be used to discriminate groups of samples assigned to different communities. It also calculates Chi-squared values as indicators of the discriminatory power of each variable in each node, and these were used to inform the successive expert selections of variables in each decision rule.

The modelled distribution of each community was assessed by comparing the mapped output with the distribution of the sample sites, as well as expert knowledge, field notes and published and unpublished reports for particular locations. Supplementary ground-truthing was also carried out for this purpose. The causes of discrepancies in the map were diagnosed by de-constructing the decision rules and exploring the efficacy of alternative sub-rules. The decision rules were revised where this could improve the agreement between the mapped output and the available information sources.

Many of the smallest patches of vegetation shown on the mapped output were identified as artefacts of the spatial intersection process. To remove these artefacts, features less than 0.5 ha in area were nibbled away and replaced by adjacent map units.

Results

Cluster Analysis and Classification of Plant Communities

Data collected from 10 832 survey sites met the criteria for inclusion in the cluster analyses. Of these, 2 297 sites could not be reliably assigned to classes due to conflicts between their dendrogram grouping and nearest neighbour checks, and were therefore omitted from further analysis. A total of 8 535 sites were assigned to 190 floristic assemblages (communities) which made up the final classification. The hierarchical classification grouped these assemblages into nine major lineages on the basis of shared floristic features (Fig. 3; parts A – I). These higher-order groupings also reflected strong structural and physiognomic relationships, as five were directly aligned with state-wide structural formations described by Keith (2004): Parts C (Freshwater Wetlands D (Rainforests); E (Heathlands); F (Dry Sclerophyll Forests –shrubby sub-formation); and G (Wet Sclerophyll Forests). Part I comprised communities of two formations: Grassy Woodlands and Dry Sclerophyll Forests (grassy sub-formation). Several lineages could be further divided into geographic or climatic sub-groups (e.g. Parts F, G &I). Part H comprised a set of sub-groups typically occurring in moist sites (either sheltered or with impeded drainage), often in rugged terrain.

Species Richness

A total of 2 894 taxa were recorded in the 8 535 survey sites classified. Of these, 2 347 were native, representing approximately 25% of the recorded native flora of NSW (NSW DEC, 2004a). Approximately 28 % of native species were recorded five times or less (i.e. present in <0.1% of sites) and 12 % were recorded only once. Only four native species were recorded in greater than 30% of sites; these were *Lomandra longifolia* (44%), *Entolasia stricta* (34%), *Microlaena stipoides* (36%) and *Pteridium esculentum* (37%). Native species richness varied considerably between floristic groups, with the mean (±s.d.) species richness per sample plot ranging from 3.9 (±2.9) for Estuarine Saltmarsh (SL p509) to 51.9 (±12.1) for Burragorang Escarpment Forest (DSF p88).

A total of 547 exotic species was recorded in the 8 535 classified survey sites, which represents approximately 25% of the introduced flora of NSW (NSW DEC 2004a). The number of exotic species recorded is likely to be an underestimate of the total introduced flora within the study area because highly disturbed and weed infested areas were under-sampled in the survey. Four exotic species were recorded in more than 5% of all samples. They were *Hypochaeris radicata* (21%), *Cirsium vulgare* (9%), *Senecio madagascariensis* (5%) and *Plantago lanceolata* (6%). The highest frequency and diversity of exotic species were recorded in grassy woodlands and riparian vegetation on clay-loam soils of both the Cumberland Plain and the tablelands. Riverbank Forest (FOW p32) recorded the highest number of exotic species (175) and contained exotics in 95% of its samples. Conversely, heathlands and woodlands on shallow, low nutrient sandstone soils had the fewest exotic species, with none recorded in 27 of these assemblages.

Coverage of Sampling

The average density of sampling across the region represents about one site for every 3 km^2 of native vegetation. Despite the emphasis on gap-filling in regional scale surveys (Keith & Bedward 1999, Tindall *et al.* 2004), the distribution of samples remains relatively uneven (Fig. 4) due to the concentration of samples produced by more localised surveys (e.g. Royal National Park – Illawarra, Coolangubra – Nalbaugh). Sampling intensity was lowest in some less accessible areas of the Blue Mountains and Morton Plateau; the upper Tuross and Deua River catchments; and some heavily cleared parts of the southern tablelands.

The distribution of samples among classes of land tenure was roughly proportional to class area, although the number of samples located on conservation reserves was disproportionably high at the expense of those on freehold land (Table 5). The proportional distribution of samples

Table 5: Distribution of land, native vegetation and survey effort by tenure type within the study area.

Tenure class:	Crown	Leasehold	Freehold	Reserve	State Forests
Area of land (ha)	188928 (5%)	52049 (1%)	2045218 (51%)	1101095 (28%)	595087 (15%)
Area of native vegetation (ha)	168577 (6%)	44753 (2%)	818301 (31%)	1074166 (41%)	534581 (20%)
Number of samples	574 (7%)	52 (1%)	3001 (36%)	3368 (40%)	1192 (14%)

Table 6: Inferred relationships between vegetation communities described in Appendix 3 and Threatened Ecological Communities listed under NSW or Commonwealth legislation. The inferred relationships are indicative only. The legal definitions of EECs are provided by the Final Determinations under the respective Acts and decisions relating to whether any particular area of vegetation constitutes a TEC should be based on field inspection and comparison with the Final Determination.

Endangered Ecological Communities listed under the TSC Act 1995	Corresponding Map Unit Name	Corresponding Map Unit	Relationship between EEC and corresponding map unit/s
Agnes Banks Woodland in the Sydney Basin Bioregion	Agnes Banks Woodland	DSF p239	EEC is equivalent to DSF p239
Bangalay Sand Forest	Coastal Sand Forest	DSF p64	EEC is included within the broader DSF p64
Blue Gum High Forest (Critically Endangered)	Blue Gum High Forest	WSF p153	EEC is equivalent to WSF p153
Blue Mountains Shale Cap Forest in the Sydney Basin Bioregion	Shale-Basalt Sheltered Forest	WSF p168	EEC is included within the broader WSF p168
Brogo Wet Vine Forest	Brogo Wet Vine Forest	GW e18	EEC is equivalent to GW e18
Castlereagh Swamp Woodland Community	Castlereagh Swamp Woodland	DSF p4	EEC is equivalent to DSF p4
Coastal salt marsh in the NSW North Coast, Sydney Basin and South East Corner bioregions	Estuarine Salt marsh	SL p509	SL p509 is included within this broader EEC
Cooks River/ Castlereagh Ironbark Forest in the Sydney Basin Bioregion	Castlereagh Ironbark Forest	DSF p1	EEC is equivalent to DSF p1
Cumberland Plain Woodland (critically endangered)	Cumberland Shale Hills Woodland + Cumberland Shale Plains Woodland	GW p28 + GW p29	EEC is equivalent to GW p28 and GW p29 combined
Dry Rainforest of the South East Forests in the South East Corner Bioregion	Southeast Dry Rainforest	RF e1	EEC is equivalent to RF e1
Duffys Forest Ecological Community in the Sydney Basin Bioregion	Sydney Shale-Ironstone Cap Forest	DSF p143	EEC is included within the broader DSF p143
Eastern Suburbs Banksia Scrub in the Sydney Basin Bioregion	Eastern Suburbs Banksia Scrub	HL p563	HL p563 is equivalent to this EEC
Elderslie Banksia Scrub Forest	not sampled or described	DSF p463	EEC is equivalent to DSF p463
Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and Southeast Corner bioregions	Coastal Freshwater Lagoon (part) + Floodplain Wetlands	FrW p313 + FoW e60	EEC includes occurrences of FRW p313 on floodplains and occurrences of FoW e60 that are not dominated by eucalypts or Angophora
Illawarra Lowlands Grassy Woodland in the Sydney Basin Bioregion	South Coast Lowland Swamp Woodland + South Coast Grassy Woodland	GW p3 + GW p34	EEC is included within two broader map units, GW p3 and GW p34
Illawarra Subtropical Rainforest in the Sydney Basin Bioregion	Subtropical Dry Rainforest (part) + Subtropical Complex Rainforest (part)	RF p111+ RF p112	EEC is included within two broader map units, RF p111 and RF p112
Kurnell Dune Forest in the Sutherland Shire and City of Rockdale	Coastal Sand Forest	DSF p64	EEC is included within the broader DSF p64
Littoral Rainforest in the NSW North Coast, Sydney Basin and South East Corner bioregions	Temperate Littoral Rainforest + Littoral Thicket (part)	RF p210 + HL p63	RF p210 is included within this broader EEC. Examples of HL p63 occurring in sheltered locations with high rainfall may be included in the EEC, particularly when fire has been excluded for long periods.
Lowland Grassy Woodland in the South East Corner bioregion	Southeast Lowland Grassy Woodland	GW e20p229	Within the SEC bioregion this EEC is equivalent to GW e20p229
Maroota Sands Swamp Forest	Sydney Swamp Forest	FoW p44	EEC is included within FoW p44
Melaleuca armillaris Tall Shrubland in the Sydney Basin Bioregion	Basalt Hilltop Scrub	HL p46	EEC is included within HL p46
Milton Ulladulla Subtropical Rainforest in the Sydney Basin Bioregion	Subtropical Dry Rainforest (part) + Subtropical Complex Rainforest (part)	RF p111 + RF p112	EEC is included within two broader map units: RF p111 and small outlying patches of RF p112
Moist Shale Woodland in the Sydney Basin Bioregion	Cumberland Moist Shale Woodland	GW p514	EEC is equivalent to GW p514

Endangered Ecological Communities listed under the TSC Act 1995	Corresponding Map Unit Name	Corresponding Map Unit	Relationship between EEC and corresponding map unit/s
Montane Peatland and Swamp of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions	Riparian Herbfield + Tableland Swamp Meadow + Tableland Bog (part) + Sub-Alpine Bog	FrW p55 + FrW p57 + FrW p53 + FrW e59	EEC includes FrW p55, FrW p57, FrW e59 and occurrences of FrW p53 with few sclerophyll taxa
Mount Gibraltar Forest in the Sydney Basin Bioregion	Southern Highlands Basalt Forest (part) + High Range Sheltered Forest (part)	WSF p266 + WSF p66	EEC is included within the broader WSF p266, and may match variants of the broader WSF p66 where this unit grades into WSF p266
O'Hares Creek Shale Forest	Sydney Shale-Ironstone Cap Forest	DSF p143	EEC is included within the broader DSF p143
Pittwater Spotted Gum Forest	Illawarra Gully Wet Forest	WSF p99	EEC is local occurrence within the broader WSF p99
River Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (incorporating the previously listed Sydney Coastal River-flat Forest)	Southeast Floodplain Wetlands + Cumberland River Flat Forest + Floodplain Swamp Forest + South Coast River Flat Forest + Burragorang River Flat Forest	FoW e60 + FoW p33+ FoW p105 + FoW p30+ FoW p31	EEC includes those parts of FOW p33, FOW p105, FOW p30, FOW p31 and FOW e60 that are dominated by eucalypts or Angophoras
Robertson Basalt Tall Open-forest in the Sydney Basin Bioregion	Southern Highlands Basalt Forest (part)	WSF p266	EEC is included within the broader WSF p266
Robertson Rainforest in the Sydney Basin Bioregion	Yarrawa Temperate Rainforest	RF p516	EEC is equivalent to RF p516
Shale / Sandstone Transition Forest	Cumberland Shale Sandstone Transition Forest	GW p2	EEC is equivalent to GW p2
Shale Gravel Transition Forest in the Sydney Basin Bioregion	Castlereagh Shale-Gravel Transition Forest	DSF p502	EEC is equivalent to DSF p502
Southern Highlands Shale Woodlands in the Sydney Basin Bioregion	Southern Highlands Shale Woodlands	WSF p268	EEC is equivalent to WSF p268
Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin	Coastal Sandstone Gully Forest	DSF p140	EEC is included within the broader DSF p140
Sun Valley Cabbage Gum Forest in the Sydney Basin Bioregion	Mapped as an outlier of Burragorang River Flat Forest	FoW p31	EEC possibly included within FoW p31, but relationship uncertain due to disturbed condition of site
Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions	Floodplain Swamp Forest + Estuarine Fringe Forest + Estuarine Creekflat Scrub	FoW p105 + FoW p106 + FoW p107	EEC includes FoW p105, FoW p106 and FoW p107
Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (incorporating the formerly listed Sydney Coastal Estuary Swamp Forest Complex in the Sydney Basin Bioregion)	Sydney Swamp Forest + Coastal Sand Swamp Forest	FoW p44 + FoW p45	EEC includes FoW p44 and FoW p45
Sydney Freshwater Wetlands in the Sydney Basin Bioregion	Coastal Freshwater Lagoon (part)	FrW p313	EEC includes occurrences of FrW p313 on sandplains.
Sydney Turpentine-Ironbark Forest	Sydney Turpentine Ironbark Forest	WSF p87	EEC is equivalent to WSF p87
Tableland Basalt Forest in the Sydney Basin and South Eastern Highlands Bioregions	Tableland Basalt Forest	GW p20	EEC includes GW p20
Themeda Grassland on Sea cliffs and Coastal Headlands	Headland Grassland	GL p434	GL p434 is included within this broader EEC
Umina Coastal Sand plain Woodland	Coastal Sand Forest	DSF p64	EEC is included within the broader DSF p64
Western Sydney Dry Rainforest in the Sydney Basin Bioregion	Grey Myrtle Dry Rainforest	RF p39	EEC is included within the broader RF p39
White Box Yellow Box Blakely's Red Gum Woodland	Tableland Grassy Box-Gum Woodland + Wollondilly-Cox-Shoalhaven Gorge Woodland + Tableland Granite Grassy Woodland	GW p24 + DSF p35 + GW p420	Some occurrences of these three map units are likely to match this broad EEC

Vulnerable Ecological Communities listed under the TSC Act 1995	Corresponding Map Unit Name	Corresponding Map Unit	Relationship between VEC and corresponding map unit/s
Blue Mountains Swamps in the Sydney Basin bioregion	Blue Mountains - Shoalhaven Hanging Swamps	FRW p130	VEC includes parts of FRW p130 within the Hawkesbury-Nepean catchment

Endangered Ecological Communities listed under the EPBC Act 1999	Corresponding Map Unit Name	Corresponding Map Unit	Relationship between EEC and corresponding map unit
Blue Gum High Forest of the Sydney Basin Bioregion (Critically Endangered)	Blue Gum High Forest	WSF p153	EEC is equivalent to WSF p153
Cumberland Plain Woodlands	Cumberland Shale Hills Woodland + Cumberland Shale Plains Woodland	GW p28 + GW p29	EEC is equivalent to GW p28 and GW p29 combined
Eastern Suburbs Banksia Scrub of the Sydney Region	Eastern Suburbs Banksia Scrub	HL p563	HL p563 is equivalent to this EEC
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Temperate Littoral Rainforest + Littoral Thicket (part)	RF p210 + HL p63	RF p210 is included within this broader EEC. Examples of HL p63 in sheltered locations with high rainfall may be included in the EEC, particularly when long unburnt.
Natural Temperate Grasslands of the Southern Tablelands of NSW and the ACT	Monaro Grassland + Frost Hollow Grassy Woodland + Tableland Grassy Box-Gum Woodland + Tableland Flats Grassland + Tableland Granite Grassy Woodland	GL e23A + GW p22 + GW p24 + GL p257 + GW p420	These Map Units include areas of low tree density that match the description of this EEC
Shale/Sandstone Transition Forest	Cumberland Shale Sandstone Transition Forest	GW p2	EEC is equivalent to GW p2
Temperate Highland Peat Swamps on Sandstone	Southeast Sub-Alpine Bog + Tableland Bog + Tableland Swamp Meadow + Blue Mountains – Shoalhaven Hanging Swamps	FrW e59 + FrW p53 + FrW p57 + FrW p130	FrW e59, FrW p53, FrW p57 and FrW p130 form part of this EEC
Turpentine-Ironbark Forest in the Sydney Basin Bioregion (Critically Endangered)	Sydney Turpentine Ironbark Forest	WSF p87	EEC is equivalent to WSF p87
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and derived native grassland (Critically Endangered)	No Map Units are directly equivalent to this EEC as it is described; however, some areas of Map Units GW p24 (Tableland Grassy Box-Gum Woodland) and GW p420 (Tableland Granite Grassy Woodland) may match the EEC description, particularly along the western edge of the study area	GW p24 + GW p420	No Map Units are directly equivalent to this EEC as described, however some areas of GW p24 and GW p420 may match the EEC description

Table 7: Summary of correspondence between the current classification compared to previous classifications covering small subsets of the study area. Correspondence was the number (proportion) of units in the previous classification that had equivalent units in the current classification within the common area.

Previous Study	Common Area (ha)	No. Sites classified in area of overlap	No. Sites classified in the current study	No. Units (previous study)	No. Units (current study)	Correspondence of previous classification to current classification
Southern CRA (Gellie 2005)	2129675	1366	3002	92	133	24 (26%)
Illawarra (NPWS 2002)	38398	182	176	33	22	31 (94%)
Warragamba (NPWS 2003a)	260708	825	788	71	51	62 (87%)
Cumberland Plain (Tozer 2003)	336946	735	735	24	22	24 (100%)

Table 8: Summary of relationships between units in the current study and NSW Formations and Classes (Keith 2004), P5MA (Tindall *et al*. 2004), Eden CRA (Keith & Bedward 1999) and Southern CRA (Gellie 2005).

Abbreviations:
DSFg – Dry Sclerophyll Forest – grassy subformation
DSFs – Dry Sclerophyll Forest – shrubby subformation
FoW – Forested Wetlands
FrW – Freshwater Wetlands
GL – Grasslands
GW – Grassy Woodlands
HL – Heathlands
RF – Rainforest
SL – Saline Wetlands
WSFg – Wet Sclerophyll Forests – grassy subformation
WSFs – Wet Sclerophyll Forests – shrubby subformation

Map code	Unit name	Form–ation	Class	P5MA unit	Eden units	SCRA FEs	Area Extant (ha):	Est. % remain-ing	Area in conservation reserves (ha):	Est. % of pre-clearing area in conservation reserves:
e1	Southeast Dry RF	RF	Dry RF	–	1	–	270	40–55	100	15–30
e3	Rocky Tops Dry Scrub Forest	DSFs	South East DSF	–	2, 3	–	1300	>95	1200	80–90
e4	Brogo Shrub Forest	DSFs	Southern Wattle DSF	–	4	–	5800	>90	4300	70–80
e6e7	Southeast Warm Temperate RF	RF	Southern Warm Temperate RF	–	6, 7	g165	9500	>90	5200	50–60
e9	Southeast High Mountain Wet Layered Forest	WSFs	Southern Escarpment WSF	–	9	–	1800	75–85	1600	65–75
e10	Southeast Mountain Wet Layered Forest	WSFs	Southern Escarpment WSF	–	10	–	17500	85–95	9900	45–55
e11	Tantawangalo Wet Shrub Forest	WSFs	Southern Escarpment WSF	–	11	–	800	>95	740	>90
e12	Mountain Wet Fern Forest	WSFs	Southern Escarpment WSF	70	12	–	48300	>95	36300	70–80
e13	Southeast Hinterland Wet Fern Forest	WSFs	South Coast WSF	–	13	–	26900	>90	14600	45–55
e14	Southeast Hinterland Wet Shrub Forest	WSFs	South Coast WSF	–	14	–	25500	>90	9600	30–40
e15	Southeast Mountain Wet Herb Forest	WSFg	Southern Escarpment WSF	–	15	–	29800	70–80	15900	35–45
e17	Southeast Flats Swamp Forest	FoW	Temperate Swamp Forests	–	17, part 58	–	3900	80–90	1500	20–35
e18	Brogo Wet Vine Forest	GW	Coastal Valley GW	–	18	part g49	5200	50–65	1400	10–20
e19	Bega Wet Shrub Forest	DSFg	Southern Hinterland DSF	–	19, W6	part g49	23600	35–50	6600	5–15
e20p229	Southeast Lowland Grassy Woodland	GW	Coastal Valley GW	229, part 34	20,21	g54	14000	10–25	780	<5
e23A	Monaro Grassland	GL	Temperate Montane Grasslands	–	23a	–				
e24	Southeast Sub-alpine Dry Shrub Forest	GW	Subalpine woodlands	–	24	part g64	6200	50–60	2000	10–20
e25	Southeast Sandstone Dry Shrub Forest	DSFs	South East DSF	–	25	–	820	65–75	720	60–70
e26	Southeast Tableland Dry Shrub Forest	DSFs	South East DSF	–	26	part g64	15000	60–70	5700	20–30
e27	Waalimma Dry Grass Forest	DSFg	Southern Hinterland DSF	–	27	–	1300	>95	300	15–25
e28	Wog Wog Dry Grass Forest	DSFg	Southern Hinterland DSF	–	28	–	920	65–75	880	60–70
e29	Nalbaugh Dry Grass Forest	DSFg	Southern Hinterland DSF	–	29	–	1800	70–80	700	25–35
e30	Wallagaraugh Dry Grass Forest	DSFg	Southern Hinterland DSF	–	30	–	800	50–60	350	20–30

Map code	Unit name	Form-ation	Class	P5MA unit	Eden units	SCRA FEs	Area Extant (ha):	Est. % remain-ing	Area in conservation reserves (ha):	Est. % of pre-clearing area in conservation reserves:
e31	Southeast Hinterland Dry Grass Forest	DSFg	Southern Hinterland DSF	–	31	–	27100	80–90	16500	45–55
e33	Southeast Coastal Range Dry Shrub Forest	DSFs	South East DSF	–	part 33	–	16300	>95	9700	55–65
e34	Southeast Coastal Gully Shrub Forest	WSFs	South Coast WSF	–	34	–	22800	>85	6900	25–35
e35	Southeast Escarpment Dry Grass Forest	DSFg	Southern Hinterland DSF	–	35	part g47	22600	65–75	9200	20–30
e37	Southeast Lowland Gully Shrub Forest	WSFs	South Coast WSF	–	37	–	13700	>95	4700	30–40
e38	Far Southeast Riparian Scrub	FoW	Eastern Riverine Forests	–	38	–	420	>90	290	55–65
e39	Bega-Towamba Riparian Scrub	FoW	Eastern Riverine Forests	–	39	–	340	<30	40	<10
e42	Southeast Inland Intermediate Shrub Forest	WSFs	South Coast WSF	–	42	–	21400	>95	5700	20–30
e43	Southeast Mountain Sandstone Shrub Forest	DSFs	South East DSF	–	43	–	2500	>95	2300	>90
e44	Southeast Foothills Dry Shrub Forest	DSFs	South East DSF	–	44	–	3100	>90	2300	65–75
e45	Southeast Mountain Dry Shrub Forest	DSFs	South East DSF	–	45	–	1800	>90	1100	50–60
e46a	Timbillica Dry Shrub Forest	DSFs	South East DSF	–	46a	–	22800	>95	3500	10–20
e46b	Southeast Lowland Dry Shrub Forest	DSFs	South East DSF	–	46b	–	14300	>90	6900	40–50
e47	Eden Dry Shrub Forest	DSFs	South East DSF	–	47	–	17100	>95	12300	65–75
e48	Mumbulla Dry Shrub Forest	DSFs	South East DSF	–	48	–	4500	>95	3500	70–80
e49	Southeast Coastal Dry Shrub Forest	DSFs	South East DSF	–	49	–	31800	>95	8000	20–30
e50	Genoa Dry Shrub Forest	DSFs	South East DSF	–	50	–	3000	>95	2100	55–70
e51	Southeast Rhyolite Rock Scrub	HL	Southern Volcanic Scrubs	–	51	–	50	>95	40	75–85
e52	Southeast Mountain Rock Scrub	HL	Southern Volcanic Scrubs	–	52	–	160	>95	160	>90
e53	Southern Montane Heath	HL	Southern Montane Heaths	123	53	g134, g135	6700	>95	3600	50–65
e54	Mt Nadgee Heath	HL	South Coast Heaths	–	54	–	370	>95	370	100
e55	Southeast Coastal Lowland Heath	HL	South Coast Heaths	–	55	–	1900	>90	1700	75–90
e56	Southeast Hinterland Heath	FrW	Coastal Heath Swamps	–	56	–	360	>90	80	15–25
e57	Southeast Lowland Swamp	FrW	Coastal Heath Swamps	–	57	–	1700	>70	1000	50–65
e59	Southeast Sub-alpine Bog	FrW	Montane Bogs and Fens	–	59	g123	2700	50–70	880	15–25
e60	Southeast Floodplain Wetlands	FoW	Coastal Floodplain Wetlands	–	60	–	1800	15–25	100	<5
e61	Coastal Foredune Scrub	DSFs	South Coast Sands DSF	65	61	–	3100	35–50	1700	25–35
e62	Beach Strand Grassland	GL	Maritime Grasslands	–	62	–				
e65	River Mangrove	SL	Mangrove Swamps	–	65	–	550	#N/A	210	<5
e67	Seagrass Meadow (Halophila)	SL	Seagrass Meadows	–	67	–	610	<50	60	5–10
e68	Seagrass Meadow (Posidonia)	SL	Seagrass Meadows	–	68	–	260	<50	20	<5

Map code	Unit name	Form-ation	Class	P5MA unit	Eden units	SCRA FEs	Area Extant (ha):	Est. % remain-ing	Area in conservation reserves (ha):	Est. % of pre-clearing area in conservation reserves:
e69	Seagrass Meadow (Ruppia)	SL	Seagrass Meadows	–	69	–	150	<50	60	5–10
e70	Seagrass Meadow (Zostera)	SL	Seagrass Meadows	–	70	–	1400	<50	80	<5
e81	Wadbilliga Dry Shrub Forest	DSFs	South East DSF	–	W1	–	6600	>95	6600	>95
e83	Wadbilliga Heath Forest	HL	Southern Montane Heaths	–	W3	–	1600	>95	1600	>95
e85	Wadbilliga Gorge Dry Forest	DSFs	South East DSF	–	W5	–	16000	>85	11000	55–65
e32A	Deua-Brogo Foothills Dry Shrub Forest	DSFs	South East DSF	part 90	part 32	-	42200	>95	27700	60-70
e32B	Far South Coastal Foothills Dry Shrub Forest	DSFs	South East DSF	-	part 32, part 33	g6	14000	>90	4700	25-35
m15	Eden Shrubby Swamp Woodland	FoW	Temperate Swamp Forests	-	-	-	0	>70	0	>80
m68	Southeast Tablelands Grassy Wetlands Complex	GL	Temperate Montane Grasslands	-	-	-				
m83	South Coast Headland Scrub	HL	Coastal Headland Heaths	-	-	-				
n183	South Coast Hinterland Wet Forest	WSFs	South Coast WSF	part 100 part 103	-	-	69400	>95	30300	40-50
n184	Clyde-Tuross Hinterland Forest	WSFs	Southern Lowland WSF	part 100	-	-	19300	>95	7400	30-40
p1	Castlereagh Ironbark Forest	DSFg	Cumberland DSF	1	-	-				
p2	Cumberland Shale Sandstone Transition Forest	GW	Coastal Valley GW	2	-	-	9700	20-40	260	<2
p3	South Coast Lowland Swamp Woodland	GW	Coastal Valley GW	3	-	-	1100	5-15	90	<1
p4	Castlereagh Swamp Woodland	DSFg	Sydney Sand Flats DSF	4	-	-	610	55-70	120	5-15
p5	Burragorang Hillslope Forest	DSFg	Central Gorge DSF	5	-	-	20700	75-90	20400	70-90
p6	Burragorang-Nepean Hinterland Woodland	DSFg	Sydney Sand Flats DSF	6	-	-	960	80-90	550	40-55
p7	Castlereagh Scribbly Gum Woodland	DSFg	Sydney Sand Flats DSF	7	-	-	3100	50-70	390	<10
p8	Tableland Ridge Forest	DSFs	South East DSF	8	-	-	44500	80-90	25600	40-60
p9	Tableland Low Woodland	DSFs	Southern Tableland DSF	9	-	-	36700	40-60	4400	<10
p10	Eastern Tablelands Dry Forest	DSFs	South East DSF	10	-	g15	48000	60-75	11200	10-25
p11	Elevated Gorge Forest	DSFg	Central Gorge DSF	11	-	g16	34600	80-95	14600	30-45
p14	Western Tablelands Dry Forest	DSFs	Southern Tableland DSF	14	22b	-	121600	45-65	24500	<15
p15	Braidwood Dry Forest	DSFs	Southern Tableland DSF	15	-	-	35200	45-65	2800	<10
p17	Lithgow-Abercrombie Grassy Forest	GW	Southern Tableland GW	17	-	-	100	35-55	0	0
p19	Abercrombie-Tarlo Footslope Woodland	GW	Southern Tableland GW	19	-	part g90	5200	70-85	1700	15-35
p20	Tableland Basalt Forest	GW	Tableland Clay GW	20	-	-	10700	5-20	280	<2
p22	Frost Hollow Grassy Woodland	GW	Subalpine Woodlands	22	part 23b	-	14100	5-20	680	<2
p23	Tableland Hills Grassy Woodland	GW	Southern Tableland GW	23	-	-	18800	20-40	710	<2

Map code	Unit name	Form-ation	Class	P5MA unit	Eden units	SCRA FEs	Area Extant (ha):	Est. % remain-ing	Area in conservation reserves (ha):	Est. % of pre-clearing area in conservation reserves:
p24	Tableland Grassy Box-Gum Woodland	GW	Southern Tableland GW	24	-	-	17900	10-25	10	<1
p27	Bungonia Slates Woodland	DSFg	Central Gorge DSF	27	-	-	21200	85-95	9200	30-50
p28	Cumberland Shale Hills Woodland	GW	Coastal Valley GW	28	-	-	4400	10-25	210	<2
p29	Cumberland Shale Plains Woodland	GW	Coastal Valley GW	29	-	-	6800	5-25	560	<2
p30	South Coast River Flat Forest	FoW	Coastal Floodplain Wetlands	30	-	-	8400	50-65	1600	<15
p31	Burragorang River Flat Forest	FoW	Eastern Riverine Forests	31	-	-	1900	>95	1800	>90
p32	Riverbank Forest	FoW	Eastern Riverine Forests	32	40	-	9400	60-85	3900	25-45
p33	Cumberland River Flat Forest	FoW	Coastal Floodplain Wetlands	33	-	-	5300	5-20	150	<2
p34	South Coast Grassy Woodland	GW	Coastal Valley GW	part 34	-	-	3100	15-30	180	<2
p35	Wollondilly-Cox-Shoalhaven Gorge Woodland	DSFg	Central Gorge DSF	35	-	-	41800	50-65	14100	20-30
p36	Kowmung-Wollondilly Gorge Forest	DSFg	Central Gorge DSF	36	-	-	26200	>95	24600	>85
p37	Kowmung-Wollondilly Grassy Gorge Woodland	DSFg	Central Gorge DSF	37	-	-	37100	>90	31700	70-90
p38	Grey Myrtle Dry RF	RF	Dry RF	38	-	-	6550	75-85	5600	55-75
p39	Western Sydney Dry Rainforest	RF	Dry RF	-	-	-	350	25-50	<20	<3
p40	Temperate Dry RF	RF	Dry RF	40	-	-	7500	>90	3500	40-50
p44	Sydney Swamp Forest	FoW	Coastal Swamp Forests	44	-	-	160	70-85	20	<10
p45	Coastal Sand Swamp Forest	FoW	Coastal Swamp Forests	45	-	-	1400	50-70	370	5-25
p46	Basalt Hilltop Scrub	HL	Southern Volcanic Scrubs	46	-	-	390	<30	0	<1
p50	Sandstone Cliff Soak	HL	Sydney Montane Heaths	50	-	-		#N/A	0	#N/A
p51	Tableland Lacustrine Herbfield	FrW	Montane Lakes	51	-	-	2600	<15	0	<1
p53	Tableland Bog	FrW	Montane Bogs and Fens	53	-	-	730	65-85	170	5-25
p54	Tableland Swamp Forest	FoW	Temperate Swamp Forests	54	-	-	1700	20-50	1100	50-70
p55	Riparian Herbfield	FrW	Montane Bogs and Fens	55	-	-		#N/A	0	#N/A
p56	Shoalhaven Riparian Scrub	FrW	Montane Bogs and Fens	56	-	-	1300	>80	30	<5
p57	Tableland Swamp Meadow	FrW	Montane Bogs and Fens	57	part 58	-	3800	15-25	470	<5
p58	Sandstone Riparian Scrub	FoW	Eastern Riparian Scrubs	58	-	-	2900	>90	1300	30-50
p63	Littoral Thicket	HL	Littoral RF	63	-	-	1800	50-70	1100	20-40
p64	Coastal Sand Forest	DSFs	South Coast Sands DSF	64	36	-	11200	50-70	6500	20-40
p66	Highland Range Sheltered Forest	WSFg	Southern Tableland WSF	66	-	-	18500	>90	12500	55-75
p68	Nepean Shale Cap Forest	WSFg	Northern Hinterland WSF	68	-	-	660	>90	0	0

Map code	Unit name	Form-ation	Class	P5MA unit	Eden units	SCRA FEs	Area Extant (ha):	Est. % remain-ing	Area in conservation reserves (ha):	Est. % of pre-clearing area in conservation reserves:
p72	Blue Mountains Basalt Forest	WSFs	Southern Escarpment WSF	72	-	-	480	50-70	160	10-30
p73	Cool Montane Wet Forest	WSFs	Southern Tableland WSF	part 73	-	-	62600	70-90	44200	35-55
p76	Moist Montane Sandstone Forest	DSFs	Sydney Montane DSF	76	-	-	4800	>95	4500	>85
p78	Southern Escarpment Ash Forest	WSFg	Montane WSF	78	41, W2	-	4400	>95	4100	>95
p84	Ettrema Gorge Forest	DSFg	Central Gorge DSF	84	-	-	8800	>90	7400	65-85
p85	Currambene-Batemans Lowlands Forest	DSFg	South East DSF	85	-	-	24700	55-75	5800	5-20
p86	Murramarang Lowlands Forest	WSFg	Southern Lowland WSF	86	-	-	7100	65-80	1500	5-15
p87	Sydney Turpentine Ironbark Forest	WSFg	Northern Hinterland WSF	87	-	-	2300	<10	250	<2
p88	Burragorang Escarpment Forest	DSFg	Central Gorge DSF	88	-	-	13200	>95	12700	>90
p89	Batemans Bay Foothills Dry Forest	DSFs	South East DSF	89	-	-	67100	>90	35200	45-65
p90	Batemans Bay Cycad Forest	WSFg	Southern Lowland WSF	part 90	-	-	56100	>85	14000	15-25
p91	Clyde-Deua Open Forest	DSFs	South East DSF	91	part 33	-	34100	>95	24500	65-75
p95	Southern Turpentine Forest	WSFg	Southern Lowland WSF	95	-	-	62400	>85	38300	45-65
p98	Clyde-Deua Ridgetop Forest	DSFs	South East DSF	98	-	-	30400	>90	23000	65-85
p99	Illawarra Gully Wet Forest	WSFs	North Coast WSF	99	-	-	7100	50-70	1900	5-20
p100	Escarpment Foothills Wet Forest	WSFg	South Coast WSF	part 100	-	-	31500	>90	12000	25-40
p102	Lower Blue Mountains Wet Forest	WSFs	North Coast WSF	102	-	-	23400	>95	19800	75-90
p103	Clyde Gully Wet Forest	WSFg	Southern Lowland WSF	part 103	-	-	17900	>90	6600	25-40
p104	Southern Lowland Wet Forest	WSFg	Southern Lowland WSF	104	-	-	25900	>85	9200	25-45
p105	Floodplain Swamp Forest	FoW	Coastal Floodplain Wetlands	105	-	-	2400	5-20	480	<5
p106	Estuarine Fringe Forest	FoW	Coastal Floodplain Wetlands	106	-	-	840	5-20	140	<5
p107	Estuarine Creekflat Scrub	FoW	Coastal Floodplain Wetlands	107	63	-	3700	70-85	1200	15-30
p109	Estuarine Mangrove Forest	SL	Mangrove Swamps	109	66	-	3700	50-75	740	<15
p110	Warm Temperate Layered Forest	WSFs	North Coast WSF	110	-	-	21500	55-70	4500	5-20
p111	Subtropical Dry RF	RF	Subtropical RF	111	-	part g167	2400	10-20	130	<2
p112	Subtropical Complex RF	RF	Subtropical RF	112	-	-	4100	50-65	440	<10
p113	Coastal Warm Temperate RF	RF	Northern Warm Temperate RF	113	-	g166	15200	85-95	7900	35-50
p114	Sandstone Scarp Warm Temperate RF	RF	Northern Warm Temperate RF	114	-	-	6800	>95	5900	80-95
p116	Intermediate Temperate RF	RF	Southern Warm Temperate RF	part 116	-	part g167	3000	75-90	1600	35-50
p117	Coastal Sandstone Plateau Heath	HL	Sydney Coastal Heaths	117	-	-	16100	>90	11300	50-70

Map code	Unit name	Form-ation	Class	P5MA unit	Eden units	SCRA FEs	Area Extant (ha):	Est. % remain-ing	Area in conservation reserves (ha):	Est. % of pre-clearing area in conservation reserves:
p120	Kanangra-Ti Willa Montane Heath	HL	Sydney Montane Heaths	120	-	-	1100	>95	1100	>95
p121	Loombah Plateau Heath	HL	Sydney Montane Heaths	121	-	-	340	>95	330	>95
p122	Morton Mallee-Heath	HL	Sydney Montane Heaths	122	-	-	37600	>95	33700	80-95
p124	Blue Mountains Heath	HL	Sydney Montane Heaths	124	-	-	7900	>95	6200	70-85
p125	Morton Rock Plate Heath	HL	Sydney Montane Heaths	125	-	-	4700	>95	4200	80-95
p126	Coastal Rock Plate Heath	HL	Sydney Coastal Heaths	126	-	-	260	>95	50	10-30
p127	Sandstone Headland Scrub	HL	Sydney Coastal Heaths	127	-	-	290	>95	200	60-80
p129	Coastal Upland Swamp	FrW	Coastal Heath Swamps	129, 303	-	part g141	4800	>90	1300	15-30
p130	Blue Mountains - Shoalhaven Hanging Swamps	FrW	Coastal Heath Swamps	130	-	part g141	5000	>95	3500	60-75
p131	Coastal Sandstone Ridgetop Woodland	DSFs	Sydney Coastal DSF	131	-	part g136	111000	75-90	49900	25-45
p136	Blue Mountains Ridgetop Forest	DSFs	Sydney Montane DSF	136	-	-	28800	80-95	21200	55-70
p139	Coastal Sandplain Heath	HL	Wallum Sand Heaths	139	-	part g136	1000	>90	530	20-40
p140	Coastal Sandstone Gully Forest	DSFs	Sydney Coastal DSF	140	-	-	24400	70-85	7700	15-35
p141	Budderoo-Morton Plateau Forest	DSFs	Sydney Montane DSF	141	-	-	5500	80-95	5200	70-90
p142	Hinterland Sandstone Gully Forest	DSFs	Sydney Hinterland DSF	142	-	-	90900	80-95	46800	35-55
p143	Sydney Shale-Ironstone Cap Forest	DSFg	Northern Hinterland WSF	143	-	-	2600	50-70	1600	30-50
p144	Wingecarribee-Burragorang Sandstone Forest	DSFs	Sydney Hinterland DSF	144	-	-	65900	80-95	41700	50-65
p146	Sydney Hinterland Transition Woodland	DSFs	Sydney Hinterland DSF	146	-	-	41800	60-80	13000	10-30
p148	Shoalhaven Sandstone Forest	DSFs	Sydney Coastal DSF	148	-	-	56500	80-95	30900	40-55
p149	Morton Sandstone Heath Woodland	DSFs	Sydney Montane DSF	149	-	-	18500	>90	16600	80-95
p153	Blue Gum High Forest	WSFs	North Coast WSF	153	-	-	180	<10	20	<2
p168	Shale-Basalt Sheltered Forest	WSFs	Southern Tableland WSF	168	-	-	2500	20-35	350	<10
p202	Burragorang Rocky Slopes Woodland	DSFg	Cumberland DSF	202	-	-	2200	45-65	2200	45-55
p210	Temperate Littoral RF	RF	Littoral RF	210	5	-	470	70-90	360	50-65
p219	Wombeyan Caves Woodland	DSFg	Central Gorge DSF	219	-	-	310	60-80	0	<1
p220	Southern Tableland Flats Forest	GW	Tableland Clay GW	220	22a, part 23b	-	58600	10-30	22100	<5
p239	Agnes Banks Woodland	DSFs	Sydney Sand Flats DSF	239	-	-	90	15-25	30	<10
p244	Megalong-Tonalli Sandstone Forest	DSFs	Sydney Hinterland DSF	244	-	-	29500	>90	26300	80-95
p246	Yalwal Shale-Sandstone Transition Forest	DSFs	Sydney Hinterland DSF	246	-	-	21100	>85	15300	55-75
p248	Morton-Budawang Sandstone Woodland	DSFs	Sydney Montane DSF	248	-	-	11600	>90	7700	60-80
p257	Tableland Flats Grassland	GL	Temperate Montane Grasslands	257	-	-	10900	<10	0	0

Map code	Unit name	Form-ation	Class	P5MA unit	Eden units	SCRA FEs	Area Extant (ha):	Est. % remain-ing	Area in conservation reserves (ha):	Est. % of pre-clearing area in conservation reserves:
p266	Southern Highlands Basalt Forest	WSFs	Southern Escarpment WSF	266	-	-	2000	20-35	690	<15
p268	Southern Highlands Shale Woodland	WSFg	Southern Tableland WSF	268	-	-	5400	10-25	20	<1
p313	Coastal Freshwater Lagoon	FrW	Coastal Freshwater Lagoons	313	-	-	3700	30-70	480	<15
p314	Budderoo Temperate RF	RF	Northern Warm Temperate RF	314	-	-	400	>95	230	45-65
p317	Southeast Cool Temperate RF	RF	Cool Temperate RF	317, part 116	8	-	3000	>95	2400	80-95
p338	Southern Range Wet Forest	WSFg	Southern Escarpment WSF	338, part 73	16, W4	-	87800	>90	38000	30-40
p343	Araluen Scarp Grassy Forest	DSFg	Southern Hinterland DSF	343	-	-	8800	75-90	2400	15-30
p420	Tableland Granite Grassy Woodland	GW	Southern Tableland GW	420	-	-	8400	20-35	20	<1
p434	Headland Grassland	GL	Maritime Grasslands	434	-	-	30	<30	20	10-20
p463	Elderslie Banksia Scrub	DSFs	Sydney Sand Flats DSF	463	-	-		<15	0	0
p502	Castlereagh Shale-Gravel Transition Forest	DSFg	Cumberland DSF	502	-	-	1700	25-35	230	<10
p509	Estuarine Saltmarsh	SL	Saltmarshes	509	64	-	2200	<50	690	10-30
p514	Cumberland Moist Shale Woodland	GW	Coastal Valley GW	514	-	-	600	25-35	10	<1
p516	Yarrawa Temperate RF	RF	Southern Warm Temperate RF	516	-	-	870	15-30	30	<2
p520	Tableland Swamp Flats Forest	FoW	Temperate Swamp Forests	520	-	-	11000	20-35	2500	<10
p563	Eastern Suburbs Banksia Scrub	HL	Wallum Sand Heaths	563	-	-	250	<10	90	<2
p599	Central Coast Wet Forest	WSFs	North Coast WSF	599	-	-	90	20-35	40	10-25

closely matched the distribution of native vegetation among land tenure classes (Table 5), although the proportion of samples located on freehold land was slightly higher than the proportion of native vegetation occurring there, leaving State Forests proportionally under-sampled (Table 5). Additional sampling carried out during this survey greatly increased the number of samples on freehold tenure. In part of the study area surveyed previously by Gellie (2005), for example, 781 additional quadrats were surveyed on private land, increasing proportional representation of sampling on freehold tenure from 25% to 39%.

Extent, Fragmentation and Structure of Extant Native Vegetation

Sixty six percent (2 657 571 ha) of the study area was mapped as extant native vegetation. Some 97.7% of polygons mapped as extant native vegetation occur as remnants of less than 50 ha (90.0% as remnants less than 10 ha) in a matrix of cleared land. These account for 7.5% of native vegetation in the study area. The majority of these small remnants occur on privately owned lands on the central and southern tablelands and highlands, and in the heavily developed semi-rural and urban areas of the Cumberland Plain and coastal lowlands. Most of the remaining vegetation lies in a large, more or less continuous band of public reserves stretching from the Blue Mountains in the north, along the eastern edge of the tablelands and the coastal ranges to the Victorian border.

Most of the field samples were located in sclerophyll forests dominated by eucalypts, although rainforest formations (RF1, RF2) had high proportional representation. A small proportion of survey sites (5.4%) was located outside of areas mapped as extant native vegetation. Examination of the species composition and structure of these samples showed that many are either in woody remnants below the minimum specifications of the mapping (i.e. 0.5 ha patches, 5% woody crown cover), or in non-woody assemblages of native vegetation. This highlights the limits of the map resolution and the difficulties of interpreting remote imagery to delineate patterns in open woody and non-woody vegetation in landscapes heavily modified by urban and rural development.

Distribution Modelling

Approximately 3 800 decision rules applied to 60 environmental and spatial variables were used to model the spatial distributions of map units over the study area. The most frequently applied spatial variables in the set of decision rules were vegetation structural category, soil landscapes and lithology. The highest-order nodes of the decision tree split the samples into groups based on the most informative regional scale variables. These included northing, annual rainfall, maximum temperature of the warmest period, minimum temperature of the coldest period, parent lithology and elevation. Lower-order splits in the decision tree reflected local variation represented by variables such as soil landscape, vegetation structure, aspect indices, solar radiation, topographic roughness, topographic position and distance to streams. Structurally distinctive vegetation communities such as Heathlands, Rainforests and Saline Wetlands were mapped using rules based on the relevant vegetation structural categories interpreted from remote imagery. Three of the 189 floristic assemblages defined in the cluster analyses could not be mapped because of low sample numbers and the lack of suitable spatial data layers to describe their distributions. These were Riparian Herbfield (FRW p55), Sandstone Cliff Soak (HL p50) and Eden Shrubby Swamp Woodland (FOW m15) all of which are likely to have very restricted distributions.

Endangered Ecological Communities

As of June 2008, 45 ecological communities occurring within the study area were listed as threatened under the NSW TSC Act 1995 (Table 6), of which 42 were Endangered, two were Critically Endangered and one was Vulnerable. Nine communities listed as Endangered or Critically Endangered under the Commonwealth EPBC Act 1999 occur within the study area (Table 6). In addition, seven of the communities identified by this study (SL e65, e67, e68, e69, e70, p109, p509) have legal protection as Protected Marine Vegetation under the *Fisheries Management Act 1994*. Inferred relationships between map units and EECs listed under the TSC Act, and the EPBC Act are shown in Table 6.

Of the 45 threatened ecological communities listed under NSW legislation, five are rainforests, seven are wet sclerophyll forests, eleven are dry sclerophyll forests, eight are grassy woodlands, one is a grassland, two are heathlands, six are forested wetlands, four are freshwater wetlands and one is a saline wetland. These are found primarily around the Sydney metropolitan area, the coastal floodplains and river valleys and throughout the tablelands. Threatened Ecological Communities account for 24% of map units described in this study, but these map units account for only 2% of the extant native vegetation mapped within the study area.

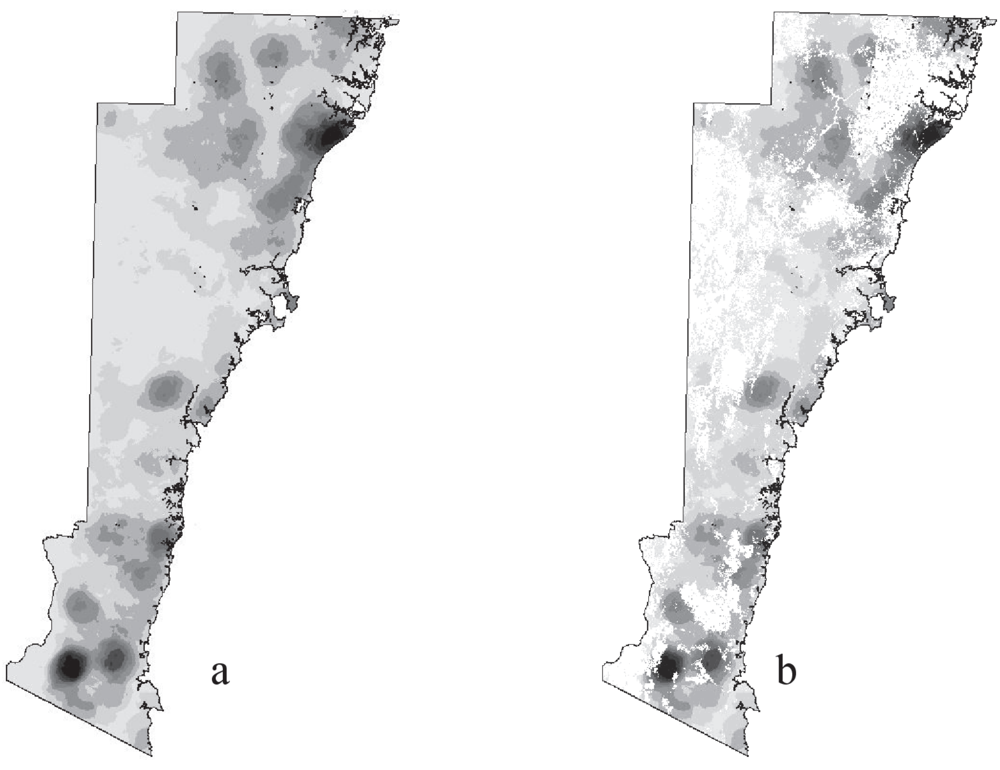


Fig. 4. Relative density of field samples for: a) whole study area; and b) areas of extant vegetation. Darker shading indicates higher density of sampling

Relationships with other classifications

A high proportion (81%) of communities described in the current study had equivalent units in previous classifications of Keith & Bedward (1999) and Tindall *et al.* (2004), indicating the robustness of the classifications. A further 11 were related to units described in both studies and were assigned the unit number from the region contributing the highest number of samples. Five new communities were identified as a result of the inclusion of additional samples located primarily in the geographic gap between the previous surveys of the Eden region (Keith & Bedward 1999) and south coast (Tindall *et al.* 2004) (m15, m68, m83), or through the reinterpretation of existing samples in the broader spatial context (n183, n184). The remaining 20 communities were derived from recombinations of nine units from Tindall *et al.* (2004) and 19 units from Keith & Bedward (1999) primarily in the southern and northern extremities of those study areas, respectively. The alternative groupings of floristic samples produced a more compatible representation of patterns in species composition across the transition zone than the two separate classifications.

There were strong similarities between the classification of this study (Appendix 3) and those of previous studies overlapping a smaller subset of the study area, as indicated by high levels of direct 1:1 correspondence between respective units (Table 7). A high proportion of communities described by Tozer (2003) had equivalent units in the current classification, while a slightly lower proportion of units described by NPWS (2002) and NPWS (2003a) had equivalent units in the current classification. The classification of Gellie (2005) showed moderate levels of correspondence with the current classification, with less than half the units in each classification having equivalent units in the other (Table 8).

Discussion

Methods and Approach

While classifications and maps covering large areas are more likely to give a complete perspective on the distribution and relationships among vegetation communities, these are often perceived as less accurate, less precise and lacking in thematic detail compared to maps of smaller areas. We sought to optimise this trade-off between extent and detail by utilising all available field and linework data from more localised studies and extending common aspects of their methods over a much larger area. Although the current project was nominally conceived as a medium scale (1:100,000) mapping project (Sivertsen & Smith 2001), the scales of interpretation and mapping of compositional patterns aimed to meet the requirements of the legislative and planning framework in NSW (e.g. Threatened Ecological Communities under the TSC Act 1995, native vegetation types under the NV Act 2003). These dictated an approach which essentially replicated the methods used in smaller projects over a much larger area.

The major constraints in describing and mapping compositional patterns related primarily to the quality and quantity of field data and spatial data layers as opposed to analytical or logistical factors. As the quality and quantity of field and spatial data continue to develop, more detail is justified over larger regions and classifications and maps become more robust to addition of new information. Hence the greatest changes to previous classifications and maps occurred where data was most limited and where new sampling substantially improved the coverage of data (Table 7). While variation in the quality and consistency of data from disparate sources necessitated exclusion of some data (due to quality control) and degradation of some detail (e.g. re-scaling of cover-abundance estimates), field and spatial data were generally as detailed as, or better than, those available for any smaller project completed within the study area. The level of classification detail (thematic scale), resolution of mapping (spatial scale) and overall accuracy therefore did not reflect a fixed scale of interpretation, but varied as a function of the best data available (e.g. Fig. 4).

Relationships with other classifications and maps

The classification and maps produced in this study differed to varying degrees from those of previous studies that covered parts of the same region (e.g. Keith & Bedward 1999, NPWS 2002, 2003a, Tozer 2003, Gellie 2005). Consequently the descriptions and boundaries of map units may not directly correspond between studies. The degree of correspondence varies depending on a number of factors.

Some of the differences between classifications were related to edge effects. This was most evident in the Eden classification (Keith & Bedward 1999) and the south coast classification of Tindall *et al.* (2004). The amalgamation of data across the respective edges of these study areas, and inclusion of data from the gap between them, changed the context of dissimilarities between samples, resulting in some re-arrangement of the classification in that area. In contrast, the study areas of previous classifications in the Illawarra (NPWS 2002) and shale areas of the Cumberland Plain (Tozer 2003) showed little evidence of edge effects, ostensibly because the boundaries of their study areas corresponded with biogeographic zones in which the vegetation showed high contrast with that of adjacent areas.

Similar classification methods were employed across this and previous studies and were therefore unlikely to account for many differences between classifications. However, differences between some of the classifications may be partly explained by differences in their thematic scales, the levels of dissimilarity at which communities are distinguished from one another (Keith 2009). For example Keith & Bedward (1999), NPWS (2002) and NPWS (2003a) classified vegetation at a slightly finer level of detail than the current study, and therefore identified a few units that were included within more broadly defined communities in the current classification. Examples include communities 6 and 7 of Keith & Bedward (1999), which were included within a single unit (e6e7) of the current classification. Some of the additional classification detail in previous classifications derived from relatively few data and was not supported by analysis of the data over a broader spatial context. For example, seven of the units described for the Illawarra were split on the basis of three or less survey samples, while three of these units were defined almost entirely by sites excluded from the current analysis by the data screening procedures. The higher number of units recognized in the Warragamba study (NPWS 2003a) derived largely from differing interpretations of the more-or-less continuous floristic variation on sandstone (12 vs. 7 units) and Devonian sediments (12 vs. 4 units).

The coverage of data on which each classification was based also influenced differences between them and was most likely to explain the relatively low correspondence with Gellie's (2005) classification. A relatively low proportion of shared data between the two studies, and there was significant unevenness in the relative distribution of sites among land tenures which was rectified by additional sampling on private land (Table 9). Some 16 units in the present study were defined entirely by sites unavailable at the time of Gellie's (2005) survey while a further 61 units were defined by 2251 sites, of which only 229 were previously available. In addition, Gellie's (2005) classification included data from the western part of the tablelands and adjacent slopes that were beyond the scope of this study, creating differences along study boundaries.

Vegetation classifications and maps of the greater Sydney region carried out by the Royal Botanic Gardens (Keith & Benson 1988, Benson 1992, Benson & Howell 1994a, 1994b and 1994c, Fisher & Ryan 1994, Fisher *et al*. 1995) differ more markedly from those presented here than the other major surveys in the region described above. Only a small fraction of the data used here were available at the time of the greater Sydney surveys, which employed subjective methods of classification and mapping at somewhat coarser scale and resolution than the current work. Nonetheless, many of the general patterns in native vegetation related to parent material, elevation and rainfall can be discerned from the classifications and maps of both surveys and in some cases parallels can be drawn between groups of maps units. For example, map units GW p28 and p29 from this study correspond generally with map units 10 c and 10d of Benson (1992).

Evaluating uncertainties in the vegetation map

Errors and uncertainties are inherent in all maps. In the present study, the main sources of error and uncertainty were: potential biases in the content and coverage of field samples; linework and attribution derived from the interpretation of remote imagery; propagation of inaccuracies in spatial data layers used to derive the vegetation map; uncertainty in the assignment of samples to plant assemblages; and insufficient data/information to determine the merits of alternative decision rules for mapping. We evaluate each of these factors below.

Observer errors in field sampling, including variability and bias in quadrat search effort and subjective estimation of cover abundance, and species misidentifications, are difficult to quantify without replication of observers, but can be important sources of uncertainty (Baran 2001, Gorrod & Keith 2009). Together with variation in coverage, age and seasonality of samples, these errors may have an influence on classification and mapping outcomes. Stringent quality-control procedures were carried out to reduce these errors and resulted in exclusion of some 20% of available data from the analysis. Spatial and environmental bias in the distribution of samples was addressed by targeting additional sampling in environments and land tenures that were identified as sample deficient. This substantially improved the evenness and intensity of field sampling. However, some under-sampled map units would benefit from further sampling because: (i) their distributions are highly restricted or depleted (e.g. Basalt Hilltop Scrub HL p46, Wombeyan Caves Woodland DSF p219); (ii) their distributions are primarily outside the study area (e.g. Lithgow-Abercrombie Grassy Forest GW p17 and Central Coast Wet Forest WSF p599); (iii) remoteness or tenure limits access (e.g. Ettrema Gorge Forest DSF p84); or (iv) some combination of these reasons (e.g. Southern Highlands Shale Woodland WSF p268).

Observer errors also influenced image interpretation, which were compiled from 26 sources and approximately 30 different interpreters. Skill levels and interpretations of standard classification concepts used to discriminate and attribute polygons varied between interpreters to an unknown degree. Consistency also varies within interpreters due to fatigue, developing experience envelopes and other subjective factors (Burgman 2005). Automated image classification approaches offer improved consistency, but may sacrifice some discriminatory power and introduce systematic biases. Both visual and automated image interpretation are subject to errors in the imagery. These are likely to be greatest in steep and dissected terrain where shadow can limit discriminatory power and orthorectification can lead to distortion of images. Variations in colour balance and resolution also generate interpretation errors, while in fragmented landscapes boundaries between woody and non-woody vegetation may be diffuse and difficult to delineate.

To our knowledge, no Australian vegetation mapping study has yet systematically assessed observer- and image-related sources of error, but this information is crucial to inform map users about the reliability of mapped occurrences of communities and estimates of their current extent. In this study, we undertook two evaluations that were both limited to assessing the accuracy of cleared land boundaries. First, a comparison of mapped boundaries with digital imagery indicated that spatial accuracy varied from 20 (± 10) m in the Western Sydney coverage to 160 (±170) m in the CRAFTI coverage for the South Coast (Keith *et al.* 2000). Boundary accuracy in the other 24 coverages used in the compilation of the vegetation structure data layer is likely to lie within these extremes. Secondly, a comparison of mapped woody vegetation with spatially explicit field observations indicated that overall accuracy of mapped native woody vegetation (sensitivity) varied from 70% to 94% between five different aerial photograph interpretation coverages within the current study area (Keith & Simpson 2008). These estimates are likely to be higher than estimates that incorporate accuracy of mapped non-woody vegetation and different types of woody vegetation. To improve consistency, currency and resolution of mapping, we carried out new interpretation using updated imagery. Based on a subsequent comparison with digital orthophotography, boundary accuracy of the resulting mapping was estimated to be 20 (± 10) m.

Estimates of the extent of clearing in each vegetation type are sensitive to the scale and resolution of mapping. For example, the estimated area of remaining native vegetation would appear higher if mapping included smaller remnants and lower thresholds of woody cover than adopted in this study, although such an analysis would be likely to include as 'extant' a greater area of vegetation in highly modified condition. Conversely, use of coarse mapping specifications would result in smaller area estimates for extant vegetation by excluding small fragments. In both of these cases, areas mapped as Non-native Vegetation (NV) are likely to include some areas that are dominated by native vegetation. These include areas that are below the patch-size threshold for mapping and areas where native woody plants are sparse (due to clearing), but the remaining matrix of non-woody vegetation is predominantly native in species composition. These effects are most pronounced in fragmented landscapes. The estimated area of Cumberland Shale Plains Woodland, for example, approximately trebles if scattered trees with native understorey are included within the estimate (Tozer, unpublished data). Users of clearing estimates therefore need to be cognisant of the sensitivity of the estimates to variation in these parameters.

Spatial data layers varied in resolution and scale from coarse scale geology maps (1:100 000 and 1:250 000 scale) and climatic surfaces to the fine resolution digital elevation model (25 m grid cells). The scarcity of weather stations in some parts of the study area may limit the accuracy of climatic surfaces. The extensive evaluation, deconstruction and revision, which were undertaken during the development of the decision tree model, reduced the likelihood that errors in these data layers were propagated to the vegetation map. Additional field reconnaissance and floristic sampling also allowed localised errors to be identified and corrected. Several of these errors were attributed to the geology and soil landscape layers, and it is likely that further such errors will be detected in future.

Finally, map accuracy was influenced by the knowledge and field experience of the modeller, as well as the number of samples available. The influence of subjective effects is likely to be smaller in this study than 'traditional' mapping approaches in which expert input is less strongly guided by site data and interpretive protocols. The most accurately mapped communities were those with strong environmental relationships or distinctive structural features detectable on remote images, particularly if they were well represented by samples. For some communities, however, there was little information (quantitative samples or expert knowledge) on which to base choices of alternative decision rules which may produce somewhat different mapping outcomes.

Ecological Relationships and Landscape Patterns

The distribution of plant communities mapped in this study strongly reflects patterns in surface geology, climate and topography. At the local scale, differences in surface geology often correspond to relatively marked changes in both landform and soil properties (Gray & Murphy 1999), which in turn support contrasting assemblages of plant species. At regional scales, variation is more subtle, but the influence of climate is evident through the turnover of species and communities with latitude and altitude (Keith & Sanders 1990). There is also a regional distinction between communities occurring on soils derived from rocks dating to the Mesozoic Era, which dominate the Sydney Basin, compared with those on soils derived from older rocks of the Palaeozoic Era, which dominate the far south coast, escarpment and tablelands. Patterns in the distribution of native vegetation communities vary between six major landscape types which can be recognised in the Sydney – south coast and tablelands region.

1. Coastal Plains

Silty alluvial soils at low elevations on the floodplains of the Hawkesbury-Nepean, Shoalhaven, Bega and Towamba rivers and along many smaller creeks and rivers support mosaics of forested and treeless freshwater and saline wetlands (Keith 2004). Tidal zones support mangroves (SL p109) and salt marsh (SL p509). Floodplain lakes, lagoons and swamps are restricted to depressions where water tables are maintained close to the surface and are dominated by treeless wetlands (FrW p313, part FoW e60) and forested wetlands (FoW e60, p30, p44, p45, p105, p106, p107). Wet sclerophyll forests (WSF p103, p104, p110) that more typically occur on lithic substrates may sometimes be found on elevated alluvial soils, which are generally restricted to the fringes and upper reaches of large and small coastal floodplains. The Hawkesbury-Nepean floodplain supports a particularly diverse suite of forested wetlands (FoW p33, p44, p105, p106).

Marine and aeolian sand deposits are a feature of the coastline and vary in size from small beach dunes to larger sand plains such as at Seven Mile Beach, Botany Bay, Jervis Bay, Burril Lake and Disaster Bay. These sand deposits are typically dominated by shrubby dry sclerophyll forests (DSF p64), heathlands and scrubs (HL p63, e61, p139, p563). Where drainage is impeded, dry sclerophyll forests are replaced by forested wetlands (Map Units FoW p44, p45) and treeless freshwater wetlands (FrW p313).

2. Coastal Rain Shadow Valleys

Rain shadows in coastal valleys surrounded by elevated foothills are dominated by grassy woodlands (Keith 2004; Tozer in press). The study area's largest, most diverse and most northerly coastal rain shadow, the Cumberland Plain, also includes a suite of grassy dry sclerophyll forests (Keith 2004). Although sharing similar tree species, the understories of the three grassy woodland communities present on the Cumberland Plain (GW p28, p29, p514) vary in floristic composition with regional gradients in elevation and rainfall, and locally with topographic variability and soil drainage and texture. The transition from shale soils of the plain to shallower, less fertile sandy soils of the surrounding sandstone is marked by grassy dry sclerophyll forest (DSF p2) in low-rainfall areas and wet sclerophyll forests (WSF p87, p153) in wetter areas. Deposits of Tertiary alluvium produce less fertile gravelly clay loam soils than the surrounding shales and support mosaics of grassy dry sclerophyll forests (DSF p1, p4, p7, p502), while unique sclerophyll woodland and scrub communities (DSF p239, p463) occupy highly localised deposits of sand.

In the far south, the Bega and Towamba valleys support other extensive areas of coastal rain shadow grassy woodlands (GW e20p229). As on the Cumberland Plain, floristic composition varies with regional gradients in rainfall and elevation as well as topographic variability. Keith & Bedward (1999) recognised two distinct assemblages (Bega Dry Grass Forest and Candelo Dry Grass Forest) along a rainfall gradient, while other woodland and forest communities occur on more sheltered slopes and flats (GW e19) and high ridges (GW e18). Local frost hollows support species more typical of higher elevations with cool temperate climates. Smaller valleys and plains along the coast support northern (Milton – Illawarra) and southern (Batemans Bay – Towamba) variants of grassy woodlands (GW p34, e20p229), although this compositional gradient is gradual and continuous. Further inland and at higher elevation, the sandy granitoid soils of the Araluen Valley also support grassy woodlands (GW e20p229) with many species in common with the more elevated and topographically variable southern parts of the Cumberland Plain (GW p29) (Tindall *et al*. 2004).

Patches of dry rainforest are found where rainfall is somewhat higher and topography more hilly, in the Cumberland Plain margins (RF p38), the southern Illawarra around Milton (RF p40, RF p111) and near Bega (RF e1). Localised areas of scrub (HL p46) are found on exposed ridges with skeletal volcanic soils in the Illawarra.

3. Sandstone Plateaux, Scarps and Lowlands

Extensive elevated sandstone plateaux of the Sydney Basin (Woronora-Nepean Ramp, Blue Mountains, Hornsby and Morton Plateaux) are characterised by shallow, low-nutrient sandy loams and are overwhelmingly dominated by dry sclerophyll forests (Keith 2004) with diverse and abundant sclerophyllous shrubs (DSF p131, p136, p140, p142, p144, p146, p148, p149, p244, p248). Heathlands (HL p117, p120, p122, p124, p125, p126, p127) dominate exposed areas and where soils are shallow or not well drained. Upland swamps (FrW p129, p130) occur in poorly drained headwaters in high-rainfall parts of the basin. Different suites of these communities occur on the Sydney coastal plateaux, the Blue Mountains and the Morton plateau, indicating high species turnover and local endemism. Further south, sandstone substrates are rare, and occurrences around Nungatta Mountain (DSF e25, e43, e50) and Nadgee (DSF e47, HL e54, e55) support a less diverse array of related communities.

Wet sclerophyll forests and rainforests (Keith 2004) are uncommon on the sandstone plateaux, but occur on basalt flows that cap the plateau in the Blue Mountains and Southern Highlands (WSF p72, p168, p266, p268, RF p116, p516). They can also be locally dominant in high rainfall areas where the plateau is dissected to expose more fertile soils of the underlying siltstones, claystones and mudstone sin sheltered gorges or escarpment slopes. For example, the wetter parts of escarpments of the Illawarra, Blue Mountains and Morton plateau support extensive wet sclerophyll forests (WSF p95, p99, p100, p102, p110) with temperate rainforests occurring patchily in the most sheltered sites (RF p113, p114, p116, p314). The drier or more exposed escarpment slopes are dominated by dry sclerophyll forests with mixed understories of grasses and shrubs (DSF p5, p6, p88, p95, p146, p246). Fine-grained sedimentary substrates (e.g. Wandrawandian Siltstone) are also exposed on the undulating coastal lowlands between Nowra and Durras, where they support a mosaic of grassy dry and wet sclerophyll forests (DSF p85, WSF p86).

4. Southern Escarpment and Foothills

The bulk of the escarpment and foothills that run south from the Sydney Basin comprise clay loam soils derived from metasediments and acid volcanics. In less dissected, moister areas within the foothills, these soils are dominated by grassy wet sclerophyll forests (WSF p86, p90, p100, p104), while shrubby wet sclerophyll forests are common in wet gullies east of the Clyde river (Map Units WSF p99, p103). Rainforests (RF p113, e6e7) are restricted to moist protected gullies.

In the heavily dissected terrain of the upper Deua and Buckenbowra Rivers and on the southern escarpment, shrubby wet sclerophyll forests (WSF e9, e10, e11, e12, e13, e14, e15, e16, e17, p66, p103, p338) occur on sheltered slopes. These are replaced by shrubby dry sclerophyll forests (DSF e19, e27, e28, e29, e30, e31, e35, p343, e43, e44, e45, e46a, e46b, e47, e48, p89, p91, p98, p248) on exposed ridges, slopes and sites with sandier soils. Grassy wet sclerophyll forests (WSF p78, p90, p100) replace shrubby wet sclerophyll forests on soils derived from the Merimbula formation, while rainforests (RF p40, p113, p116, p317, e6e7) are scattered throughout the escarpment and foothills as many small patches within moist gullies.

5. Gorge Country

The eastern edge of the tablelands is deeply incised by sections of the Hawkesbury-Nepean, Shoalhaven, Brogo and Tuross River systems forming a complex of steep rocky gorges including the Burragorang, Coxs, Ettrema, Kanangra, Kowmung, Shoalhaven, Wollondilly, Tuross and Brogo Gorges. These deep gorges predominantly cut through metasediments and porphyries, with shallow clay-loam soils. Dry sclerophyll forests with mixed understories of grasses and shrubs (DSF e85, p5, p11, p27, p35, p36, p37, p84, p88, p202) form the dominant vegetation cover of the gorge slopes, while dry rainforests (RF p38, p40) are scattered throughout the gorges in sheltered pockets. Forested wetlands (FoW p30, p31, p32) occur within the narrow corridors of riverine alluvium.

6. Central and Southern Tablelands

The central and southern tablelands cover over one third of the study area and comprise an extensive area of rain shadow west of the escarpment range. The bulk of the tablelands comprise clay loams derived from a range of metasediments. In undulating terrain, and on flats with deeper soil development, grassy woodlands (GW p19, p22, p23, p24) are the dominant vegetation. Similar terrain on granite and basalt substrates includes a larger group of grassy woodlands (GW e24, p20, p22, p23, p24, p220, p420, p520). Grassy woodlands (GW p22, p520) also occur on well-drained areas of alluvium in broad valleys, while peaty soils accumulate in poorly drained sites that support swamp vegetation (FrW e59, p53, p55, p57, GL p257). The largest deposits of alluvium on the tablelands have accumulated on intermittent lake beds within internally draining basins. These support an ephemeral aquatic flora and periodically inundated herbfields (FrW p51).

Dry hills, ridges and dissected terrain with shallow, rocky soils support dry sclerophyll forests with shrubby understories (DSF p8, p9, p10, p14, p15). Sandy, infertile Tertiary alluvial deposits on undulating terrain between Bombay and Oallen also support shrubby dry sclerophyll forests (DSF p9, p15).

The transition between escarpment and tablelands is marked by grassy wet sclerophyll forests (WSF p268, p338). The most elevated ranges experience high rainfall (upper Blue Mountains, Gourock Range and the Southern Scarp), and are also dominated by wet sclerophyll forests (WSF p66, p70, p73, p78, p338), although shrubby dry sclerophyll forests occur on exposed ridges (DSF p8, p91, p98). Small areas of distinctive heathlands are found on exposed shallow soils on ranges on the Boyd plateau (HL p120, p121) and from the upper Shoalhaven valley south to Bombala (HL e53).

Threatening Processes

Threatening processes affecting native vegetation within the study area include habitat destruction and degradation, biological interactions with introduced plants and animals, alterations to disturbance regimes, and climate change. Each of these processes has had, and continues to have, differential effects across the range of plant communities within the study area.

Habitat destruction and degradation

The pattern of land clearing across the study area is strongly biased towards particular substrates and landscape types. Flat to undulating terrain, particularly where soils are fertile, has been preferentially cleared of native vegetation for agricultural or urban development, while shallow low-nutrient soils in strongly dissected terrain still retain large areas of native vegetation. Consequently, plant communities that typify agriculturally suitable environments have sustained proportionally large reductions in extent (Appendix 3; Fig. 5). These include virtually all 20 of the grassy woodland and grassland communities, five forested wetland communities, three freshwater wetlands and one or two types of rainforest, wet sclerophyll forest, dry sclerophyll forest and heathland. All of these occur on low-relief terrain, and most occur on comparatively rich soils.

Some of the communities that were originally fragmented by agricultural clearing are now undergoing renewed clearing pressures associated with expansion of the major urban centres of Sydney and Wollongong, as well as regional growth centres and coastal holiday settlements. Blue Gum High Forest (WSF p153), Sydney Turpentine-Ironbark Forest (WSF p87), Cumberland Shale Plains Woodland (GW p29), Eastern Suburbs Banksia Scrub (HL p563), South Coast Grassy Woodland (GW p34) and Estuarine Saltmarsh (SL p509) have been heavily fragmented by urban expansion. Outside the metropolitan areas, Estuarine Saltmarsh (SL p509), Coastal Sand Swamp Forest (FOW p55), Littoral Thicket (HL p63), South Coast Grassy Woodland (GW p34), Coastal Headland Grassland (GL p434) and Coastal Sand Forest (DSF p64) are exposed to continuing clearing associated with coastal development. Extractive industries, though restricted in area, have also resulted in some significant clearing and fragmentation, most notably affecting Agnes Banks Woodland (DSF p239), Elderslie Banksia Scrub (DSF p463) and Basalt Hilltop Scrub (HL p46).

Clearing of native vegetation has been listed as a Key Threatening Process on Schedule 3 of the NSW *Threatened Species Conservation Act* 1995. Many of the map units mentioned above are listed as Endangered Ecological Communities under that Act (Table 6), while others are yet to be assessed.

Habitat degradation is pervasive in many of the surveyed communities, results from a diversity of causes and is expressed in many different ways. The increased fragmentation that results from land clearing generates secondary processes and synergistic effects of other threatening processes, such as edge effects, degradation associated with increased human access (e.g. rubbish dumping, trampling and physical damage), weed invasion and genetic isolation. Land clearing sometimes involves selective removal of some components of the plant community, while other components persist in a modified form of the original community. For example, many of the native grasslands mapped by Walter & Schelling (2004) on the southern tablelands and by Pellow and French (2003) at the Orchard Hills Defence Site (western Sydney) were originally grassy woodlands, from which the woody components of the native vegetation had been removed. Although these non-woody remnants are traditionally lumped with 'cleared land', they often have significant conservation values because they retain components of the biota complementary to those represented within woody remnants (Keith *et al.* 2005).

Other forms of habitat degradation involve modification to soils. Soils in some areas have undergone nutrient enrichment, either directly as a result of fertiliser application (particularly superphosphate and nitrogen-based fertilisers) or indirectly as a result of enriched stormwater runoff from improved pastures, croplands, urban or industrial areas upslope (e.g. Clements 1983, King & Buckney 2002, Leishman *et al.* 2004). The most extensively affected communities include grassy woodlands, grasslands and wetlands. Wetlands and riparian vegetation are particularly vulnerable because, despite some resilience to nutrient enrichment, they act as sinks in the landscape where large quantities of nutrients accumulate and transform habitats to a degree that they become unsuitable for many native species. Although the exposure of dry sclerophyll forests and heathlands to nutrient enrichment is more localised, the impacts on these communities are generally more severe because many of their component species have adaptations to extract nutrients from highly infertile soils that make them highly sensitive to toxicity from elevated levels of nutrients, particularly phosphorus, or to competition from faster-growing exotic species. Soils have also undergone compaction and/or erosion, particularly where the cover of native vegetation has been partially or completely removed and/or where stocking rates have been high (Beadle 1948). This reduces the ability to recruit seedlings in many native plant species and may also reduce survival rates of existing plants.

Biological interactions

The invasion and spread of introduced plants is the most serious biological interaction that threatens native vegetation in the region. Introduced plants may displace native plant taxa and 'transform' the habitats of native plants and animals (Richardson *et al.* 2000, Grice *et al.* 2004). Transformer weeds may alter vegetation structure, reduce available light, nutrients and water available to native plants, reduce shelter, food or breeding resources available to native animals or alter fire regimes, for example, by reducing the flammability of vegetation. Disturbances resulting from urban or rural development and agriculture (e.g. removal or reduction of native vegetation cover, nutrient enrichment of soils, changes to hydrology, physical disturbance to soil) may enhance growth, reproduction and dispersal of introduced plants, giving them competitive dominance over native species.

Riparian zones and fragmented remnant vegetation with long edges are highly susceptible to weed invasion. Within the study area, the communities most prone to weed invasion include grasslands (GL p257, p434), grassy woodlands (GW e18, e20p229, e24, p2, p3, p20, p22–24, p28, p29, p34, p220, p420, p520), wet sclerophyll forests with grassy understories (WSF e15, p87, p143, p168, p266, p268), forested wetlands (FOW e17, e38, e39, e60, m15, p30, p32, p44, p45, p105–107) and swamp meadows (FrW e56, e57, e59, p51, p55, p57).

Exotic plant species represented approximately 19% of the total flora recorded in the survey and about 25% of the total known exotic flora in New South Wales. This may slightly under-estimate the extent of invasions because the most degraded forms of native vegetation and non-native vegetation were poorly represented among samples. The exotic species recorded fall into four main groups: perennial grasses, vines, shrubs and forbs. Many species from these groups are listed as Key Threatening Processes under the NSW *Threatened Species Conservation Act* 1995 (NSW Scientific Committee, undated). The most frequently recorded perennial grasses include *Chloris gayana, Ehrharta erecta, Eragrostis curvula, Nassella trichotoma, Paspalum dilatatum, Pennisetum clandestinum, Phalaris aquatica* and *Setaria gracilis*. These species readily invade disturbed grassy woodlands, grasslands, forested wetlands and swamp meadows, as well as grassy wet and dry sclerophyll forests. Introduced vines (e.g. *Anredera cordifolia, Araujia sericifera, Asparagus* spp., *Cardiospermum grandiflorum, Ipomoea* spp., *Lonicera japonica*) are especially problematic in disturbed wet sclerophyll forests and rainforests. Shrubs such as *Ageratina adenophora, Lantana camara, Ligustrum* spp., *Ochna serrulata, Olea europaea* subsp. *cuspidata* and *Rubus* spp. readily invade mesic habitats (RF p111, p112, p210, WSF p87, p143, p168, p266, HL p63). Several of these species have fleshy fruits that are dispersed by native birds and appear capable of invading some habitats that have apparently undergone little recent disturbance. For example, African

Olive has undergone a conspicuous expansion into grassy woodlands and wet sclerophyll forests in recent decades (Cuneo & Leishman 2007) and was recorded within 43% of the 198 samples within map units GW p28 and GW p29, which represent Critically Endangered Cumberland Plain Woodland. Other shrub species threaten more specialised habitats, including *Salix* spp. (forested and freshwater wetlands) and *Chrysanthemoides monilifera* (communities on coastal sand plains including DSF p64, HL e61, p63, p139, p563, RF p210). Herbaceous species are pervasive throughout many grassy woodlands, grasslands, forested and freshwater wetlands and grassy wet and dry sclerophyll forests. Although this group includes the most frequently recorded exotic taxa in the region (*Hypochaeris radicata*, *Cirsium vulgare*, *Senecio madagascariensis* and *Plantago lanceolata*), their impacts on native plant communities tend to be less severe, as they transform habitats less aggressively than some species in the other weed groups. The exceptions are aquatic forbs such as *Eichhornia crassipes, Ludwigia* spp. and *Salvinia molesta, which* pose significant threats to freshwater and forested wetlands (FrW p313, FoW p32, p33, p105).

Excessive grazing and browsing by feral and domestic vertebrate herbivores is a second group of biological interactions that pose threats to native vegetation in the region. Grazing and browsing may result in significant changes in the species diversity and structural complexity of native vegetation, depending on the grazing regimes and resilience of component plant taxa (Leigh & Holgate 1979, Wimbush & Costin 1979, Prober & Thiele 1995, Clarke 2000). The resilience of individual plant taxa to grazing depends on their palatability, regenerative capacity, growth form and the existence and phenology of dormant life stages relative to the grazing regimes that they are exposed to (Clarke 2000). Continued heavy grazing may reduce the relative abundance or eliminate a number of woody taxa and palatable forbs and simplify the structure of native vegetation. The simplification of vegetation structure has implications for the suitability of habitats for a wide range of native fauna.

The vegetation most susceptible to grazing impacts includes remnants of grasslands, grassy woodlands, wetlands and grassy wet and dry sclerophyll forests. The most affected communities occur within the pastoral districts of the Central and Southern Tablelands and Southern Highlands (GW e24, p17, p20, p22–24, p220, p420, p520; GL p257, p434; FrW p51, p53, p55, p57, p257, FOW p54, DSF p8–10, p14, WSF p73, p168, p266, p268) and coastal rainshadow valleys (GW e20p229, p2, p3, p28, p29, DSF p1, p502). The principal herbivores that affect native vegetation in the region include feral goats, rabbits, deer, pigs, and domestic sheep and cattle. All of these feral herbivores are listed as Key Threatening Processes under the NSW *Threatened Species Conservation Act* 1995 (NSW Scientific Committee, undated). Their effects, and those of domestic herbivores, may add to those of native macropods, which may have significant impacts in localised areas where their densities are artificially inflated.

Excessive grazing and browsing may interact with other threatening processes producing synergistic impacts on native vegetation. For example, heavy grazing may initiate or accelerate erosion of topsoil. These effects are exacerbated where soils are unconsolidated, on inclined slopes or low in clay content, particularly where hoofed animals are involved. Grazing may also provide gaps for the establishment of introduced plants, which may also compete with some native plant taxa resulting in further declines in native species diversity and alterations to vegetation structure. Flushes of weed invasion commonly occur after long periods of grazing have opened up the structure of native vegetation, allowing entry and establishment of weeds when grazing activity is temporarily or permanently reduced. Active management is required to control weeds during such periods until cover of native vegetation has re-established, providing greater resilience to invasion. The effects of grazing may also interact with climatic variability, particularly where remnants of native vegetation are managed as stored fodder and grazed more heavily during drought years

Alteration to disturbance regimes

Alteration to two key disturbance regimes (water and fire) poses threats to numerous plant communities within the region. Hydrological changes, including the draining of wetlands (e.g. Wollogorang Lagoon, Nowra Floodplain), increases in stormwater runoff from sealed surfaces (e.g. Lane Cove and Georges River catchments), impoundment of water in reservoirs and dams, and interruption to stream and seepage flows (e.g. metropolitan catchments) affect the vegetation of freshwater and saline wetlands and riparian corridors (Map Units FOW e17, e38, e39, e60, m15, p30–33, p44, p45, p54, p58, p105–107, SL p109, p509, FrW e56, e57, e59, p51, p53, p56, p55, p57, p257, p313). Significant areas of wetland have been drained in the past for agricultural and pastoral development (e.g. around Nowra, Windsor, Jamberoo, Albion Park, Breadalbane, Goulburn and Taralga), while more localised infilling and reclamation of wetlands continues for urban, industrial or recreational development in the Sydney – Illawarra metropolitan area and around expanding settlements on the south coast. Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands is listed as a Key Threatening Process on Schedule 3 of the NSW *Threatened Species Conservation Act* 1995.

Changes in fire regimes may result in declines of some plant species, enhanced spread of some others, and changes to vegetation structure. This occurs through a range of different mechanisms (Keith 1996). Fauna may be affected by resulting changes in the availability of food, shelter and breeding sites (Whelan *et al*. 2002). Some urban bushland areas are exposed to increased ignition rates due to arson and hazard reduction management, while in some rural areas, fire is used by some graziers to promote green pick for livestock. Under these circumstances native vegetation may be exposed to high fire frequencies that result in declines of many woody plant species, the spread of native rhizomatous plants and some introduced species. Ecological consequences of high frequency fire are listed as a Key Threatening Process on Schedule 3 of the NSW *Threatened Species Conservation Act* (1995). In other areas, there may be substantial declines in fire frequencies which may be associated with isolation and fire exclusion from vegetation remnants or long-term changes in fuel structure attributable to processes such as nutrient enrichment or grazing. Fire exclusion may result in the loss of species that depend on fires as a cue to recruitment, including relatively short-lived native plants and those without persistent seed banks or other types of propagules.

Climate change

Climate change is the most pervasive and least predictable of all threatening processes. The communities likely to be most affected include those that are restricted to cool temperate bioclimatic zones (e.g. RF p317, WSF e9, e10, e11, p338), those susceptible to climatic drying or reduced rainfall reliability (e.g. FrW p51, p55, p130, FoW p32, p54) and those likely to contract as a result of sea-level rise (e.g. DSF p64, FoW e60, p45, p104, FrW p313, SL509). Major impacts of climate change are likely to be played out through interactions with other threatening processes, including habitat loss and degradation, invasion of exotic species and changes to hydrological and fire regimes. Anticipatory and adaptive management of these other threats and their synergies are therefore an essential component of any strategy for climate change adaptation (Dunlop & Brown 2008, Auld & Keith 2009).

Conservation

Approximately 66% of the study area still has native vegetation cover, comprising 27% within dedicated conservation reserves, 20% on freehold land, 13% within State Forests and 5% on other crown lands (see Table 5 above). These tenures are of course not distributed evenly across the landscape; historical allocation of lands to maximise human use has meant that freehold lands (comprising 51% of the total study area) dominate the more fertile and undulating tablelands and coastal river valleys, while State Forests (15% of study area) and conservation reserves (28%) are concentrated along the rugged coastal escarpments and ranges. These patterns are reflected in the clearing and reservation status of different vegetation types.

Some 115 map units are estimated to have 70% or more of their original extent remaining uncleared (see Table 8 above), dominated by heaths, rainforests and dry and wet sclerophyll forests of steep terrain and/or poor soils (shallow, rocky or sandy, low fertility). The majority of these less-cleared units are well represented in conservation reserves, with 57 units having more than 50% of their original extent reserved in National Parks, Nature Reserves or Flora Reserves. However, 25 units have less than 30% of original extent reserved and their extant areas occur predominantly on other tenures including State Forests, water catchment lands, freehold and coastal crown land, where they may be subject to continuing threats such as frequent fire or logging.

Conversely, some 38 units have been heavily cleared, with an estimated loss of 70% or more of original extent (Table 8), and these units are dominated by swamps, grasslands, woodlands, and basalt and alluvial forests. Almost all of these over-cleared units are also poorly conserved, with 35 units estimated to have less than 10% of their original extent within conservation reserves. Extant areas of these units are predominantly on freehold lands, and commonly occur as small scattered remnants subject to ongoing degradation including over-grazing, weed invasion and altered fire or flooding regimes.

A number of communities are of conservation concern because their distributions are naturally restricted. Restricted distributions predispose communities and species to greater impacts from stochastic events from known threats, such as those outlined above, as well as unexpected threats. The most spatially restricted map units in the study area are typically limited to rare substrates and landforms (Map Units RF e1, p314, p317, WSF p72, p68, DSF p219, p239, p463, HL e52, m83, p46, p120, p121, p126), localised areas of poor drainage (DSF p4, FoW p44, p54, m15, FrW p56, p129, p303), and specialised coastal habitats (RF p210, HL p127, GL p434, SL p509). Other spatially restricted units are apparently at the limit of their distribution in the study area and have more extensive distributions elsewhere (e.g. WSF p599, GW p17). Seven of the restricted units are distributed almost entirely within conservation or water catchment reserves (Map Units HL e52, HL p120, HL p121, HL p126, FrW p303, WSF p68), or partly within reserves (HL m83), while three have little or no representation in any conservation reserves (Map Units HL p46, FoW m15 and FrW p56) (Appendix 3).

The study area contains a large number of listed Threatened Ecological Communities (see Table 6 above), partly reflecting the diversity of the region and the levels and diversity of threatening processes that influence its native vegetation. Many of the heavily cleared, poorly conserved and/or spatially restricted map units discussed above are referrable to ecological communities recognised as threatened at state or national level, and these units must be targeted as priorities for coordinated incentive, education and regulatory programs including protection from further clearing, voluntary conservation agreements with private landholders, and education and incentive programs for the management of threatening processes.

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Appendix 1: Map Unit Habitat Characteristics

The following table summarises elevation, climate and lithology data for the field survey sites allocated to each map unit. Data were derived in a geographic information system by intersecting the locations of classified sites against spatial environmental data layers (see Table 4).

Values given for elevation, rainfall and temperatures are (minimum) 25th percentile – 75th percentile (maximum). Lithology indicates the mapped lithological classes which the field samples for each map unit were most frequently located on (ae=aeolian sediments; al=alluvium, gr=granitic; hqs=high-quartz sedimentary; ia=inactive alluvium; li=limestone; lqs=low-quartz sedimentary; ma=marine/coastal sands; mf=transitional sedimentary; va=acid volcanic; vb=basaltic; xx=excavated/filled land; and water=water bodies including rivers and lakes).

Map Unit	n	Elevation (metres above sea level)	Average Annual Rainfall (mm)	Maximum Temp. of Warmest Period (degC)	Minimum Temp. of Coldest Period (degC)	Soil Landscape Lithology (% frequency)
e1	22	(16) 213-377 (569)	(784) 903-964 (1057)	(23.5) 24-24.3 (25.3)	(0.3) 0.9-2.4 (5)	gr(82) lqs(14) hqs(5)
e3	18	(90) 268-548 (784)	(773) 952-1047 (1082)	(22.6) 23.2-24 (25.6)	(-0.4) 0.3-2.4 (3.7)	gr(56) hqs(33) lqs(11)
e4	14	(85) 321-462 (634)	(917) 950-1012 (1087)	(23.2) 24.2-25 (25.2)	(-0.2) 0.5-1.2 (2)	lqs(57) hqs(43)
e6e7	88	(13) 220-432 (675)	(839) 938-1035 (1229)	(21.2) 23.6-24.7 (25.6)	(-0.4) 0.8-3.1 (6)	lqs(38) gr(36) hqs(18)
e9	12	(797) 840-1000 (1030)	(1056) 1071-1238 (1267)	(20.7) 20.7-22.9 (23.2)	(-1.7) -1--0.6 (-0.5)	gr(92) lqs(8)
e10	100	(183) 735-919 (1185)	(808) 1049-1104 (1311)	(20.8) 22.3-23.1 (24.8)	(-1.6) -1--0.1 (3)	gr(87) lqs(4) al(3) hqs(3)
e11	23	(752) 856-910 (945)	(885) 1087-1108 (1139)	(22.2) 22.5-22.7 (23.2)	(-1.1) -0.8--0.6 (-0.4)	gr(96) hqs(4)
e12	95	(165) 588-789 (1060)	(841) 996-1091 (1296)	(21.3) 23-23.7 (24.8)	(-1.3) -0.3-0.8 (5.4)	gr(55) lqs(22) va(14)
e13	65	(6) 144-450 (839)	(833) 922-1018 (1318)	(21) 23.6-24.3 (25.2)	(-0.4) 1.1-2.7 (6.9)	gr(46) lqs(23) hqs(17)
e14	46	(59) 295-482 (700)	(863) 1000-1131 (1221)	(21.5) 22.2-23.4 (25)	(0.6) 1.7-2.7 (6)	hqs(50) gr(24) lqs(20)
e15	139	(267) 613-845 (1127)	(911) 1036-1116 (1390)	(19.7) 22.1-23.2 (24.5)	(-1.2) -0.6-0.4 (1.8)	gr(94) lqs(4) hqs(1) va(1)
e17	28	(93) 483-565 (922)	(895) 959-1001 (1082)	(22.5) 23.3-23.7 (24.2)	(-1) 0.2-0.8 (4.6)	gr(93) lqs(7)
e18	28	(104) 161-254 (802)	(846) 942-1019 (1091)	(22.6) 24.5-25 (25.3)	(-0.3) 1.5-2 (4.5)	gr(86) lqs(7) hqs(4) vb(4)
e19	95	(4) 125-246 (482)	(763) 869-984 (1081)	(23.3) 24.6-25.2 (26.1)	(0.2) 1.6-2.2 (4)	gr(61) lqs(23) al(5)
e20p229	128	(7) 101-204 (862)	(566) 815-980 (1049)	(23.8) 24.7-25.6 (26.3)	(-1.8) 1.5-2.2 (4.5)	gr(69) lqs(25) al(3) hqs(3)
e24	32	(772) 948-1090 (1210)	(769) 874-1031 (1184)	(21.3) 22.2-22.6 (23.6)	(-2) -1.3--1.1 (-0.8)	gr(59) lqs(28) hqs(9)
e25	11	(370) 798-887 (1040)	(920) 1089-1216 (1256)	(20.7) 21.3-22.2 (24)	(-1.7) -0.6--0.5 (1.2)	lqs(91) gr(9)
e26	38	(273) 390-704 (870)	(897) 949-1020 (1104)	(22.1) 23-23.3 (24.2)	(-1.2) 0-1.7 (2.7)	gr(71) lqs(29)
e27	7	(330) 360-396 (501)	(987) 1003-1029 (1091)	(22.6) 22.9-23.1 (23.2)	(1.5) 1.8-2.3 (2.5)	gr(100)
e28	11	(424) 456-488 (491)	(903) 919-942 (1064)	(23.3) 23.9-24.1 (24.2)	(0.6) 0.6-0.8 (1.1)	gr(100)
e29	19	(392) 535-655 (731)	(927) 963-1041 (1172)	(22.1) 23.2-23.7 (24.1)	(-0.8) 0-0.6 (1.7)	gr(89) lqs(11)
e30	11	(11) 207-424 (610)	(839) 941-1009 (1084)	(22.5) 23.1-23.7 (24.6)	(0.1) 1.7-3.3 (5)	gr(45) hqs(18) lqs(18) va(18)
e31	56	(145) 389-570 (916)	(858) 914-1044 (1138)	(22.3) 23.1-24.1 (24.3)	(-1.2) 0.6-1.2 (2.9)	gr(95) lqs(5)
e32a	93	(23) 78-221 (647)	(876) 988-1048 (1100)	(23.7) 24.1-24.3 (25.7)	(-0.2) 2.5-3.9 (4.5)	lqs(73) hqs(23) gr(4)
e32b	45	(12) 80-179 (375)	(884) 945-1011 (1071)	(21.5) 24-24.3 (24.6)	(2) 2.5-3.4 (5.4)	lqs(51) hqs(24) va(18)
e33	32	(54) 278-385 (641)	(863) 964-1037 (1226)	(21.5) 23.2-23.9 (24.2)	(0.4) 1.7-2.5 (4)	lqs(41) gr(28) hqs(25)

Map Unit	n	Elevation (metres above sea level)	Average Annual Rainfall (mm)	Maximum Temp. of Warmest Period (degC)	Minimum Temp. of Coldest Period (degC)	Soil Landscape Lithology (% frequency)
e34	49	(9) 51-163 (426)	(849) 958-1019 (1101)	(23.1) 24.2-24.7 (25.2)	(1.2) 2.2-3.7 (5.5)	lqs(78) hqs(12) gr(6)
e35	59	(32) 280-466 (756)	(806) 893-1050 (1149)	(22.8) 23.7-24.5 (25.2)	(0) 1-1.9 (3.5)	gr(68) lqs(27) hqs(3)
e37	20	(2) 9-127 (262)	(838) 892-992 (1062)	(21.2) 21.8-23.2 (24.5)	(2.5) 4.6-6.2 (7.1)	hqs(60) lqs(30) ma(10)
e38	5	(12) 26-325 (369)	(842) 885-919 (958)	(22.5) 23.2-24 (24.2)	(1.1) 2.2-5.1 (6)	gr(40) al(20) hqs(20) lqs(20)
e39	14	(30) 100-202 (269)	(783) 798-855 (951)	(24.6) 24.7-25.5 (25.8)	(1.1) 1.3-2.4 (3.5)	al(57) gr(29) hqs(7) lqs(7)
e42	67	(94) 354-516 (938)	(932) 1018-1112 (1242)	(20.7) 22.6-23.2 (24.2)	(-0.3) 1.3-2.3 (5.1)	gr(64) hqs(13) va(13)
e43	15	(100) 490-733 (942)	(905) 980-1130 (1158)	(21.3) 22.2-23.5 (24.1)	(-0.8) -0.2-0.8 (4.3)	lqs(80) gr(20)
e44	42	(91) 601-833 (1006)	(874) 1033-1107 (1202)	(21.2) 22.2-23.1 (24)	(-1.3) -0.6-0.5 (3.7)	gr(79) lqs(14) hqs(7)
e45	29	(16) 595-911 (1007)	(911) 1006-1102 (1240)	(20.7) 22.1-23.1 (23.7)	(-1.2) -1-0.2 (7)	gr(86) hqs(7) lqs(7)
e46b	25	(16) 49-114 (169)	(860) 886-983 (1044)	(21.8) 22.8-24.2 (24.7)	(2.5) 3.7-4.9 (6.9)	hqs(64) lqs(24)
e47	22	(20) 117-499 (789)	(867) 960-1146 (1389)	(20.3) 21.2-22.1 (23.8)	(1.1) 2.1-5 (7.3)	hqs(82) lqs(14) ae(5)
e48	15	(118) 212-446 (548)	(1012) 1040-1132 (1171)	(22.8) 23.2-24 (24.6)	(1.3) 1.7-2.4 (2.7)	gr(100)
e49	43	(56) 245-537 (888)	(893) 952-1099 (1201)	(21.7) 22.8-23.7 (24.7)	(-0.6) 1.4-2.7 (4.8)	hqs(37) va(37) gr(12)
e50	7	(325) 368-570 (725)	(903) 931-978 (1008)	(22.8) 23.3-23.7 (24.1)	(-0.8) 0.3-1.2 (2.7)	lqs(57) gr(29) hqs(14)
e51	16	(141) 216-394 (613)	(896) 948-1063 (1211)	(21.8) 22.8-23.7 (24)	(1.5) 2-3 (3.4)	va(81) hqs(13) al(6)
e52	8	(591) 654-776 (1020)	(1057) 1169-1215 (1232)	(20.7) 21.6-22.2 (23)	(-1.1) -0.4-0.7 (1.1)	gr(100)
e53	30	(525) 762-1055 (1226)	(575) 886-1007 (1194)	(20.6) 22.2-23.8 (25.1)	(-1.7) -1.3--0.6 (0.6)	hqs(43) lqs(43) gr(7) va(7)
e54	18	(33) 82-445 (527)	(892) 931-1209 (1271)	(20.2) 20.6-21.6 (22.6)	(3.4) 3.9-5.7 (7)	hqs(100)
e55	25	(16) 23-44 (76)	(851) 875-919 (924)	(21.3) 21.7-22.7 (24.3)	(3.5) 5.3-6.9 (7.3)	hqs(92) al(4) va(4)
e56	13	(48) 153-374 (666)	(872) 950-1003 (1022)	(22.7) 23.1-23.3 (23.5)	(0) 2.2-3.9 (5.4)	gr(62) al(38)
e57	19	(3) 25-198 (516)	(869) 912-1059 (1262)	(20.3) 21.2-21.7 (23.2)	(3.5) 5-7 (7.1)	hqs(68) ae(11) al(11)
e59	18	(768) 935-1100 (1183)	(854) 1001-1082 (1238)	(20.7) 21.7-22.5 (23.2)	(-2) -1.3--1 (-0.5)	gr(56) al(22) lqs(17)
e60	11	(6) 7-72 (148)	(860) 863-880 (897)	(23.7) 24.7-25.2 (25.2)	(2.2) 2.4-2.7 (4.8)	al(73) gr(18) lqs(9)
e61	31	(0) 2-4 (11)	(840) 856-955 (1228)	(21.5) 23.7-24.6 (25)	(3.5) 3.9-6 (7.4)	ma(83) ae(9)
e62	26	(0) 2-3 (6)	(840) 858-953 (1266)	(21.5) 23.7-24.6 (25.5)	(3.5) 3.7-5.5 (7.4)	ma(90) water(7) gr(3)
e46a	20	(147) 196-329 (358)	(939) 958-999 (1036)	(22.6) 22.8-23.2 (23.5)	(2.2) 2.7-3.6 (4)	gr(90) al(5) hqs(5)
e81	20	(64) 761-935 (1037)	(870) 1011-1127 (1202)	(21.6) 22.7-23.4 (24.7)	(-1.2) -1--0.1 (3.2)	lqs(50) hqs(45) gr(5)
e83	15	(1085) 1156-1273 (1333)	(1061) 1101-1228 (1288)	(19.7) 20.3-21.2 (21.8)	(-1.8) -1.7--1.5 (-1.3)	hqs(100)
e85	34	(62) 187-336 (615)	(849) 910-941 (1015)	(24.2) 25.2-25.7 (26.2)	(0) 0.7-1.5 (2.5)	gr(53) lqs(38) al(6)
m15	8	(6) 7-41 (60)	(837) 849-876 (901)	(22.5) 22.7-23.7 (24.2)	(4) 4.5-5.8 (6)	hqs(63) ma(38)
m68	20	(675) 854-1023 (1292)	(533) 802-912 (972)	(21.7) 22.6-23.5 (25.8)	(-2.9) -1.6--1.1 (0)	gr(55) lqs(20) vb(15)
m83	9	(2) 7-21 (29)	(840) 844-921 (931)	(21.3) 21.6-22.7 (24.6)	(3.7) 6-7.1 (7.4)	hqs(56) ae(22) ma(22)
n183	76	(8) 131-401 (745)	(857) 1000-1075 (1164)	(22.2) 24.1-24.7 (26)	(-0.1) 2-3.5 (5.1)	lqs(55) hqs(21) gr(13)
n184	33	(7) 101-293 (474)	(848) 980-1093 (1234)	(23.1) 23.8-24.7 (26.2)	(0.6) 2.4-3.7 (5.5)	lqs(55) gr(36) hqs(6)
p50	2	(10) 192-557 (739)	(1099) 1123-1170 (1193)	(25) 25.3-25.9 (26.2)	(1) 2.3-4.8 (6.1)	hqs(100)
p1	42	(1) 19-46 (84)	(803) 824-898 (1158)	(25.8) 27.2-28.7 (29.1)	(3.2) 3.6-5 (6.8)	al(48) lqs(31) mf(7) xx(7)
p2	79	(10) 113-199 (370)	(790) 855-902 (1094)	(25.8) 26.7-27.7 (28.7)	(1.7) 2.7-3.7 (4.9)	lqs(62) mf(24) hqs(14)
p3	19	(5) 9-22 (250)	(889) 1043-1163 (1249)	(23.7) 24.1-25.5 (25.8)	(2.2) 4.7-7.1 (7.4)	hqs(42) gr(37) al(11) lqs(11)

Map Unit	n	Elevation (metres above sea level)	Average Annual Rainfall (mm)	Maximum Temp. of Warmest Period (degC)	Minimum Temp. of Coldest Period (degC)	Soil Landscape Lithology (% frequency)
p4	7	(12) 18-38 (60)	(746) 808-843 (869)	(27.3) 27.7-28.9 (29.1)	(2.9) 3.5-4.4 (4.8)	al(71) ae(14) lqs(14)
p5	56	(120) 164-410 (623)	(780) 843-900 (1015)	(26.2) 27.5-28.6 (29.2)	(0.6) 1.2-1.8 (2.2)	lqs(52) hqs(46) gr(2)
p6	25	(26) 128-585 (953)	(801) 842-952 (1242)	(23.7) 26.3-29 (29.2)	(0.2) 1.7-3 (5.3)	hqs(40) lqs(40) mf(12)
p7	25	(7) 30-39 (63)	(807) 824-829 (899)	(27.1) 28.7-28.8 (29)	(3.2) 3.4-3.5 (5.1)	al(96) lqs(4)
p8	84	(628) 842-988 (1217)	(732) 856-967 (1183)	(21.6) 23.5-24.6 (26.2)	(-2.2) -0.8-0.1 (1.3)	lqs(46) va(25) hqs(19)
p9	42	(556) 610-695 (802)	(650) 691-754 (897)	(24.7) 25.9-26.5 (26.7)	(-0.6) 0.4-1.2 (1.5)	lqs(48) ia(24) gr(14)
p10	63	(263) 664-774 (906)	(695) 741-842 (959)	(24.2) 25.5-26.1 (26.6)	(-0.1) 0.2-1.2 (1.8)	lqs(51) hqs(38) ia(5)
p11	63	(400) 600-725 (853)	(702) 770-870 (980)	(25.2) 25.7-26.3 (27.8)	(0) 0.6-1.2 (2)	lqs(67) hqs(27) va(3)
p14	143	(516) 708-882 (1160)	(672) 720-793 (1035)	(22.2) 25.2-26.6 (28.5)	(-1.2) -0.4-0.1 (0.8)	lqs(82) gr(6) va(6) vb(6)
p15	40	(210) 610-719 (1076)	(669) 780-876 (1030)	(22.5) 24.7-25.4 (26.3)	(-1.6) -0.6-0.7 (1.7)	lqs(40) ia(23) hqs(18) va(18)
p17	7	(624) 748-971 (1072)	(589) 763-918 (930)	(23.2) 24.1-25.2 (26.1)	(-1.5) -0.4-0.7 (0.8)	lqs(57) al(14) gr(14) va(14)
p19	36	(532) 590-769 (1040)	(687) 723-751 (866)	(23.8) 26.4-27.4 (28.2)	(-0.6) -0.1-0.3 (1.5)	lqs(83) va(8) gr(6)
p20	28	(595) 731-951 (1272)	(769) 818-981 (1114)	(21.6) 24.6-25.1 (26)	(-1) -0.4-1.2 (2.2)	vb(68) lqs(25) ia(4) water(4)
p22	68	(586) 676-806 (1140)	(641) 696-809 (958)	(22.3) 25-26.3 (27.1)	(-2.7) -0.4-0.2 (1.2)	lqs(29) gr(22) ia(21)
p23	119	(523) 652-887 (1127)	(664) 711-820 (940)	(23.1) 25.1-26.5 (27.2)	(-1.6) -0.4-0.8 (1.6)	lqs(47) gr(17) va(12)
p24	78	(611) 676-788 (916)	(664) 688-767 (923)	(24.8) 26-26.7 (27.6)	(-0.4) 0-0.5 (1.6)	lqs(47) gr(26) ia(10)
p27	13	(330) 492-561 (600)	(704) 712-723 (771)	(25.7) 26-26.7 (27.6)	(1.2) 1.3-1.7 (2.2)	lqs(85) li(15)
p28	44	(50) 74-150 (328)	(752) 789-827 (885)	(26.6) 27.5-27.9 (28.7)	(1.7) 2.7-3.2 (4)	lqs(93) al(7)
p29	150	(1) 37-89 (390)	(739) 818-859 (953)	(25.8) 27.5-28.5 (29.1)	(1.2) 3.2-4 (5.6)	lqs(73) al(20) mf(3)
p30	39	(2) 10-92 (286)	(825) 974-1091 (1243)	(23.7) 24.4-25.5 (29.2)	(1.3) 3.5-4.9 (7)	lqs(54) al(13) hqs(13)
p31	16	(120) 128-158 (564)	(813) 830-854 (964)	(26.6) 28.7-29.2 (29.2)	(0.8) 2-2 (2.7)	lqs(75) al(13) hqs(6) vb(6)
p32	41	(15) 76-251 (562)	(688) 793-1032 (1289)	(25) 26.2-28.7 (29.5)	(1) 1.7-4 (7.3)	al(32) hqs(22) lqs(22)
p33	74	(1) 15-154 (398)	(732) 803-867 (1100)	(26.6) 27.4-28.6 (29.1)	(1.6) 2.7-4.1 (5.1)	al(51) lqs(27) mf(13)
p34	39	(5) 24-142 (357)	(964) 1158-1398 (1818)	(23.7) 24.8-25.3 (28)	(3.5) 5.5-7 (7.8)	lqs(38) hqs(31) vb(21)
p35	94	(130) 307-589 (836)	(695) 735-804 (1018)	(25.1) 26.5-28.2 (29.1)	(0.2) 1-1.7 (4.9)	va(74) gr(11) lqs(11)
p36	55	(114) 232-465 (803)	(741) 821-884 (1025)	(24.7) 27.2-28.7 (29.2)	(0.6) 1.1-1.6 (3.4)	lqs(65) va(15) hqs(13)
p37	58	(190) 550-695 (847)	(764) 829-934 (1019)	(24.7) 25.5-26.7 (28.5)	(0.3) 0.6-1 (2.2)	va(43) lqs(29) gr(17)
p38	47	(10) 189-408 (808)	(740) 792-861 (1085)	(24.5) 27.2-28.5 (29.3)	(0.8) 1.2-2 (4.3)	lqs(47) va(23) gr(9) hqs(9)
p39	9	(140) 227-275 (499)	(795) 831-874 (901)	(26.5) 26.7-27.3 (28.2)	(1.2) 1.7-2 (3.5)	lqs(78) gr(11) hqs(11)
p40	124	(2) 61-203 (581)	(795) 972-1046 (1254)	(23.5) 24.3-25.3 (29.3)	(0.6) 2.5-4 (6.3)	lqs(61) hqs(20) gr(8)
p44	15	(4) 10-24 (186)	(869) 902-928 (1261)	(26.2) 28.1-28.2 (28.5)	(2.5) 4.4-4.5 (5.6)	hqs(40) al(27) mf(20)
p45	18	(2) 3-10 (56)	(1151) 1207-1258 (1301)	(24.2) 24.9-25.4 (26.3)	(5.6) 6-7.5 (8.1)	ma(39) hqs(22)
p46	3	(104) 122-160 (181)	(1251) 1353-1484 (1514)	(24.7) 24.7-24.7 (24.7)	(5) 6-7 (7)	vb(67) gr(33)
p51	2	(673) 673-673 (673)	(694) 694-694 (694)	(26.3) 26.3-26.3 (26.3)	(0.2) 0.2-0.2 (0.2)	water(100)
p53	12	(532) 556-673 (1081)	(696) 801-961 (1140)	(22.7) 25.4-26.3 (26.7)	(-0.1) 0.9-1.6 (2)	al(42) hqs(25) ia(17)
p54	17	(606) 675-807 (1109)	(668) 860-915 (979)	(22.5) 24.6-25.5 (26.2)	(-0.8) -0.6-0.5 (1.7)	lqs(35) hqs(24) va(24)
p55	6	(30) 156-789 (936)	(703) 721-832 (908)	(25) 25.3-27.8 (28.2)	(-0.4) 0.2-1.8 (4)	al(33)
p56	8	(492) 704-925 (977)	(605) 734-931 (1032)	(22.6) 23-25.2 (25.7)	(-1.6) -1.2--0.7 (0.6)	al(50) gr(50)

Map Unit	n	Elevation (metres above sea level)	Average Annual Rainfall (mm)	Maximum Temp. of Warmest Period (degC)	Minimum Temp. of Coldest Period (degC)	Soil Landscape Lithology (% frequency)
p57	16	(4) 310-645 (915)	(788) 885-1097 (1290)	(23.2) 23.5-25.9 (27.7)	(-0.4) 0.6-2.4 (6.9)	**al(56) gr(25) hqs(13)**
p58	22	(10) 47-258 (413)	(836) 905-1144 (1452)	(24.6) 25.9-27.2 (29.2)	(1.6) 3.1-5 (6.4)	hqs(86) lqs(14)
p63	31	(1) 5-21 (175)	(998) 1205-1304 (1475)	(23.6) 24.6-25.5 (25.7)	(4.6) 6.5-7.3 (8.3)	hqs(47) ae(16) ma(16)
p64	65	(0) 4-22 (130)	(847) 1194-1291 (1476)	(23.6) 24.3-25.2 (27.2)	(3.5) 5.8-7.5 (8.1)	ma(33) ae(26) hqs(26)
p66	56	(161) 587-817 (1108)	(744) 821-972 (1195)	(22.7) 24.5-26.1 (27.5)	(-0.8) 0.3-1.6 (2.5)	lqs(52) va(16) hqs(14)
p68	8	(339) 395-473 (477)	(930) 1028-1176 (1189)	(25.1) 25.2-25.4 (25.7)	(2.5) 2.7-3.3 (3.7)	hqs(75) mf(25)
p72	21	(427) 907-993 (1028)	(930) 1245-1336 (1358)	(22.5) 22.8-23.5 (27.2)	(0.5) 0.8-1 (1.8)	vb(67) hqs(24) gr(5) lqs(5)
p73	99	(667) 911-1161 (1280)	(761) 908-991 (1073)	(21.3) 22.3-24.3 (26.3)	(-1.8) -0.6--0.2 (0.4)	lqs(55) va(18) gr(14)
p76	14	(646) 847-989 (1106)	(1016) 1082-1171 (1322)	(22.2) 23-24 (25.6)	(0.1) 0.3-0.8 (1.1)	lqs(64) hqs(29) va(7)
p78	65	(620) 871-1118 (1285)	(859) 1095-1243 (1369)	(20.2) 21-22.3 (23.5)	(-1.8) -1.3--0.6 (2.2)	gr(45) hqs(43) lqs(11)
p84	3	(159) 163-304 (442)	(893) 895-947 (997)	(25.7) 26.3-26.9 (27)	(2.9) 3.5-4 (4)	lqs(100)
p85	43	(9) 19-53 (98)	(1067) 1130-1227 (1346)	(24.1) 24.7-25.6 (26.5)	(4) 6-7.1 (8.3)	lqs(58) hqs(40) gr(2)
p86	28	(5) 10-31 (51)	(887) 1041-1223 (1259)	(23.7) 24.1-24.6 (25.5)	(3.2) 4.5-5.5 (7.5)	lqs(36) hqs(32) al(21)
p87	72	(2) 65-307 (567)	(869) 995-1105 (1257)	(25.2) 26.7-27.5 (29)	(1.6) 2.2-4.9 (5.9)	lqs(50) hqs(26) mf(17)
p88	74	(117) 205-416 (680)	(821) 853-921 (1064)	(25.3) 27.2-28.3 (29.2)	(0.6) 1.2-1.7 (2)	hqs(57) lqs(42) al(1)
p89	91	(9) 113-308 (862)	(846) 1027-1088 (1241)	(22.5) 24.1-24.8 (25.7)	(-0.6) 2.2-3.7 (5.4)	lqs(44) hqs(40) gr(8) va(8)
p90	90	(3) 40-166 (404)	(929) 1040-1120 (1235)	(23.7) 24.1-24.7 (26.3)	(2) 3.5-4.5 (5.5)	lqs(62) gr(24) hqs(6)
p91	73	(25) 246-431 (804)	(891) 981-1061 (1153)	(22.2) 23.5-24.7 (25.5)	(-0.3) 1.5-2.5 (4.6)	lqs(52) hqs(36) gr(10)
p95	54	(7) 132-340 (599)	(947) 1119-1210 (1543)	(24.1) 24.8-25.7 (27.1)	(1.8) 3.9-5 (6.5)	hqs(67) lqs(26) gr(7)
p98	48	(43) 480-805 (1075)	(908) 1032-1097 (1188)	(22) 23.2-24.2 (25.2)	(-1.2) 0-1.6 (3.7)	lqs(40) hqs(27) gr(21)
p99	87	(2) 33-225 (461)	(1022) 1266-1426 (1673)	(23.7) 24.7-25.3 (26.7)	(3.7) 5.1-6.5 (8.1)	lqs(44) hqs(42) vb(8)
p100	33	(199) 352-452 (693)	(1000) 1419-1578 (1845)	(23.7) 24.3-25.5 (26.3)	(2.5) 3.9-4.3 (5.1)	hqs(42) lqs(42) vb(15)
p102	83	(37) 208-490 (700)	(810) 892-1065 (1475)	(24.5) 26-27.2 (28.7)	(0.8) 1.3-2.5 (6.4)	hqs(89) lqs(7)
p103	30	(6) 59-135 (555)	(824) 1117-1240 (1266)	(24) 24.3-25.5 (27)	(2) 4.5-5.4 (6)	lqs(57) hqs(37) al(3) gr(3)
p104	88	(4) 31-99 (338)	(975) 1174-1246 (1289)	(23.6) 24.2-24.7 (26.7)	(2.2) 4.9-5.5 (6.1)	lqs(64) hqs(32) gr(5)
p105	28	(0) 3-7 (38)	(837) 999-1241 (1293)	(23.7) 24.6-25.4 (27.7)	(4.1) 4.8-7.4 (7.9)	al(34) ma(24) hqs(21)
p106	32	(1) 2-6 (107)	(841) 894-1165 (1286)	(22.8) 24.5-25.6 (27.7)	(2.7) 4.2-6.8 (8.1)	ma(33) al(20) lqs(17)
p107	35	(2) 4-7 (206)	(837) 906-1227 (1341)	(21.7) 24.5-24.8 (26.6)	(1.5) 3.5-7 (8.3)	ma(49) hqs(23) al(17)
p109	30	(0) 1-3 (5)	(840) 842-1121 (1312)	(24) 24.5-25.7 (27.6)	(3.5) 3.7-6.6 (8.1)	ma(79) ae(9) hqs(6)
p110	103	(4) 60-321 (479)	(969) 1272-1582 (1922)	(23.7) 24.6-25.7 (26.7)	(3.7) 4.8-5.9 (7.9)	hqs(41) lqs(40) vb(16)
p111	55	(5) 51-181 (332)	(804) 1209-1440 (1817)	(24.2) 24.8-25.6 (28.7)	(2) 5.5-7 (8)	hqs(44) vb(27) lqs(16)
p112	62	(31) 124-279 (551)	(996) 1392-1723 (1978)	(23.2) 24.5-25.1 (26.3)	(2.2) 5.1-6.5 (7.9)	hqs(52) vb(32) lqs(11)
p113	147	(10) 92-364 (594)	(909) 1079-1514 (1931)	(23.2) 24.3-25.3 (28.3)	(2) 3.1-5.3 (6.6)	hqs(47) lqs(43) vb(7)
p114	32	(18) 352-671 (982)	(823) 896-1103 (1264)	(22.8) 25.2-27.1 (28.8)	(0.8) 1-1.7 (5.1)	hqs(81) lqs(9)
p116	36	(8) 137-531 (898)	(797) 973-1070 (1719)	(23.2) 23.7-25.2 (26.5)	(0) 1.8-3.9 (5.5)	hqs(33) gr(28) lqs(28)
p117	134	(9) 82-357 (762)	(898) 1213-1375 (1610)	(23.7) 24.3-25.2 (28.1)	(1.2) 4-6 (8.3)	hqs(75) mf(16) lqs(8)
p120	8	(661) 939-1030 (1057)	(997) 1075-1137 (1161)	(22.7) 23.1-23.5 (25.6)	(0) 0.3-0.5 (1)	hqs(88) lqs(13)
p121	4	(1125) 1143-1153 (1158)	(1030) 1039-1048 (1048)	(22.3) 22.5-22.6 (22.7)	(-0.6) -0.5--0.5 (-0.5)	hqs(75) lqs(25)

Map Unit	n	Elevation (metres above sea level)	Average Annual Rainfall (mm)	Maximum Temp. of Warmest Period (degC)	Minimum Temp. of Coldest Period (degC)	Soil Landscape Lithology (% frequency)
p122	41	(4) 84-641 (755)	(921) 1097-1227 (1370)	(23.7) 24.2-25 (26.2)	(1.5) 2-6 (8)	hqs(90) lqs(5) ae(2) gr(2)
p124	25	(591) 850-1050 (1137)	(988) 1144-1270 (1357)	(22.2) 22.7-23.7 (25.6)	(0) 0.6-1 (1.5)	hqs(100)
p125	4	(688) 704-729 (751)	(951) 966-1029 (1060)	(24.2) 24.4-24.8 (25.2)	(1.2) 1.3-1.4 (1.5)	hqs(100)
p126	15	(14) 56-345 (661)	(940) 1258-1340 (1447)	(23.7) 24.5-25.2 (25.8)	(1.7) 4.2-7.5 (8.1)	hqs(87) mf(13)
p127	11	(23) 45-73 (90)	(1240) 1278-1434 (1438)	(23.7) 23.7-25.2 (25.3)	(6.5) 6.9-8.1 (8.3)	hqs(100)
p129	77	(8) 75-375 (595)	(1039) 1314-1456 (1729)	(23.7) 23.8-24.8 (26.5)	(3) 3.9-7.9 (8.3)	hqs(81) al(16) ae(3)
p130	36	(27) 434-641 (1030)	(861) 1257-1481 (1851)	(22.6) 24-24.7 (26.2)	(0.8) 1.9-3.8 (8)	hqs(75) al(25)
p131	317	(35) 151-404 (850)	(856) 1063-1282 (1658)	(23.7) 25.1-26.7 (28.2)	(0.8) 3.5-5 (7.9)	hqs(77) mf(20) al(2) lqs(2)
p136	50	(367) 704-970 (1052)	(840) 1164-1316 (1377)	(22.3) 23-24.8 (26.5)	(0.6) 1-1.2 (2.2)	hqs(84) mf(8) al(4)
p139	42	(10) 60-78 (141)	(1209) 1305-1446 (1468)	(23.6) 23.7-24.3 (25.5)	(6.5) 7.4-8.3 (8.3)	hqs(64) ae(36)
p140	127	(1) 103-292 (584)	(1023) 1139-1339 (1535)	(24.2) 24.8-25.7 (27)	(2.9) 4.5-5.5 (7.5)	hqs(95) al(2) lqs(2) mf(2)
p141	29	(469) 551-609 (1054)	(1128) 1238-1864 (2012)	(22) 23.5-24 (25)	(-0.3) 2.7-4 (4.1)	hqs(97) al(3)
p142	150	(0) 77-311 (647)	(847) 903-1090 (1455)	(24.6) 26.2-27.2 (28.7)	(1.2) 2.2-4.8 (6.4)	hqs(82) mf(9) lqs(8)
p143	58	(73) 153-211 (434)	(1089) 1261-1312 (1561)	(24.2) 25.1-25.8 (26.8)	(4) 4.7-5.5 (6)	hqs(69) mf(17) lqs(14)
p144	123	(194) 470-657 (967)	(796) 856-939 (1380)	(23.3) 25.4-26.2 (28)	(0.4) 1.2-1.7 (2.9)	hqs(83) mf(9) lqs(8)
p146	213	(1) 110-253 (505)	(845) 902-1011 (1127)	(25.6) 26.7-27.7 (28.8)	(1.5) 2.2-4.1 (5.5)	hqs(49) mf(40) lqs(11)
p148	87	(8) 111-590 (756)	(870) 1107-1217 (1685)	(23.7) 24.9-26 (27)	(1.2) 2.2-5.3 (7.3)	hqs(79) lqs(16)
p149	19	(565) 639-746 (972)	(752) 880-991 (1170)	(23.8) 24.5-25.7 (26)	(-0.3) 1.2-1.6 (2)	hqs(79) lqs(11) al(5) vb(5)
p153	10	(8) 59-155 (178)	(860) 884-1145 (1258)	(26.2) 26.7-28.3 (29.1)	(3.2) 4.3-4.5 (5)	lqs(50) hqs(30) al(10) mf(10)
p168	51	(245) 575-679 (977)	(823) 1094-1389 (1660)	(23.1) 24.2-25.7 (27)	(0.8) 1.6-2.9 (5)	hqs(49) lqs(29) vb(16)
p202	14	(127) 157-199 (440)	(773) 819-848 (927)	(27.2) 28.1-28.8 (29.2)	(1.2) 1.7-2 (2)	lqs(86) hqs(14)
p210	31	(2) 6-24 (156)	(958) 1310-1339 (1416)	(24.1) 24.3-24.8 (25.6)	(4.3) 7.6-8.1 (8.1)	lqs(42) ae(35) hqs(13)
p219	4	(580) 597-646 (647)	(753) 753-755 (756)	(26.6) 26.6-26.9 (27.1)	(0.5) 0.5-0.6 (0.6)	li(100)
p220	57	(600) 759-1043 (1139)	(625) 818-908 (1124)	(21.3) 22.7-24.6 (26.1)	(-1.8) -1.5--0.8 (0.1)	gr(61) lqs(11) va(11) vb(11)
p239	2	(30) 31-31 (31)	(830) 830-830 (830)	(29.1) 29.1-29.1 (29.1)	(3.4) 3.4-3.4 (3.4)	ae(100)
p244	77	(150) 520-689 (1076)	(818) 888-990 (1130)	(22.7) 25.3-26.6 (28.8)	(0.3) 0.8-1.3 (2)	hqs(53) lqs(39) mf(5)
p246	20	(39) 73-176 (620)	(869) 992-1066 (1182)	(25.5) 26.2-26.8 (27.2)	(1.6) 4.5-5.4 (5.6)	lqs(55) hqs(45)
p248	16	(50) 263-717 (792)	(917) 1004-1058 (1240)	(23.7) 24.6-25.1 (25.3)	(0.8) 1.2-3 (5.1)	lqs(56) hqs(38) gr(6)
p266	15	(5) 692-770 (859)	(946) 1102-1276 (1344)	(23.5) 23.8-24.2 (24.5)	(1.3) 1.7-2.2 (4.8)	vb(47) va(27) lqs(20)
p268	4	(588) 600-628 (646)	(886) 1006-1071 (1084)	(24.7) 24.8-25.1 (25.3)	(2) 2.2-2.4 (2.4)	lqs(75) mf(25)
p314	4	(465) 566-606 (615)	(1571) 1794-2004 (2004)	(23) 23-23.5 (24.2)	(3.7) 3.7-4 (4.1)	hqs(100)
p317	69	(353) 577-808 (1066)	(872) 1020-1150 (1392)	(20.2) 22.6-24.2 (25.1)	(-1.1) 0.1-1.1 (2.7)	hqs(43) gr(35) lqs(17)
p338	135	(321) 901-1106 (1374)	(693) 919-1059 (1168)	(20.3) 22.1-23.6 (24.7)	(-2.4) -1.6--1 (1.7)	gr(67) lqs(17) hqs(7)
p343	12	(204) 305-551 (625)	(826) 860-902 (923)	(24.6) 25.2-26.1 (26.2)	(-0.1) 0.4-1.3 (1.8)	gr(100)
p420	24	(239) 700-923 (1050)	(587) 796-904 (950)	(23.1) 24.6-25.5 (26.8)	(-1.5) -0.4-0.6 (1.2)	gr(75) lqs(17) ae(8)
p434	15	(2) 8-19 (26)	(943) 1004-1041 (1243)	(23.7) 23.7-23.8 (24.6)	(4.6) 4.9-5 (6)	lqs(40) ma(27) gr(20)
p502	25	(19) 23-39 (320)	(802) 817-869 (935)	(23.7) 27.3-28.7 (29)	(2) 3.5-4.6 (4.8)	al(52) lqs(24) mf(12)
p509	45	(0) 0-3 (58)	(837) 949-976 (1313)	(23.8) 24.3-24.6 (26.5)	(3.7) 3.9-4.5 (8.1)	ma(46) water(28) lqs(13)

Map Unit	n	Elevation (metres above sea level)	Average Annual Rainfall (mm)	Maximum Temp. of Warmest Period (degC)	Minimum Temp. of Coldest Period (degC)	Soil Landscape Lithology (% frequency)
p514	9	(61) 174-280 (304)	(813) 823-859 (878)	(26.5) 26.7-27.6 (28.7)	(1.7) 2-2.2 (3.7)	lqs(100)
p516	19	(605) 697-756 (796)	(1281) 1563-1633 (1763)	(23.2) 23.3-23.8 (24.2)	(2) 2.5-2.8 (3.2)	vb(79) lqs(21)
p520	35	(513) 604-812 (1231)	(580) 697-851 (984)	(21.7) 24.7-26.2 (27.1)	(-1.6) -0.5-0.8 (1.7)	lqs(37) al(20) gr(14) va(14)
p599	8	(44) 50-74 (90)	(1092) 1281-1286 (1294)	(25.7) 26-26.3 (27.1)	(4.8) 5.3-5.6 (5.6)	lqs(88) hqs(13)

For Maps and Appendices see accompanying CD

Appendix 1: Map Unit Habitat Characteristics

Appendix 2: Index to Map Unit Descriptions

Appendix 3: Descriptions of Map Units

Appendix 4: Survey data collated for classification

Appendix 5: Coverages used in API compilation

Appendix 6: Details of remote imagery used to upgrade and enhance interpretations of contemporary native vegetation cover