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NSW Vegetation Classification and Assessment Project

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Foreword

NSW Vegetation Classification and Assessment Project

This issue of *Cunninghamia* contains the first two papers of a project involving the classification and assessment of the native vegetation of New South Wales, Australia (NSWVCA). Besides developing a comprehensive typology of the vegetation, the project aims to assess the protected area and threat status of the State's vegetation. It collates information on vegetation composition, geographic distribution of plant communities, physiographic features, threats, aspects of condition, planning and management and representation in protected areas into a single database system. A photographic library is also being collated for use with the database and use in publications and education programs.

Due to the scope of the project, it is to progress across four sections of New South Wales: Western Plains, Western Slopes, Tablelands and Coast and Escarpment. These sections are based on the IBRA Version 6 Bioregional boundaries. On completion, a uniform, fine resolution, vegetation classification would exist on a single database system.

The introductory paper describes the aims and methods of the project including classifying the NSW vegetation and description of the NSWVCA database. A number of database reports can list plant communities by planning regions such as bioregions or catchment management authority (CMA) areas. It also describes threat criteria for grading plant communities into five threat categories and also methods of determining the protected area status of each community.

Part 1 of NSWVCA describes 213 plant communities classified for the NSW Western Plains that cover 57% of NSW. This section of the State mainly comprises arid and semi-arid alluvial plains, sand plains and some stony ranges of low relief. Part 1 also contains an analysis of the protected area and threat status of the plant communities in the NSW Western Plains. This provides a detailed audit of the protected area system in that region.

This vegetation classification and database system has been constructed to fulfil local, regional, state and national vegetation classification, planning, assessment and reporting requirements. While the classification should improve with better information, this initial effort should contribute to the conservation and management of native vegetation, native species and the ecological processes that underpin them.

J.S. Benson, March 30, 2006.

New South Wales Vegetation Classification and Assessment: Introduction — the classification, database, assessment of protected areas and threat status of plant communities

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Abstract: A vegetation classification titled, NSW Vegetation Classification and Assessment (NSWVCA), is described. It aims to classify the native vegetation of New South Wales, Australia covering 80 million hectares distributed across 18 Australian bioregions. It is estimated that between 800 and 1200 plant communities will be described. The best available data is used to establish the classification including vegetation map descriptions, floristic groups derived from plot data and expert advice. Extensive field checking assists with the classification and status assessments. Plant communities are listed under five hierarchical levels and are recorded on a database containing 90 fields supported by 45 tables and 64 forms. 39 database reports list plant communities for several types of planning regions and under State and national broad vegetation classifications. Database fields include plant community scientific name, common name, three layers of characteristic species, an 'Authority' field that cites references supporting the definition of a community, substrate, soils, landform, distribution by various regions including bioregions and Catchment Management Authority areas, descriptions and lists of threatening processes and aspects of condition. Estimates of pre-European extent, current extent and areas in public reserves and secure property agreements are recorded and qualified with accuracy levels. One of five threat categories: 'critically endangered', 'endangered', 'vulnerable', 'near threatened' or 'least concern' is assigned to each plant community based on the application of six criteria including: the proportion of remaining extent compared to an estimated pre-European extent, loss of key species and plant community integrity.

The NSWVCA will progress over four geographical sections of NSW commencing with the mainly arid and semi-arid Western Plains (this volume), progressing eastwards to the Western Slopes, the Tablelands and finally the biologically complex Coast and Escarpment. The NSWVCA will assist with: selecting new protected areas, guiding incentive payments and land use decisions in the NSW property vegetation planning process, site assessment in environmental impact assessments, assisting with nominations and definitions of threatened ecological communities in State and Federal laws, prioritizing CMA and other regional targets for the protection and restoration of vegetation and assisting in public education about native vegetation.

A CD accompanying the paper contains a read-only version of the database and outputs of Part 1 of the NSWVCA project – the vegetation of the NSW Western Plains.

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Introduction

This paper describes the aims and methods of the project titled the New South Wales (NSW) Vegetation Classification and Assessment (NSWVCA) which aims to classify the native vegetation of NSW and evaluate the conservation significance of its components. Subsequent parts of this project will contain plant community descriptions and assessments of the protected area and threat status of plant communities in four sections of NSW, NSW Western Plains, NSW Western Slopes, NSW Tablelands and NSW Coast and Escarpment. Part 1, the NSW Western Plains, is published in this volume.

The main aim of the project is to deliver a typology of plant communities in NSW in a database format that can be easily accessed and manipulated. Each plant community is cross-referenced to several other ecological and vegetation classifications covering NSW or Australia. The database format facilitates queries of combinations of the information fields and a series of database reports allows lists of plant communities to be generated for particular planning regions or for broad vegetation classification categories. Criteria for assessing the threat and protected area status of each classified plant community are included in this paper. These assist with prioritizing management or conservation programs.

The NSWVCA scheme is pertinent to environmental assessments under various laws and regulations (Figure 1) including:

- *NSW Environmental Planning and Assessment Act 1979* that directs local, regional and state planning;
- *NSW Threatened Species Conservation Act 1995,* amended 2004 that provides for the nomination and listing of ecological communities as critically endangered, endangered or vulnerable;
- *NSW Native Vegetation Act 2003* that contains provisions for property vegetation planning that require site assessment of vegetation and a regional perspective;
- *NSW Catchment Management Act 2003* that provides for the preparation of Catchment Management Plans and setting targets for protecting facets of the environment;
- *NSW Natural Resource Commission Act 2003* that provides for the setting of State standards and targets for natural resource management, including on the topics of vegetation, biodiversity, soils, salinity and wetlands;
- *Australian Environmental Protection and Biodiversity Conservation Act 1999*, that provides for the nomination and national listing of ecological communities as critically endangered, endangered or vulnerable. Breaching certain threat thresholds can trigger Commonwealth action to protect sites.

The summarized knowledge about each classified community, along with threat and protected area status assessments should assist with:

- Setting priorities for new conservation reserves or property agreements;
- Setting priorities for payments to landholders under property agreements;
- Assisting with site assessment in land use change applications;
- Setting targets for protecting and restoration ecological communities;
- Listing of threatened ecological communities under legislation;
- Monitoring progress in protecting aspects of biodiversity;
- Educating the public about the habitats and native vegetation.

The study area: regional partitions of New South Wales

New South Wales is located in south-eastern Australia (Figure 2) and is about 80 million hectares in area (Table 1). A number of regional divisions of NSW are used in land use planning and are used in describing the distribution of plant communities:

NSW Administrative Divisions

There are three Administrative Divisions in NSW (Figure 2) that broadly correspond to major land uses:

- The *Western Division* is composed of arid and semi-arid plains and peneplains, mainly used for stock grazing with some cropping on the eastern margins on lake beds and on some floodplains. It is about 70% naturally vegetated but the vegetation structure and composition have been severely modified by 150 years of stock and feral animal grazing. Most of the land is held under long term Western Lands Leases.

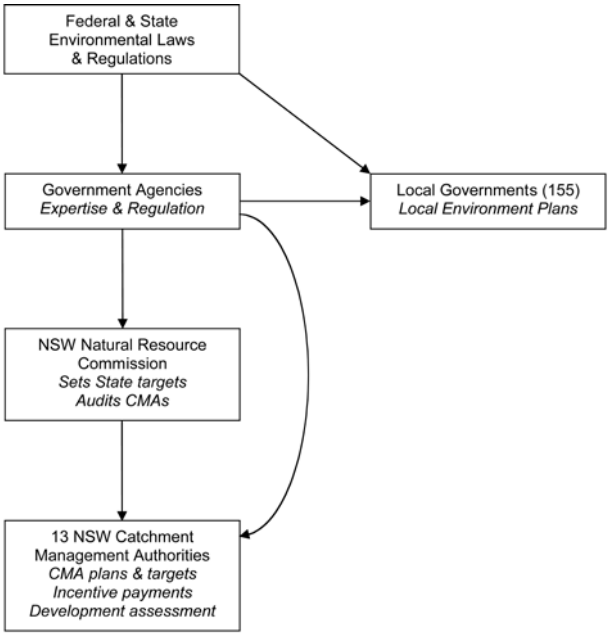

Fig. 1. Natural resource organisations and regulations in New South Wales.

Table. 1. Area of New South Wales, Australian Capital Territory and the Murray Darling River Basin.

Region	Hectares
NSW	79,939,847
ACT + Jervis Bay Territory	242,249
NSW + ACT + Jervis Bay	80,182,096
Murray Darling Basin in NSW	59,847,469 (75% NSW)

• The *Central Division* is mainly composed of alluvial plains and floodplains with some ranges and hills. It is the main agricultural region of NSW and the centre for cropping and irrigation. Between 20 and 30% of the native vegetation remains (Benson 1999) but less than 5% remains of some plant communities. The extent of clearing has resulted in a very fragmented cover of native vegetation and continual clearing is reducing existing patch sizes. Most of the Central Division is freehold land with only 1.2% in public conservation reserves and 3.9% in state forests (NSW State Forests and DEC Estate GIS shape files 2004).

• The *Eastern Division* is composed of the higher altitude, undulating western slopes and tablelands including alpine regions. It also includes the wet and topographically rugged eastern escarpment, coastal valleys and plains and the NSW coastline. It is rich in biodiversity. Vegetation has been cleared for agriculture on better soils and on flatter terrain. Large patches of vegetation remain on poor soils or rugged topography, including on granite or sandstone ranges, along the eastern escarpment and along some sections of the coast. About half of the Division is held under freehold title but large areas of public land remains in public conservation reserves, state forests and held under various types of leases. Over 90% of the seven million people who reside in NSW live in this Division. Urbanization is a major threat to the natural environment along the coast.

Climate zones

NSW contains eight major climate zones (Figure 3) using the Stern et al. (2000) modification of the world climatic zone map in Koppen (1931). The climatic zones are defined through combining average rainfall and temperature with the distribution of rainfall through the year.

IBRA Bioregions

The Interim Biogeographic Regionalization of Australia (IBRA) (Thackway & Cresswell 1995) was produced through cooperative efforts of Australian, State and Territory governments to provide a broad framework for conservation planning. The Bioregion classification is based on combinations of climatic, substrate and soils. 18 of the 80 IBRA Bioregions in Australia (Thackway & Cresswell 1995, version 6.0) are wholly or partly in NSW (Figure 4). The biodiversity, conservation and history of 17 of these Bioregions (excluding the recently enlarged South Eastern Queensland Bioregion) are described in NSW National Parks and Wildlife Service (2003) and Benson (1999).

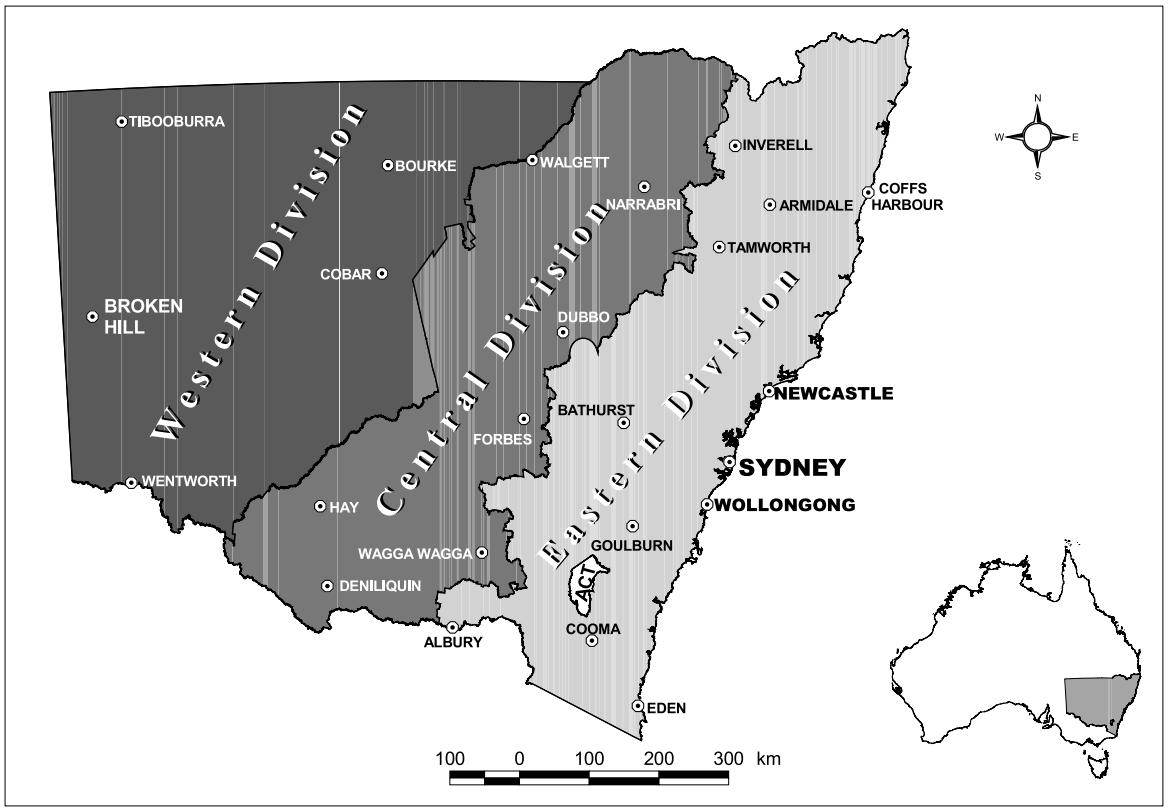

Fig. 2. New South Wales Administrative Divisions. Most of the Western Division is held under long term leases for grazing.

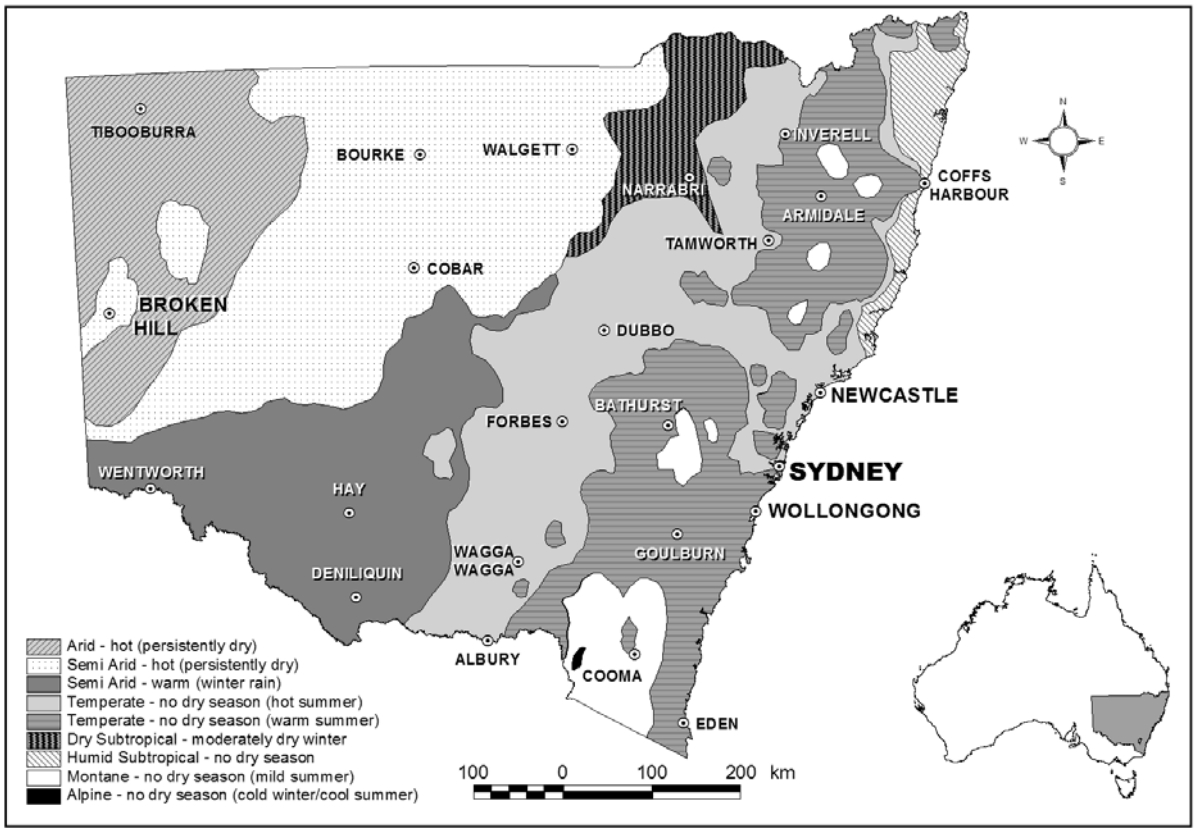

Fig. 3. Climate zones of New South Wales based on Stern et al. (2000).

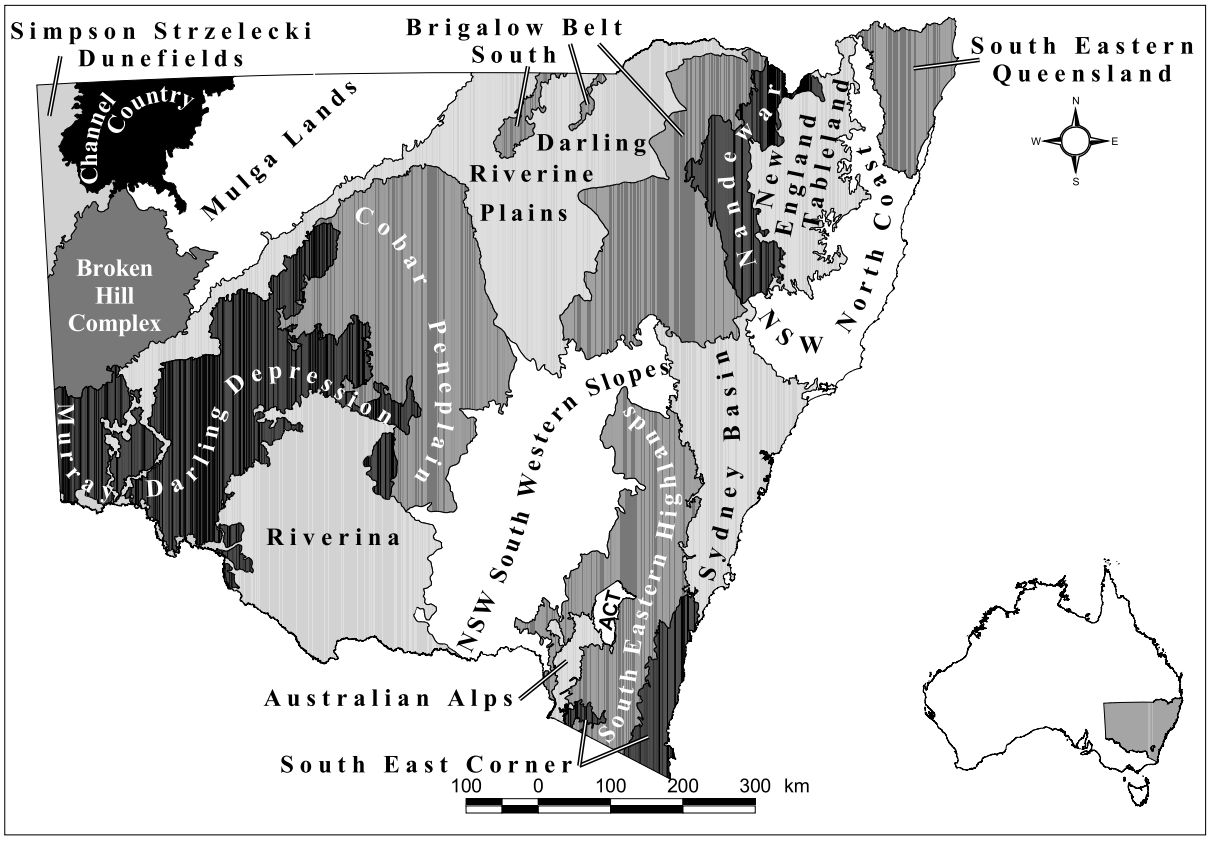

Fig. 4. IBRA Bioregion areas in NSW (IBRA Version 6.0, Thackway & Cresswell 1995)

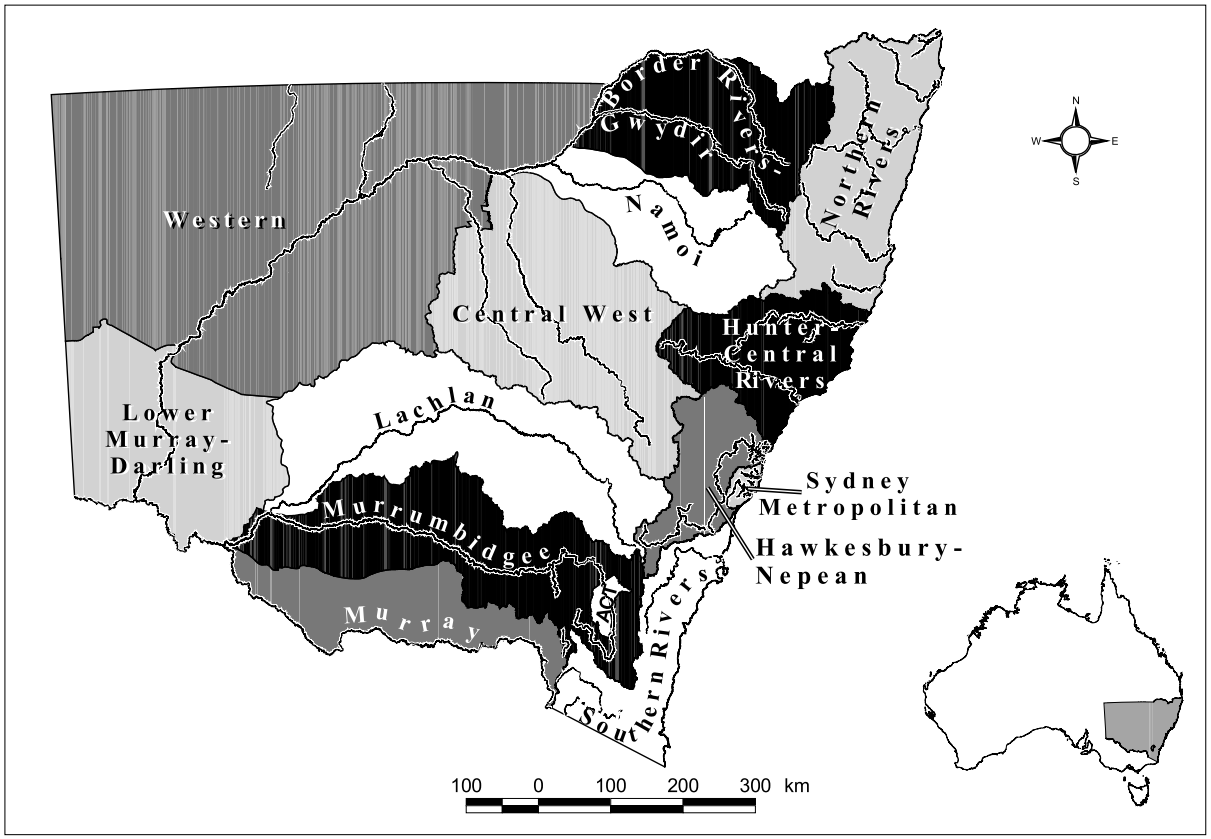

Fig. 5. Catchment Management Authority area boundaries showing the major rivers in New South Wales

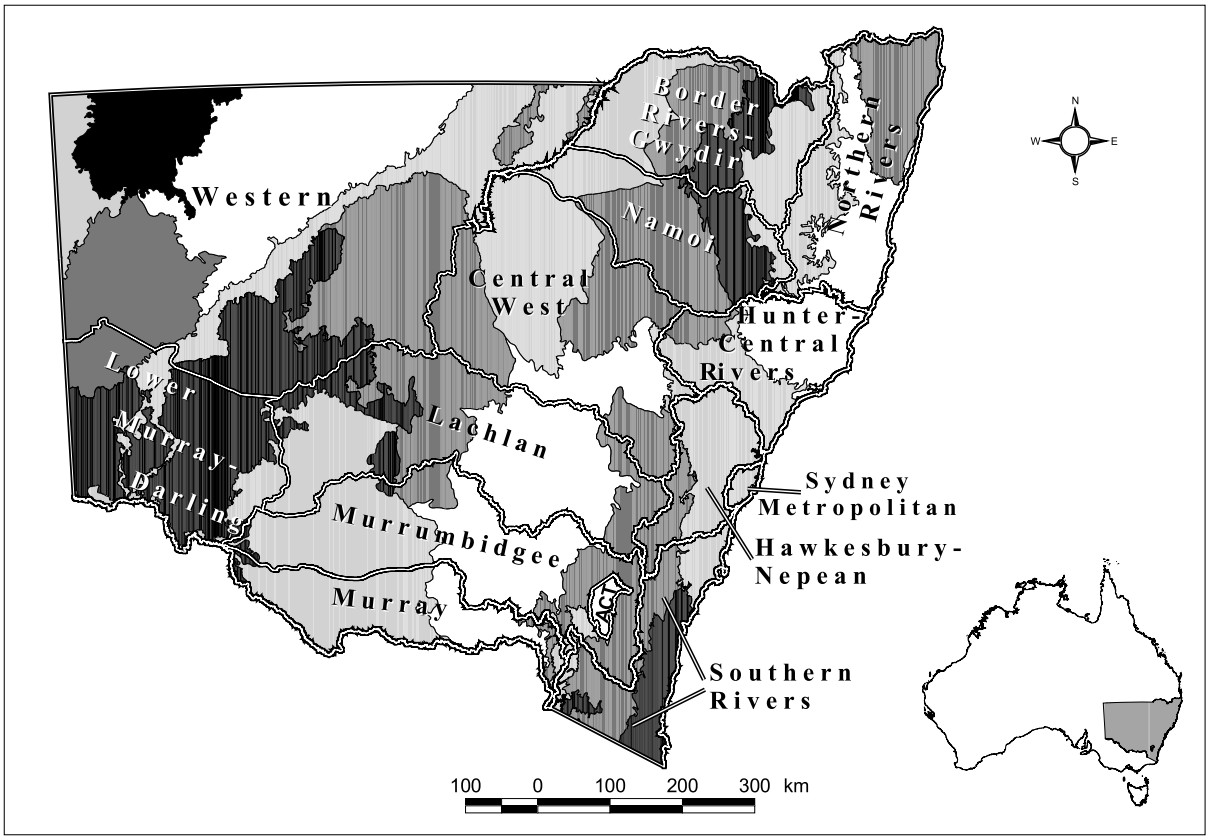

Fig. 6. Catchment Management Authority area boundaries in relation to the IBRA Bioregions Version 6.0 boundaries in New South Wales

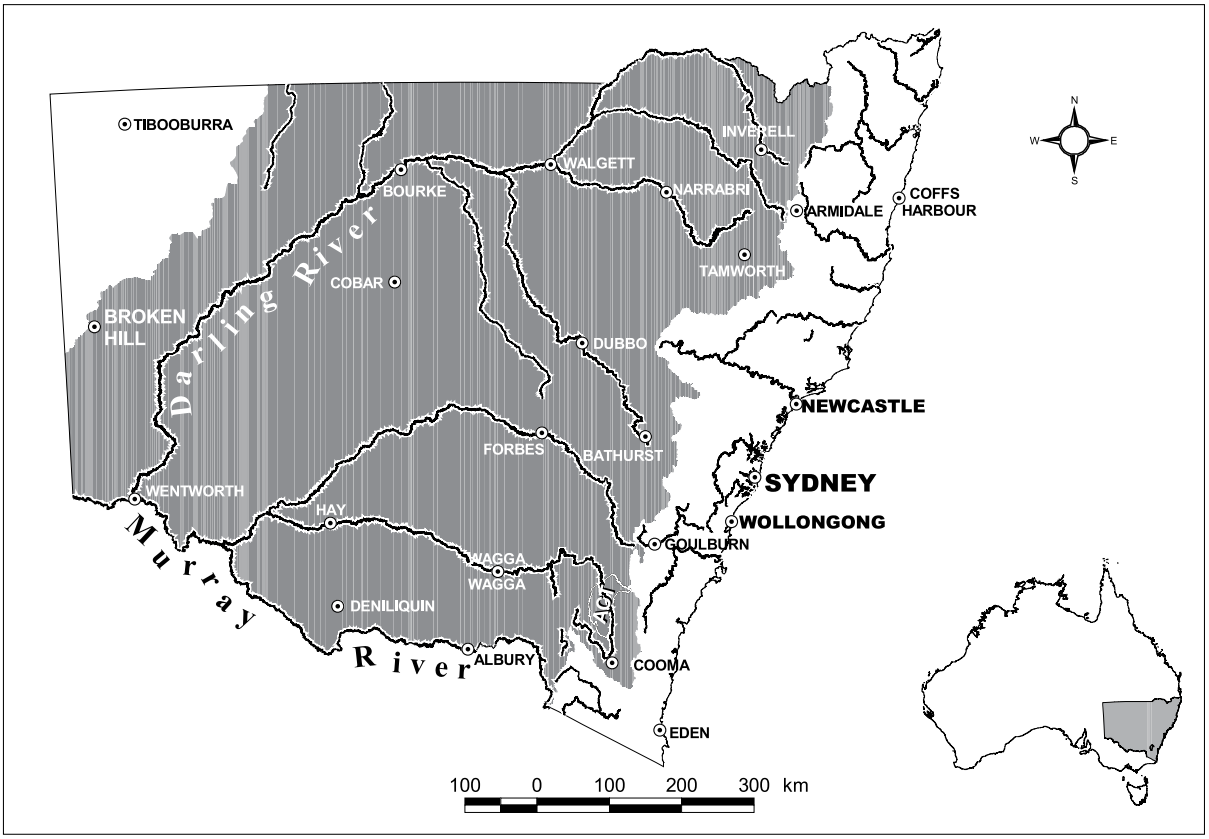

Fig. 7 The Murray-Darling Basin in relation to New South Wales. The Basin covers about 75% of NSW.

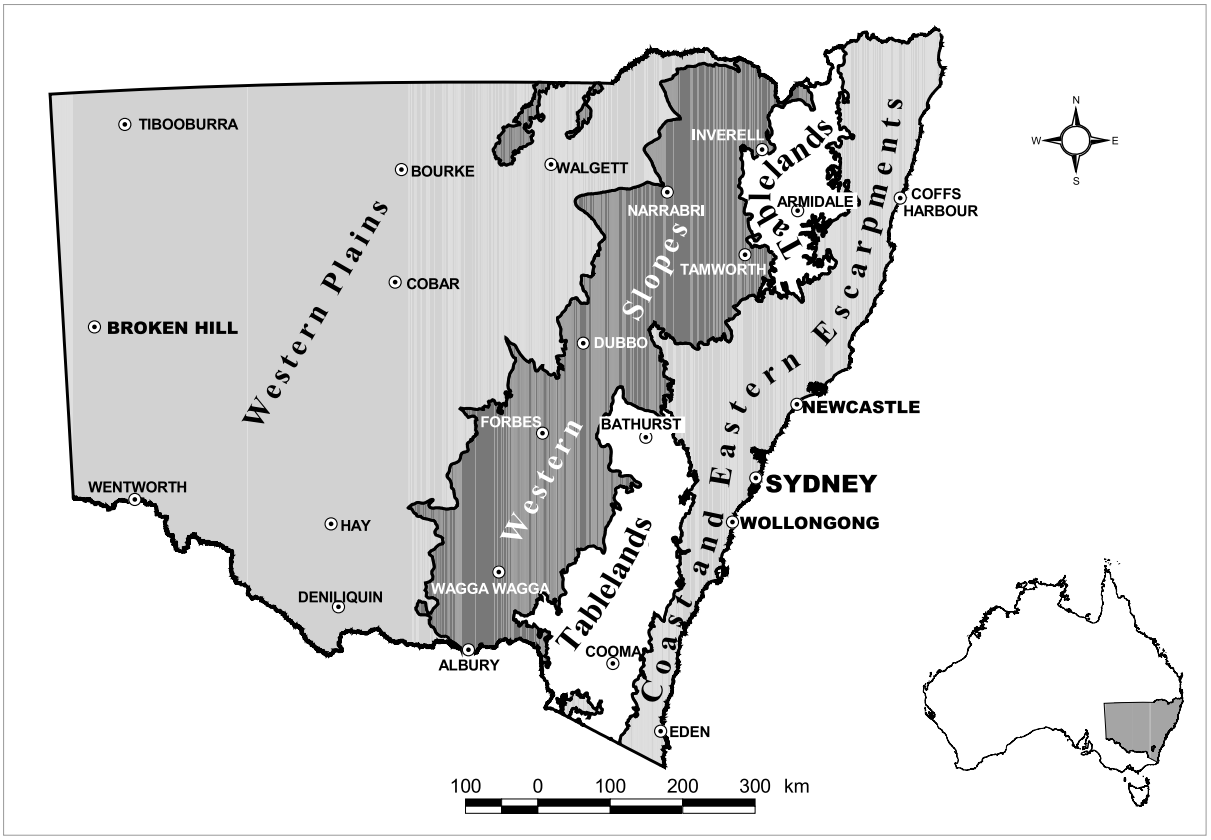

Fig. 8. The NSWVCA is progressing across fours sections of New South Wales from the Western Plains to the Western Slopes, Tablelands and Coast and Eastern Escarpment. These sections are defined by the boundaries of groups of IBRA (Version 6.0) Bioregions.

IBRA Bioregion sub-regions

Some Australian States have sub-divided the IBRA Bioregions into smaller units to produce more homogenous classifications for environmental planning. In NSW, this began with descriptions of sub-regions of western NSW (Morgan & Terry 1992) and was extended across the whole State by the NSW Department of Environment and Conservation (DEC) (2004). The resulting NSW IBRA sub-region map divides the 18 IBRA Bioregions in NSW into 129 sub-regions.

Botanical Divisions of NSW

Anderson (1961) described 12 Botanical Divisions of NSW. While this classification is older than the IBRA Bioregions, some of the Botanic Divisions make good sense from the botanical viewpoint and are still used to describe distributions of plant communities. Location in Botanic Divisions is recorded for about 300 000 plant specimens collected in NSW and housed in the New South Wales Herbarium, Sydney.

Catchment Management Authority Areas

The NSW Catchment Management Act 2003 defines 13 Catchment Management Authority areas (CMAs) (Figure 5) administered by Catchment Management Authorities. The Authorities are charged with making statutory Catchment Action Plans that contain targets for protecting aspects of landscapes in the catchments. The CMA boundaries include river catchments and vary considerably from the IBRA Bioregion boundaries (Figure 6). The four CMAs that run eastwards and the six that run westwards off the NSW Great Dividing Range contain large altitudinal gradients and landform variation compared to the IBRA Bioregions. For this reason the IBRA Bioregions tend to contain a more homogenous group of vegetation types compared to the CMA areas.

Local Government Areas

As of December 2004, there were 155 Local Government Areas (LGAs) in NSW but future amalgamations are likely to reduce this number. Local Governments are able to make Local Environmental Plans (LEP) under the NSW Environmental Planning and Assessment Act 1979. These LEPs can substantially affect land use and the management of vegetation.

Murray-Darling Basin

The Murray-Darling Basin is Australia's most important agricultural region, accounting for 41 per cent of the nation's gross value of agricultural production (Murray Darling Basin Commission http://www.mdbc.gov.au/naturalresources/basin_stats/statistics.htm). About 57% (59 847 470 ha) of the M-D Basin occurs in NSW (Figure 7, Table 1) covering about 75% of the State. Large areas of the Basin are under threat from salinity, soil degradation, clearing of native vegetation and biodiversity loss.

Producing the NSWVCA across four sections of NSW

Due to the scope of the project, the production of the NSWVCA is to will be divided between four sections of NSW beginning with the arid/semi-arid inland plains and progressing to the humid, east coast: (Figure 8) (Table 2). The NSW sections are based on groups of bioregional boundaries (IBRA Version 6.0 of Thackway & Cresswell 1995) (Figure 4). The order of production of the NSWVCA is:

- This introduction and overview paper that describes the aims and methods of the project;
- Part 1 (Benson et al. 2006, this volume) covering the classification and assessment of the plant communities of the NSW Western Plains. This incorporates the NSW sections of the eight IBRA Bioregions: Simpson-Strezelecki, Channel Country, Mulga Lands, Broken Hill Complex, Murray-Darling Depression, Riverina, Cobar Peneplain and the Darling Riverine Plain Bioregions (Figure 4). It includes the entire Western and Lower Murray/Darling Catchment Management Authority areas (CMAs) and the western parts of the Border Rivers/Gwydir, Namoi, Central West, Lachlan, Murrumbidgee and Murray CMAs (Figure 5).
- Part 2 is planned to cover the classification and assessment of the plant communities of the NSW Western Slopes incorporating the NSW sections of the three IBRA Bioregions: Brigalow Belt South, Nandewar and the New South Wales South Western Slopes Bioregions (Figure 4). The Western Slopes includes the middle sections of the Border Rivers/Gwydir, Namoi, Central West, Lachlan, Murrumbidgee and Murray CMAs (Figure 5);
- Part 3 is planned to cover the classification and assessment of the plant communities of the NSW Tablelands that incorporate the NSW sections of the three IBRA Bioregions: New England Tableland, South Eastern Highlands and Australian Alps Bioregions (Figure 4). The tablelands include the upper sections of the Border Rivers/Gwydir, Namoi, Central West, Lachlan, Murrumbidgee, Murray, Northern Rivers, Hunter/Central Rivers, Hawkesbury/Nepean and Southern Rivers CMAs (Figure 5);
- Part 4 is planned to cover the classification and assessment of the plant communities of the NSW Eastern Escarpment and Coast. This is the most complex section biologically. It incorporates the NSW sections of the four IBRA Bioregions: South East Queensland, NSW North Coast, Sydney Basin,

South East Corner (Figure 4). It includes most of the area in the Northern Rivers, Hunter/Central Rivers, Hawkesbury/Nepean and Southern Rivers CMAs (Figure 5).

Once the classification and assessment of the vegetation is complete for each section, the results and descriptions of the plant communities will be published and made available on the internet.

Vegetation Classification

Any region can be sub-divided into units based on subjective or objective analyses of biotic or abiotic variables. The units may vary in number and size depending on the scale and purpose of the classification. They are often used as surrogates for biodiversity in landscape management. Mapped units can be used in GIS applications to form a basis for conservation planning (Margules & Usher 1989) including in irreplaceability analyses (Pressey et al. 1994, Ferrier et al. 2000). Abiotic landscape classifications based on geology, landforms and soil types include the ecosystem mapping of British Columbia, Canada by Banner et al. (1996) and the categorisation and mapping of landscapes in New South Wales by Pressey et al. (2000) and Mitchell (2002). Biotic ecological classifications are mainly based on structural or physiognomic attributes of vegetation and vascular plant species composition. Species of lower plants (bryophytes, algae) can also be used in vegetation classification. Species of fauna are less often used because many species are highly mobile and therefore unsuitable in static landscape classifications. Other classes of species such as invertebrates, bacteria, viruses, lichens, fungi lack taxonomic treatment or are difficult to recognise in the field, so are rarely used.

Benefits of vegetation classification

Vegetation composition and structure are often selected for classifying landscapes because:

- Vascular plant species are well described and defined in taxonomic treatments – at least in 'western' countries;
- It is relatively easy to record vegetation structure and/or the presence or absence of plant species;
- Variation in plant species composition/abundance and vegetation structure often reflects natural or human-induced disturbance;
- Trained ecologists and land managers can generally recognize dominant plant species and vegetation structure in the field;
- Some evidence exists for correlations of vertebrate animal species with vegetation patterns (Mazzer et al. 1998) but there is less congruence of vegetation types with invertebrate species (Dangerfield et al. 2003).

Classifying vegetation

Vegetation can be classified through structural or physiognomic attributes such as life form, leaf size, height of strata and canopy cover. Alternatively, vegetation can be classified through a floristic approach by describing variation in species composition across a region. The latter can involve analyses of patterns of dominant plant species or all plant species (Kent & Coker 1992). Often elements of both structural and floristic approaches are used in vegetation classification. Sometimes a vegetation classification is nested under broader abiotic classifications exemplified in the approach to ecosystem definition in Queensland, Australia (Sattler & Williams 1999, Queensland Herbarium 2003, Wilson et al. 2002).

The attributes of leaf size and deciduous versus evergreen leaf retention have often been used to define high hierarchical orders in northern hemisphere vegetation classification (Dansereau 1951). However, these attributes are less useful for dividing most Australian vegetation. Dominant plant species life forms (Raunkiaer 1934) have been widely used in categorising vegetation throughout the world. In Australia, life forms form a core of the influential vegetation classification scheme of Beadle & Costin (1952). They are also a major component in the structural classifications of the widely used projected foliage cover / height class classification of Specht (1970) and the crown separation / height class classification of Walker & Hopkins (1990). These structural classifications have the advantage of requiring minimum knowledge of plant species taxonomy but they tend to classify vegetation into broad classes such as 'tall open forest' or 'open shrubland' and each class contains numerous floristic communities generally spread over large distributions.

Floristic approaches to ecological community classification commenced in Europe in the late 19th and early 20th Century culminating in the Zurich-Montpellier School of phytophysiology described by Braun-Blanquet (1932), with subsequent modifications by various botanists including Poore (1955). Bridgewater (1981) comments on the use of the Braun-Blanquet approach in classifying Australian vegetation. These early methods involved subjective analyses of species occurrences in sample plots, grouping plots with similar plant associations and attributing a name to that grouping. Modern numerical methods of classification require similar plot data to that used in the Braun-Blanquet method and include species presence/absence or a scaled cover abundance scores. Today, sample plots and numerical analyses form a basis of most modern ecological classifications and underpin many vegetation map unit classifications.

A long debate ensued between the plant sociologist (community) school (Clements 1928, Braun-Blanquet 1932), who maintain that assemblages of species exist in serial and climax stages, and the 'individualist' or 'continuum concept'

school (Gleason 1926 later modified by Whitaker 1962 and others) who question plant community theory and argue that individual species distribution is dictated by environmental determinants and not by association with other species. Austin (1991) and Grossman et al. (1998) summarize this debate. Based on his nodal ordination analysis of 193 vegetation plots in semi-arid vegetation in south-eastern Australia, Noy Meir (1971) suggested that vegetation can be described by using both continuous and discontinuous mathematical models. Recently, there has been some rapprochement between the 'schools' (Austin & Smith 1989, Austin 1991) partly due to the acknowledgment that the community concept has practical advantages in landscape management. Austin (1991) proposes that the community concept is useful for descriptive purposes on a 'regional' basis but less applicable over larger areas.

The concept of fidelity or 'characteristic species' to describe plant communities arose in Switzerland (Gradmann 1909) and was pivotal in the plant community classification methodologies developed by Braun-Blanquet (1932) in the first half of the 20th Century. Subsequently, Goodall (1953) developed an index of fidelity using statistical methods applied to plant species frequency plot data. The issue of setting desired degrees of similarity among vegetation stands to distinguish plant communities is discussed in Mueller-Dombois & Ellenberg (1974) who suggest using a 25–50% index of similarity of shared species occurrences in stands as a rule of thumb to define a 'plant association'. Homogeneity analysis of group associations (Bedward et al. 1992) derived in cluster analyses, such as those described in Faith (1991), can assist with selecting floristic groups in floristic datasets. However, species composition varies from place to place depending on land use history or changes in the environment. It is the degree of species dissimilarity over a geographical range that determines when species assemblages should be considered as separate communities and recorded as such.

Vegetation mapping

Vegetation mapping generally involves aerial photographic interpretation of vegetation structure, major life forms and dominant species patterns. The quality of vegetation mapping is limited by the quality of aerial photographs and the interpretation of them, along with the quality of underpinning data layers such as geology and soils maps. Rarely does vegetation mapping depict all floristic groups derived in numerical analysis of plot data or discerned through expert field observation. Some vegetation map units are more homogeneous than others. This is largely dictated by scale, the methods used in the mapping and the complexity of the vegetation patterns. Benson (1995) describes four different qualities of vegetation mapping based on scale and the quantity and quality of field sampling.

International vegetation classifications

An example of a quantitative data-driven classification includes the past 30 years sampling of the British flora in over 33 000 plots to deliver a National Vegetation Classification of over 400 plant communities (Rodwell 1991, 1992, 1995). This classification, and a qualitative one that preceded it (Ratcliff 1977), have been important for setting conservation priorities in Britain. A European Vegetation Classification (Mucina et al. 1993), involving most European countries, continues to develop using the sampling and plant community concepts of Braun-Blanquet.

Intense plot sampling and numerical classification are conceivable for places such as Europe where there are high numbers of expert botanists and ecologists. In contrast, developing countries in the tropics that contain species-rich ecological communities have few field biologists to undertake intense sampling. The Australian situation lies somewhere between the two. Australia contains over 20 000 vascular plant species, has patchy (in terms of quality and extent) sampling and mapping of its vegetation, and, given the size of the country, has a limited number of expert ecologists to research vegetation.

A pertinent example of vegetation classification relevant to the Australian situation is the United States National Vegetation Classification (USNVC) produced by The Nature Conservancy (Grossman et al. 1998, Anderson et al. 1998). This took a practical approach that combines quantitative and qualitative data to develop a classification across the USA. Where quantitative data was incomplete for a region the USNVC used qualitative assessments arguing that 'qualitative assessments of vegetation across its range can be more robust than quantitative analyses based on incomplete and unrepresentative data sets' (Grossman et al. 1998). Expert plant ecologists from the various US states identified over 4100 'plant associations' within a physiognomic-floristic hierarchical framework of vegetation classification. The USNVC uses physiognomic criteria at the coarsest hierarchical levels while the floristic criteria are used at the finer levels. This classification has been widely adopted by US government agencies as a useful classification of the USA landscapes.

Continental scale vegetation classification and mapping in Australia

Beadle (1981) provides a thorough floristic classification and description of the vegetation in Australia as well as a coarse vegetation map based on the distribution of dominant genera.

A continental scale classification and vegetation map of Australia was developed by Carnahan (1976) updated in AUSLIG (1990). These coarse, 1:5 000 000 million scale

maps, depict present day and pre-European vegetation with the vegetation types coded for their main genera, life form and projective foliage cover.

In an attempt to classify the vegetation of Australia objectively, Specht et al. (1995) analysed floristic plots using the polythetic-divisive program TWINSPAN (Hill 1979), then added or split these groups based on other information. Specht et al. (1995) lists 921 major and minor floristic groups for Australia with some locations shown on small scale maps. Criticisms of this work focus on the relatively low number of floristic plots used in the analysis and the coarseness of some of the classified floristic groups (Hager & Benson 1994).

Sun et al. (1996) describe different vegetation classification and mapping systems in the forest areas of Australia and Bolton (1991) documents mandatory attributes to be recorded when sampling vegetation. The Australian National Vegetation Assessment section of the National Land & Water Resources Audit (2001) broadly classified the vegetation of Australia. It collated various vegetation maps to produce a small scale national vegetation map with basic descriptions of the map units. The National Vegetation Information System (NVIS), which arose from the vegetation theme in the Audit (National Land & Water Resources Audit 2001), is a more detailed project aimed at classifying Australian vegetation at a fine scale of resolution, i.e. to the plant association level where possible. However, this approach has encountered difficulties in comparing classifications across State boundaries and too little sample data is available for several parts of Australia to meet its definitional requirements. NVIS combines floristic and structural parameters to describe all various layers of a vegetation type.

Australian State and Territory vegetation classifications and mapping

Since the 1950s Australian States and Territories have classified and mapped their vegetation at various scales. Examples include: Beard & Webb (1974) 1:250 000 scale vegetation mapping of Western Australia, Kirkpatrick & Dickinson (1984) vegetation map of Tasmania (finer scale maps and classifications have since been produced for Tasmania) and a series of maps covering South Australia such as Forward & Robinson 1996 and Playfair & Robinson (1997). Most of Queensland has now been mapped at either 1:100 000 or 1:250 000 scale (Wilson et al. 2002). In Victoria, Ecological Vegetation Classes (EVCs) are mapped at 1:100 000 scale across the State (Victorian DNR 2001). Additionally, numerous regional and local scale vegetation maps have been produced in each state or territory.

Table 2. Area of the four sections of NSW in which the vegetation of NSW is proposed to be classified and assessed.

Sections of NSW	Hectares	% NSW
Western plains	45,756,718	57.1%
Western Slopes	15,473,443	19.3%
Tablelands	8,178,110	10.2%
Coast and Escarpment	10,618,319	13.2%

An unfortunate feature of State-based vegetation survey and mapping projects is that they ignore similar work in adjoining States. Therefore, there are major inconsistencies in vegetation (or ecological) community classification across the State and Territory boundaries in Australia.

In terms of conservation assessment, Davies (1982) assessed the South Australian plant communities. Kirkpatrick et al. (1995) assessed plant communities in Tasmania. In Queensland, Sattler & Williams (1999) described and assessed the threat status of about 1100 regional ecosystems. The Queensland regional ecosystems are regularly updated on the web site: http://epa.qld.gov.au/nature_conservation/biodiversity/regional-ecosystems).

Vegetation mapping and classification in NSW

The history of vegetation mapping and survey in NSW is reviewed in Benson (1999) and Keith (2004). Beadle (1945) produced a broad scale vegetation map of the western half of NSW, one of the first vegetation maps produced in Australia. Subsequently, Beadle (1948) described the pastures, soils and soil erosion of western NSW. Costin (1954) mapped the Monaro section of the Southern Tablelands and later co-authored a classification and map of the alpine vegetation in Kosciuszko National Park (Costin et al. 1979). Moore (1953) mapped part of the South Western and Central Western Slopes. These early, studies were followed by further regional mapping such as Biddiscombe (1963) covering the Macquarie River region of central NSW. The first attempt to produce a vegetation map covering all of NSW was a compilation map by Hayden (1971) but this was incomplete and very coarse in its scale.

In response to a growing awareness of ecology and environmental issues, the Royal Botanic Gardens and Domain Trust, Sydney (RBG) instigated a vegetation survey and mapping program in 1972. The RBG mapped most of the Sydney Basin Bioregion and published eight 1:100 000 map sheets for this area between 1986 and 1996 (eg Keith & Benson 1988, Benson 1992). It mapped the south-western section of NSW at 1:250 000 scale in four publications between 1991 and 1997 (Fox 1991, Scott 1992, Porteners 1993 and Porteners et al. 1997) and published a 1:1 million map of the north-west quarter of NSW (Pickard & Norris 1994). The RBG initiated a fine scale (1:25 000 published at 1:100 000) mapping of the Northern Tablelands (Benson & Ashby 2000). The RBG also completed a number of fine scale maps of conservation reserves. The RBG web site http://www.rbgsyd.nsw.gov.au/publications/cunninghamia includes a list of vegetation maps and surveys published in this journal.

Over the last 25 years, the NSW National Parks and Wildlife Service mapped the vegetation in many of its conservation reserves at fine scales of resolution. These maps sample vegetation types in locations across the State. From 1985 to 2000 the NSW NPWS mapped the remnant vegetation of about two thirds of the NSW wheat belt in the Central Division of NSW (Sivertsen & Metcalfe 1995, Metcalfe et al. 2003) as well as financing botanical surveys, mapping and classifications of broad vegetation types. Examples include the 1976–1990 survey and classification of rainforest vegetation of NSW (Floyd 1990) and the classification and mapping of the coastal heaths on the NSW north coast (Griffith et al. 2003).

Benson (1989) published a list of 430 plant communities in NSW and assigned reservation and threat codes to each community, however, this contained little detail about each community. Using available mapping information, Hager & Benson (1994) classified and assessed the status of forest communities in north-eastern NSW.

During the 1990s, the NSW NPWS initiated biological surveys and modelling of forest ecosystems as part of comprehensive regional assessments (CRA) of the forests in NSW. CRAs provide a basis for decisions on forest allocation to conservation or to timber production. Forests mainly occur in the wetter, eastern third of the State, however the last CRA covered the Brigalow Belt South Bioregion on the northern inland slopes and plains of NSW (RACAC 2004). These CRA projects have delivered a large volume of flora site data that have been used for modelling vegetation, for example, the vegetation of the Southern Forests by Gellie (2005).

In response to needs for regional vegetation planning under the NSW Native Vegetation Conservation Act 1998, the NSW Native Vegetation Mapping Program (NSWVMP) was initiated in 2000 and has surveyed and mapped approximately forty 1:100 000 map sheet areas. The inland areas cover parts of Hay Plain in the Riverina Bioregion, the eastern fringe of the Cobar Peneplain Bioregion and adjoining north-western parts of the NSW South-western Slopes Bioregion, parts of the Brigalow Belt South and Nandewar Bioregions, and the coastal and tablelands south of Sydney to Nowra in the Sydney Basin and NSW South Eastern Highlands Bioregions. Vegetation was sampled in thousands of plots (for example, Cannon et al. 2002, Horner et al. 2002, Lewer et al. 2002). However, the NSWNVMP program was curtailed in 2004 when there was a switch of emphasis to property planning and most of the vegetation maps have not been published.

Regional and fine scale vegetation mapping in NSW remains patchy and there is no ongoing program to fill the data gaps. Some parts of NSW contain no vegetation mapping or plot data. In other parts very detailed data exists. As of 2006, not one of the 18 IBRA Bioregions or 13 Catchment Management Authority areas had the native vegetation over its total area adequately field sampled or mapped at a reasonable scale. The coastal Sydney Basin Bioregion is the closest to having attained this goal.

To meet State and continental-scale environmental reporting, Keith (2004) compiled a 1:1 500 000 scale compilation vegetation map of NSW and developed this into a book that describes 99 'vegetation classes' in 12 'vegetation formations'. The NSWVCA plant communities are correlated to the Keith (2004) 'vegetation classes' in the NSWVCA database (described below) and a database report option can list plant communities for any of the Keith (2004) 99 vegetation classes.

Methods

The NSWVCA includes several inter-related stands of work:

- A classification of the vegetation of NSW including listing characteristic species for each plant community;
- An assessment of available data of each listed plant community such as pre-European and current extent, distribution in various regions, physiographic attributes and other details;
- Defining the protected areas in NSW, determining occurrences of communities in these areas and assessing the protected area status of each community;
- Assessment of the threat status of each plant community using definitions of threat categories and threat criteria;
- The construction of a database on which to store a range of information about each classified plant community that also relates the plant communities to other ecological classifications;
- Development of a number of standard reports in the database that list plant communities for regions used in land use planning in NSW or for commonly used broad vegetation classifications.

Classifying the plant communities

The NSWVCA is developing a vegetation classification derived from compilation and critical evaluation of existing information complemented by expert opinion and rapid field checking. The patchiness of vegetation data across NSW prevents a purely numerical classification. The approach is flexible depending on data availability. In Western NSW there is very little plot data or fine scale vegetation mapping so the classification requires a considerable degree of expert judgment. In the eastern quarter of NSW (Coast and Tableland Sections), there is considerable plot data and fine-scale vegetation mapping that could form a basis of quantitative assessment for the classification. The author does not have the resources to singly-handedly gap-fill survey plot data or vegetation mapping across the whole of NSW. The following methods are being employed:

1. Thoroughly review the published and unpublished literature including vegetation maps, vegetation

descriptions and selected plot data. Most of the literature in NSW on vegetation is held by government agencies. Some information is published. Much of the most useful information is unpublished including vegetation maps in Geographical Information System (GIS) format;

2. Interrogate vegetation map GIS files using ArcView version 3.3 (ESRI Inc. 1992–2002) software or later versions. Tables are produced on the extent of the vegetation map units from all the vegetation maps including those covering protected areas;

3. Assemble plot data for the region being studied. Analyses may or may not be undertaken depending on time. Existing analyses and descriptions are given priority for use in the classification;

4. Relate different datasets to each other through field checking, comparing botanical lists, plot data records or by comparing vegetation map unit descriptions. This mainly involves cross-comparisons of dominant or otherwise characteristic plant species, vegetation structure, soil types and geographical location;

5. If an area has been well surveyed and/or mapped for its vegetation, priority is given to using vegetation units described in such work. There are perhaps 30 000 floristic sample plots recorded on various databases in NSW (author's estimate). Parts of eastern NSW contain large amounts of vegetation plot and map data but there are gaps, particularly on private land. Furthermore, even in relatively well sampled regions, expert judgment is required to compare adjoining or overlapping vegetation datasets in order to derive a state-wide classification. Sample plot data and fine-scale vegetation mapping are non-existent or incomplete for large sections of the tablelands, western slopes and western plains of NSW. In these regions, broad-scale vegetation maps, plant community descriptions in reports or notes taken during field checks are key sources for describing plant communities;

6. Derive an initial plant community classification for a section of the State based on dominant and otherwise characteristic plant species;

7. Enlist the assistance of field botanists and ecologists who are experts on the vegetation of particular regions to critique the initial classification;

8. Check the plant communities in the field (see below);

9. Based on the notes taken during the field traverses and the expert critique, revise the initial classification for final documentation.

The 'Authorities' field in the NSWVCA database lists the main references used to define a community and the relationship between map units and the community. This should assist with future revisions of the classification by other researchers. Other information sources are cited in other fields in the database.

Field checking

Rapid vehicular field traverses are used to check the plant community classification including occurrences in protected areas. The sample points in the traverses are selected from vegetation maps or descriptions, areas containing floristic groups in reports, or, in cases where no data exists, by traversing major environmental gradients to sample the vegetation. At the time of writing there had been six field trips covering the NSW Western Plains and part of the of NSW Western Slopes. Over 500 hundred site assessments had been made over 18 000 km of field traverse. At each stop, dominant plant species are recorded or collected, threatening processes such as weeds are noted and notes are taken on soil, substrate and landscape features. Photographs are taken and a GPS latitude and longitude reading is recorded. This field information is important in verifying past work but also in gap-filling where data is poor. In some cases, plant communities are described using the information gathered during these surveys.

Listing characteristic species

Vegetation descriptions, plot data, expert knowledge of species composition of vegetation types, along with field checking, contribute to the listing of characteristic plant species in three vegetation layers. These layers are defined by life-form: trees (including mallee trees and emergent trees); shrubs (>0.5 m high), woody vines, epiphytes; and groundcover that includes all herbaceous vegetation and shrubs less than 0.5 m high.

It was deemed too cumbersome for a state-wide floristic classification to incorporate database fields to cater for the full range of potential vegetation strata i.e. emergent, tallest, several mid-layers and ground. In this sense the current database is similar to NVIS level 5 (NLWRA 2001, ESCAVI 2003) in its classification details.

A characteristic species is either common in one or more strata of the vegetation, or has high fidelity to a particular type of vegetation as determined in numerical analyses of plot data or through recorded observation. Common species are deemed to be those that occur at >40% of sample sites in a defined plant community. They should also be numerous at a site or contain consistent high cover classes in plot data recordings or observations. High fidelity species can be selected from survey plot data using the approach of Westhoff & van de Maarel (1980). For example, Benson & Ashby (2000) set a fidelity minimum of 0.8 for selecting high fidelity species in plant communities in the Guyra region on the Northern Tablelands of NSW.

Up to four of the most dominant or indicative plant species in the three layers are used to define the 'Scientific Name' of a plant community. The database's search function allows for a search and listing of plant communities with a specified species name in its Scientific Name.

Photography

During field traverses colour transparencies (slides) and digital photographs are taken of as many plant communities as possible, if possible over their range. Where the Botanic Gardens Trust is unable to take photographs of a plant community, images are obtained from other sources.

Images selected for the photographic archive are labelled and filed. The labelling includes plant community number (ID), list of main plant species photographed, location, latitude, longitude, date and photographer's name. A select number of these images are maintained at high and low resolutions. High resolution images are stored on DVDs. Low resolution (72 DPI) jpg images are linked to the NSWVCA database and stored on the Botanic Gardens Trust computer file server and on backup CDs. These can be viewed in the NSWVCA database in the Main Table Form (the main data entry form), via MS Internet Explorer, by selecting the Photo 1, Photo 2 or Photo 3 keys.

Relationship of the classification with vegetation maps

Some of the listed communities in the database will have a direct correlation to map units in various vegetation maps. However, many will not, either because the map unit is too heterogeneous and therefore has been sub-divided to reflect more homogenous floristic groups, or the plant community occurs in small areas or linear strips (such as along watercourses) that have not been mapped. In some cases, floristic groups derived and described from analyses of plot data are adopted as a plant community even though these groups are often not mapped in vegetation maps. It is likely that the NSWVCA classification will influence future vegetation map unit descriptions for areas that the NSWVCA covers but where mapping is absent or of poor quality.

Relationship of NSWVCA to other landscape classifications

The NSWVCA database contains fields that allow each plant community to be cross-referenced to other NSW or national vegetation and abiotic classifications. Database fields include:

- 'Forest Type RN 17' that lists the 235 forest types described in Research Note 17 published by the Forestry Commission of NSW (1989). Rarely does a plant community equate with a forest type so there is an option of selecting the qualifier 'part of a forest type';
- 'State Vegetation Map' that lists 99 vegetation classes depicted on a 1:1 500 000 compilation vegetation map covering NSW in Keith (2004);
- NVIS that lists 28 major vegetation groups and 56 major vegetation sub-groups (version 3, 2005) used by the Australian Government (ESCAVI 2003) in a broad classification of the vegetation of Australia;
- 'State Landscapes' that lists about 500 landscapes classified from abiotic layers of land systems, soil and geology in Mitchell (2002).

Interstate comparisons

The NSWVCA database contains a field titled 'Interstate Equivalent' that facilitates documentation of vegetation map units or plant communities described in other Australian States and Territories that appear similar to the plant communities in the NSWVCA. While inter-jurisdictional comparisons can be difficult, it can be done if there are reasonable descriptions of vegetation and/or lists of dominant or characteristic plant species. For example, the classification of the Vegetation of the Western Plains of NSW (see Benson et al. 2006, this volume) compares the NSWVCA communities with map units in South Australia described in Forward & Robinson (1996), Playfair & Robinson (1997), Foulkes & Gillen (2000) and Davies (1982); in Queensland the key reference is the ecosystem classification in Sattler & Williams (1999); and Victoria, comparisons are made with ecological vegetation classes (Victorian Department of Natural Resources 2001) and vegetation descriptions in other regional studies.

Derived or expanded plant communities

A number of plant communities listed in the NSWVCA have a larger estimated current extent compared to their estimated pre-European extent. These are judged to be 'derived' or 'expanded' plant communities. Deciding on whether a plant community is 'derived' is not easy because most plant communities across Australian and NSW have been substantially altered since European settlement. Also, there is no way of proving a community now considered to be 'derived' did not exist at the time of European settlement – perhaps in smaller patches or even in different locations than at present. However, if evidence or expert opinion suggests that plant communities are grossly modified in their structure and floristic composition they will be recorded as derived native vegetation. Setting a date from which a community can be judged as being derived would vary throughout the world. In Australia it is appropriate to use 1788, the time of European settlement.

Derived vegetation contains biodiversity and landscape values. An example of derived vegetation in NSW includes native grasslands derived from previously treed or shrub-dominated landscapes where the trees and shrubs have been cleared or grazed out. Other examples include shrublands or grasslands that have been derived from previous shrublands that were dominated by different species. For example, large areas of the inland south-western plains of NSW were once dominated by perennial saltbushes (*Atriplex* spp.) that have disappeared due to grazing and dieback.

Derived native vegetation is classed as 'native vegetation' under Section 6 of the NSW Native Vegetation Act 2003

wherein native vegetation is defined as being indigenous trees, understorey plants, ground cover and plants in a wetland. Section 20 of the Act stipulates that a native ground cover is one that contains greater than 50% indigenous species.

NSWVCA Hierarchy

The NSWVCA contains five hierarchical levels (Table 3) modified from the floristic — physiognomic approaches to vegetation classification in Beadle & Costin (1952) and sections IV to VI in the National Vegetation Information System (National Land and Water Resources Audit 2001, ESCAVI 2003). The hierarchy is similar to some levels in *The Terrestrial Vegetation of the United States* (Grossman et al. 1998). The NSWVCA hierarchies use combinations of vegetation structure, dominant life form, floristic composition and physiographic features to classify vegetation.

Structural class:

Vegetation structure is recorded in the 'structure' field in the NSWVCA database by selecting options from tables containing the structural classes in Walker & Hopkins (1990). These combine dominant growth-form, crown density and height of the tallest stratum. The growth forms are tree, tree mallee, shrub, mallee shrub, heath shrub, chenopod shrub, tussock grass, hummock grass, sod grass, sedge, rush, forb, fern, moss and vine. Wetlands are generally covered by sedgeland, forbland or rushland but may also include trees and shrubs. The height classes terms extremely tall, very tall, tall, mid-high, low and dwarf apply to different height thresholds depending on the growth-form (Walker & Hopkins 1990). For example, an 'extremely tall' tree is >35 m high, while an 'extremely tall' tussock grass is 3–6 m high. More than one density or height class can be recorded for each plant community because they may vary through successional or regrowth stages after natural or human-induced disturbance. If a plant community is deemed to be rainforest, the same structural formation code is recorded as for non-rainforest vegetation but additional codes are also added. These are based on the Australian rainforest physiognomic/structural classification of Webb (1968). They codify attributes of rainforest structure describing its complexity as being simple, simple-complex or complex; recording its leaf size based on average leaf size of canopy trees exposed to sunlight; recording indicator growth forms such as moss, fern, fan palm, feather palm, vine or none; and recording presence of emergents and whether they are sclerophyllous or rainforest species.

Formation Group:

These are coarse level floristic/ecological groupings of plant communities. The Formation Groups are modified from the major groups of plant communities described in *The Vegetation of Australia* by Beadle (1981). Beadle understood variation in vegetation across Australia and applied an understanding of ecological processes, soil and substrate in describing vegetation units. Over 60 Formation Groups are listed for NSW in the NSWVCA (Table 4). The classified plant communities can be listed from the database under any of these Groups. The standard reports from the database, described in Appendix A, list plant communities

Table 3: Summary of the NSW vegetation classification and assessment hierarchy

Hierarchical level	Main features for classification	Example(s)	Key references
Structural Class	Height and crown density of highest stratum and dominant life-form of major stratum.	Tall Closed Forest, Mid-high Open Woodland, Low Sedgeland, Very Tall Grassland	Walker & Hopkins (1990), Specht (1970), Beadle & Costin (1952)
Formation Group	Broad grouping of plant communities by dominant genera and environmental factors including climate, hydrology, soil type, landforms and distribution	Acacia shrublands of the inland slopes and plains	Beadle (1981) with Baur (1957) and Floyd (1990) used to define major rainforest groups.
Sub-formation	Grouping of communities with dominant/diagnostic species usually in the upper-most stratum	ID119 Sandplain Mulga	Analogous to 'Alliance' in Beadle & Costin (1952) and Beadle (1981). Similar to sub-formation in NVIS (NLWRA 2001).
Association	Dominant/diagnostic species from any strata	ID27 Yarran shrubland on peneplains and alluvial plains of central-northern NSW	Analogous to 'Association' in Beadle & Costin (1952) and association in NVIS (NLWRA 2001).
Sub-association	Variation of dominant/diagnostic species from subordinate strata in an Association	ID220 Purple Wood wattle shrubland of the arid zone sandplains	Analogous to 'Sub-association' in Beadle & Costin (1952) and sub-association in NVIS (NLWRA 2001).

in alphabetical order of the Formation Groups so that similar plant communities are bundled in the reports.

The Formation Groups are more complex than the 20 or so broad vegetation types used to describe Australian vegetation in Groves (1994) but similar in concept to the vegetation classes mapped and described for NSW in Keith (2004) – see the comparisons in Table 4. Some of Keith's (2004) vegetation class names are based on NSW geography (for example 'North-west Alluvial Sand Woodlands') whereas most of the Formation Groups used in the NSWVCA have generic names based on dominant genera or landscape types that can apply to any part of Australia.

The three finer hierarchical levels in the NSWVCA are generically labeled 'plant communities' for the purposes of describing the vegetation. The definitions of these three levels of classification are analogous to those used to define alliances, associations and sub-association in Beadle & Costin (1952) and reflect the national classification definitions used in the National Vegetation Information System (NLWRA 2001). The definitions are:

Sub-formation:

A group of floristically related associations of similar structure (*alliance* in Beadle & Costin 1952), or, a community with shared dominant growth form, cover, height and broad floristic code usually dominant Genus and Family for the three traditional strata (upper, mid and ground) (NLWRA 2001).

Association:

A community of which the dominant stratum has a qualitatively uniform floristic composition and which exhibits a uniform structure (*association* Beadle & Costin 1952), or, a community with shared dominant growth, height, cover and species (3 species) for the three traditional strata (upper, mid and ground) (NLWRA 2001).

Sub-association:

A sub-division of an association determined by a variation in the most important subordinate stratum of the association, without significant qualitative changes in the dominant stratum (Beadle & Costin 1952), or, a community with shared dominant growth form, height, cover and species (5 species) for all layers/strata (NLWRA 2001);

Assigning a plant community to a level of classification is done subjectively, although objective rules could be made if sufficient floristic data were available. The reasons for selecting a particular classification level can be entered in the Authority field of the NSWVCA database. Allocation takes into account the overall species variation in all strata of a mapped or described plant community. Variation in species composition is documented through field-checking, judgment from the literature and/or from expert advice. If a recorded plant community contains a high degree of floristic consistency across its range, in all of its strata, it will be listed as an association. If a community contains significant species variation, often over a large geographical area, it will be assigned as a sub-formation. A number of communities in western NSW described in Benson et al. (2006) have been assigned as sub-formations due to the scarcity of floristic data or fine scale vegetation mapping that could form the basis of a finer level of classification. It is anticipated that plant communities listed as sub-formations will be sub-divided in the future with improved plot data and/or vegetation mapping.

Parameters of the NSWVCA

The NSWVCA is based on existing native and semi-native vegetation dominated by indigenous plant species that persist without regular human intervention or maintenance. This includes shallow freshwater and saline wetlands containing rooted or floating plants and communities in the littoral zone and shallow marine environments including seagrass beds. Deep marine flora are excluded at this stage but could be added in the future. The classification excludes highly altered vegetation such as croplands or highly modified pastures where natural woody canopy species and most natural ground species have been removed. It concentrates on listing late successional stages of vegetation but post-disturbance, early successional stages can be described in the 'variation and natural disturbances' field in the database.

The NSWVCA uses a floristic approach to classifying plant communities but records vegetation structural classes and abiotic features for each plant community. While species occur as continuums in environmental space and time, it is considered that species distribution overlaps, within regions, can be described or mapped. Most communities classified in the NSWVCA should be able to be mapped at scales of 1:100 000 for the western plains, 1: 50 000 for the western slopes and tablelands and 1: 25,000 for the geographically and ecologically complex coast.

The NSWVCA also lists floristically distinct plant communities that occur in small patches or in linear strips that are often overlooked in regional scale vegetation mapping. These include seepage zones wetlands such mound springs, stream-side vegetation and distinct vegetation types that occur in small patches mosaics and are often mapped as complexes with other communities.

If information is available, the classification describes seasonal floristic variations. This is particularly relevant in the low rainfall regions of inland NSW where many ground species are ephemeral and only appear after rain.

All citations used to describe any aspect of a plant community are referenced in each record and produced in full in the 'Reference' field of the database. The plant species

Table 4. Formation Groups used in the NSWVCA that are based on the major groupings in Beadle (1981) compared to the NSW Map Unit Vegetation Classes in Keith (2004). Notes: DSF = Dry Sclerophyll Forests, WSF = Wet Sclerophyll Forests

Formation Groups in NSWVCA	Acron.	Equivalent Vegetation Classes in Keith (2004)
Acacia Forests and Shrublands of the East Coast and Tablelands	AST	Southern Wattle DSF; Northern Gorge DSF
Acacia Woodlands and Shrublands of the Inland Slopes and Plains	ASI	Riverine Plain Woodlands; Brigalow Clay Plain Woodlands; North-west Plain Shrublands; Gibber Transitional Shrublands; Stony Desert Mulga Shrublands; Sand Plain Mulga Shrublands
Alpine Bogs and Fens	ABF	Alpine Bogs and Fens
Alpine Fjaeldmarks	AF	Alpine Fjaeldmarks
Alpine Heaths and Shrublands	AHS	Alpine Heaths
Alpine Herbfields	AHG	Alpine Herbfields
Casuarina Woodlands of the Inland Slopes and Plains	CCI	Riverine Sandhill Woodlands; Semi-arid Sand Plain Woodlands
Chenopod (Halophytic) Shrublands of the Inland	CHS	Riverine Chenopod Shrublands; Aeolian Chenopod Shrublands; Gibber Chenopod Shrublands
Coastal Cliff Communities	CCC	Maritime Grasslands
Coastal Sand Dune Grasslands, Forblands and Shrublands	CSD	Maritime Grasslands; Wallum Sand Heaths
Cypress Pine (*Callitris*) Woodlands Mainly of the Inland Slopes and Plains	CPW	North-west Alluvial Sand Woodlands; Riverine Sandhill Woodlands; Inland Rocky Hill Woodlands
Ephemeral Grasslands in Semi-arid or Arid Regions	EGA	Gibber Chenopod Shrublands; Sand Plain Mulga Shrublands
Eremophila, *Melaleuca* and *Dodonaea* Shrublands of the Inland	EMDI	North-west Plain Shrublands
Eucalyptus Box Woodlands of the East Coast Valleys	EBWC	Clarence DSF; Hunter-Macleay DSF; Cumberland DSF; Southern Hinterland DSF; Northern Gorge DSF; Central Gorge DSF
Eucalyptus Box (Mostly Grassy) Woodlands of the Inland Plains	EBWP	Floodplain Transition Woodlands; Riverine Sandhill Woodlands; Inland Rocky Hill Woodlands; Western Peneplain Woodlands
Eucalyptus Box Woodlands of the Tablelands and Western Slopes	EBWT	New England Grassy Woodlands; Tableland Clay Grassy Woodlands; Southern Tableland Grassy Woodlands; Western Slopes Grassy Woodlands; Upper Riverina DSF; Pilliga Outwash DSF
Eucalyptus (Grassy or Shrubby) Woodlands and Forests on Low Fertility Soils on the East Coast	EWLFSC	Clarence DSF; Hunter-Macleay DSF; Northern Gorge DSF; Southern Hinterland DSF; Coastal Dune DSF; North Coast DSF; Sydney Coastal DSF; Sydney Hinterland DSF; Sydney Sand Flats DSF; South Coast Sands DSF; South East DSF
Eucalyptus (Grassy or Shrubby) Woodlands and Forests on Low Fertility Soils on the Eastern Tablelands	EWLFST	New England DSF; Northern Escarpment DSF; Sydney Montane DSF; Northern Tableland DSF; Southern Tableland DSF
Eucalyptus (Grassy or Shrubby) Woodlands and Forests on Low Fertility Soils on the Western Slopes	ESWWS	North-west Slopes DSF; Upper Riverina DSF; Pilliga Outwash DSF; Western Slopes DSF; Yetman DSF
Eucalyptus Communities of Inland Watercourses and Inner Floodplains	EIW	Inland Riverine Forests; Inland Floodplain Woodlands; North-west Floodplain Woodlands
Eucalyptus / *Corymbia* Woodlands of the Tropics	EWT	North-west Alluvial Sand Woodlands; Desert Woodlands
Eucalyptus Ironbark Forests of the East Coast and Tablelands	EIFC	Clarence DSF; Hunter-Macleay DSF; Cumberland DSF
Eucalyptus Ironbark Woodlands and Forests of the Inland Slopes, Plains and Peneplains	EIWI	Inland Rocky Hill Woodlands; Subtropical Semi-arid Woodlands
Eucalyptus Subalpine Woodlands and Forests	ESAW	Tableland Clay Grassy Woodlands; Subalpine Woodlands
Eucalyptus Swamp Communities of the Eastern Coast and Tablelands	ESCT	Coastal Swamp Forests;
Eucalyptus Tall Dry Shrub Forests and Woodlands of the Eastern Coastal Lowlands on Soils of Higher Fertility	TDSFEC	Clarence DSF; Hunter-Macleay DSF; Cumberland DSF; Central Gorge DSF
Eucalyptus Tall Grassy Forests or Woodlands of the Eastern Coastal Lowlands on Soils of Higher Fertility	TGFEC	Coastal Valley Grassy Woodlands
Eucalyptus Tall Wet Shrub Forests of the Eastern Coastal Lowlands on Soils of Higher Fertility	TWFEC	North Coast WSF; South Coast WSF; Northern Escarpment WSF; Southern Escarpment WSF; Northern Hinterland WSF; Southern Lowland WSF

Formation Groups in NSWVCA	**Acron.**	**Equivalent Vegetation Classes in Keith (2004)**
Eucalyptus Wet Forests of the Eastern Tablelands	ECT	Northern Tableland WSF; Southern Tableland WSF; Montane WSF
Eucalyptus Woodlands on Rocky Hills of the Inland	EWRHI	Inland Rocky Hill Woodlands
Freshwater Wetlands: Aquatic communities of Coastal Lakes, Lagoons and Rivers	FWACL	Coastal Freshwater Lagoons
Freshwater Wetlands: Coastal Swamp Forests and Shrublands	FWECSF	Coastal Swamp Forests; Coastal Floodplain Wetlands
Freshwater Wetlands: East Coast and Tablelands Sedgeland Swamps	FWSS	Coastal Heath Swamps
Freshwater Wetlands: Inland Aquatic, Swamp and Shrubland Communities	FWI	Inland Floodplain Swamps; Inland Floodplain Shrublands
Freshwater Wetlands: Montane and Alpine Freshwater Lakes	FWMAL	Montane Lakes
Freshwater Wetlands: Montane Bogs and Fens	FWMB	Montane Bogs and Fens
Grasslands of Freshwater Aquatic Habitats of Periodically Flooded Soils	GFAPF	Semi-arid Floodplain Grasslands
Grasslands of Montane Regions often Dominated by *Poa*	GTM	Temperate Montane Grasslands
Grasslands on Coastal Headlands	GLZH	Maritime Grasslands,
Grasslands on Fine Texture Soils on the Inland Slopes and Plains	GFTI	Western Slopes Grasslands; Riverine Plain Grasslands; Semi-arid Floodplain Grasslands
Heaths and Shrublands on Coastal Headlands	HSCH	Coastal Headland Heaths
Heaths and Shrublands on Coastal Sands	HSCS	Wallum Sand Heaths; South Coast Heaths
Heaths on Siliceous Outcrops on the Tablelands and Western Slopes of South-eastern Australia	HSOT	Northern Montane Heaths; Southern Montane Heaths
Heaths on the Triassic Sandstones of Central-eastern New South Wales	HSOI	Sydney Coastal Heaths; Sydney Montane Heaths
Hummock Grasslands and Woodlands of the Inland Plains and Peneplains	HGI	Subtropical Semi-arid Woodlands; Dune Mallee Woodlands; Sand Plain Mulga Shrublands
Mallee Heaths and Shrublands of the East Coast and Tablelands	EMCT	Southern Hinterland DSF; Central Gorge DSF; New England DSF; North Coast DSF; Sydney Coastal DSF; Sydney Hinterland DSF; South East DSF; Sydney Montane DSF
Mallee Woodlands and Shrublands of Inland Sandplains and Sand Dunes	MWSI	Dune Mallee Woodlands; Sandplain Mallee Woodlands
Mallee Woodlands and Shrublands on Stony Ridges of the Inland	MWSR	Inland Rocky Hill Woodlands Slopes and Plains
Rainforest: Cool Temperate	RCT	Cool Temperate Rainforest
Rainforest: Dry	RD	Dry Rainforests
Rainforest: Gallery	RG	Subtropical Rainforest
Rainforest: Littoral	RL	Littoral Rainforest
Rainforest: Oceanic Islands	RO	Oceanic Cloud Forests, Oceanic Rainforests
Rainforest: Semi-Evergreen Vine Forests and Ooline	RSEVT	Western Vine Thickets
Rainforest: Sub-tropical	RST	Subtropical Rainforest
Rainforest: Warm Temperate	RWT	Northern and Southern Warm Temperate Rainforests
Rainforest-derived Genera Woodlands and Shrublands of the Inland Slopes and Plains	RDGI	Gibber Transitional Shrublands; North-west Plain Shrublands; Semi-arid Sand Plain Woodlands
Riparian Forests and Shrublands of the Eastern Coast and Tablelands (non-rainforest)	RIFEC	Eastern Riverine Forests
Saline Wetlands: Coastal Brackish Lakes	SWCBL	Coastal Freshwater Lagoons; Seagrass Meadows
Saline Wetlands: Coastal Salt-marsh	SWSM	Saltmarsh
Saline Wetlands: Mangrove Mudflats	SWM	Mangrove Swamps
Saline Wetlands: Saline and Clay Lakes (Playas) of the Inland	SWISL	Inland Saline Lakes
Saline Wetlands: Seagrass Meadows	SWSG	Seagrass Meadows

names listed in the characteristic fields or elsewhere in the database use the nomenclature of the *Flora of New South Wales* (Harden 1991–1993) and the Botanic Gardens Trust Sydney *Online Flora* http:www.rbgsyd.nsw.gov.au/search_plant_net.

Estimating pre-European and current extent

Pre-European extent and current extent estimates are recorded for each plant community. These assist with determining the loss of extent, threat status and protected area status of each community. The estimates are based on the best available data including pre-European and current extent vegetation maps, modeled vegetation maps, descriptions in the literature and expert advice. An estimate of a pre-European extent can be derived by extrapolating current extent to cleared areas by using abiotic information such as soil, geology or land system maps along with field checking (the term 'pre-European extent' is preferred to using the alternative term 'pre-clearing' because European settlement has impacted in many ways on native vegetation – not just through clearing).

Current extent does not include significantly altered areas where the vegetation is now dominated by exotic species. So, for example, areas of a woodland that have lost their native ground cover and are now dominated (>50% cover) by exotic species, would not be included in estimates of the woodland's current extent. However, the fact that scattered trees persist in landscapes would be noted in the current extent comments field in the database because such trees may be important to elements of biodiversity and for vegetation restoration.

Explanation and qualification fields in the database list the main means used to determine the pre-European, current and protected area extent estimates.

Confidence limits

Accuracy levels are attached to pre-European extent, current extent and extent in protected areas. 10% accuracy implies that a relatively reliable source of information was used to derive an extent figure, while a 50% accuracy level implies the source information was of medium quality. The remaining extent statistic is the percentage of the current extent over the pre-European extent. An accuracy estimate for the remaining extent percentage is calculated as the mid-range of the accuracy levels of the pre-European and current extent figures. This results in a conservative accuracy qualification on remaining extent. Data entries on plant community extent and their accuracy estimates are detailed in the database field descriptions in Appendix A. Improved survey and vegetation mapping would improve the accuracy levels for the extent estimates for most plant communities.

Edaphic and physiographic data

The database contains fields that record substrate mass, lithology, Australian Great Soil Groups (Stace et al. 1968), landforms patterns and landform elements (see Appendix A for details). The classifications used in these fields are based on the Australian Field Soil and Land Survey Handbook (McDonald et al. 1990). This handbook is widely used by Australian vegetation, soil and landform field surveyors. Recording these features for each plant community allows queries to be made in the NSWVCA database about physiographic factors and plant communities. For example, it is possible to list all communities with a certain soil type that occurs in a certain landform pattern etc.

Vegetation condition

The average condition of a plant community can be gleaned by examining various information fields in the classification including the list of threatening processes, the weediness index, the fragmentation category and the recoverability category. Appendix A defines each of these variables.

A recoverability level is selected based on an expert judgment about the average condition of a plant community across its range compared to its estimated composition and structure prior to European settlement (1788). Recoverability ranks from 1 (near pristine) to 6 (destroyed) using the scheme developed by McDonald (1996). In most communities condition varies from place to place due to variations in past land uses. Therefore, this assessment is not meant to apply to individual sites but rather to be an average grading over the distribution of a plant community. Some highly degraded communities may be able to recover condition if certain processes are changed, for example, the recovery of a wetland with the provision of water or the recovery of native grassland after excessive grazing is removed. Other communities may not be able to recover quickly, for example where most topsoil has been lost or where key perennial plant species are slow to regenerate or re-colonize sites.

Assessing the protected area status of plant communities

Defining protected areas in NSW

A protected area is defined by the World Conservation Union (IUCN) as '*an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means*' (IUCN 1994). The definition covers areas where biodiversity conservation is the principal purpose of land management and where there

is long-term security for conservation. The JANIS (1997) criteria for forest protection in Australia provide guidance for interpreting the IUCN (1994) term 'legal and effective means' of protection. The Australian Natural Resource Management Ministerial Council (2004) discusses future directions for the Australian national reserve system and the issue of the security of private property agreements.

IUCN (1994) provides that protected areas can be allocated a management category that is defined by the management emphasis (IUCN 1994). The categories are:

I Strict natural reserve / wilderness area
II National park
III Natural monument
IV Habitat / species management area
V Protected landscape / seascape
IV Managed resource protected area

The management category is independent of any formal reserve classification. For example, while most NSW National Parks are Category II, some reserves match IUCN categories I, III, IV or V. A national list of conservation reserves with their agreed IUCN category is maintained on the Collaborative Australian Protected Area Database (CAPAD) by the Commonwealth Department of Environment and Heritage available through the web site: http://deh.gov.au/parks/nrs/capad/index.html.

There are three main types of protected areas in NSW:

1. Secure public conservation reserves that are dedicated over public land and are managed primarily to protect biodiversity and natural features under plans of management;

2. Secure property agreements over private or public land that are not owned by government conservation agencies but where a long term caveat is tied to the title of the land and the area is being managed primarily to protect biodiversity;

3. Private conservation reserves where areas of land have been purchased by private conservation organisations and are being managed for nature conservation. These have a similar security as the secure property agreements.

1. Public conservation reserves

There is inconsistency between Australian States in the level of protection afforded to different types of 'protected areas'. A national park in one state may allow grazing whereas in another this would not be allowed unless to satisfy an ecological requirement under a management plan. Within NSW, there are different levels of protection afforded to different types of conservation reserves. Nature reserves have the highest level of protection whilst state conservation areas permit a wider range of activities, including mineral exploration.

Public reserves can be large in area with the largest national park in NSW (Kosciuszko National Park) being 690 000 ha. Property agreements are usually small in area and less than 500 ha in size although some recent ones in arid zone regions have been over large former pastoral leases. A summary of the size of the different types of conservation reserves and secure property agreements in NSW, as of December 2005, are presented in Table 9 in Benson et al. (2006).

NSW has strong laws on establishing and managing public conservation reserves. NSW public conservation reserves can only be revoked with the agreement of both Houses of the NSW Parliament. NSW public reserves, with the exception of Historic Sites and Aboriginal Areas, meet the IUCN (1994) definition of a protected area.

In NSW, public conservation reserves include:

- National Parks, Nature Reserves, Karst Conservation Reserves, State Conservation Areas and Regional Parks, reserved under the NSW *National Parks and Wildlife Act 1974* managed by NSW DEC. Historic Sites and Aboriginal Areas are also under the NPW Act but do not meet the IUCN definition of a 'protected area' as they are not established for biodiversity conservation (NSW DEC pers. comm.). However, Historic Sites and Aboriginal Areas are included in analyses of vegetation protection if it is considered that native vegetation in them is being managed for conservation;

- Lands outside the NPWS reserves that are Declared Wilderness under *NSW Wilderness Act 1987*;

- Flora Reserves under the *Forestry Act (1916)* managed by NSW State Forests. Most of these reserves are described in Research Note 47, Forestry Commission of New South Wales (1989a). Some new Flora Reserves have been dedicated since Research Note 47 was published. "Forest Preserves" are not included in this assessment because their tenure is not as secure as "Flora Reserves" under the New South Wales Forestry Act 1916 i.e. they can be easily revoked. Some of the Flora Reserves, documented in Research Note 47 (Forestry Commission of NSW 1989a) located in the NSW coast and tablelands have been recently incorporated into DEC reserves under the NSW National Parks and Wildlife Act (1974). This has mainly occurred through Regional Forest Agreements (RFA) covering the forest regions of eastern NSW. As of 2005, most of the Flora Reserves located in the NSW Western Plains and Western Slopes exist as they did in 1989.

2. Secure property agreements

There are several types of caveats of private property ownership that can be considered as secure property agreements in NSW. These agreements are considered to meet the requirements of protected area category VI in IUCN (1994).

2a. Conservation Agreements (VCAs).

Changes to the *NSW National Parks and Wildlife Act 1974* in 1987 allow the NSW Department of Environment and Conservation (DEC) to enter into conservation agreements (VCAs) with landholders. These are bound to the title of the land in perpetuity. Management plans can be drawn up between DEC and the landholder. VCAs are not as secure as some types of the public conservation reserves because mining can take place under certain circumstances and they can be revoked more easily than public reserves (currently by the Minister).

A spreadsheet has been developed that summarises information about each VCA. This includes the following fields: VCA identification code, area of the VCA, the Bioregion in which the VCA occurs and any information on the vegetation protected in the VCA. Most VCAs are located in the eastern third of NSW with only a few in the Western Plains. In order to maintain the confidentiality of landholders, VCAs are recorded in the NSWVCA database by the NSW DEC administrative code rather than by a property or owner name. Where VCAs cover public land, such as a cemetery, the place name may be recorded.

2b. Conservation Agreement in a Wilderness Area.

A conservation agreement can be entered into over Crown lease or freehold land to protect wilderness values. A plan of management may be prepared. Such agreements are rare in NSW to date.

2c. Property Agreements in perpetuity

The *NSW Native Vegetation Conservation Act 1997* and its replacement the *NSW Native Vegetation Act 2003* provide for a range of management or property agreements to be entered into between landholders and the NSW Government.

The information on these agreements is held in two related systems in the NSW Department of Natural Resources (DNR). One is the database PANet that lists information on vegetation, soils and other factors and the other is a GIS system containing shape files of boundaries of property agreements. These two systems are linked by an administrative code. Only the property agreements (PAs) that are bound to the title of the land in perpetuity and contain native vegetation that is being managed for conservation are recorded as protected areas in the NSWVCA assessment.

In order to distinguish 'secure' agreements from those not deemed to be secure, all of the property agreements in the DNR PANet database were sorted by attribute codes that describe the purpose of each property agreement. Of the 57 DNR Condition of Consent codes, those considered to afford the required protection status were: MNF — areas of existing vegetation being managed without fencing; MEV — same with fencing; MCA — management by sustainable grazing without fencing; and MRZ – management of riparian zones. The codes MNR (improvement of existing native vegetation by fencing, destocking and allowing regrowth) and MRP (improvement of existing native vegetation by fencing, destocking, weed control and/or replanting) are not included unless one of the 46 separate 'purpose codes' designates it as native vegetation to be retained. As with conservation agreements under the *NSW National Parks and Wildlife Act 1974*, property agreements in the NSWVCA database are labelled by the DNR administrative code rather than by a property or owner name. Where property agreements cover public land the place name may be recorded in addition to the administrative code.

2d. Property Agreements under the NSW Nature Conservation Trust 2001

Areas of vegetation protected under long term, secure property agreements entered into under the *NSW Nature Conservation Trust Act 2001* may also be listed in the secure property agreements field in the NSWVCA database.

3. Private conservation reserves

There are a number of private organisations in Australia including The Australian Bush Heritage Fund (ABH) and the Australian Wildlife Conservancy that purchase land and manage it for nature conservation. As at 2005 the ABH Fund owned three properties in NSW. Areas of plant communities in these private reserves are registered in the NSWVCA database as a type of secure property agreement.

Areas not qualifying as 'protected areas'

Protection to native vegetation is afforded through conditions imposed on leases under the *NSW Western Lands Act* (covering Western Lands Leases in the NSW Western Division) and on other leasehold land in the Central and Eastern Divisions of NSW. A number of Western Lands Lease lessees in the southern mallee region of NSW (Murray-Darling Depression Bioregion) have de-stocked and fenced off areas of vegetation in exchange for clearing other parts of their leases. These areas are not included as protected areas in the NSWVCA because the lease conditions are not secure. They can be altered relatively easily.

Similarly, Reserves for Flora and Fauna under the *NSW Crown Land Act 1989* are deemed not to be secure enough to warrant listing as a protected area because such reserves are not protected by Parliament. Local Government reserves also play a role in protecting vegetation but these reserves do not meet the protected area security requirements unless they are also protected under a long term property agreement.

Short term property agreements under the *Native Vegetation Conservation Act 1997* and *Native Vegetation Act 2003* also do not qualify as protected areas even though they may achieve some positive conservation outcomes. It is possible

that changes in land ownership or land use could negate any gains in conservation after the short term agreement lapses.

Estimating the extent of plant communities in protected areas

To keep track of information on vegetation in the protected areas in NSW, digital and manual filing systems have been developed that collate information on each protected area including: published, unpublished papers and reports on vegetation, plant species lists, vegetation maps in both GIS and hard copy formats, statistics on the extent of different plant communities or vegetation map units and other relevant information. Notes in the 'Explanation of protected areas' field in the database explain the sources behind the estimates recorded for each protected area for each plant community. References are listed in the Reference field at the end of each database record. When more than one vegetation map or description covers a protected area the one deemed most accurate is adopted. In the absence of information on vegetation in protected areas, estimates are derived from expert advice and field checking.

The size of protected areas is mostly based on GIS shape files rather than field calculations because GIS files facilitate comparison of the protected area boundaries with other types of digitised maps, including vegetation maps. In flat terrain such as the NSW Western Plains there is little difference between GIS and field surveyed areas but discrepancies increase with hillier terrain.

Each protected area plant community extent estimate is qualified by an accuracy code, applied using best judgement. The code 'M' (measured) implies the figure is accurate to within 10%. This is applied when very reliable data exists such as a fine scale vegetation map or detailed estimates from ground checking. The codes E1, E2, E3 and E4 offer a range of less precise estimates of accuracy. These are defined in Appendix A and can be viewed in the database on-screen in the main data entry form through the 'Accuracy' field key.

The steps in calculating the extent of plant communities in protected areas are:

1. Obtain the GIS shape files for the boundaries of all protected areas. For the public reserves managed by NSW Department of Environment and Conservation (DEC), such as national parks and nature reserves, regular updates of shape files are forwarded to the Botanic Gardens Trust by the Parks and Wildlife Division of DEC. Shape files of the NSW Flora Reserve boundaries are obtained from NSW State Forests. Shape files of the boundaries of NPW Conservation Agreements are obtained from DEC. Shape files of the boundaries and database records for all property agreements entered into under the *Native Vegetation Conservation Act 1997* and the *Native Vegetation Act 2003* are obtained from the NSW Department of Natural Resources (DNR);

2. Obtain available and relevant digitised vegetation maps that cover protected areas and interrogate them using the GIS software Arcview (ESRI Inc. 1992–2002). This delivers statistics on the extent of vegetation map units in each protected area. In the absence of digitised vegetation maps, areas of vegetation units in non-digitised vegetation maps are manually calculated for protected areas. Where no mapping exists for a protected area, other sources of information on the vegetation are collated and interpreted. These include published and unpublished descriptions of vegetation, NSW Public Service file notes, expert advice and field checking. Descriptive information from the DNR database PANet for property agreements or DEC files for VCAs are also consulted;

3. Reconcile the NSWVCA plant community classification against the vegetation map units or descriptions available for each protected area. This involves comparing the plant species lists and general descriptions of vegetation map units or floristic communities;

4. Field-check protected areas to check the plant communities in them and the extent of each community;

5. Enter an extent figure in the relevant plant community record(s) in the 'Conservation reserves' and/or 'Secure PAs' fields of the NSWVCA database. Note: the summed extents of plant communities in a protected area may not match the size of that protected area if there is cleared land or if there have been recent boundary changes;

6. Apply an accuracy qualification to this extent data based on the quality of the data used;

7. Note the data source for the estimate in the 'Explanation of protected area' field in the NSWVCA the database.

The NSWVCA database provides for the reporting of a list of plant communities in any NSW protected area through selecting a protected area in either the 'Reserves' or 'Secure PA' report options in the opening menu of the database.

Assigning protected area status

The database registers the number of representations in reserves and secure property agreements and sums the two. It also automatically sums all areas recorded in the reserves and secure PAs fields and sums these to yield a 'total area protected' statistic with an accuracy qualification applied to it. This statistic underpins the assessment of each plant community's protected area status.

Each plant community is assigned one of 15 protected area codes, see below. These codes are based on the percentage of each plant community's pre-European extent in protected areas. This mirrors the methods used for assessing the protected area status of Australia's forests in JANIS (1997). The threshold of the percentage of a community in protected areas alters with the estimated pre-European extent of that community. JANIS (1997) recommended that adequate

representation of 'common in 1750' communities should be 15% of their pre-European extent in protected areas. Higher thresholds are applied to communities that are assessed to have been 'restricted' or 'rare' prior to European settlement. Similar pre-European extent rarity levels are applied to Queensland ecosystems in Sattler & Williams (1999). In the NSWVCA they are labelled: 'common in 1750' i.e. > 10 000 ha, 'restricted in 1750' 1000–10 000 ha or 'rare in 1750' <1000 ha.

The 15 protected area code options grouped within these categories are:

1. 'Common' communities (pre-European extent >10 000 ha in 1750): 1a = >25%, 2a = 15–25%, 3a = 5–15%, 4a = 1–5%, 5a = <1% in protected areas.

2. 'Restricted' communities (pre-European extent 1000–10 000 ha in 1750): 1b = >50%, 2b = 30–50%, 3b = 15–30%, 4b = 5–15%, 5b = <5% in protected areas.

3. 'Rare' communities (pre-European extent <1000 ha in 1750): 1c = >75%, 2c = 50–75%, 3c = 30–50%, 4c = 15–30%, 5c <15% in protected areas.

Communities with protected area codes 1a, 1b, and 1c could be considered to be exceptionally well represented in protected areas. Alternatively, communities with codes 5a, 5b and 5c could be considered to be very poorly represented in protected areas.

The protected area codes are only a guide in assessing the protected area status of each plant community. They should not be used to negate arguments to protect particular sites of well protected communities that are in good condition or are important for other reasons. For many plant communities in the NSW Central Division (including the NSW wheatbelt) where most of the vegetation has been cleared, it will be very difficult to attain a target of sampling 15% of pre-European extent in protected areas. In contrast, many of the plant communities that occur on the rugged and mainly naturally vegetated NSW eastern escarpment already have greater than 15% of their pre-European extent in protected areas.

Assessing the threat status of plant communities

Over the last few decades there have been a number of attempts to classify and assess the conservation status of plant communities in Australia. The first major work was Specht et al. (1974). This used an expert committee approach to subjectively classify the vegetation of Australia and Papua New Guinea using both floristic and structural features. It also assessed the reservation status, at that time, of the listed communities.

Threat categories and threat criteria have been developed for assessing the NSW plant communities. Appendix B describes the threat categories 'critically endangered' (CE), 'endangered' (E), 'vulnerable' (V), 'near threatened' (NT) and 'least concern' (LC). These categories mirror those used for classifying the threat status of species (IUCN 2001). Appendix B also describes six criteria used to allocate each plant community into one of the threat categories. These criteria are based on a number of sources including the guidelines for nominating ecological communities under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*. However, unlike previous definitions, the threat categories and criteria described here extend beyond the three threat categories (CE, E, V) to also ascribe definitions for the categories 'near threatened' and 'least concern'.

A summary of the six criteria detailed in Appendix B are:

1. Remaining extent thresholds (with the qualification that there is a continuing decline in extent for CE, E and V threat categories) of CE = <10%, E = 10–30%, V = 31–50%, NT = 51–70% and LC = >70% remaining extent;

2. Loss of area of occupancy combined with the rate of decline of the community;

3. Degree of loss of key species that play a major ecological role in a community;

4. The degree of loss of integrity of a community including loss of species, physical degradation and other factors leading to differing prospects for regeneration or recovery;

5. Rate of continued loss of integrity over time;

6. Quantitative analysis on the probability of destruction or severe degradation (rarely available for plant communities).

Threat criterion 1 categorises the threat status of a plant community based on its estimated (or measured) current extent compared to an estimate of its pre-European extent. The concept of pre-European extent can be adopted in Australia due to an assumed, accelerated degradation of the Australian natural environment since the colonization by Europeans in 1788.

The remaining extent thresholds used in criterion 1 are based on thresholds in habitat fragmentation where there is an apparent accelerated loss of species (Andren 1994, Fahrig 1997, With 1997). For example, once a plant community is highly fragmented and less than 30% remains, there is a likelihood of accelerated loss of species, particularly of mammals (Andren 1994). Accelerated break-up of habitat connection leads to increased barriers to dispersal for many species. Over time, this leads to local, regional and sometimes total extinctions of species. Even bird species, many of which disperse relatively easily, are affected. Empirical evidence on the decline in bird populations on the extensively cleared, northern plains of Victoria, Australia (Bennett & Lord 1997) shows that declines accelerate after the point of 80% loss of habitat is reached. For these reasons, when communities are cleared or severely degraded by more than 70%, and there is continued degradation of what remains, it is suggested that

such communities should be recorded as 'endangered'. When there is less than 10% of a community remaining and there is continuing decline through various threatening processes, it is recorded as 'critically endangered'.

Any of the six threat criteria can be used to allocate a threat category. If the application of different threat criteria delivers options for threat categories, the most threatened category is selected. In some instances, a community could be categorized as 'endangered' or 'vulnerable', even if greater than 50% of its pre-European extent remains. This could happen in cases where the main threats are from threatening processes other than loss of extent. For example, a plant community may be judged to be 'vulnerable' because it is in very poor condition under criterion 4 of the threat criteria due to threatening processes such as lack of regeneration of key species, significant weed invasion or detrimental changes in hydrology.

Threat status may or may not correlate with protected area status. It is conceivable, for example, that a plant community that is totally protected in a national park or other protected area could be 'endangered' if it was threatened by climate change, a pathogen or concentrated human visitation. Consider the threats of climate change on well-reserved alpine communities or root pathogens on well-reserved heaths and forests. Some well-reserved plant communities in the arid and semi-arid areas of NSW remain under threat due to grazing by goats or rabbits (Benson et al. 2006, this volume).

Expert judgment is required when using the threat criteria. The NSWVCA database allows comments to be made in the fields 'Threatening processes' and 'Planning and management' to provide more detail about the threats to each community.

The database contains fields that record the main threatening processes for each listed community (described in Appendix A). The 'Threatening processes' field allows for a description of the main threats to a plant community. The 'Threatening process lookup' field contains a table of 33 threatening processes (eg clearing, salinity, sheet soil erosion, exotic weed invasion etc) from which multiple entries can be recorded. Additionally, the database contains fields in which it is possible to record information on the variation and natural disturbance and fire regimes for each plant community. Key references can be cited in these fields.

The combined threat/protected area code is one of the last fields in the NSWVCA database. It summarises the overall status of a plant community.

Developing a bio-information system: the NSWVCA database

Because many combinations of data on ecological communities are often sought to answer particular ecological or land use questions, the NSWVCA has been produced in a database format. The full version of the database provides access to the query mode at its 'backend'. This allows a wide range of queries to be made using combinations of the fields. To satisfy common queries for listing plant communities in geographical areas such as CMAs or bioregions and under broad vegetation groupings, 39 reports have been developed in MS Access and MS Word formats. These are accessed through the Administration Menu of the database. These report options, are available in the 2006 published version of the database, are described in Appendix A.

The database contains 90 fields of information (Table 5). Data entry for some of these fields relies on selection of options in lookup tables. Other text-based, descriptive fields require manual data entry. There are 47 Tables (Table 6) in the database ranging from a list of all NSW plant species names to a list of all conservation reserves. Some of the fields provide for comparisons with other NSW, interstate or national vegetation classifications. However, most fields deal with aspects of the plant community itself including listing characteristic species, weed species, threatened species, regional distribution, soils, substrate, landforms, threatening processes, threat code and criteria, protected area occurrences, protected area code and photographs and captions. Regional distribution includes recording occurrence in climate zones, CMA area, bioregion, sub-region of bioregions, botanical divisions and local government areas. Options in the reports menu allow the selection of plant communities for a number of types of regions including bioregions and CMAs. Similarly, plant communities can be listed for public reserves and secure property agreement areas and this serves as an audit of the types of vegetation in the NSW protected area system. Considerable effort has gone into programming the database so it can perform actions such as summing areas in protected areas and producing reports.

A read-only version of the database that contains the classification of the vegetation of the NSW Western Plains is on the CD in the back pocket of the journal. This allows viewing of the plant community data and generation of reports from the Reports menu but it prevents access to the backend of the database where the tables and data are held. The concern is to prevent users of the database from changing the data without central coordination or agreement. A drawback is that the read only version does not allow the user to access the query mode and carry out a range of possible queries. Full versions of the database will be made available under a license agreement and at a fee by the Botanic Gardens Trust, Sydney.

Appendix A describes the database in detail covering its software requirements, current software limitations, database reports and the 90 information fields. Appendix A should be consulted by those wishing to use the database. It can be accessed in digital form by selecting the 'Database Descriptions' key located at the top of the data entry screen in the database.

Discussion

The NSWVCA could serve as an information source for NSW plant communities. It links a plant community classification to threatening processes, threatened species, landscape features, broader vegetation and abiotic classifications and the NSW protected area system. Such integration of different data is a prerequisite to applying an ecosystems approach (Shepherd 2004) in landscape management.

The 'plasticity' of the 'community concept' renders any species-based ecological community classification less than perfect. It would be difficult to develop a vegetation classification that caters for species variation through space and time including accounting for successional stages. Although the NSWVCA collates research and expert knowledge into a single classification, it is likely that some vegetation types will not be recorded because of data gaps in botanical sampling and vegetation mapping.

The adjoining States of Queensland and Victoria have developed different ecological classifications. Queensland has produced vegetation-based regional ecosystems (Sattler & Williams 1999, Wilson et al 2002 and Queensland Herbarium 2003). These ecosystems are associated with particular combinations of substrate, soils and landforms and each one is generally confined to one national IBRA Bioregion. The Queensland regional ecosystem database is far more limited in its data compared to the NSWVCA but has the benefit of being supported by a more consistent vegetation mapping base.

Victoria has developed a list of ecological vegetation classes (EVCs) based on major vegetation structure, combinations of plant communities and similar soil and climatic types (DNR 2001). The Victorian EVCs are text-based descriptions making it difficult to conduct queries.

Both of the last mentioned approaches were rejected for use in NSW. The Queensland ecosystem (Sattler & Williams 1999) tends to duplicate listings of virtually the same vegetation community because it adheres to bioregional boundaries as a high level determinant in the classification. Many of the Victorian EVCs are poorly defined and contain many plant species compositions (Burgman et al. 1996). Ecosystem processes appear to take precedence over biotic variation

Table 5. List of fields in the NSW Vegetation Classification and Assessment database.
Notes: All fields are reported in the full query reports in the database. Fields marked with an * are reported in the 'short' reports in the database.

1. Vegetation community ID No.*
2. Common Name*
3. Scientific Name*
4. Original data entry
5. Date of entry
6. Last modified by
7. Last modified date
8. Formation Group
9. State Vegetation Map (Keith 2004)
10. State landscapes (Mitchell 2002)
11. NVIS major sub-groups
12. Forest type (RN 17)
13. Characteristic trees*
14. Characteristic shrubs, vines epiphytes*
15. Characteristic groundcover*
16. Characteristic weed species
17. Weediness
18. Threatened plants
19. Threatened fauna
20. Mean native species richness
21. Characteristic species qualifiers
22. Authority(s):
23. Authority qualifiers
24. Reference list*
25. Interstate equivalents
26. Classification confidence level
27. Level of classification
28. Rainforest structure
29. Structure*
30. Height class
31. Vegetation description*
32. Mapped or modeled
33. Mapping information
34. Adequacy of plot sampling
35. Climatic Zone
36. IBRA Bioregion*
37. IBRA sub-region
38. Botanical Division
39. Local Government Area (LGA)
40. Catchment Management Authority areas (CMAs)*
41. Murray-Darling Basin
42. Substrate mass
43. Lithology
44. Great Soil Group
45. Soil texture
46. Landform pattern
47. Landform elements
48. Land use
49. Impacts of European settlement
50. Pre-European extent (ha)*
51. Pre-European accuracy*
52. Pre-European qualifiers
53. Pre-European comments
54. Current extent (ha)*
55. Current extent accuracy*
56. Current extent qualifiers
57. Current extent comments
58. Percent remaining*
59. Percent remaining accuracy*
60. Degree of fragmentation
61. Recoverability
62. Threatening processes
63. Threatening processes lookup
64. Variation and natural disturbance
65. Adjoining communities
66. Fire regime
67. Conservation reserves (ha)*
68. Total area in reserves (ha)*
69. No. of reps. in reserves
70. Explanation of protected areas
71. Secure property agreements (ha)*
73. Number of reps in secure property agreements
74. Total area protected (ha)*
75. Total area protected accuracy (%)*
76. Protected pre-European extent (%)
77. Protected current extent (%)
78. Total reps in protected areas
79. Protected area code
80. Key sites for protection
81. Threat category*
82. Threat criteria*
83. Threat/protected area code*
84. Planning controls
85. Planning and management
86. Listed under legislation
87. Recovery plan
88. Recovery plan status
89. Photograph fields (1*, 2, 3)
90. References

such as floristic assemblages. This can lead to a confused landscape classification where quite different species assemblages are lumped into the same ecological unit.

In contrast to the classifications in Queensland and Victoria, the NSWVCA concentrates on listing plant communities based on differences in floristic assemblages, generally within one or two structural (canopy cover, height of tallest stratum) classes. Many of the plant communities classified in the NSWVCA occur in more than one Bioregion because their required physical environments extend across bioregional boundaries. Where data is lacking to differentiate occurrences of ubiquitous species-dominated vegetation, such as the inland River Red Gum (*Eucalyptus camaldulensis*) or Poplar Box (*Eucalyptus populnea* subsp. *bimbil*) woodlands, bioregional boundaries may be used as a basis for a classification.

Since vegetation classifications are often used as surrogates for biodiversity and for reserve selection or setting priorities for private land conservation actions, the coarseness of classification is important (Pressey & Bedward 1991, Pressey & Logan 1994). Too coarsely or too finely divided classifications may be poor surrogates for biodiversity, but the scientific literature on this is limited. Analyses of fauna site data with forest ecosystems classified through vegetation mapping in the north east NSW forests (NSW NPWS 1999) indicates that the level of surrogacy of fauna to vegetation type varies with groups of fauna. Rarely do vegetation classifications produce units with similar levels of similarity and this may confound surrogacy assessments (S. Ferrier pers comm.).

Most of the classified plant communities in the NSWVCA are suitable for property planning, regional priority setting and national reporting because it is pitched at reasonably fine scales of classification that if mapped would mostly be discernable at 1:100 000 in the NSW Western Plains, 1:50 000 in the western slopes and tablelands and 1:25 000 in the NSW Coast. Also, floristically distinct, small patch-sized types of vegetation that may contain features important for protection, are often not depicted on vegetation maps but can be described in the NSWVCA. This flexibility is required in natural resource planning and site assessment.

The 1:1.5 million scale map and descriptions of 99 vegetation classes in the book on NSW vegetation by Keith (2004), while highly educational, is less directly relevant to regional or local planning.

Caution is required in applying uniform management practices for any one plant community. For example, prescription for appropriate fire regimes may vary depending on factors such as previous fire history at a site or the presence of certain fire-sensitive species (Morrison & Renwick 2000).

Table 6. List of tables in alphabetical order in the NSWVCA database.

Notes: Single or multiple entry selections are made from drop down lists of these tables in the Main Details data entry form of the database. The tables cannot be viewed or altered in a 'read-only' version of the database. Some tables, such as Reserves (conservation reserves) and Species (current names of NSW plant species), require frequent revision by the administrator of the database.

Accuracy codes for extent estimates	IBRA sub-region	Rare community protected area thresholds 1c-5c
Adequacy of plot data	Impacts of European settlement	Rare community adequacy of sampling across range.
Botanical Divisions of NSW	Landform elements (McDonald et al. 1990)	Recoverability
Climate zone	Landform patterns (McDonald et al. 1990)	References
Catchment Management Authority	Landscapes (McDonald et al. 1990)	Reserves
Common community protected area thresholds 1a-5a	Land uses	Restricted community protected area thresholds 1b-5b
Common community adequacy of sampling across range	Level of classification	Restricted community adequacy of sampling across range
Confidence level of classification	Local Government Areas	Soil texture (McDonald et al. 1990)
Current extent lookup qualifiers	Listed as threatened under legislation	Species (NSW plant species names)
Degree of fragmentation	Lithology	State Map Classes (Keith 2004)
Forest Types (Research Note 17)	Main (this contains all data)	Substrate mass (McDonald et al. 1990)
Forest type qual (part of equal to)	NVIS major sub-groups	Threat category (CE, E, V, NT, LC)
Formation Group	Remaining percent accuracy	Threat criteria (1-6)
Great Soil Group	Pre-European qualifications	Weediness
Height Class (from Walker & Hopkins 1990)	Proportion mapped or modelled	
IBRA Bioregion	Protected in PA/VCA – list of all secure property agreements	

Particular locations of a plant community may contain populations of threatened species of flora or fauna and these may require different management practices to maintain their populations.

Future improvements to the NSWVCA

With feedback on the NSWVCA, changes to the database and the information on plant communities will occur. Some of the existing fields may be deleted and new ones added. New reports may be developed to cater for frequent inquiries. The lists of threatened plant and fauna species in the database will require refinement. Information in fields such as threatening processes, fire regimes and planning and management will improve as more research is done. Also, since part of the maintenance of the database requires updating species names in the database records to match currently accepted names, it would be logical for the Species Table in the database to be linked to the Botanic Gardens Trust's Master Name Index in order to maintain an up to date list of plant species names.

If technically feasible, it would be useful to place the NSWVCA database on the internet and link it to GIS vegetation maps to show a map of a plant community. This would be relevant where there was a correlation between a listed community and a vegetation map unit. However, it would also be relevant if a community was part of a broader map unit. A central internet repository of vegetation maps in NSW has commenced at the NSW natural resources atlas web site www.nratlas.nsw.gov.au/wmc. It would be beneficial if the map units depicted on this web site could be cross-referenced with the plant community ID numbers in the NSWVCA.

Presently, the soil classification recorded in the database is that of the Australian Great Soils Group (Stace et al. 1968). This could be replaced or complemented by correlations with the most recent classification of Australian soils by Isbell (2002).

The NSWVCA database could be transferred to software that overcomes present limitations documented in Appendix A, particularly in respect of incorporating images in reports. Preferably, it would be advantageous to hold an up to date version of the database, the database description document (Appendix A) and some useful database reports on the Botanic Gardens Trust Sydney and/or NSW DEC websites. This would allow users to query the database over the internet as if they had the full version on their personal computer thus negating the need to distribute updated versions.

A key to the Formation Groups and to the plant communities would be worthwhile. Such a key would primarily use characteristic species, vegetation structure, adaphic factors (soils, landscape type etc) and geographic distribution.

A major challenge is to link the results of expert assessments such as the NSWVCA to computer models used in landscape planning. This could be done by listing the plant communities and their protected area and threat status for particular geographical areas where they are recorded, such as CMAs, bioregions or local government areas. A plant community's presence could be predicted by using edaphic or landscape features.

Maintenance of the data and the NSWVCA database

Information systems require maintenance. It is proposed that the following steps should be taken to enhance and maintain the NSWVCA database.

1. Proposed changes to any part of any plant community record in the database should be documented on the feedback proforma in Appendix C and sent by mail to the BGT or emailed to nswvca@rbgsyd.nsw.gov.au. A digital version of this proforma is linked to the database via the 'Feedback' field key.

2. An independent Vegetation Classification and Assessment Scientific Committee (VSC) could be established to vet suggested major changes. It would review proposed major changes to the classification or assessment such as splitting, amalgamating, adding or deleting a community or changing a threat category. It should consult with experts as part of the review process. On-going minor alterations to records and updating tables such as species names, reserves and the various regions can be done by the database administrator.

3. All changes to the database should be made at a central location by a NSWVCA database administrator to ensure that a single, ratified version of the database exists at any one time.

4. Maintenance of software and hardware technical aspects of the NSWVCA database should become a core duty of the NSW Department of Environment and Conservation Information Technology Section. Such maintenance will include maintaining the internet site, hardware, software, programming and transferring the database to other software if required.

Contents of the accompanying CD

The CD is located in the back pocket of this journal and includes:

1. Read Me CD Contents note: Describes the files in the three folders on the CD and how to install the database from the CD onto a computer;

2. Folder 1: Contains a read only version of the MS Access NSWVCA database containing the 213 plant communities of the Western Plains (future editions will include plant communities of the western slopes, tablelands and coast). The read only version of the database allows access to the data entry form, to the database reports and to the search mode but it prevents access to the query mode and to the data tables at the backend of the database;

3. Folder 2. Contains a PDF version of this paper;

4. Folder 3. Contains a PDF file of NSWVCA Part 1 – the NSW Western Plains paper (Benson et al. 2006), NSW Western PLainsAll Records Full Report (90 fields), All Records Full Report of the Western Plains communities split into the 19 Formation Groups. Full Report and Short Report for the Lower Murray/Darling and Western CMAs, Short Report (28 fields) of the plant communities classified for the NSW Western Plains, a spreadsheet of the NSW Western Plains bibliography, a spreadsheet list of the NSW Western Plains plant communities with their threat and protected area codes — allowing them to be sorted by threat or protected area status.

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References

Anderson, M., P. Bourgeron, M. T. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K. Goodin, D. H. Grossman, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, L. Sneddon & Weakley, A.S. (1998) International classification of ecological communities: terrestrial vegetation of the United States. Volume II. The National Vegetation Classification System: list of types (The Nature Conservancy: Arlington, Virginia, USA).

Anderson, R.H. (1961) Introduction. Flora series Nos. 1–18: 1–16. *Contributions from the New South Wales National Herbarium* (Royal Botanic Gardens: Sydney).

Andren, H. (1994) Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat. *Oikos* 71: 355–366.

ANZLIG (1990) Australia: Natural vegetation. *Atlas of Australian resources*. Volume 6 Vegetation (ANZLIG: Canberra)

Austin, M.P. (1991) Vegetation theory in relation to cost-effective surveys. Pp 17–28 in Margules, C.R. & Austin, M.P. (Eds.) *Nature conservation: cost effective biological surveys and data analysis* (CSIRO: Australia).

Austin, M.P. & Smith, T.M. (1989) A new model for the continuum concept. *Vegetatio* 83: 35–47.

Banner, A., Meidinger, D.V., Lea, E.C., Maxwell, R.E. & Von Sacken, B.C. (1996) Ecosystem mapping methods for British Columbia. *Environmental Monitoring and Assessment* 39: 97–117.

Beadle, N.C.W. (1945) *Vegetation map of western New South Wales* (NSW Government Printer).

Beadle, N.C.W. (1948) The vegetation and pastures of western New South Wales, with special reference to soil erosion (Department of Conservation of NSW: Sydney).

Beadle, N.C.W. (1981) *The vegetation of Australia* (Cambridge University Press: Cambridge England).

Beadle, N.C.W. & Costin, A.B. (1952) Ecological classification and nomenclature. *Proceedings of the Linnean Society of New South Wales* 67: 61–82.

Beard, J.S. & Webb, M.J. (1974) The vegetation survey of Western Australia: its aims, objects and methods. Part 1 of exploratory notes to Sheet 2, Great Sandy Desert, *Vegetation survey of Western Australia* (University of Western Australia: Nedlands).

Bedward, M., Keith, D.A. & Pressey, R.L. (1992) Homogeneity analysis: assessing the utility of classifications and maps of natural resources. *Australian Journal of Ecology* 17: 133–139.

Bennett, A.F., & Lord, L.A. (1997) Land use, habitat change and the conservation of birds in fragmented rural environments: a landscape perspective from the Northern Plains, Victoria, Australia. *Pacific Conservation Biology* 3: 244–261.

Benson, D.H. (1992) The natural vegetation of the Penrith 1:100 000 map sheet. *Cunninghamia* 2(4): 541–596.

Benson, J.S. (1989) Establishing priorities for the conservation of rare or threatened plants and plant associations in New South Wales. Pp 17–82 in Hicks, M. & Eiser, P. (eds.) *The conservation of threatened species and their habitats* (IUCN: Canberra).

Benson, J.S. (1995) Sampling, strategies and costs of regional vegetation mapping. *The Globe*, Journal of the Australia Map Circle 43:18–28.

Benson, J.S. (1999) *Setting the scene: the native vegetation of New South Wales*. Background Paper No. 1 (Native Vegetation Advisory Council: Sydney).

Benson, J.S. (1999–2004) Unpublished field note books recording species at various locations in western NSW. Copy held in BGT Library (Royal Botanic Gardens and Domain Trust: Sydney)

Benson, J.S. & Ashby, E.M. (2000) The natural vegetation of the Guyra 1:100000 map sheet New England Bioregion, New South Wales. *Cunninghamia* 6(3): 747–872.

Benson, J.S., Allen, C., Togher, C. & Lemmon, J. (2006) New South Wales Vegetation Classification and Assessment: Part 1 Plant communities of the NSW Western Plains. *Cunninghamia* 9(3): 383–450.

Biddiscombe, E. F. (1963). A vegetation survey in the Macquarie Region, New South Wales. *Division of Plant Industry Technical Paper No 18*. (CSIRO: Australia).

Bolton, M.P. (ed.) (1991) Vegetation: from mapping to decision support (ERIN Commonwealth of Australia: Canberra).

Braun-Blanquet, J. (1932) (Translated, revised and edited by Fuller, G.D. & Conrad, H.S. in 1983) *Plant sociology: the study of plant communities* (Koeltz Scientific Books: Germany).

Bridgewater, P.B. (1981) Potential application of the Zurich-Montpellier system of vegetation description and classification in Australia. In Gillison, A.N. & Anderson, D.J. (Eds.) *Vegetation classification in Australia* (CSIRO: Australia).

Burgman, M., Benson, J., Kinnear, S., Kirkpatrick, J. and Parsons, R. (1996) Report on Victorian Ecological Vegetation Classes use in East Gippsland Regional Forests Agreement Report. Unpublished Report (Victorian Department of Natural Resources: Melbourne).

Carnahan, J.A. (1976) Natural vegetation. Map with accompanying booklet commentary. *Atlas of Australian resources*. Second series (Australian Government Printer: Canberra)

Cannon, G., Cannon, M., Harding, W., McCosker, R., Spunner, B., Steenbeeke, G. & Watson G. (2002) Native vegetation map 6 report No 3: Bellata, Gravesend, Horton and Boggari 1:100 000 map sheets. (NSW Department of Infrastructure, Planning and Natural Resources).

Clements, F.E. (1928) *Plant succession and indicators* (Wilson: New York).

Costin, A.B. (1954) *A study of the ecosystems of the Monaro Region of New South Wales with special reference to soil erosion* (NSW Government Printer: Sydney).

Costin, A., Gray, M., Totterdell, C.J. & Wimbush, D.J. (1979) *Kosciusko alpine flora* (CSIRO/Collins: Australia).

Dangerfield, J.M., Pik, A.J., Britten, D., Holmes, A., Michael, G., Oliver, I., Briscoe, D. & Beattie, A.J. (2003) Patterns of invertebrate biodiversity cross a natural edge. *Austral Ecology* 28: 227–236.

Dansereau, P. (1951) Description and recording of vegetation upon a structural basis. *Ecology* 32: 172–229.

Davies, R.J.P. (1982) The conservation of major plant associations in South Australia (Conservation Council of South Australia Incorporated: Adelaide).

Environmental Systems Research Institute, Inc. (ESRI) (1992–2002) ArcView GIS Version 3.3 (HCL Technologies Ltd).

Executive Steering Committee for Australian Vegetation Information (ESCAVI) (2003). *Australian Vegetation Attribute Manual: National Vegetation Information System, Version 6.0* (Department of the Environment and Heritage, Canberra, URL: http://www.deh.gov.au/erin/nvis/avam/
index.html).

Fahrig, L. (1997) Relative effects of habitat loss and fragmentation on population extinction. *Journal of Wildlife Management* 61(3): 606–610.

Faith, D.P. (1991) Effective pattern analysis methods for nature conservation. Pp. 47–53 in Margules, C.R. & Austin, M.P. (eds.) *Nature conservation: cost effective biological surveys and data analyses* (CSIRO: Melbourne).

Floyd, A.G. (1990) *Australian Rainforests in New South Wales* Volumes I and II (Surrey Beattie & Sons Ltd: Sydney)

Foulkes, J.N. & Gillen, J.S. (Eds.)(2000) A biological survey of the Murray mallee, South Australia (Biological Survey and Research, Department for Environment and Heritage, Department for Transport, Urban Planning and the Arts: Adelaide).

Forestry Commission of New South Wales (1989) Forest types in New South Wales. Research Note 17 (Forestry Commission of New South Wales: Pennant Hills).

Forestry Commission of New South Wales (1989a) Forest preservation in State Forests of New South Wales. Research Note 47 (Forestry Commission of New South Wales: Pennant Hills).

Forward, L.R. & Robinson, A.C. (eds.) (1996) A biological survey of the South Olary Plains South Australia (Department of Environment and Natural Resources: South Australia).

Fox, M.D. (1991) The natural vegetation of the Ana Branch – Mildura 1:250 000 map sheet (New South Wales). *Cunninghamia* 2(3): 443–493.

Gellie, N.J.H. (2005) Native vegetation of the Southern Forests: South-east Highlands, Australian Alps, South-west slopes and SE Corner bioregions. *Cunninghamia* 9(2): 219–253.

Gleason, H.A. (1926) The individualistic concept of the plant association. *Bull. Torrey Botanical Club* 53: 1–20.

Goodall, D.W. (1953) Objective classification of vegetation II. Fidelity and indicator value. *Australian J. Botany* 1: 434–456.

Goodall, D.W. (1980) Numerical classification. Pp 249–286 in Whittaker, R.H. *Classification of Plant Communities* Second Edition (W. Junk, the Hague: Netherlands).

Gradmann, R. (1909) Uber Begriffsbidilbung in der Lehre von den Pflanzenformationen. *Englers Bot. Jb., Beibl.* 99: 91–103.

Griffith, S.J., Bale, C., Adam, P. & Wilson, R. (2003) Wallum and related vegetation on the NSW North Coast: description and phytosociological analysis. *Cunninghamia* 8(2): 202–252.

Grossman, D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, & Sneddon, L. (1998) International classification of ecological communities: terrestrial vegetation of the United States. Volume I. The National Vegetation Classification System: development, status, and applications (The Nature Conservancy: Arlington, Virginia, USA).

Groves, R.H. (Ed.) (1994) *Australian vegetation* Second Edition (Cambridge University Press: Cambridge).

Hager, T. & Benson, J.S. (1994) Assessment of the conservation status of forest plant communities in north eastern NSW. Report to the Australian Heritage Commission (NSW National Parks and Wildlife Service: Hurstville).

Harden, G. (1990–1993) (ed.) *Flora of New South Wales* Volumes 1–4 (New South Wales University Press: Sydney).

Hayden, J.E. (1971) The natural plant communities of New South Wales. MSc Thesis (Australian National University: Canberra).

Hill, M.O. (1979) *TWINSPAN – a Fortran program for arranging multivariant data in a two-way table by classification of individuals and attributes* (Cornell University: Ithaca).

Horner, G., McNellie, M., Nott, T.A., Vanzella, B., Schliebs, M., Kordas, G.S., Turner, B. & Hudspith, T.J. (2002) Native vegetation map report series: No. 2 Dry Lake, Oxley, Hay, One Tree, Moggumbill & Gunbar 1:100 000 map sheets. (NSW Department of Infrastructure Planning and Natural Resources: Sydney).

Isbell, R.F. (2002) *The Australian soil classification* Revised Edition (CSIRO: Australia).

IUCN (1994) *Guidelines for protected area management categories*. Commission on National Parks and Protected Areas with the assistance of the World Conservation Monitoring Centre (IUCN: Gland, Switzerland).

IUCN (The World Conservation Union) (2001) *IUCN Red List Categories*: Version 3.1 Prepared by the IUCN Species Survival Commission (IUCN: Gland, Switzerland and Cambridge).

JANIS (Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-committee)(1997). Nationally agreed criteria for the establishment of a comprehensive, adequate and representative reserve system for forests in Australia (Commonwealth of Australia: Canberra).

Keith, D.A. (2004) *From ocean shores to desert dunes: the vegetation of New South Wales and the ACT* (Department of Environment and Conservation NSW: Hurstville).

Keith, D.A. & Benson, D.H. (1988) The natural vegetation of the Katoomba 1:100 000 map sheet. *Cunninghamia* 2(1):107–143.

Kenny, B., Sutherland, E., Tasker, E. & Bradstock, R. (2003) Guidelines for ecologically sustainable fire management. Project 43.1 NSW Biodiversity Strategy (NSW National Parks and Wildlife Service: Hurstville).

Kent, M. & Cocker, P. (1992) *Vegetation description and analysis*: *a practical approach* (John Wiley & Sons Ltd: Chichester, England).

Kirkpatrick, J.B. & Dickinson, K.J.M. (1984) *Vegetation map of Tasmania* (Tasmanian Forestry Commission: Hobart).

Kirkpatrick, J.B., Barker, P., Brown, M.J., Harris, S. & Mackie, R. (1995) *The reservation status of Tasmanian vascular plant communities*. Wildlife Scientific Report 95/4 (Parks and Wildlife Service: Tasmania).

Koppen, W. (1931) *Klimakarte de Erde*. Grundriss der Klimakunde, 2nd Ed. Berlin.

Lewer, S., Ismay, K., Grounds, S., Gibson, R., Harris, M., Armstrong, R., Deluca, S. & Ryan, C. (2002) Native vegetation map report Bogan Gate, Boona Mount, Condobolin, Dandaloo, Tottenham and Tullamore 1:100 000 map sheets. (NSW Department of Infrastructure, Planning and Natural Resources).

Mazzer, T., Ellis, M., Smith, J., Ayers, D., Cooper, M., Wallace, G and Langdon, A. (1998) The Fauna of Western New South Wales: the Southern Mallee Region. (NSW National Parks and Wildlife Service: Hurstville).

McDonald, M. C. (1996) Ecosystem resilience and the restoration of damaged plant communities: A discussion focusing on Australian case studies. Ph.D. Dissertation, University of Western Sydney.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. & Hopkins, M.S. (1990) *Australian Soil and Land Survey: Field Handbook*. 2nd edition (Inkata Press: Melbourne).

Metcalfe, L., Sivertsen, D.P., Tindall, D. & Ryan, K.M. (2003) Natural vegetation of the New South Wales wheatbelt (Cobar-Nyngan-Gilgandra, Nymagee-Narromine-Dubbo 1:250000 vegetation sheets. *Cunninghamia* 8(2): 253–284.

Mitchell, P.B. (2002) NSW Ecosystems study: background and methodology. Report 13.7 NSW Biodiversity Strategy (NSW Department of Environment and Conservation: Sydney).

Moore, C.W.E. (1953) The vegetation of the south-eastern Riverina, New South Wales 1: the climax communities. *Australian Journal of Botany* 1: 485–547.

Morgan, G. & Terrey, J. (1992) Nature conservation in western New South Wales (National Parks Association of NSW: Sydney).

Morrison, D.A. & Renwick, J.A. (2000) Effects of variation in fire intensity on regeneration of co-occurring species of small trees in the Sydney region. *Australian Journal of Botany* 28: 71–79.

Mucina, L., Rodwell, J.S., Schaminée, J.H.J. & Dierschke, H. (1993). European Vegetation Survey: current state of some national programmes. *Journal of Vegetation Science* 4: 429–438.

Mueller-Dombois, D. & Ellenberg, H, (1974) *Aims and methods of vegetation ecology* (John Wiley and Sons: New York).

National Land and Water Resources Audit (2001) The Native Vegetation Classification System (NLWRA, Vegetation Theme: Canberra).

Natural Resource Management Ministerial Council (2004) Directions for a national reserve system — a partnership approach (National Reserve System Taskforce, Natural Resource Management Ministerial Council, Commonwealth of Australia: Canberra).

New South Wales Department of Environment and Conservation (2004) IBRA sub-regions. Unpublished GIS map (NSW DEC: Sydney).

New South Wales National Parks and Wildlife Service (1999) Derived forest ecosystems: an evaluation of surrogacy value and internal biological variation. NSW Comprehensive Regional Assessment of forests. Project No. NA44/eh (NSW National Parks & Wildlife Service: Sydney).

New South Wales National Parks and Wildlife Service (2003) *The bioregions of New South Wales: their biodiversity, conservation and history* (NSW National Parks and Wildlife Service: Hurstville).

Noy-Meir, I. (1971) Multivariant analysis of the semi-arid vegetation in south-eastern Australia: nodal ordination by component analysis. *Proceedings of the Ecological Society of Australia* 6: 159–193.

Pickard, J. & Norris, E.H. (1994) The natural vegetation of north-western New South Wales: notes to accompany the 1:1 000 000 vegetation map sheet. *Cunninghamia* 3(3): 423–464.

Playfair, R.M. & Robinson, A.C. (1997) (eds.) A biological survey of the North Olary Plains, South Australia 1995–1997 (Natural Resources Group, Department of Environment and Natural Resources: South Australia).

Poore, M.E.D. (1955) The use of phytosociological methods in ecological investigations. The Braun-Blanquet system. *Journal of Ecology* 43: 606–651.

Porteners, M.F. (1993) The natural vegetation of the Hay Plain: Booligal-Hay and Deniliquin-Bendigo 1:250 000 maps. *Cunninghamia* 3(1): 1–122.

Porteners, M.F., Ashby, E.M. & Benson, J.S. (1997) The natural vegetation of the Pooncarie 1:250 000 map. *Cunninghamia* 5(1): 139–231.

Pressey R.L. & Bedward, M. (1991) Mapping the environment at different scales: benefits and costs for nature conservation. Pp 7–13 in C.R. Margules and M.P. Austin (eds.) *Cost effective biological surveys and data analysis* (CSIRO: Australia).

Pressey, R.L. & Logan, V.S. (1994) Level of geographical subdivision and its effects on assessments of reserve coverage: a review of regional studies. *Conservation Biology* 8: 1037–1046.

Pressey, R.L., Hager, T.C., Ryan, K.M., Schwarz, J., Wall, S., Ferrier, S. & Creaser, P.M. (2000) Using abiotic data for conservation assessments over extensive regions: quantitative methods applied across New South Wales, Australia. *Biological Conservation*: 96: 55–82.

Queensland Herbarium (2003) Regional Ecosystem Description Database (REDD). A database describing regional ecosystems (Environmental Protection Agency: Brisbane, Queensland).

Raunkaier, C. (1934) *The life forms of plants and statistical plant geography* (Clarendon Press: Oxford).

Ratcliffe, D. (ed.) (1977) *A Nature Conservation Review: the selection of biological sites of national importance to nature conservation in Britain* (Cambridge University Press: London)

Resource and Conservation Assessment Council of NSW (RACAC) (2004) Joint vegetation mapping project, Brigalow Belt South Western Regional Assessment Stage 2 (Resource and Conservation Division, Department of Infrastructure, Planning and Natural Resources: Sydney)

Rodwell, J.S. (ed.) (1991, 1992, 1995) *British Plant Communities* Volumes 1–5. (Cambridge University Press: Cambridge).

Sattler, P.S.& Williams, R.D. (1999) (eds.) *The conservation status of Queensland's bioregional ecosystems* (Department of Environment and Heritage: Brisbane).

Scott, J.A. (1992) The natural vegetation of the Balranald – Swan Hill area. *Cunninghamia* 2(4): 597–652.

Shepherd, G. (2004) *The ecosystem approach: five steps to implementation* (IUCN: Gland, Switzerland and Cambridge, UK).

Sivertsen, D. & Metcalfe, L. (1995) Natural vegetation of the southern wheat-belt (Forbes and Cargelligo 1:250 000 map sheets. *Cunninghamia* 4(1): 103–128.

Specht, R.L. (1970) Vegetation. Pp 44–47 in Leeper, G.W. (ed.) *The Australian environment* Edition 4 (Melbourne University Press: Melbourne).

Specht, R.L., Roe, E.M. & Broughton, V.H. (1974) Conservation of major plant communities in Australia and Papua New Guinea. *Australian Journal of Botany*, Supplement No. 7.

Specht, R.L., Specht, A., Whelan, M.B. & Hegarty, E.E. (1995) *Conservation atlas of plant communities in Australia* (Centre for Coastal Management, Southern Cross University Press: Lismore).

Stace, H.C.T., Hubble, G.D., Brewer, R., Northcote, K.H., Sleeman, J.R., Mulcachy, M.J. & Hallsworth, E.G. (1968) *A handbook of Australian soils*. (Rellim Technical Publications, Glenside: South Australia).

Stern, H., Hoedt, G. & Ernst, J. (2000) Objective classification of Australian climates (Bureau of Meteorology Australia: Melbourne).

Sun, D., Hnatiuk, R.J. & Neldner, V.J. (1996) Vegetation classification and mapping systems for Australian forest management (Bureau of Resource Sciences: Canberra).

Thackway, R. & Cresswell, I.D. (eds.) (1995) An interim biogeographic regionalisation for Australia. Version 6.0 (Australian Nature Conservation Agency: Canberra).

Victorian Department of Natural Resources (2001) Descriptions of Ecological Vegetation Classes of Victoria. Unpublished working document. (Department of Natural Resources: Melbourne).

Walker, J. & Hopkins, M.S. (1990) Vegetation. In McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. & Hopkins, M.S. (1990) *Australian soil and land survey: field handbook* (Inkata Press: Melbourne).

Webb, L.J. (1968) Environmental relationships of the structural types of Australian rain forest vegetation. *Ecology* 49: 296–311.

Westhoff, V. & Van der Maarel, E. (1980) The Braun-Blanquet approach. Pp 289–329 in Whittaker, R.H. *Classification of Plant Communities* Second Edition (W. Junk, the Hague: Netherlands).

Whitaker, R.H. (1962) Classification of natural communities. *Botanical Review* 28: 1–239.

With, K.A. (1997) The application of neutral landscapes models in conservation biology. *Conservation Biology* 11: 1069–1080.

Wilson, B.A., Neldner, V.J. & Accad, A. (2002) The extent and status of remnant vegetation in Queensland and its implications for statewide vegetation management and legislation. *The Rangelands Journal* 24: 6–35.

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Appendix A. Description of the NSW Vegetation Classification and Assessment MS Access database

(Comments on the database should be forwarded to the NSWVCA database administrator through email nswvca@rbgsyd.nsw.gov.au)

The NSW Vegetation Classification and Assessment database (NSWVCA) is a vegetation classification, threat and protected area status information system to assist with the protection and management of vegetation in New South Wales.

The NSWVCA database contains 90 information fields, 47 tables and 64 forms. A number of standard reports are included to allow for the listing of plant communities by geographical area or by broader vegetation or landscape classifications. Most of the fields could be adapted for use in any jurisdiction of the world. However, some of their names are pertinent to particular landscape classifications or administrative boundaries used in NSW. Programming is in MS Visual Basic. Some of the programming is concerned with exporting reports directly to MS Word (discussed below). Therefore, changes to field names in the database need to be mirrored with changes to field names in the templates used for exporting records to MS Word.

Interrogation of combinations of fields in the database can be achieved by using the query mode of MS Access but this is only available to users who have the full version of the database. In order to maintain a single version of the database, changes to it should be made through a central database administrator. Proposed changes can be sent to the email address on the Feedback form accessible in the database.

A future step in the development of the database is to have it accessible over the internet including a provision for users to access the query mode. This would avoid the need to issue updated versions of the database.

Software requirements

The database runs on Personal Computers not on Macintosh computers. The software required is Microsoft **Access XP 2000** or later versions running under recent versions of **MS Windows**. It will not work on MS Access 1997. MS Access was selected because it is a commonly used database, however, it does have limitations and these are described in the 'Software limitations' section at the end of this document. The MS Word Reports require **MS Word 2002** or later versions. **MS Internet Explorer** is required to access photographs stored in a separate 'Image' folder. The database links to images in the 'Image' folder via shared label names in the 'Photo File Name' field of the database and the image file name. PDF Reports are converted to editable PDF format via pdf 995s.exe writer that is included with the files associated with the database.

Getting started: installing and opening the database

Installing the database

The 15 files required to run the NSWVCA database contain the MS Access database itself, an image folder, pdf995s.exe print driver freeware, ps2pdf995.exe PDF converter freeware, 10 other files and a batch file that can be used to save all of these files to the c:\vegclass folder from the CD. The database reports cannot be run by using the database from the CD.

There are two ways of transferring the files to a computer.

1. Double click on the *vegclass.bat* file to automatically save the files associated with the NSWVCA database to the folder C:\vegclass; or

2. Manually copy and save the files from the CD to an appropriate computer drive and folder. Once the files are transferred, locate and double click on the pdf995s.exe file and follow the instructions for loading it. Then double click on the ps2pdf995.exe file to load the supporting free software. You will require administrative rights to your PC to load this pdf995 print driver.

Do not alter the supplied file names or directories or risk the database not working.

The files are:

1. *NSWvegclass.mdb*: this is the Access 2002 database file containing the plant community records, tables, forms and reports. The read only version does not allow access to its backend – i.e. tables and data;

2. *Vegword.doc*: a MS Word template that facilitates the Word reports that contain all fields in the records;

3. *Vegwordc.doc*: a MS Word template that facilitates Word reports when operating the database from the c:\vegclass folder;

4. *Vegwordd.doc*: a MS Word template that facilitates Word reports when operating the database from the d:\vegclass folder;

5. *Vegshort.doc*: a MS Word template that facilitates Word Reports reports that contain a subset (28) of the fields;

6. *Vegnoref.doc*: a MS Word template that facilitates the production of full records without the text of the references but with the Reference number list. This is useful for reducing the length of a report by eliminating the full text references. It maintains the reference list field that lists the numerical code of the references that can be looked up in the Excel bibliography on the CD;

7. *Vegquick.doc*: a MS Word template that facilitates the Word Reports Quick Reference Report that contains 8 fields from all records in the database;

8. *Threat.doc*: A MS Word document that includes the descriptions of the threat categories and threat criteria used for assigning each community to a threat category;

9. *Database Description.doc*: this is a digital form of this document that can be used as a reference while using the database. It is retrievable by selecting the 'Database Description' field at the top of the TBL Main Details data entry screen;

10. *Feedback.doc*: a document that contains a proforma for comments on the classification or the database that can be submitted either digitally or in hard copy form to the Database Administrator. Suggested changes can be major such as changing the classification or minor such as changing information in some of the fields. Major changes should be vetted by a NSWVCA Scientific Committee, and after agreement to the change, they should be made by the Database Administrator. The feedback form is accessed through the 'Feedback' field in the top section of the TBL Main Details data entry screen;

11. *Noimage.bmp*: a background file used in reports;

12. The 'Images' folder contains jpeg images that are incorporated in PDF reports. This folder should be saved as a sub-folder in the Vegclass folder. Its title must remain Images due to this name being used in Visual Basic computer code. Within this folder is another folder titled Images_big. This contains larger resolution images for use on-screen with the images being linked to the View Photo fields in the TBL Main Details data form in the database;

13. *pdf995s.exe*: free software that allows Access Reports to be saved in *pdf* format;

14. *ps2pdf995.exe*: free software that allows pdf995s.exe to operate;

15. *Vegclass.bat*: a batch file that automatically saves all 15 files described here to the c:\vegclass folder.

Opening the database

Once the NSWVCA files are saved to an appropriate folder (and perhaps a shortcut made to the database), double click on the file *NSWvegclass.mdb*. An Administration Menu appears with six menu keys:

- *Data Entry*: opens the Main Table Details at the first record. This is the where data is viewed or entered. Once opened, the Veg Comm ID number, Common Name of the plant community and Photo keys remain in the top part of the screen when scrolling down a record;
- *Search*: opens a search option screen for finding a plant community using key words in conjunction several fields such as Scientific Name, Formation Group or Bioregion;
- *PDF Reports*: opens the PDF Report options that are described below;
- *Word Report* : opens the same report options as the PDF Reports key except these are delivered directly to MS Word but without photos;
- *Database details*: raises an explanation note about the database;

- *Exit database* closes the database. It can also be closed through 'X' in the top right corner of the toolbar.

Compacting the database

When exiting or closing the database it automatically compacts. In the full version compaction and repair can be run at any time through 'tools/database utilities/compact and repair' but in the read only version this is not possible. When a series of reports are generated, Access expands in size and this can create faults that may cause it to close. Therefore, it is advisable to close and re-open the database occasionally during extensive use.

Database queries and reports

The prime reason for using a database to record information on ecological classifications is to facilitate queries of combinations of data fields. Such queries are not possible from text-based ecological community descriptions. An example of a simple query would be 'list plant communities in the Riverina Bioregion'. A more complicated query may be: 'list plant communities, that are endangered, that occur on sandplain landform pattern, that are in the Riverina Bioregion and that are under the Formation Group *Grasslands on Fine Texture Soils on the Inland Slopes and Plains'*. The first example can be delivered by one of the standard reports (see below). The second example requires a full version of the database and knowledge of using the MS Access query mode.

39 query reports have been developed and are accessed from the PDF Reports and 'Word Reports' keys in Administration Menu. Most of the reports are available as either full reports (all 90 fields) or short reports (28 fields). For example, if the user wished to list all plant communities in a particular Catchment Management Authority area they would select a CMA from the drop down list for either the full of short CMA report options. The same applies to bioregions, reserves, Formation Groups, Keith (2004) map units etc.

The plant communities that are listed in reports of geographical regions or broad vegetation groups are arranged in alphabetical order of the names of the high order hierarchical unit 'Formation Group' used in the NSWVCA project, thus beginning with *Acacia woodlands and shrublands of the inland slopes and plains* through to *Wetlands: Inland freshwater, swamp and shrubland communities*. This ensures that similar types of plant communities are grouped in the reports (consecutive ID numbers do not necessarily contain similar plant communities).

PDF Reports

PDF Reports are available through the 'PDF Reports' key in the Administration Menu. pdf995s automatically incorporates images into the reports and its text can be searched and copied. The Main Table in the database can be imported to MS Excel. This will exclude images but the text fields and the image file names are searchable and able to be edited.

Hint 1: If you are finding the Access reports and pdf files are overlapping onto extra pages, in Windows go to Start / Printer Settings / pdf995 and make sure its settings are set for A4 sized paper.

Hint 2: Close the pdf995 sponsorship advertisements when saving a report to file.

Hint 3: If a previous report is saved in a PDF Report, re-run and save the report.

Word Reports

Word Reports are available through the 'Word Reports' key in the Administration Menu. They produce text that can be edited and searched for key words – handy if you are looking for a particular community dominated by a particular species for example. They are generated by the Word template files *Vegwordc.doc, Vegwordd.doc, Vegshort.doc* or *Vegquick.doc* via a merge routine that converts the Access text into MS Word format. To use the 'Word Report select a report option from the menu then wait as MS Word is 'reading the records', then wait while MS Word is 'merging the records'. The user can observe these two processes happening in the bottom left hand corner of the screen which also shows how many records are being processed. Once complete, the report can be saved as a Word file. The advantage of Word reports is that they contain searchable text and can be cut, pasted and edited. However, images have to be manually transferred into Word reports from the 'image' folder and this can be tedious if the report contains many records.

Full and short reports and reports with or without full text references or images

Within both the PDF Reports and Word Reports, there are options for producing different length reports depending on requirements. These are:

- *Full Reports* include all 90 database fields and are generally three to four A4 pages in length per plant community;
- *Full Report Without References* are selected from a question that appears on the screen asking 'Do you want full reference to print?' By selecting 'yes' the report will include the text of all references. By selecting 'no' the report will not list the text of the references. Selecting the report without references saves considerable space. Note: this option still lists the Reference List field i.e. the numbers of the references, the names of which can be correlated via the References Report in the PDF Reports Menu or in the *Bibliography NSW Western Plains.xls* file on the CD accompanying the *Cunninghamia* journal where this Database Description is published;

- *All Records Report* and the four section reports *Western Plains, Western Slopes, Tablelands, Coast and Escarpment* contain an option '*without images'*;
- *Short Reports* contain 28 of the 90 fields and are normally one A4 page in length per plant community. The fields are: Veg. Comm. ID No, Common Name, Scientific Name, Characteristic Trees, Characteristic Shrubs/Vines/Epiphytes, Characteristic Groundcover, Structure, Vegetation Description, IBRA Bioregion, Catchment Management Authority, Pre-European Extent (ha), Pre-European Accuracy (%), Current Extent (ha), Current Extent Accuracy (%), Percent Remaining, Percent Remaining Accuracy, Conservation Reserves, Total Area in Reserves, Area in Secure Property Agreements, Total Area in Reserves (ha), Secure Property Agreements, Total Area in Secure PAs, Total Area Protected, Total Area Protected Accuracy %, Threat Category, Threat Criteria, Threat/Protection Area Code, Photo 1 label, Photo 1 caption and Reference List.

Database Report Options

Currently, the NSWVCA database contains 39 report options for listing plant communities. These are:

1. **Vegetation ID:** This report is useful for selecting a single record or several sequential records. It lists all 90 fields of information for one or a sequence of plant communities in order of their ID Number listing in the database. Type the required ID Number into the first data entry box. Using the tab key or clicking the mouse raises the same number in the next box. If a range of ID numbers is sought, type in a second ID number in the second entry box;

2. **Vegetation ID Short Report**: Same as for 1. above except this report lists 28 fields only;

3. **All Records:** Lists all 90 fields for all plant communities in the database. This report is very long with the NSW Western Plains section alone being over 700 pages in length;

4. **All Records Short Report:** Lists all plant communities in the database with 28 fields of information including name, characteristic plant species, occurrences in protected areas and threat/protected area code;

5. **Quick Reference Report**: Lists 8 fields of each record in the database arranged by Formation Group name by alphabetical order. This can be used to quickly review records in the database. An example is:

ID Number: **26**

Scientific Name: *Acacia pendula/Rhagodia spinescens — Maireana decalvans/Austrodanthonia caespitosa — Atriplex semibaccata — Alternanthera denticulata — Austrostipa aristiglumis*

Common Name: **Weeping Myall open woodland of the Riverina and NSW South-western Slopes Bioregions**

Char. Trees: *Acacia pendula; Casuarina cristata; Eucalyptus largiflorens; Eucalyptus camaldulensis; Eucalyptus melliodora*

Char. Shrubs/Vines: *Rhagodia spinescens; Maireana decalvans; Atriplex nummularia; Chenopodium nitrariaceum; Maireana aphylla; Muehlenbeckia florulenta; Acacia stenophylla; Acacia oswaldii; Acacia salicina; Hakea tephrosperma; Santalum lanceolatum; Amyema quandang*

Char. Ground Cover: *Austrodanthonia caespitosa; Atriplex semibaccata; Alternanthera denticulata; Austrostipa aristiglumis; Atriplex spinibractea; Atriplex leptocarpa; Enchylaena tomentosa; Austrostipa nodosa; Austrodanthonia setacea; Sporobolus caroli; Einadia nutans* subsp. *Nutans*.

Formation Group: Acacia Woodlands and Shrublands of the Inland Including the Semi-Arid Zone;

6. **Scientific Name Report**: Lists all plant communities with a particular species name in the scientific name field. This is useful for seeking records where a particular dominant species is of interest. For example, selecting '*Acacia pendula*' from the drop down list of all NSW plant species names lists all the communities where *Acacia pendula* is part of the scientific name;

7. **Scientific Name Report Short Report**: Short report of 6. above;

8. **Formation Group Report:** Lists plant communities under any Formation Group selected from the Formation Group Table drop down list. This is useful for listing similar structural and floristic communities;

9. **Formation Group Short Report**: Short report of 8. above;

10. **State Map (Keith 2004):** Lists plant communities in any of the 99 Vegetation Classes covering NSW mapped and described in Keith (2004);

11. **State Map (Keith 2004) Short Report**: Short report of 10. above;

12. **NVIS Major Veg. Sub-groups:** Lists plant communities in order of the Formation Groups correlated with any of the Native Vegetation Information System vegetation sub-groups for Australia developed in the National Land and Water Resources Audit (2001);

13. **NVIS Major Veg. Sub-groups Short Report:** Short report of 12. above;

14. **Catchment Management Areas:** Lists plant communities in order of the Formation Groups for any of the 13 Catchment Management Authority areas in NSW as described under the NSW Catchment Management Act 2003. CMAs are key areas for planning and natural resource funds expenditure in NSW;

15. **Catchment Management Areas Short Report:** Short report of 15. above;

16. **IBRA Bioregion:** Lists plant communities in order of the Formation Groups for any of the 18 IBRA Bioregions (Version 6.0) in NSW;

17. **IBRA Bioregion Short Report:** Short report of 16. above;

18. **IBRA sub-regions:** Lists plant communities for any of the 129 IBRA sub-regions which are divisions of the IBRA Bioregions (Version 6.0) in NSW;

19. **IBRA sub-regions Short Report:** Short report of 18 above;

20. **Local Government Areas (LGA):** Lists plant communities for any of the Local Government Areas in NSW;

21. **Local Government Areas (LGA) Short Report:** Short report of 20 above;

22. **Reserves:** Lists plant communities in any public conservation reserve in NSW;

23. **Reserves Short Report:** Short report on 22 above;

24. **Secure Property Agreements (SPAs):** Lists plant communities for any secure property agreements under the Native Vegetation Conservation Act 1998, Native Vegetation Act 2003 or Conservation Trust in NSW 2001, Voluntary Conservation Agreements under the National Parks and Wildlife Act 1974 and private secure reserves including those owned by the Australian Bush Heritage Fund and the Australian Wildlife Conservancy;

25. **Secure Property Agreements (SPAs) Short Report:** Short report of 24 above;

26. **Western Plains Section:** Lists plant communities in the area defined as the 'NSW Western Plains' being the eight western-most IBRA Bioregions (Version 6.0) in NSW: Darling Riverine Plains, Riverina, Cobar Peneplain, Mulga Lands, Murray-Darling Depression, Broken Hill Complex, Simpson-Strzelecki Dunefields and Channel Country Bioregions;

27. **Western Plains Section without images:** Same as 26 above but without images thus saving space and avoiding limitations of memory in some computers;

28. **Western Plains Section Short Report:** Short report of 26 above;

29. **Western Slopes Section:** Lists all records in the area defined as the 'NSW Western Slopes' being the three central IBRA Bioregions (Version 6.0) in NSW: Brigalow Belt South, Nandewar and NSW South Western Slopes Bioregions;

30. **Western Slopes Section without images:** Same as 29 above but without images thus saving space and avoiding limitations of memory in some computers;

31. **Western Slopes Section Short Report:** Short Report of 29 above;

32. **Tablelands Section:** Lists all records in the area defined as the 'NSW Tablelands' being the three IBRA bioregions (Version 6.0) in NSW: New England Tablelands, Southern Eastern Highlands and Australian Alps Bioregions;

33. **Tablelands Section without images:** Same as 32 above but without images thus saving space and avoiding limitations of memory in some computers;

34. **Tablelands Section Short Report:** Short report of 32 above;

35. **Coast and Escarpment Section:** Lists plant communities in the area defined as the 'NSW Coast and Escarpment' being the four coastal IBRA Bioregions (Version 6.0) in NSW: NSW North Coast, Sydney Basin, South-Eastern Corner and South-East Queensland Bioregions;

36. **Coast and Escarpment Section without images:** Same as 35 above but without images thus saving space and avoiding limitations of memory in some computers;

37. **Coast and Escarpment Section Short Report:** Short report of 35 above;

38. **Murray-Darling Basin:** Lists plant communities in the Murray Darling Basin;

39. **References:** Available in the 'Reports' menu, it lists the references in the database in order of their data entry. This can be exported to Excel and re-arranged by author name.

Reports from the Search routine

An alternative means of producing reports to using the PDF Reports or Word Reports menu options, described above, is to generate reports from the Search screen. This is done by highlighting the Search screen through the 'Search' key on the Administration Menu. Once a search has been made using the fields available, the plant communities selected can be written to a report via the report button on the screen. Options allow for generating short or full reports in PDF or MS Word formats. This is useful for grouping all plant communities with, for example, the same species name in their scientific name. For example, if you want a report listing all plant communities that have *Eucalyptus microcarpa* in their scientific name you would type this species name into the 'scientific name' field and then save the report. Similarly, you could use the common name field to generate a report for common name usage – in this case 'Inland Grey Box'. However, some communities have no common species names in their title and rarely do they contain more than two.

Note: You must ' Clear' the screen between queries.

Using the 'species' key

Users of the database will not need to use the 'species' key. It is located in the toolbar on the data entry screen. It links to the Species Table which contains a list of current NSW plant species names. The species key is useful when entering species names in some fields in the database, for example, the 'vegetation description' field. This ensures the proper spelling of the name. The Species Table is kept up to date with taxonomic name changes but it lists only the latest accepted names, not synonyms. Should previous species names need to be replaced or altered, a *find/replace* procedure can be applied, by the database administrator, to the Main Table at the backend of the database.

Description of NSWVCA database fields

(Notes: the fields are described as they appear in the data entry screen not in the reports. Some of the descriptions of the fields apply to data entry and are not relevant to general users of the database).

1. ID Number: This number as assigned automatically by MS Access and cannot be changed. If a community is deleted this number cannot be re-used. If in the future a community is split into more communities this number will be used by one of the new communities. Changes to consecutive versions of the database should trace the history of vegetation community number changes;

2. Common Name: A colloquial description of the plant community that can be understood by non-botanists. It may include common names of dominant plant species, names of a geographical region, a substrate, a soil type or a climatic zone. For example the common name of the scientific name example in 3 below could be called *Ribbon Gum—Mountain Gum Grassy Forest of the New England Basalt Plateau*;

3. Scientific Name: This includes up to 12 scientific names of species that are deemed to be dominant or characteristic of the community. The species are selected from quantitative analyses or qualitative descriptions. Up to four species can be used for each of three layers and are listed in descending order of dominance or indicator value to each layer. Layer 1 lists trees. Layer 2 includes shrubs above 0.5 in height, robust vines, epiphytes in may include tall grasses in grasslands. Layer 3 includes the dominant ground cover species including small shrubs less than 0.5 m high, grasses, weak climbers, sedges, forbs, ferns and bryophytes. A dash ('—') between species implies they are from the same layer. A slash ('/') indicates they are from different layer. An example is *Eucalyptus viminalis — Eucalyptus dalrympleana* subsp. *heptantha* /*Acacia dealbata* /*Poa sieberiana* tall open forest on the basalt plateau, New England Bioregion;

4. Original data entry: Name of person who first entered a record;

5. Date of entry: Date of first data entry;

6. Last modified by: Name of person who made the last modification;

7. Last modified date: Date of last modification;

8. Formation Group: Formation Groups are a high order hierarchy useful for grouping similar plant communities. They are based on the major group of Australian vegetation described in Beadle (1981) and contain plant communities with similar life forms and growth forms and often occur in similar ecological environments. There are currently 63 Formation Groups in the NSWVCA. For each data entry, a Formation Group is selected from a lookup table. Plant communities can be listed in any Formation Group through the 'Formation Group' report options in the reports menu of the database. Most of the reports generated in the database list plant communities in alphabetical order by Formation Group name;

9. State Vegetation Map (Keith 2004): Select from a drop down table one of the broad Vegetation Classes depicted on a State vegetation compilation map produced by Keith (2004). Through the reports menu it is possible to list all plant communities that are grouped under any of the Keith (2004) vegetation classes;

10. State landscapes (Mitchell 2002): These landscapes are based on land-systems, soils maps and geological maps. Over 500 cover NSW. As of 2006 the database had not recorded these landscapes but it is anticipated this will be done over the next few years;

11. NVIS major sub-groups: The Australian Government through its Department of Environment and Heritage (DEH) has developed a list of major vegetation sub-groups covering Australia (ESCAVI 2003). This is part of a program to describe the vegetation of Australia (NLWRA 2001). For each data entry one of the NVIS sub-groups is selected from a lookup table. Using the report menu it is possible to report all NSWVCA communities for any of the NVIS sub-groups;

12. Forest type (RN 17): A typology of NSW forest types was published in Research Note 17 by the NSW Forestry Commission of NSW (1989). Forest types had been developed over 50 years, mainly aimed at classifying and mapping commercial tree species for forestry purposes. For each data entry in the database, one or more forest types are selected from the list of 235 forest types in Research Note 17. A qualifying attachment to each community data entry records whether the community is considered to be equivalent (E) to the forest type or is part (P) of a number of communities that would comprise the forest type. In most cases the communities in this classification are more finely classified than forest types, especially for inland NSW;

13. Characteristic trees: Trees are woody plants that are generally single stemmed and greater than 2 m high (Walker & Hopkins 1990). Eucalypt 'mallee trees' are included in this field if they contain a main stem that often develops in mallee that has not been burnt for decades or mallee growing on clayey soils. Up to 15 tree species can be listed for each community. The species are selected from a drop down table of all current plant species names in NSW in the Species Table in the database. The selected species are derived from the best available quantitative or qualitative data. They include dominant species or species with high fidelity to the community;

14. Characteristic shrubs/vines/epiphytes: Shrubs/vines and epiphytes are defined in (Walker & Hopkins 1990). For the purposes of this classification shrubs listed in this mid-layer are woody plants >0.5 m high, often multi-stemmed at the ground or if singled stem less than 2 m high. Woody vines such as Wonga Vine (*Pandorea pandoreana*) are listed in the same stratum as shrubs because they usually occupy mid-level space in vegetation structure. Up to 20 species can be listed in this field for each community. The species are selected from a drop down table of all current plant species names in NSW in the Species Table in the database. The selected species are derived from the best available quantitative or qualitative data. They include dominant species or species with high fidelity to the community;

15. Characteristic groundcover: Ground cover includes low shrubs less than 0.5 m in height along with most grasses, sedges, rushes, forbs, ferns (see life form definitions in Walker & Hopkins 1990) and decumbent climbers such as species of *Convolvulus* or *Glycine*. Up to 30 species can be listed in this field for each community. The species are selected from a drop down table of all current plant species names in NSW in the Species Table in the database. The selected species are derived from the best available quantitative or qualitative data. They include dominant species or species with high fidelity to the community;

16. Characteristic weed species: Up to 10 major exotic weed species or non-indigenous native weed species, documented from a listed community, can be recorded. They are selected from a drop down list of the Species Table that contains current NSW plant species names. The selected weed species are derived from the best available quantitative or qualitative data. A weed species may be any life form and occur in any layer of the vegetation;

17. Weediness: Select from a drop down table the average estimated degree of weediness per sample point for each community. This table combines percentage cover with proportion of the total flora. The options for selection are:

- Low (<5%) with <10% cover
- Low (<5%) with 10–30% cover
- Low (<5%) with >30 % cover
- Medium (5–15%) with <10% cover
- Medium (5–15%) with 10–30% cover
- Medium (5–15%) with >30% cover
- High (15–30%) with <10% cover
- High (15–30%) with 10–30% cover
- High (15–30%) with >30% cover
- Very high (>30%) with <10% cover
- Very high (>30%) with 10–30% cover
- Very high (>30%) with >30% cover
- Data deficient
- Not accessed

Weed species numbers vary considerably in many communities with the seasons (e.g. flushes of spring annual weeds). This listing should take all seasons into account. Note that weed species are defined as species that are not indigenous to a plant community. They are mainly exotic species but may include native species that have become weeds outside their normal range. The so called 'native woody weeds' of the inland plains are not considered weed species because they are within their natural range but for undetermined reasons have increased in abundance;

18. Threatened plants: List of plant species listed under the NSW Threatened Species Conservation Act 1995 or species that are otherwise considered to be regionally significant are documented for each community from the literature or expert advice. The data will improve over time.

19. Threatened fauna: List of species of fauna that are listed under the NSW Threatened Species Conservation Act 1995 or other species that are otherwise considered to be regionally significant that occur in the community. Such lists are derived from the literature, expert advice or predictive modeling. The data will improve over time. Unlike with threatened plant species, vertebrate fauna are listed by common name due to the standard of world-wide common name naming systems available for such taxa.

20. Mean native species richness: A figure is recorded if quantitative plot data allows mean native species richness to be calculated from plots sampled in a community. This is often determined in vegetation surveys. The plot size used in this analysis is also noted;

21. Characteristic species qualifiers: An attached lookup table has three qualification options: 'based on quantitative data', 'based on qualitative estimate', 'based on a combination of quantitative data and qualitative estimate'. One of these is selected based on the origin of the information used to list the characteristic species;

22. Authority(s): This field records sources of information used to define the classified plant community. These sources also provide much of the information on the species composition, distribution and extent of the

community. It is analogous to the authorship of species except in this community classification there are often many references. These references include regional botanical surveys, maps, site-specific project reports or papers. Comment is provided as to whether a listed community is equivalent to or part of a particular map unit or floristic group in a referenced source;

23. Authority qualifiers: Depending on the nature of the source data, select one of the following qualifications: 'based on quantitative data', 'based on expert opinion', 'based on a combination of expert opinion and quantitative data';

24. References: There are two fields in the database titled 'Reference'. The first reference field is the reference list field. It is adjacent to the 'Authority' field in the main screen because most references for each record relate to the Authority field. Selecting the 'Reference' key raises the Reference Table as a drop down file. This table increases as new references are typed into it as the classification proceeds or is revised. A relevant reference in the Reference Table can be selected and its number will appear in this reference field while the full text of the reference (linked to this number) appears in the Reference field at the end of the data entry screen. These full text references are therefore positioned as the last paragraph in reports generated from the database. New references can be added to the Reference Table at this point by typing them into the screen provided. Each additional reference is automatically assigned a sequential number. References that are pertinent to other fields in the database (e.g. Fire Regime or Planning and Management) are also entered here. MS Access cannot order references into alphabetical order. However, this can be done through an export/import routine from Access to Excel and return to Access that has been developed for maintaining the database;

25. Interstate equivalents: This field lists ecological communities, vegetation map units or floristic groups in other Australian States or Territories, that appear from floristic descriptions, to correspond to a listed NSW plant community. Key sources of interstate classifications include Sattler & Williams (1999) for Queensland ecosystems, Ecological Vegetation Classes for Victoria and South Australian vegetation map units. In some cases there is no interstate equivalent – e.g. for restricted communities or communities in central NSW. Inter-jurisdictional comparison requires expert judgment. If plot data were available it may be possible to refine this through cross-border data compilations and data analyses of data;

26. Classification confidence level: Lookup table with descending scale of confidence – high (1), medium (2) and low (3). These confidence ratings relate to the completeness of the data on the listed community (for example, only part of its range may have been mapped or surveyed), the level of analyses that were undertaken on the available data and the degree of expert agreement on the classification. An example of a high confidence level (1) is where floristic survey and/or fine scale vegetation mapping have defined a plant community. A medium confidence level (2) would include a situation where a plant community has been consistently mapped and referred to in several publications but may be under-supported by plot data or fine scale mapping. A low confidence level (3) is assigned to a plant community that has no or little plot data and or mapping covering it, and is ill-defined in the literature, but enough is known about it to suggest it may prove to be definable with more investigation;

27. Level of classification: In addition to listing vegetation structure classes (see fields 28 and 29 below), the database contains an option to list one of three levels of classification: *sub-formation, association, sub-association*. Selecting the 'Details' key adjacent to this field raises a lookup table that provides definitions of these categories. The three classification levels are based on the definitions in Beadle & Costin (1952) and the National Vegetation Information System developed under the vegetation theme of the National Land and Water Resources Audit (NLWRA 2001). Assigning a community to a level of classification takes into account the overall species variation in the community in all strata. If the described community contains a high degree of consistency in all strata it will be listed as a sub-association or association. If the community contains significant species variation, often over a large geographical area, it will be assigned a sub-formation level. The aim of this project is to list vegetation to the 'association' level as defined. It is anticipated that communities listed as 'sub-formation' will be split into two or more 'associations' in the future with floristic data analysis and finer scale mapping.

The definitions to guide the three levels of classification are:

Sub-formation: *A group of floristically related associations of similar structure ('alliance' in Beadle & Costin 1952), or, a community with shared dominant growth form, cover, height and broad floristic code usually dominant Genus and Family for the three traditional strata (upper, mid and ground) (NLWRA 2001).*

Association: *A community of which the dominant stratum has a qualitatively uniform floristic composition and which exhibits a uniform structure ('association' Beadle & Costin 1952), or, a community with shared dominant growth, height, cover and species (3 species) for the three traditional strata (upper, mid and ground) (NLWRA 2001).*

Sub-association: *A sub-division of an association determined by a variation in the most important subordinate stratum of the association, without significant qualitative changes in the dominant stratum ('sub-association' in Beadle & Costin 1952), or, a community with shared dominant growth form, height, cover and species (5 species) for all layers/strata (NLWRA 2001*).

28. Rainforest structure: This field only applies to plant communities that are deemed to be rainforest. This is a text field that summarises the structural typologies outlined in Webb (1968), summarized and coded in Walker & Hopkins (1990). These typologies include forest complexity, leaf size, floristic composition of the tallest stratum, indicator growth forms, height and crown cover classes (as per fields on 'Structure' and 'Height class' below), emergent species and sclerophyll species in upper stratum;

29. Structure: This uses the growth form and canopy crown separation ratio definitions in Walker & Hopkins (1990) to define structural classes. For example, if the vegetation is dominated by shrubs that are 'clearly separated' (crown separation ratio of 0.25–1), and the shrubs are generally 1–3m high, then the vegetation structure is 'tall open shrubland'. Structural description is often used in the common name description of the plant community (see field 2 above). The structural classes are set out in Tables 14a and 14b in Walker & Hopkins (1990) which are reproduced as tables A and B in the database that are accessed by entering the 'Structure' field key. In some cases, floristically similar vegetation can contain more than one type of structural class due to natural variation or disturbance in the community. For example, a community may exhibit denser but shorter re-growth after a disturbance such as fire, flood or clearing. This variation in structure is accommodated by selecting multiple entries from the Structure Tables A and B;

30. Height class: Enter one or multiple entries from the lookup table of height classes in the database for the life form of the highest stratum in the listed plant community. Height classes can only be selected by examining table 15 in Walker & Hopkins (1990) that lists height classes for the different life-forms. So a 'tall' entry for a community dominated by trees requires a different average height than a 'tall' entry for a shrubland or grassland;

31. Vegetation description: This is a concise one paragraph summary of the plant community. It summarizes the plant species composition, structure, physiographic features, distribution, threats and conservation status of the community. It is compiled after the other fields of database are completed. It is envisaged that this vegetation summary would be suitable for use in summary reports or educational literature especially if it were accompanied by a photograph and caption of a community;

32. Mapped or modeled: A selection is entered from a lookup table that contains the following options:

a. Current extent mapped or modelled;

b. Current extent mapped or modelled as part of a broader type;

c. Current extent not mapped or modelled;

d. Current extent partly mapped or modelled;

e. Current and pre-European extent mapped or modelled;

f. Current extent and part of pre-European extent mapped or modelled;

g. Pre-European extent and part of current extent mapped or modelled;

h. Pre-European extent partly mapped or modelled;

i. Pre-European extent mapped or modelled as part of a broader type;

j. Pre-European extent mapped or modelled.

33. Mapping information: This field allows for a text description of vegetation mapping information. It also allows for 'map ability' for each community to be discussed. Some listed plant communities are not easily mapped due to scale or problems in their definition using remote sensing — examples being narrow riparian vegetation and grassland communities. In the future, links to vegetation maps on geographical information systems could be attached to either this field or the previous field so the user could display maps containing a particular plant community;

34. Adequacy of plot sampling: Select one of the following options:

N = no sampling known;

I = inadequate sampling: less than 70% of the range of the community has been sampled and/or sampling is considered to be too scattered to cover major variations in the community;

A = adequately sampled: sampling covers >70% of range of community and the plots are of sufficient density to cover major variations in the community;

NA = not assessed.

Selection is dependent on expert opinion based on the number of plot samples in the community, the quality of the sampling and the coverage of the sampling;

35. Climatic Zone: From a drop down list of their names, select one or more of the nine climate zones covering NSW (see Figure 3) that overlap with the distribution of the community. These climatic zones have been derived from combinations of rainfall and temperature,

36. Interim Biogeographic Regionalisation for Australia (IBRA): Select one or more IBRA Bioregions from a lookup table that lists the 18 IBRA Bioregions (Thackway & Cresswell 1995, Version 6.0) occurring in NSW. Multiple entries of bioregions are often required because some plant communities occur in more than one bioregion. In addition to listing the bioregions where a community occurs, it is possible to qualify the extent its current extent in each bioregion by applying a tag to the data entry of >70% or 30–70% or 1–30%;

37. IBRA sub-region: The 18 IBRA Bioregions that occur in NSW have been subdivided into 129 sub-regions by the NSW Department of Environment and Conservation (2004). This provides a finer scale breakup of the State

that can be useful in describing the distribution of plant communities. Plant communities may occur in more than one sub-region, therefore multiple entries of sub-regions are possible. A proportion of current extent >70% or 30–70% or 1–30% is attached to each entry;

38. Botanical Division: These divisions of NSW are based on Anderson (1961). They have long been used by botanists and the National Herbarium of NSW to describe plant species distributions. Select one or more of the Botanical Divisions from a lookup table. A proportion of current extent >70% or 30–70% or 1–30% is attached to each entry;

39. Local Government Area (LGA): Select one or more LGAs from lookup table that lists all Local Government Areas in NSW. A proportion of current extent >70% or 30–70% or 1–30% is attached to each entry;

40. Catchment Management Authority areas (CMAs): Select one or more CMA from a lookup table that lists the 13 CMAs in NSW. A proportion of current extent >70% or 30–70% or 1–30% is attached to each entry. The catchment boundaries are those listed in the 2003 revision of the NSW Catchment Management Act. It is likely these boundaries will remain for some time. A majority of natural resource management funding is being directed towards meeting actions and targets set in CMA management plans;

41. Murray-Darling Basin: Tick the field in the database if the community occurs in the Murray- Darling Basin in NSW. Leave field blank if the community does not occur in the MD Basin. The reports state 'yes' or 'no'. This data entry facilitates the report of all communities in the MD Basin;

42. Substrate mass: Select one or more substrate mass types from a lookup table that contains the generic classification of Australian substrate masses from Table 29 in Speight & Isbell (1990);

43. Lithology: Select one or more lithological types from a lookup table that contains a list of lithological type of rock material and unconsolidated material from Table 27 in Speight & Isbell (1990);

44. Great Soil Group: Select one or more Great Soil Groups (GSG) from a lookup table that contains a list of Australian Great Soil Group categories from *The Handbook of Australian Soils* (Stace et al. 1968). Modifications have been made to this classification since it was produced but it is recorded because of its history of application in the field by soil scientists and botanists;

45. Soil texture: Select one or more soil texture classes from a lookup table containing soil texture grades as described in McDonald & Isbell (1990);

46. Landform pattern: Select one or more landform patterns from a lookup table containing the list of landform patterns described in Speight (1990);

47. Landform elements: Select one or more landform elements from a lookup table containing the list of landform elements described in Speight (1990);

48. Land use: Select one or more options from a lookup table containing the terms: grazing, cropping and horticulture, timber production, urban, water storage, nature conservation. The rule for selection is that it is measured or estimated that >10% of the pre-European extent is now used for one or more of these land uses;

49. Impacts of European settlement: Multiple selection from lookup table containing the options:

a. Major reduction (>70%) in extent and /or range
b. Medium reduction (30–70%) in extent and/or range
c. Minor reduction (<30%) in extent and/or range
d. Increased extent/range
e. Dieback due to disease or senescence
f. Older age class over most of distribution
g. Younger age class over most of distribution
h. Major alteration of species composition
i. No significant impacts known

50. Pre-European extent (ha): Record a measured or estimated pre-European extent in hectares of the plant community based on the best available information including mapping, modeling or expert advice;

51. Pre-European accuracy: This applies an accuracy rating to the pre-European extent figure. Select an accuracy level from a lookup table containing the accuracy options of 10%, 30% 50%, 70% or 90% that applies. For example, a 30% accuracy about 1000 ha implies a range of 700 to 1300 ha;

52. Pre-European qualifiers: This gives an indication how the pre-European extent figure was derived with the options being:

- Estimated from extant vegetation maps: full range
- Estimated from extant vegetation maps: part range
- Estimated from pre-European map: full range
- Estimated from pre-European map: part range
- Expert estimate not based on any mapped vegetation
- Modelled from sound plot or polygon data

53. Pre-European comments: Comments on the pre-European extent figure describing any qualifications about the figure;

54. Current extent (ha): Record a measure or estimate for the current extent in hectares of a plant community based on the best available information including mapping, models and expert advice;

55. Current extent accuracy: This applies an accuracy rating to the current extent figure. Select an accuracy level from a lookup table containing the accuracy options of 10%, 30% 50%, 70% or 90% that applies. For example, 10% accuracy about 1000 ha implies a range of 900 to 1100 ha;

56. Current extent qualifiers:

- Measured from map of extant vegetation
- Estimated from mapped extant vegetation: full range
- Estimated from mapped extant vegetation: part range
- Estimated from broadly classified current extant vegetation map
- Estimated from pre-European map: full range
- Estimated from pre-European map: part range
- Expert estimate
- Modelled from sound plot data over unclassified map of extant vegetation

57. Current extent comments: Comments on the current extent figure describing any qualifications about the figure;

58. Percent remaining: The database automatically calculates this percentage by dividing the 'Current extent' (field 54) by the 'Pre-European extent' (field 50);

59. Percent remaining accuracy: This places an accuracy level around the percent remaining statistic. It is derived from the mid-points of the accuracy ranges that are calculated from the pre-European and current extent estimates. The results are a conservative accuracy calculation;

60. Degree of fragmentation: Using mapping data or expert opinion, select one of five options from a lookup table:

- Contiguous stands with high connectivity with >60% extent remaining and low edge to area ratio
- Human induced fragmented stands with 30–60% extent remaining and moderate edge to area ratio
- Human induced highly fragmented small stands with <30% extent remaining and high edge to area ratio
- Naturally fragmented, disjunct stands of variable patch sizes with >50% extent remaining
- Naturally fragmented, disjunct stands of variable patch sizes with <50% extent remaining;

61. Recoverability: Select one of six options from a lookup table by considering the average recoverability of a plant community. These categories range from 1 near pristine to 6 ecosystem totally destroyed (based on McDonald 1996):

1. Healthy, structure and composition intact. Insignificant indicators of degradation. Likely to continue in good health if maintained;

2. Moderate health as structure and/or composition altered. Likely to recover considerably if causal factors and secondary impacts removed;

3. Poor health as structure and/or composition significantly altered. But sufficient biota remain for natural regeneration if causal factors and their secondary impacts removed and dynamic processes reinstated;

4. Very poor health as structure and/or composition severely altered. Insufficient biota remain for natural regeneration except some ruderal species;

5. Nil native vegetation remaining but substrate conditions still suitable (or able to be amended) for pre-existing plant community;

6. Nil native vegetation and substrate conditions no longer suitable (or able to be amended) for pre-existing plant community.

Factors that should be taken into account in ranking recoverability are:

- Degree of fragmentation;
- Regeneration success of a range of plant or animal species;
- Loss of structural complexity in overstorey and understorey due to grazing, logging or other impacts;
- Estimate of relative species richness compared to what it may have been before European settlement;
- Condition of ground litter and lichen crust layer;
- Degree of senescence of vegetation due to age, dieback, salinity or other factors.

In some areas the only native vegetation that remains is in "poor condition". This may have the potential to improve in condition with management. It may also play key roles in maintaining ecological processes such as reducing saline water tables and forming links between remnants in better condition.

An example of vegetation in category 1 would be a Sydney sandstone plant community that is well protected in reserves, contains few weeds and is being managed with appropriate fire regimes to maintain its species richness over time.

An example of vegetation in category 3 would be an inland box woodland plant community that has been extensively cleared and is highly fragmented, contains many weed species, has a depleted floristic composition due to grazing pressures but where regeneration of many species could occur if there were controls over some key threatening processes;

62. Threatening processes: A text description of the most important threatening processes that affect the community;

63. Threatening processes lookup: Select one or more types from a lookup table containing these options:

- Acid soils due to fertilizer use;
- Acid sulphate soil pollution;
- Age class of woody vegetation;
- Clearing for agriculture;
- Clearing for pine plantations;
- Clearing on small lots: hobby farms;
- Climate change;
- Disease and/or dieback (abnormal);
- Dryland cropping;
- Firewood collection;

- Herbicides, pesticides or other chemical pollution;
- Hydrology: disruption of natural flooding regimes;
- Hydrology: drainage;
- Hydrology: impoundment;
- Inappropriate fire regimes;
- Irrigated cropping;
- Major impacts on structure due to logging;
- Mining or quarrying;
- Nutrient changes through fertilizers or runoff;
- Over harvesting or collecting of key species;
- Phytophthora dieback;
- Recreation over-use;
- Salinity;
- Sedimentation;
- Soil erosion, water: gully, tunnel, landslips;
- Soil erosion, water: sheet erosion;
- Soil erosion, wind;
- Unsustainable grazing and trampling by stock;
- Unsustainable grazing by introduced animals;
- Unsustainable grazing by native animals;
- Urban or industrial expansion;
- Weed (exotic) invasion;
- Woody shrub (native) invasion.

64. Variation and natural disturbance: Description of floristic variation in the community and natural disturbances that affect successional stages and species composition;

65. Adjoining communities: Description of communities that adjoin the listed community;

66. Fire regime: Description of known or postulated fire regimes for the appropriate management of the community and comments on the impacts of fire on the community. In most cases appropriate fire regimes are unknown. However, aspects of fire ecology may be documented in the literature. References to the literature should be entered in the Reference field. General guidelines on fire management for broad vegetation classes in NSW is provided in Kenny et al. (2003);

67. Area in conservation reserves (ha): Conservation reserves are defined as areas that meet the World Conservation Union (IUCN) criteria as Protected Area categories I to IV (see http://www.ea.gov.au/parks/iucn.html for the IUCN protected area definitions). In NSW this is interpreted to include reserves managed by the NSW Department of Environment and Conservation (DEC) being National Parks, Nature Reserves, Karst Conservation Areas, State Conservation Reserves, Aboriginal Areas, Historic Sites, Declared Wilderness, Regional Parks and lands purchased by and held by the NSW DEC with the anticipation of them becoming reserves. It also includes all NSW State Forests Flora Reserves. With the exception of the acquired lands, these reserves cannot be revoked without the consent of the NSW Parliament.

All NSW conservation reserves are listed in the Reserves Table in the database that also includes their gazette area and GIS calculated area (these often vary by a small percent for a number of reasons). The NSW DEC reserves are kept up to date through regular GIS editions exchange with the Parks and Wildlife Division of DEC. Alterations to the Reserves Table are made when there are new reserves, amalgamation of reserves or reserves that have name changes. The extent of plant communities in reserves is derived from GIS inquires if there are digitized vegetation maps, the literature or field checks. The literature includes vegetation maps, survey reports or expert knowledge. Most reserves contain more than one plant community, with many containing over 10. After determining that a community occurs in a reserve, its measured or estimated area is entered into the database in the following way: select the reserve name from the table of conservation reserves on the screen, add the extent (hectares), then tag the data entry with an accuracy code M to E4 depending on the reliability of the data. Entering the 'Code Accuracy' key highlights the definitions of the accuracy code tag assigned to each data entry. These are:

M: measured from detailed mapping or ground checking with >90% accuracy;
E1: estimated from mapping or ground checking with 90–70% accuracy;
E2: estimated from mapping or observations with 70– 50% accuracy;
E3: estimated from mapping or reports with 50–30% accuracy;
E4: estimated from poor information with <30% accuracy.

An example of M is where a reserve's vegetation has been plot sampled, classified and mapped in detail at a fine scale. An example of E4 is where no, very coarse or unreliable survey data or vegetation mapping covers a reserve but where anecdotal evidence suggests a community occurs there. Such evidence may include expert opinion or uncorroborated field notes. E1 to E3 range between these extremes. It is up to the data entry person to make a judgement on reliability depending on the quality of information available for the reserve or secure property agreement.

Note: changing areas previously recorded in conservation reserves (and secure property agreements, see below) should only be done by the database administrator. This is done by either pressing the 'clear' key adjacent to the conservation reserves lookup table and re-entering all areas again (after noting them down separately), or by going to the Main Table in the database and manually adjusting several fields associated with the areas recorded. One needs to then return to the Main Details form and press the two sum keys to calculate the new percentages protected.

68. Total area reserved: The database automatically sums the areas protected in all reserves to deliver a total area reserved figure;

69. Number of representations in reserves: The database automatically calculates the number of representations of reserves for each plant community;

70. Explanation of protected areas: A text description of the sources supporting the data entries in the protected area fields (reserves, secure property agreements). This may include references to the literature. Sometimes this may explain why one extent estimate or measurement, for a particular plant community in a protected area, was favoured over another;

71. Area in secure property agreements (ha): The area in hectares protected under secure 'non-reserve' property agreements. These qualify as IUCN protected area category VI (see definitions at http://www.ea.gov.au/parks/iucn.html) and include:

1. Property Agreements entered into under the NSW Native Vegetation Conservation Act 1998 or under the NSW Vegetation Management Act 2003 that are bound to the title of the land, protect native vegetation and are in perpetuity (legally this implies running for 99 years);

2. Conservation Agreements (VCLs) entered into between landholders and the NSW Department of Environment and Conservation (DEC) under the NSW National Parks and Wildlife Act 1974;

3. Long term property agreements entered into under the NSW Nature Conservation Trust Act 2001;

4. Properties owned and appropriately managed for nature conservation by private conservation organizations such as the Australian Bush Heritage Fund or the Australian Wildlife Conservancy.

Short term property agreements or lease conditions under certain NSW Government leasehold land (such as Western Lands Leases) are not considered to meet the IUCN (1994) criteria as secure protected areas

The extent of plant communities in each secure property agreement was calculated by interrogating information on NSW DEC and NSW DNR databases and/or overlaying digitized GIS vegetation maps over the property agreement boundaries. As with data entries for conservation reserves each entry is tagged with a reliability code.

Note. In order to maintain confidentiality, the names of private properties under property agreements are not entered into the database. Rather, the codes used by NSW Department of Natural Resources, NSW DEC or the NSW Nature Conservation Trust are used to identify the agreement. However, place names may be used where property agreements cover public land, such as a cemetery or a roadside reserve;

72. Total area under secure property agreements (ha): The database automatically sums the areas entered for listed property agreements to deliver a total area protected under secure property agreements;

73. Number of representations in secure property agreements: The database automatically calculates the number of representations in secure property agreements for each plant community;

74. Total area protected (ha): The database automatically sums the areas in reserves (field 68) with the areas in secure property agreements (field 72). This yields a sum in hectares of all protected area occurrences for each listed plant community;

75. Total area protected accuracy (ha): A separate key allows for the recording of an accuracy assessment to the total area protected figure. The options are 10%, 30%, 50%, 70%, 90% accuracy;

76. Protected pre-European extent (%): This percentage is calculated automatically in the database by dividing the total area protected (field 74) by the pre-European extent (field 50);

77. Protected current extent (%): This percentage is calculated automatically in the database by dividing the total area protected (field 74) by the current extent (field 54);

78. Total representations in protected areas: The database automatically calculates this by adding the total representations in reserves (field 69) to the total representations in secure property agreements (field 73);

79. Protected area code: Select one of 15 codes provided in tables on screen by using two pieces of information. Firstly, from the 'pre-European extent field' (field 50) determine whether, at the time before European settlement (1750), the community was 'common' (>10 000 ha), 'restricted' (1000–10 000 ha) or 'rare' (<1000 ha). This determines whether to use the codes 'a', 'b' or 'c' below. Apply the percentage calculated in the 'Protected pre-European extent' field (field 76) to select one of 15 options (1a–5a, 1b – 5b or 1c – 5c) from the lookup table in the database. The rarer the community the greater the proportion needs to be protected to achieve a protected area adequacy target. The 'A' for adequate or 'I' for inadequate qualifications are selected to reflect the adequacy of sampling in protected areas of the community across its distribution. The 15 protected area adequacy codes are:

a. Common communities (>10 000 ha in 1750)

* 1a = >25% in protected areas
* 2a = 15–25% in protected areas
* 3a = 5–15% in protected areas
* 4a = 1–5% in protected areas
* 5a = <1% in protected areas

and either

A = adequately represented in protected areas across range
I = inadequately represented in protected areas across range.

b. Restricted communities (>1000 <10 000 ha in 1750)

* 1b = >50% in protected areas
* 2b = 31–50% in protected areas
* 3b = 15–30% in protected areas
* 4b = 5–15% in protected areas
* 5b = <5% in protected areas

and either

A = adequately represented in protected areas across range
I = inadequately represented in protected areas across range.

c. Rare communities (<1000 ha in 1750)

* 1c = >75% in protected areas
* 2c = 50–75% in protected areas
* 3c = 30–50% in protected areas
* 4c = 15–30% in protected areas
* 5c = <15% in protected areas

and either

A = adequately represented in protected areas across range
I = inadequately represented in protected areas across range.

Notes: The Protected Area Code provides only a summary of the protected area status of a community. It is not a threat code – that is provided in Field 81 below. The JANIS (1997) criteria on assessing the protected area status of ecological communities could be applied to the proportion protected compared to pre-European extent. This would imply that a 'moderate' protected area status would only be achieved at percentage protected levels 3a, 3b or 3c in the tables above. However, even if a community is relatively well represented in protected areas, there may be justifiable reasons to protect more sites from disturbance because they may be in sound condition in terms of their floristic composition, structure and degradation indicators. Such patches of vegetation may be important for landscape protection such as mitigating salinity or soil erosion, contain variations in floristic variation or because they contain habitat of a threatened species;

80. Key sites for protection: Text description of documented or predicted areas or sites considered to be important to improve the protection status of a plant community. Often this will be based on expert knowledge or recommendations in botanical survey reports;

81. Threat category: Select one category from a lookup table with the following options:

* X = presumed extinct (totally destroyed);
* CE = critically endangered;
* E = endangered;
* V = vulnerable;
* NT = Near threatened;
* LC = least concern (common and generally well conserved);

These threat categories mirror those applied by the World Conservation Union to species (IUCN 2001). They are defined in Appendix B of this paper and are available to users of the database through the 'Full Details' key adjacent to the Threat Criteria field. The 'Full Details' key raises a MS Word document which contains descriptions of the threat categories and a table listing six threat criteria that are used for ranking each community into one of the threat categories.

82. Threat criteria: Multiple entries of the threat criteria 1–6 are recorded based on the descriptions of these criteria in Appendix B of this paper. The adjacent Full Details key raises the Word file that describes the threat criteria; The threat criteria include: remaining extent relative to estimated pre-European extent thresholds; original rarity; rate of decline of extent; loss of key species; relative condition; and, if analysis is available, predicted loss of area and condition. The user needs to read the threat criteria before applying a threat category to community;

83. Threat/protected area adequacy code: This is a summary code of the threat and reservation status of each community that is automatically generated by combining the 'Threat category' field (field 81) with the 'Protected area adequacy' field (field 79). For example, a threat/protected area code of E/5a implies the community is Endangered and <1% of its pre-European extent is in protected areas and that it covered >10 000 ha in pre-European times. A LC/3b implies a community is of Least Concern in terms of threats, 15–30% of its pre-European extent is in protected areas and it was a 'Restricted' community that occupied 1000–10 000 ha in pre-European times. Once a user of the database is familiar with the 'Threat status' and 'Protected area adequacy' codes, the combined 'threat/protected area adequacy' code yields a summary about the status of a plant community;

84. Planning controls: The database contains keys for the NSW State Environmental Planning Policies SEPP 26 (littoral rainforest) and SEPP 14 (coastal wetlands). Additions could be made to this list;

85. Planning and management: Descriptive text field wherein planning regulations and management issues are discussed relating to the conservation of the plant community. This is the appropriate field in the database to discuss whether Catchment Management Plans or Local Environmental Plans are affording protection to the listed plant community. A general discussion on management of the plant community can also be inserted here;

86. Listed under legislation: Select one or more options from a lookup table if the community is listed, preliminary listed or nominated for listing as a threatened community under the Australian Government's Environmental Protection and Biodiversity Conservation Act (EPBC

Act 1999) or the New South Wales Threatened Species Conservation Act (TSC Act 1995);

87. Recovery plan: If a recovery plan exists for a plant community this is recorded by selecting the 'yes' key. An 'Add Plan' key is highlighted and pressing this highlights the Reference field (field 24) where the title of the recovery plan can be entered and saved to the Reference Table. The reference is automatically copied to the reference list that appears at the end of each record.

88. Recovery plan status: Select from a lookup list of options: 'exists', 'in preparation', 'not required', 'required'. If a plant community is critically endangered or endangered it is considered that a recovery plan should be required to be prepared to focus attention on it.

89. Photograph fields: Up to three images of each plant community can be accessed via the three keys View Photo 1, View Photo 2 and View Photo 3 situated at the top of the Main Details form in the database. MS Access functions poorly when images are embedded in it. To overcome this problem a file titled 'Images' has been established in parallel with the database. Where photography is available, up to three photographs are scanned for each plant community. Each image is labeled in the field titled 'Photo file name'. The labels of each image reflect the origin of that image in a master catalogue of images and information on each image held at the Botanic Gardens Trust. This allows the original digital photo or colour slide to be traced if necessary. For example, ID71a_img343pc.jpg is the label in Photo 1 of the community ID71 Carbeen woodland. The 'img343' section of this label indicates the original photograph was a colour slide that was scanned as number 343 scan. Most jpg images have been derived from high resolution TIFF images for use in publications. A caption is provided for each image linked to the database. The 'Photo caption' fields contain the captions for each image. This caption contains the vegetation community number, main species, location, latitude/longitude if known, date of photograph and photographers name. Some plant community records may not have photos, or less than three. If a photo button is selected and there is no photo linked to it a message appears stating 'there isn't a (first, second or third) photo attached to this record';

90. References: This last field contains the full text of all the references that have been entered via the Reference field (field 24).

Software limitations

Exporting from MS Access to MS Excel results in the truncation of fields with more than 255 characters displayed in the Excel cells, however the data is actually there and can be retrieved. It is best to use MS Excel to import the Main Table from the MS Access database rather than export to Excel. Importing from MS Excel imports all data.

The best means of exporting records generated in the PDF Reports is to use the PDF995 writer software supplied. These PDF reports can be searched but unless you have access to pdf editing sotware, the document can not be edited and copied. If the PDF document is not correctly formatted and produces an extra page at the end of each record, try changing the PDF995 page size by going to Printers in Control Panel or Printers and Faxes in Start/Settings and select the 'PDF995' printer driver. Select Printer/Properties/ Printing Preferences…/Advanced… and change Paper Size: to A4 and select OK.

The MS Word reports are accessed through the 'Word Reports' option on the Administration Menu. This report option does **not** automatically include images. Images have to be manually transferred into documents from the Images folder. Also, there is a software limitation to MS Word reports. Records larger than about 17,000 characters fail to report in the 'Word Reports' due to limitations in the size of document that MS Word can merge. This applies to long records when selecting 'yes' to list full references. If the database is loaded into any directory other than either the C:\vegclass or D: \vegclass directories, some references will be truncated to keep the reports below the MS Word merge limit and a comment 'References Truncated' is printed at the end of each record. Due to a bug in Microsoft Service Pack 3, PCs using this Service Pack will need to load the database into either the C:\vegclass or D: \vegclass directories, otherwise the Word Reports will fail to operate. Therefore, Microsoft Service Pack 3 users using the 'Word Reports' will only be able to report the first 2,500 Reference characters when generating any of the full reports that include full references.

Italic font: While it is possible to apply italic font to all text in a field in MS Access (e.g. to the characteristic species fields), it is not possible to mix italic and standard fonts in fields where both are required (e.g. the Vegetation Description field that includes scientific names). Therefore, the scientific names of plants are not italicized in the Reports from the database for some fields.

Read only version of NSWVCA

To ensure that different users do not change the data, tables, forms, reports or the programming in the database, most issued CD copies of the database will be a 'read only' version. This allows the user to view all of the plant community records in the data entry screen, use the report options and use the search module, but it restricts access to the database's 'backend', preventing the use of the query mode to generate queries involving combinations of fields. Full versions of the database that allow access to the query mode will be issued by the Botanic Gardens Trust, Sydney under license conditions and for a fee (see Botanic Gardens Trust web site for details www.rbgsyd.gov.au). Over the longer term, the database may be placed on the internet in such a configuration that users will be able to use the query mode. Any changes that users of

the vegetation classification and the database consider should be made should be submitted to the Database Administrator using the *Feedback.doc* proforma that is accessed from the top of the data entry screen in the database or from the file *feedback.doc* that is one of the files that comprises the NSWVCA database system.

References to NSWVCA Database Descriptions

Anderson, M., P. Bourgeron, M. T. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K. Goodin, D. H. Grossman, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, L. Sneddon & Weakley, A.S. (1998) International classification of ecological communities: terrestrial vegetation of the United States. Volume II. The National Vegetation Classification System: list of types (The Nature Conservancy: Arlington, Virginia, USA).

Anderson, R.H. (1961) Introduction. Flora series Nos. 1–18: 1–16. *Contributions from the New South Wales National Herbarium* (Royal Botanic Gardens: Sydney).

Beadle, N.C.W. & Costin, A.B. (1952) Ecological classification and nomenclature. *Proceedings of the Linnean Society of New South Wales* 67: 61–82.

Braun-Blanquet, J. (1932) (Translated, revised and edited by Fuller, G.D. & Conrad, H.S. in 1983) *Plant sociology: the study of plant communities* (Koeltz Scientific Books: Germany).

Executive Steering Committee for Australian Vegetation Information (ESCAVI) (2003). *Australian vegetation attribute manual: national vegetation information system, version 6.0* (Department of the Environment and Heritage, Canberra, URL: http://www.deh.gov.au/erin/nvis/avam/index.html).

Forestry Commission of New South Wales (1989) Forest types in New South Wales. Research Note 17 (Forestry Commission of New South Wales: Pennant Hills).

Grossman, D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, & L. Sneddon (1998) International classification of ecological communities: terrestrial vegetation of the United States. Volume I. The National Vegetation Classification System: development, status, and applications (The Nature Conservancy: Arlington, Virginia, USA).

IUCN (The World Conservation Union) (2001) *IUCN red list categories*: Version 3.1 Prepared by the IUCN Species Survival Commission (IUCN: Gland, Switzerland and Cambridge, UK).

JANIS (Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-committee) (1997). Nationally agreed criteria for the establishment of a comprehensive, adequate and representative reserve system for forests in Australia (Commonwealth of Australia: Canberra).

Keith, D.A. (2004) *From ocean shores to desert dunes: the vegetation of New South Wales and the ACT* (Department of Environment and Conservation: Hurstville).

Kenny, B., Sutherland, E., Tasker, E. & Bradstock, R. (2003) Guidelines for ecologically sustainable fire management. Project 43.1 NSW Biodiversity Strategy (NSW National Parks and Wildlife Service: Hurstville).

McDonald, M. C. (1996) Ecosystem resilience and the restoration of damaged plant communities: A discussion focusing on Australian case studies. Ph.D. Dissertation (University of Western Sydney).

McDonald, R.C. & Isbell, R.F. (1990) Soil Profile. In McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. & Hopkins, M.S. *Australian soil and land survey: field handbook*. 2nd edition (Inkata Press: Melbourne).

Mitchell, P.B. (2002) NSW Ecosystems study: background and methodology. Report 13.7 NSW Biodiversity Strategy (Department of Environment and Conservation NSW: Sydney).

National Land and Water Resources Audit (2001) The Native Vegetation Classification System (NLWRA, Vegetation Theme: Canberra).

Department of Environment and Conservation NSW (2004) IBRA sub-regions. Unpublished GIS map (NSW DEC: Sydney).

Sattler, P.S. & Williams, R.D. (1999) (eds.) *The conservation status of Queensland's bioregional ecosystems* (Department of Environment and Heritage: Brisbane).

Speight, J.G. (1990) Landform. In McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. & Hopkins, M.S. *Australian soil and land survey: field handbook*. 2nd edition (Inkata Press: Melbourne).

Speight, J.G. & Isbell, R.F. (1990) Substrate. In McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. & Hopkins, M.S. *Australian soil and land survey: field handbook*. 2nd edition (Inkata Press: Melbourne).

Stace, H.C.T., Hubble, G.D., Brewer, R., Northcote, K.H., Sleeman, J.R., Mulcachy, M.J. & Hallsworth, E.G. (1968) *A handbook of Australian soils*. (Rellim Technical Publications, Glenside: South Australia).

Thackway, R. & Cresswell, I.D. (eds.) (1995) *An interim biogeographic regionalisation for Australia*. Version 6.0 (Australian Nature Conservation Agency: Canberra).

Walker, J. & Hopkins, M.S. (1990) Vegetation. In R.C., Isbell, R.F., Speight, J.G., Walker, J. & Hopkins, M.S. *Australian soil and land survey: field handbook*. 2nd edition (Inkata Press: Melbourne).

Webb, L.J. (1968) Environmental relationships of the structural types of Australian rain forest vegetation. *Ecology* 49: 296–311.

Appendix B. Threat Categories and Threat Criteria Guidelines for Assessing the Threat Status of Plant Communities in NSW

The NSW Threatened Species Conservation Act 1995 (TSC Act 1995) and the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act 1999) are able to list ecological communities as critically endangered, endangered or vulnerable.

Comprehensive threat categories and threat criteria guidelines have been developed to assess the status of ecological (particularly plant) communities. They are similar to the EPBC Act 1999 regulations 7.06 2c and 7.02 and associated guidelines for nominating ecological communities. However, two threat categories, Near Threatened and Least Concern, have been added to the Critically Endangered, Endangered and Vulnerable categories used in the EPBC and TSC Acts. This five category system reflects the threat categories used for species in IUCN (2001). Besides EPBC 1999 guidelines, the main sources used in developing these threat criteria were IUCN (2001); the criteria used to assess the status of Queensland ecosystems (Sattler & Williams 1999); and the criteria used to assess the status of the Ecological Vegetation Classes of Victoria (Victorian Department of Natural Resources 2001). The remaining extent thresholds in criterion 1 are based on the habitat reduction and fragmentation thresholds at which there is an apparent acceleration of species extinction as described in fragmentation theory (Andren 1994, Simberloff 1992, Fahrig 1997, With 1997). Much of this theory is based on declines of vertebrate species.

These criteria are designed to apply to plant communities and may not be transferable to mobile fauna assemblages. Criterion 4 deals with intactness of ecological integrity that is often labelled 'condition'. In many cases, this is difficult to judge due to the problem of establishing a pre-major disturbance (i.e. in Australia pre-European) benchmark for species assemblage, vegetation structure and edaphic factors for each classified ecological community.

The threat categories are defined in Section A. The criteria for each threat category are listed in the table in Section B. A description of the criteria and of the terms used in them is given in Section C.

Section A: Threat Categories

*** Presumed extinct (X)**

An ecological community is eligible to be included in the **presumed extinct** category if it has been totally destroyed, or so modified throughout its range, that it is unlikely to recover its species composition and/or structure in the *very long term.*

*** Critically Endangered (CE)**

An ecological community is eligible to be included in the **critically endangered** category, at a particular time if, at that time, it is facing a high risk of becoming extinct in the *immediate term*, as determined in accordance with the prescribed criteria.

*** Endangered (E)**

An ecological community is eligible to be included in the **endangered** category at a particular time if, at that time:

(a) it is not critically endangered; and

(b) it is facing a very high risk of becoming extinct in the *near term*, as determined in accordance with the prescribed criteria.

*** Vulnerable (V)**

An ecological community is eligible to be included in the **vulnerable** category at a particular time if, at that time:

(a) it is not critically endangered or endangered; and

(b) it is facing a high risk of becoming endangered in the *medium-term*, as determined in accordance with the prescribed criteria.

*** Near Threatened (NT)**

An ecological community is eligible to be included in the **Near Threatened** category at a particular time if, at that time:

(a) it is not critically endangered, endangered or vulnerable; and

(b) it is facing a high risk of becoming vulnerable in the *long-term* future, as determined in accordance with the prescribed criteria.

*** Least Concern (LC)**

An ecological community is eligible to be included in the **Least Concern** category at a particular time if, at that time:

(a) it is not critically endangered, endangered, vulnerable or of least concern; and

(b) it is **NOT** facing a high risk of becoming vulnerable in the *very long-term* future, as determined in accordance with the prescribed criteria.

Section B: Criteria for Assessing Status of Ecological Communities

The relevant consideration for a particular ecological community is whether any one criterion is met, not whether more than one or all criteria are met.

The definitions of terms provided in Section C should be used to assist with interpreting the criteria.

No.	**Criterion**	**Threat Category And Definitions**				
	Presumed Extinct	**Critically Endangered**	**Endangered**	**Vulnerable**	**Near Threatened**	**Least Concern**
1 Its decline in *geographical distribution* is:	**Total :** 100% decline in decline geographical distribution	**Very severe:** >90% decline in geographical distribution	**Severe:** 70–90% decline in geographical distribution	**Substantial:** 50–70% decline in geographical	**Moderate:** 30–50% decline in geographical distribution	**Minor:** less than 30% in geographical distribution
2 Its *area of occupancy* is:	**Eliminated:** totally destroyed from original area of occupancy.	**Very restricted:** total area of occupancy of < 1000 ha and significant degradation or destruction is continuing.	**Restricted:** total area of occupancy of 1000–10 000 ha and significant degradation or destruction is continuing**.**	**Limited:** total area of occupancy of 10 000–50 000 ha and significant degradation or destruction is continuing.	**Common:** total area of occupancy of 50 000–500 000 ha and only minor degradation or destruction is occurring.	**Widespread:** total area of occupancy of >500 000 ha and no significant degradation or destruction is occurring.
And the combination of depletion, degradation and continued threaten ing processes makes it likely that it could be lost in the:	NA (already lost) -	immediate term	Near term	medium term	long term	very long term
3 For a population of a native species that is likely to play a major role in the community, there is on a regional basis a:	**Total decline:** demonstrated or estimated a total loss of the key species, with no re-generation occurring, and that the natural recovery of the species is unlikely to occur. Artificial revegetation is the only means of re-establishing the species.	**Very severe decline:** demon strated or estimated a decline of >90% in the pre-European abundance of key species and no or very little recruitment is occurring, and recovery is unlikely over the *very long-term* unless the threatening processes are	**Severe decline:** demonstrated or estimated a decline of 70–90% of the pre-European abundance of key species, and little recruitment is occurring and that natural recovery is unlikely over the *long-term* unless the threatening eliminated.	**Substantial decline:** demonstrated or estimated a decline of 50–70% of the pre-European abundance of key species, and little recruitment is occurring and that natural recovery is likely over the *medium term* unless the threatening processes are substantially reduced or eliminated.	**Minor decline:** demonstrated or estimated a decline of 30–50% of the pre-European abundance of key species, and moderate recruitment is occurring and natural recovery is likely over the *near term* if the threatening processes are reduced. processes are reduced.	**Insignificant decline:** demonstrated or estimated a decline of <30% of the pre-European abundance of key species, and vigorous recruitment is occurring and there is no apparent threat of major decline in the key species or the community.

No.	Criterion	Threat Category And Definitions				
	Presumed Extinct	**Critically Endangered**	**Endangered**	**Vulnerable**	**Near Threatened**	**Least Concern**
4 The reduction in its integrity (condition and recoverability) across most of its *geographic distribution*, as indicated by loss of species and/or habitat structure, degradation of soils, changes in nutrient levels, or disruption of important community processes is:	**Destroyed:** integrity totally lost, community structure destroyed, a few species may survive as isolated individuals.	**Very severe:** many species extinct at most occurrences; major structural change including loss of some strata; edaphic processes severely degraded, exotic species abundant. *Regeneration* of substantial areas unlikely within the *long term* without the control of threatening processes.	**Severe:** many species extinct at some occurrences; structural change including loss or near loss of some strata; edaphic processes degraded, exotic species common. *Regeneration* of substantial areas is unlikely within the *medium term* without the control of threatening processes.	**Serious:** some species extinct from some occurrences; moderate structural change but most strata remain; edaphic processes often degradation, exotic species common. *Regeneration* is unlikely within the *near term* without the control of threatening processes.	**Minor:** few species extinct over its distribution; minor structural change with most of the strata remaining; edaphic processes near normal, exotic species uncommon and if present are not threatening the community. *Regeneration* of disturbed areas is likely within the *near term* with the control of threatening processes.	**Insignificant:** very few species extinct over its distribution; no or minor structural changes to strata and all of the original strata remain; edaphic processes functioning well, exotic species mostly absent or if present not a threat to the community. *Regeneration* not necessary as most of the community is relatively intact.
5 Its rate of continuing detrimental change is: As indicated by: (a) a rate of continuing decline in its *geographic distribution*, or populations of a native species that are believed to play a major role in the community, or (b) intensification, across most of its *geographic distribution*, of degradation, leading to disruption of important ecological processes.	**Destroyed:** rate of decline not applicable as the community is totally destroyed and not able to naturally regenerate.	**Very rapid:** an observed, estimated, inferred or suspected detrimental change of at least 30% projected in the *immediate term.*	**Rapid:** an observed, estimated, inferred or suspected detrimental change of at least 30% projected in the *near term.*	**Moderate:** an observed, estimated, inferred or suspected detrimental change of at least 30% projected in the *medium term.*	**Slow:** an observed, estimated, inferred or suspected detrimental change of at least 30% projected in the *long term.*	**No change or improvement:** an observed, estimated, inferred or suspected detrimental change of less than 10% projected for the *very long term* or improvement in condition.
6 A quantitative analysis shows that its probability of extinction, or extreme degradation over all of its *geographic distribution*, is:	100% already extinct	at least 50% in the *immediate term*	at least 50% in the *near term*	at least 50% in the *medium term*	at least 30% in the *long term*	less than 10% in the *very long term*

Section C: Definitions of Terms

C1. Definitions of time scales used in threat criteria 2, 3, 5 and 6

- **Immediate term**: the next 10 years, or 3 generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 60 years.
- **Near term:** the next 20 years, or 5 generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 100 years.
- **Medium-term**: the next 50 years, or within 10 generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 200 years.
- **Long-term**: the next 100 years, or within 20 generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 400 years.
- **Very long term**: the next 200 years, or within 40 generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 800 years.

Generation length is set at 20 years. This covers the time it takes for most long-living species (including plants such as *Eucalyptus* or *Acacias*) to reach reproductive maturity and reproduce. Re-sprouting plant species are not taken into account in defining generation length.

C2. Definitions of 'geographic distribution' including 'extent of occurrence' and 'area of occupancy' used in criteria 1, 2, 4 and 5

Geographic distribution of an ecological community can be considered as a combination of *extent of occurrence* and *area of occupancy* in the sense defined in the IUCN (2001) red list criteria for species.

Extent of occurrence (sometimes called range) is the total area contained within the shortest continuous boundary that can be drawn to encompass all the areas where the ecological community occurs.

Area of occupancy is defined as the area within its *extent of occurrence* that is actually occupied by the community. The distinction reflects the fact that a community will not usually occur throughout its extent of occurrence, which may, for example, contain areas of unsuitable habitats. *Area of occupancy* is the more precise measure, but the size of the area of occupancy is a function of the scale at which it is measured, which should be relevant to the attributes of the particular community being considered. Ecological communities have a range of patch size that reflects the nature of the habitat and is relevant to their assessment

For assessing a community's change in *geographic distribution,* it is important to demonstrate the decline to its current state from a defined former state, usually set at 1750 (onset of the Industrial Revolution and prior to European settlement of Australia).

Where possible, a measurable contraction in distribution should be demonstrated by an appropriate scale of mapping. Where it is not possible to provide precise spatial information on the distribution of an ecological community, particularly at the map scale available, other supporting evidence demonstrating a contraction in distribution is considered. This includes expert opinion.

C3. Descriptions of threat criteria

Criterion 1: Decline in geographical distribution

This criterion deals with the degree to which a community has lost its *geographical distribution* (*area of occupancy* and *extent of occurrence*) compared to pre-European times.

Criterion 2: Area of occupancy coupled with demonstrable threat

This criterion deals with *areas of occupancy* coupled with degree of degradation or destruction. Communities with small areas of occupancy that are also declining are likely to be threatened (CE, E or V).

Criterion 3: Decline in functionally important species

This criterion refers to native species that are critically important in the processes that sustain or play a major role in the ecological community, and whose removal has potential to precipitate change in community structure or function sufficient to lead to the community's eventual extinction. Examples of species that are functionally important in some ecological communities include:

- dominant species that play a major role in controlling light or other aspects of the micro-climate. Examples may include a dominant canopy tree or shrub, or a species of seagrass.
- a species that is the principle source of nutrition or host for reproduction of other species in a community.

The risk of loss of such species from the community should be assessed against the IUCN (2001) Red List Species Criteria and be applied at a regional scale commensurate with the distribution of the ecological community. For example, if a critically important species to an ecological community is assessed as being endangered using the IUCN (2001) criteria (within the region in which the community occurs), this may lead to an assessment of the whole ecological community as being endangered. Such a decision would have to be weighed up against the other threat criteria.

It is not expected that this criterion will be used as often as criteria 1, 2, 4 and 5.

Criterion 4: Reduction in community integrity: condition and recoverability ***(threat category in brackets)***

This criterion recognises that an ecological community can be threatened through on-going modifications that do not necessarily lead to total destruction (eg clearing) of all elements of the community. It is intended to capture detrimental changes in species composition and abundance and the state of the abiotic environment that supports them. It includes irretrievable loss of native species and invasion by non-native species, as well as changes in the physical environment sufficient to lead to ongoing change in biota.

This criterion also recognises that ecological processes are important to maintain an ecological community (eg fire regimes or flooding) and that disruption to those processes can lead to the decline of the ecological community. This criterion could apply where disruption of processes is evident or imminent (eg altered hydrology leading to rising water tables and/or dryland salinity) prior to a measurable decline in the ecological community. It could also apply where recruitment of species to the community is known to be disrupted but where long lived species mask immediate community breakdown (eg when seedlings of a dominant tree species are not able to persist in the face of grazing by exotic herbivores). Such a criterion allows for recognition of a problem at an early stage.

Regeneration is defined as the re-establishment of ecological processes, species composition and community structure within the range of variability exhibited by the original community; and the *indicative time frames* associated with extinction risk are defined above.

In order apply this criterion, expert opinion should be sought to judge the condition and recoverability of communities over their distribution.

Criterion 5: Rate of continuing detrimental change

A continuing change refers to a recent, current or projected future change whose causes are either not known or not adequately controlled, and so is liable to continue unless remedial measures are taken. Natural fluctuations will not normally count as a continuing change, but an observed change should not be considered to be part of a natural fluctuation unless there is evidence for this.

This criterion contains two alternative expressions of the indication of rate of detrimental change: (a) reductions of geographic distribution or populations of critically important species and (b) degradation or disruption of important ecological processes.

The rate of continuing detrimental change occurring in a community is relevant to its risk of extinction independently of any pre-European data. It is difficult to quantify because detrimental change can be manifest in many different ways and adequate data for monitoring change may not be available. 'Ecological judgement' will need to be applied to these criteria.

Criterion 6: Quantitative analysis showing probability of extinction

The probabilities for each threat category are presented in the table in Section B above.

This criterion is intended to include any form of analysis that estimates the extinction probability of an ecological community based on known characteristics of important species or other components, habitat requirements, ecological processes, threats and any specified management options. This is an emerging area of science and will require acceptable modelling based on sound data.

Population Viability Analysis (PVA) is an example of such a technique appropriate for species, but no formal equivalent has been developed for ecological communities. Regardless of their form, quantitative analyses should make full use of all relevant available data. In a situation in which there is limited information, such data as are available can be used to provide an estimate of extinction risk (for example, estimating the impact of stochastic events on habitat). In presenting the results of quantitative analyses, the assumptions (which must be explicitly stated) and the data used must be documented.

References to Appendix B

Andren, H. (1994) Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat. *Oikos* 71: 355–366.

Environment Protection and Biodiversity Conservation Act 1999 regulations 7.06 2c and 7.02 (Commonwealth of Australia: Canberra).

Fahrig, L. (1997) Relative effects of habitat loss and fragmentation on population extinction. *Journal of Wildlife Management* 61(3): 606–610.

IUCN (2001) *IUCN Red List Categories: Version 3.1*. Prepared by the IUCN Species Survival Commission (IUCN: Gland, Switzerland and Cambridge, UK).

Sattler, P. & Williams R. (eds.) (1999) *The conservation status of Queensland's bioregional ecosystems* (Environmental Protection Agency: Queensland).

Simberloff, D. (1992) Do species-area curves predict extinction in fragmented forest? Pp 75–89 in T.C. Whitmore & J.A. Sayer (eds.) *Tropical deforestation and species extinction* (Chapman and Hall: London).

Victorian Department of Natural Resources (2001) Conservation status of Ecological Vegetation Classes (EVCs) at bioregional level. Unpublished (Victorian Department of Natural Resources: Melbourne).

With, K.A. (1997) The application of neutral landscapes models in conservation biology. *Conservation Biology* 11: 1069–1080.