Native Vegetation Advisory Council

SETTING THE SCENE
THE NATIVE VEGETATION
OF NEW SOUTH WALES

A background paper of the

Native Vegetation Advisory Council

of New South Wales.

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Native Vegetation Advisory Council NSW

Role of the Native Vegetation Advisory Council

The Native Vegetation Advisory Council (NVAC) was established in 1998 by the Native Vegetation Conservation Act to take a proactive role in advising the New South Wales government on native vegetation issues throughout the state. NVAC's role is to foster relationships between community groups, landholders and government agencies; develop initiatives in native vegetation management; promote the benefits of native vegetation; provide direction and leadership in native vegetation management; and create incentives and co-ordinate funding opportunities for native vegetation conservation. The membership of NVAC represents a wide range of interests and includes rural representatives, conservation groups and government agencies.

One of the key tasks of NVAC is to develop and advise the Minister for Land and Water Conservation on a Native Vegetation Conservation Strategy for New South Wales. This paper is one of a series of background papers to be published by NVAC. These seek to stimulate discussion regarding native vegetation conservation and management and in particular to inform the development of the Native Vegetation Conservation Strategy for New South Wales.

CONTENTS

SUMMARY

This paper provides an overview of the status of native vegetation in New South Wales and comments on the type and quality of information on it. A discussion on pre-European and current native vegetation is followed by descriptions of the vegetation in each of the 17 Interim Biogeographic Regionalisation of Australia Bioregions that occur in NSW. Statistics on clearing and conservation in each Bioregion are provided along with listings of threatened broad vegetation types and proposed management activities. The bioregions with the highest degree of clearing and largest number of threatened plant communities tend to be those on the western slopes, western plains of the Central Division, and flatter parts of the tablelands. The NSW South-eastern Slopes Bioregion has been cleared more than any other bioregion with 85% of its native vegetation having been removed.

The state of mapping and survey of the vegetation of NSW is summarised. Although, a significant amount of survey and mapping has been done (and some at the highest standards), NSW lacks a standardised vegetation mapping program. This contrasts with programs in other States in Australia. Major gaps in data are identified and four standards of mapping and survey are described. The aim of future survey should be to meet high quality standards to fulfil the needs of local and regional vegetation planning. Duplication of mapping should be avoided. This can be assured by a thorough gap analysis using the Australian and New Zealand Land Information Council dataset linked to a map of NSW. This should be made accessible to all interested parties. Guidelines for vegetation survey need to be prepared to ensure that government, consultants and community groups maintain standards.

The impacts of clearing, over-grazing and weed invasion on the vegetation are summarised. Clearing has decreased significantly since the 1980s but broad-scale clearing is still occurring in regions suitable for cropping. This has implications for biodiverstiy conservation, catchment management and national and state greenhouse emission targets. Environmental weeds, such as Bitou Bush along the coast and Salvinia in wetlands, threaten ecological communities and native species. A table of the worst environmental weeds in NSW is provided. While much of Australia's flora has adaptations that allow it to survive burning, different plant communities require different fire regimes. There is no universal fire regime that should be applied to all bushland. A major consequence of clearing and overgrazing has been the loss of fauna habitat. Many species of animals have become extinct or are on the verge of extinction - particularly in western NSW.

Land tenure is important in protecting vegetation. A high proportion of the native vegetation in NSW occurs on Crown leasehold leases in eastern NSW and western lands leases in the Western Division. While the 6.2% of NSW that is dedicated as conservation reserves provides a backbone for conservation, a key challenge in protecting native vegetation lies with protecting and managing remnants on private land in agricultural regions. This will require the implementation of well-researched regional vegetation management plans, property incentive schemes and the judicious use of regulation. The Native Vegetation Management Fund, established under the Native Vegetation Conservation Act, is a positive initiative for private land conservation.

INTRODUCTION

There is growing interest in the conservation and management of native vegetation in Australia because of its long-term value for agricultural production and its importance for the conservation of native species and their habitats. This paper provides an overview of the status of native vegetation in New South Wales and provides a context for improved planning for vegetation management. Other background papers to be produced by the Native Vegetation Advisory Council (NVAC) will deal with economic, social and cultural benefits of native vegetation and natural ecosystems.

Over the last few centuries, but particularly this century, human dominance of the world's ecosystems has resulted in arguably the greatest rate of extinction of species since the meteor impact that ended the reign of the dinosaurs 65 million years ago (Wilson 1988, Kerr 1991). The current human-induced extinction episode may be worse because it is causing the extinction of more plant species than previous catastrophic events (Knoll 1984). Also, rates of extinction are likely to increase if current rates of habitat destruction continue.

Presently, 20% of the world's vascular plant species are rare or threatened. This is indicative of the decline in the world's biota as a whole that led to the establishment of the World Biodiversity Convention in 1992, to which Australia is a signatory.

Clearing, alteration and fragmentation of habitat leads to a decline in populations of native species and ultimately may result in extinctions. In June 1998, the Australian and New Zealand Environment Conservation Council, which is composed of State and Commonwealth government environment ministers, resolved that *native vegetation clearance and decline is a major threat to the conservation of Australia's biological diversity and was an issue of national importance.*

When over 80% of the landscape is cleared over 30% of biodiversity may be lost (Simberloff 1992). This loss of species increases over the longer term, due to competition with invasions of exotic species, difficulties in dispersing to distant remnants and genetic inbreeding. Currently, only about 30% of pre-European native vegetation cover remains in the more intensively farmed landscapes of NSW including the cropping zone of the Central Division and grazing/cropping areas of the tablelands and coastal valleys (author's estimate). In these regions the largest vegetation remnants often survive on non-arable soils on stony ridges. These contain a different suite of species than remnants in the predominantly cleared alluvial valleys.

About one quarter of the native mammal species present in New South Wales in 1788 are now extinct (NSW State of the Environment Report 1997). Medium-sized mammals that once lived in inland NSW have been most affected (National Parks and Wildlife Service 1984). The main causes have been the clearing of over 50% of forests and woodlands (Wells *et al.* 1984, Graetz *et al*. 1995), predation by introduced foxes and cats, and competition for food from stock and rabbits. Many woodland bird species in the wheatbelts of southern Australia are on the brink of extinction due to loss of habitat through clearing, cropping and over-grazing (Recher and Lim 1990). Over 700 of the 5300 native plant taxa in NSW are listed as either threatened or rare (Briggs and Leigh 1995). Numerous plant communities are also threatened, mainly due to over-clearing, over-grazing or weed invasion (Benson 1989, 1991).

The actual loss of species is difficult to estimate as new species are being discovered and described regularly - this includes vascular plant species in NSW. Taxonomy of the lower plants and invertebrate animals is lagging behind that of vascular plants and vertebrate animals. For example, only 5% of the minimum 250 000 species in the Fungi Kingdom estimated to occur in Australia are described (T. May Melbourne Herbarium pers. comm.), yet fungi play a critical role in the function of all ecosystems and most plant species.

In addition to loss of species and habitats, large tracts of Australia's agricultural zone are degraded due to soil erosion, land salinisation and acidification. Rising saline water tables threaten over five million hectares of NSW (Bradd & Gates 1995, Walker *et al.* 1998). It has been estimated that up to 50% of the upland regions of the Murray-Darling Basin may need to be re-vegetated to counter salinisation (Walker *et al.* 1998).

Ecological communities are not static. Over thousands of years, species evolve and ecological communities change in response to changes in the environment. Over shorter time frames, natural disturbances, such as fire, may drastically alter the species composition at a site. However, given the current imbalances caused by the dominance of human beings, a principal objective of conservation should be to *"minimise modern human impacts that impinge upon the system from without, and to keep Nature's options open"* (Lawton 1997). To achieve this, the Commonwealth, State and Territory Governments of Australia have enacted a range of laws to protect species, habitats and soil aimed at achieving ecologically sustainable management of the landscape. The Native Vegetation Conservation Act 1997 (NVCA) is one such law. It aims to improve the quantity and quality of native vegetation in New South Wales, assist with sustainable management of vegetation and control inappropriate vegetation clearing.

VEGETATION OF NSW - PAST AND PRESENT

Pre-European vegetation

As Australia drifted northwards into the lower latitudes over the last 50 million years, the continent's original mesic (moisture loving) vegetation became more sclerophyllous (hard-leaved). This adaptation is partly a response to a progressive leaching of nutrients from ancient soils (Beadle 1966) that have had little renewal from volcanic or glacial activity for over two hundred million years (White 1997). Adaptations to aridity, drought, low nutrient soils and herbivory also assisted many plant species to survive in a more fire-prone environment.

When the British settled in Sydney in 1788 they were preoccupied with establishing a penal colony and survival rather than studying vegetation. Early botanists such as Robert Brown and Alan Cunningham collected many specimens of plant species that formed the basis for later collections and taxonomic descriptions. However, there was no scientific assessment of the vegetation, nor was there any systematic recording of the way Aboriginal people interacted with or burnt different vegetation types. Journal entries of early explorers such as Oxley, Leichhardt and Lhotski give some insight about the vegetation in parts of NSW before Europeans had inflicted change. Their descriptions of the flora and structure of the vegetation largely corresponds to present day vegetation where this remains relatively intact (Benson and Redpath 1997). However, in areas that have been cleared, trampled and heavily grazed the vegetation has changed substantially. Native or introduced pastures or patches of even-aged regrowth have replaced stands of mixed-aged trees. Stock grazing, altered fire regimes and invasion of weed species have changed the composition and structure of the understorey in most forest and woodland remnants in agricultural regions. The "Australian Felix", so described by Surveyor General Thomas Mitchell in 1848, has largely disappeared from the landscape. The understorey of these grassy woodlands of inland NSW were composed of tall perennial native grasses growing with a large variety of native wildflowers and shrubs (yams, peas, daisies and wattles), but these have now mostly been replaced by exotic pastures and annual weeds.

Woodlands with a grassy and herbaceous understorey dominated only parts of southeastern Australia. However, some authors (for example Ryan *et al.*1995), postulate that this type of vegetation covered most of the landscape and that there has been a thick regrowth of the bush since the cessation of annual burning by Aborigines. These views require qualification and are not supported by historical accounts or scientific research of the biology of plant species (Benson and Redpath 1997). Prior to European settlement, like today, there was a range of vegetation in southeastern Australia, including vegetation intolerant of frequent fire. This diversity of pre-European vegetation is revealed in a historical study of the vegetation of Bathurst region by Croft *et al.* (1997) who found that early survey notes more or less matched modern vegetation maps. In some places the bush may have thickened up as a consequence of dense regrowing after clearing or logging, and lack of fire in some places may have prevented natural thinning. However, the basic structure and species composition of most vegetation types is similar today to 200 years ago. For example, Fensham and Holman (1998) compared old surveyors' records and old photographs with current remnant vegetation on the Darling Downs in Queensland. They demonstrated that there has been little change in the density of remaining native vegetation over the last 150 years.

The main environmental variables dictating vegetation patterns are climate, soil type and hydrology (including drainage). Rainforest tends to require high rainfall and higher nutrient soils. The largest patches of rainforest occurred on the basalt-derived or alluvial soils in the Richmond/Tweed valleys, Dorrigo Plateau, Barrington Tops and on the Illawarra. Drier rainforest types grew in lower rainfall areas protected from fire such as on scree slopes and in gullies - for example in the gullies and screes of the upper Macleay River on the north coast. Small patches of semi-arid rainforest occurred inland, for example the microphyll vine thickets of the Southern Brigalow Belt Bioregion on the NSW northwestern slopes.

The shrubby, sclerophyllous vegetation on Sydney sandstone on the central coast and tablelands of NSW has adapted to low nutrient soils, as have the various heathlands along the NSW coast.

Various types of grassy box woodland grew on medium to high-nutrient soils (loams and clays), receiving rainfall between 400 and 900 mm, in the drier coastal valleys, on the tablelands and on the western slopes. The tree density of this woodland varied, but on average may have been about 30 large trees per ha (Benson and Redpath 1997). Large areas of treeless grassland occurred on the Darling Riverine Plains, Liverpool Plains, the Monaro tableland, with subalpine and alpine grasslands in the Australian Alps. Smaller areas of grassland occurred in valley bottoms subject to cold air drainage and with heavy clay soils. These included a 12 000 ha grassland at Bathurst, the Salisbury Plain near Armidale, 10 000 ha of grassland at Limestone Plains which is now Canberra, a small plain at Goulburn and some coastal clayey headland grasslands. The early settlers were attracted to these grasslands because trees did not have to be removed and fodder for grazing was readily available. The one million hectares of Riverina grasslands of today have been derived from a saltbush-dominated plant community present at the time of settlement (Benson *et al*. 1997).

Further west, an array of *Acacia, Allocasuarina*, cypress pine, mallee and chenopod shrublands dominated the landscape. Only 1% of NSW contained alpine vegetation - on the high peaks of the Snowy Mountains. Riverine vegetation ranged from rainforest, teatree (*Leptospermum* spp.) or bottlebrush (*Callistemon* spp.) dominated thickets on the coast and tablelands to River Red Gum (*Eucalyptus camaldulensis*) forests along inland rivers. Coolabah and Blackbox woodlands and lignum shrublands covered inland floodplains. Various combinations of mangrove, saltmarsh and seagrass species occurred in estuaries and bays on the coast. Hundreds of freshwater wetlands occurred in the river valleys of the coastal plain (over 60% of these have since been drained and destroyed (Goodrick 1970)). Peat bogs and lagoon wetlands were widespread on the tablelands, and ephemeral wetlands occupied low-lying areas on inland floodplains.

Over thousands of years Aboriginal people came to understand the properties of plant species and used them for medicines, food, weapons, ceremonial purposes and shelter. Much of this knowledge has not become widely available (Clegg 1998). Aboriginal burning was an important factor in managing vegetation but not all vegetation was burnt in the same way (see section on fire ecology below).

Carnahan (1990) provides a coarse scale map of the pre-European vegetation of Australia, while Beadle (1981) and Groves (1994) describe the major vegetation communities of Australia. The most widely accepted structural classifications of Australian vegetation have been produced by Specht (1981) and Walker and Hopkins (1990). These are based on life form, foliage cover and height of strata.

Current native vegetation in NSW

Vegetation cover of woody vegetation in NSW is presented on Figure 1. This shows where vegetation has been cleared and where forest and woodland remains. It does not show thinned forest, naturally sparse woodlands or treeless native grasslands. Figure 1 is a product of amalgamating the NPWS Eastern Bushland database, generated from LANDSAT TM 1:100 000 images covering eastern NSW, with the woody/non woody data from the BASINCARE M305 project (Ritman 1995) that mapped vegetation in the Murray-Darling Basin using 1991 LANDSAT 1: 100 000 satellite images. In these studies woody vegetation was defined as trees and shrubs taller than two metres with a canopy cover greater than 20%.

There are about 5300 species of native vascular (higher) plants in NSW. These occur in a wide range of plant communities from alpine herbfields to semi-arid shrublands to various types of rainforest. These species are described in the *Flora of New South Wales* (Harden 1990-1993). Such complexity reflects the State's diversity of geological patterns that overlap with humid temperate, humid subtropical and semi-arid climatic regimes. An additional 1000 plant species have been introduced from overseas. Some of these are major environmental or agricultural weeds.

Benson (1989) expanded on the floristic classification of Beadle (1981) in developing a list of 430 plant communities in NSW with assessments of their threat and conservation status. Hager and Benson (1994) improved on this classification for the forest communities in northeastern NSW. There has been a proliferation of flora surveys and ecological studies of plant species over the last decade, including the Comprehensive Regional Assessment (CRA) for forests, rendering these classifications and assessments out of date. It is estimated that between 600 and 1000 plant communities could be recognised at a regional scale in NSW if a review of the literature of vegetation surveys was undertaken (author's estimate). Not all of the plant communities in these floristic classifications have been mapped and this makes it difficult to plan for their conservation and management. A revision of the classification of Benson (1989) may be undertaken over the next two years. This would collate information and adopt criteria for assigning threat and conservation status codes for each listed plant community.

The main causes of decline and change to native vegetation since European settlement have been clearing for cropping and grazing by stock, grazing by feral animals, logging, weed invasion, mining, soil degradation through compaction, salinisation and acidification, and pollution including nutrification of waterways (Benson 1991). The least disturbed ecosystems in NSW are on the eastern escarpment and on poorer soils on the coast. Many of these areas are in national parks or state forests. Most of the vegetation west of the escarpment has been subjected to intensive grazing by stock, feral animals and elevated numbers of large macropods for over 100 years. This has altered the structure and biomass of the vegetation with significant changes to the understorey and little regeneration of palatable plant species (Denny 1992).

A description of the vegetation in the 17 Interim Biogeographic Regionalisation for Australia (IBRA) Bioregions (Figure 2, Thackway and Cresswell 1995) in NSW is given below and is summarised in Table 1. Because of the heterogeneity of vegetation in the Bioregions these descriptions represent a brief overview only. Key vegetation surveys and mapping projects are referenced and these should be consulted for more information about the vegetation.

The native vegetation in the IBRA Bioregions of NSW (also see Table 1)

1. **Australian Alps (AA)** Alpine herbfields, fens, bogs, feldmark, heath and woodland cover only 1% of NSW - wholly within Kosciuszko National Park. The park contains the only alpine and the bulk of the subalpine vegetation in New South Wales. This area is still recovering from past grazing and soil erosion. Grazing ceased in 1950s in the alpine zone and in 1969 in most subalpine parts of the park. Over 300 plant species occur in the alpine zone forming 11 major communities that have been mapped by Costin *et al*. (1979). Woodland, grassland and shrublands containing several hundred additional plant species occur in the sub-alpine zone. The vegetation of the non-alpine section of Kosciuszko NP has been coarsely mapped by the NPWS but this could be refined with more plot sampling and more detailed mapping of vegetation communities. The vegetation is well protected in conservation reserves. A large number of studies on the vegetation have been undertaken, but not all are published. A bibliography and resource library is maintained by the NPWS at the Kosciuszko National Park administrative office.

   The main threats to the alpine vegetation are increased visitation by tourists and expanding ski developments, the management of fire in the lower elevations and climate change over the next century.

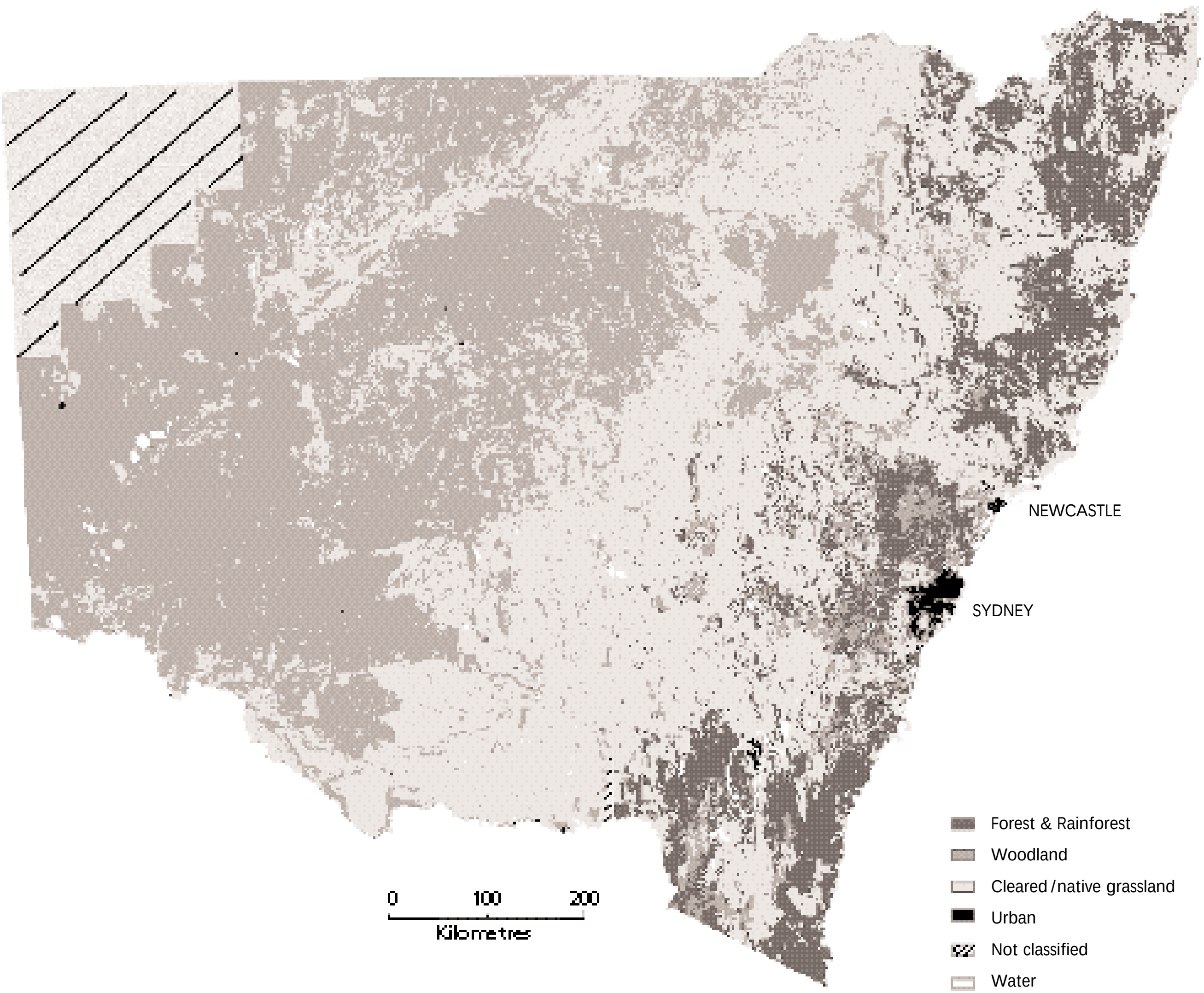

Figure 1. Woody native vegetation in NSW with canopy cover >20%. Sparse woodlands, native grasslands and low shrublands are not shown. Also, there is no indication of the relative degradation of the vegetation. The vegetation of the far north western corner of NSW is not shown - this is mainly rangelands composed of shrublands, grasslands and sparse woodlands (data supplied by the NSW National Parks and Wildlife Service GIS Division).

2. **Brigalow Belt South (BBS)** The southern part of this Bioregion occurs in NSW and 60% has been cleared. The main vegetation is grassy woodland dominated by White Box (*Eucalyptus albens*), Bimble Box (*Eucalyptus populnea*), Pilliga Box (*Eucalyptus pilligaensis*) with several ironbark eucalypts. Other woodland or denser thickets are composed of Belah (*Casuarina cristata)*, Bulloak (*Allocasuarina luehmannii*) and Brigalow (*Acacia harpophylla*). Only about 5000 of the original 250 000 ha of Brigalow remain today (Pulsford 1984). White Cypress Pine (*Callitris glaucophylla*) and White Box mix with microphyll vine thickets on basalt rises (Benson *et al*. 1995) but along with Brigalow this plant community is now endangered having been mostly cleared. The vegetation in the western part of this Bioregion has been surveyed and mapped by Sivertsen (unpublished NPWS). Most of the vegetation types in this Bioregion are poorly conserved and threatened by further clearing and overgrazing.

3. **Broken Hill Complex (BHC)** Little or none of the semi-arid vegetation of this Bioregion has been cleared but all has been subjected to stock grazing and wood cutting for over 100 years. This has changed the structure of the vegetation with a decreased understorey in most places and a lack of regeneration of palatable species. The soil has been compacted by stock and sheet soil erosion is widespread. The vegetation is primarily composed of a range of chenopod (saltbush and bluebush) shrubland and mulga tall shrubland communities. Belah, Rosewood (*Alectryon oleifolius*), White Cypress Pine and mallee communities are also widespread. The only NSW occurrence of the mallee *Eucalyptus gillii* occurs in the Barrier Range near Broken Hill. The vegetation has been mapped at a coarse scale (1: 1 million) by Pickard and Norris (1994). The Department of Land and Water Conservation (DLWC) has produced land systems mapping at 1:250 000 scale and various property maps of a finer scale.

4. **Channel Country (CHC)** A small part of this Bioregion is located in the far northwest corner of NSW containing the Paroo and Bulloo River overflows. The vegetation is uncleared but has been extensively grazed. It is composed of Mitchell Grass (*Astrebla* spp.) and Canegrass (*Eragrostis australasica*) grasslands, Gidgee (*Acacia cambagei*) shrublands, and other acacia shrublands (Pickard and Norris 1994). The area contains the most extensive wetlands in inland NSW. The river systems and wetlands are threatened by alterations to water flows due to irrigation development in Queensland. The vegetation is sampled in Sturt National Park. The land systems of the area are mapped by DLWC at 1:250 000 scale.

5. **Cobar Peneplain (CP)** This Bioregion is mainly composed of rocky outcrops with limited alluvial soils. The vegetation in the Western Division section is mainly uncleared but a high proportion of the Central Division section has been cleared. The region has been heavily grazed in the past and parts are now affected by increased abundance of woody, unpalatable native shrubs. The main vegetation is woodland composed of Bimble Box, Red Box (*Eucalyptus intertexta*) and White Cypress Pine, along with Mulga (*Acacia aneura*) and Ironwood (*Acacia excelsa*) shrublands. The NPWS have undertaken an assessment of this Bioregion (Creaser and Knight 1996) that includes vegetation mapping and fauna surveys. Sivertsen and Metcalfe (1995) have mapped the remnant vegetation in part of the Central Division section of the Bioregion. Land systems mapping by DLWC cover the section in the Western Division. Less than 2% of the Bioregion is protected in conservation reserves. The recently declared Gundabooka National Park has improved the conservation status of some plant communities.

6. **Darling Riverine Plains (DRP)** The vegetation remnants in the mainly cleared Central Division section of this Bioregion have been mapped and described by Sivertsen (unpublished NPWS data). They consist of Coolabah Box woodlands on floodplains; native grasslands dominated by Mitchell Grass and wiregrass on heavier soils of the floodplains; small patches of Carbeen (*Eucalyptus tessellaris*) on sandy rises. A large proportion of the vegetation has been cleared

for grazing or cropping and the understorey of most vegetation remnants has been heavily grazed. Less than 1% of the Bioregion is protected in reserves and the reserves that do exist are small and isolated. The remaining vegetation in the Central Division section is under threat of clearing for crops. National Land and Water Resources Audit funding has been obtained by DLWC to update BASINCARE M305 data and survey the native grasslands of the Walgett Shire. This should help clarify the usefulness of M305 data and help delineate native grassland of conservation significance in the Walgett Shire, thus assisting with regional vegetation planning for that area.

7. **Mulga Lands (ML)** The southern portion of this Bioregion extends into northwestern NSW. The dominant vegetation is Mulga (*Acacia aneura*) growing in a number of plant communities on sedimentary substrates on undulating plains (Pickard and Norris 1994). Bimble Box, Bloodwood (*Eucalyptus trachyphloia*), Brigalow and Gidgee woodlands are also present. Little clearing has occurred, but heavy grazing has effected regeneration of the vegetation. Less than 2% of the Bioregion is protected in conservation reserves, mostly in Nocoleche Nature Reserve.

8. **Murray-Darling Depression (MDP)** This clay and sand plain is situated in far southwestern NSW extending into Victoria and South Australia. Clearing has occurred on loamy soils and along the Murray and Darling Rivers, but elsewhere has been minimal. Large stands of mallee occur on aeolian sand dunes, with Belah-Rosewood and *Acacia* shrublands on loams and clays. Chenopod shrublands occur on dry lake beds and on sandplains. White Cypress Pine grows on prior stream channels and elsewhere, while Murray Pine (*Callitris gracilis*) grows on source-bordering dunes along the Murray River. The vegetation has been described and mapped at 1:250 000 scale by the Royal Botanic Gardens (Fox 1991), Scott (1992), and Porteners *et al*. (1997). Land systems mapping by DLWC also cover the area. The mallee of Nombinee and Round Hill Nature Reserves in the northern part of the Bioregion has been documented and mapped at 1:100 000 scale by Cohn (1995). DLWC has combined the Royal Botanic Gardens Sydney (RBG) mapping with the BASINCARE M305 data to produce a 1:100 000 vegetation map for the southern mallee planning region section of the Bioregion to assist with regional vegetation assessments (Val 1997). 3.6% of the Bioregion is protected in reserves including Mungo and Mallee Cliffs National Parks and Yathong, Round Hill, Nombinnie and Tarawi Nature Reserves.

9. **Nandewar (N)** This Bioregion is located on the northwestern slopes of NSW and is subject to summer rainfall. About 66% of the woody vegetation has been cleared and less than 2% is protected in conservation reserves. Box woodlands composed of White Box, Grey Box (*Eucalyptus moluccana*) and Yellow Box (*Eucalyptus melliodora*), Silver-leaved Ironbark (*Eucalyptus melanophloia*) and Narrow-leaved Ironbark (*Eucalyptus crebra*), and occasionally Fuzzy Box (*Eucalyptus conica*) occur on clay or loam soils. These woodlands have been substantially cleared and are poorly conserved. Large areas of derived native grasslands, that remain in areas that were previously box woodlands, are threatened by the invasive Coolatai Grass (*Hyparrhenia hirta*). Denser forests occur on siliceous soils derived from acid volcanic rocks in the region. These are dominated by Caley's Ironbark (*Eucalyptus caleyi*). Tumbledown Gum (*Eucalyptus dealbata*) and Black Cypress Pine (*Callitris endlicheri*) with a shrubby understorey. Less of these forests have been cleared and they are represented in several conservation reserves in the Bioregion. The vegetation of the Ashford 1:100 000 map sheet has been sampled and is being mapped by the RBG, while DLWC have obtained National Heritage Trust funds for mapping woody vegetation in the Bioregion through aerial photographic interpretation.

10. **New England Tableland (NET)** This undulating elevated plateau covers the northern tablelands of NSW extending into southern Queensland. It receives both summer and winter rainfall and is composed of a complex mixture of sedimentary, metamorphic, igneous and volcanic rocks

including granite, leucogranite, basalt, shale and greywacke. About 60% of the native tree cover has been cleared, primarily for grazing. While native grasslands originally were present in valley bottoms, few remain in good condition. The removal of tree cover left large areas of derived native grasslands. Most of these have been altered through the introduction of exotic species such as clover, but remain mainly native in their composition. Other grasslands are completely exotic.

The largest patches of forest occur on granitic outcrops that also contain mallee, swamps and heathlands. Hunter and Clarke (1998) describe the granite outcrop vegetation. Stringybark eucalypt communities dominated by New England Stringybark (*Eucalyptus caliginosa*) and Silver-topped Stringybark (*Eucalyptus laevopinea*) grow on poorer soils on ridge tops composed of siliceous substrates such as greywacke (trap rock). Communities dominated by Snow Gum (*Eucalyptus pauciflora*), Mountain Gum (*Eucalyptus dalrympleana*), Ribbon Gum (*Eucalyptus viminalis*) occur on high plateaux, often on basalt soil and have mostly been cleared. Black Sally (*Eucalyptus stellulata*) and New England Peppermint (*Eucalyptus nova-anglica*) communities grow on poorer drained soils in valleys. Plant communities composed of Blakely's Red Gum (*Eucalyptus blakelyi*), Yellow Box (*Eucalyptus melliodora*) and other box species are widespread in valleys on clayey soils. Along with New England Peppermint they have been extensively cleared with many isolated trees having been killed by the major dieback events of the 1970s (Nadolny 1995).

The RBG has sampled and mapped the vegetation of the Guyra 1:100 000 map sheet area at scales of 1:25 000 in a digital format and at 1:100 000 in a hard copy format for publication (Benson and Ashby in prep.). This mapping may extend to other parts of the Bioregion pending funding. The conservation of land systems and major vegetation types is addressed in Morgan and Terrey (1990). Many of the state forests and conservation reserves have been surveyed and mapped at a fine scale, for example Torrington State Recreation Area by Clarke *et al*. (1997). 7.5% of the Bioregion is represented in conservation reserves with very little box woodland or New England Peppermint conserved.

11. **NSW North Coast (NNC)** This Bioregion contains the greatest biological diversity in NSW but also contains the largest number of threatened species. Griffith (1993) classifies and assesses the conservation status of coastal plant communities including woodland, heathland, grassland and swamps. Heathland is relatively well conserved in a series of coastal national parks that cover over 30% of the north coast. In contrast, grassy woodlands or freshwater swamps are poorly conserved and highly threatened because they mainly occur on private land on the floodplains. Hager and Benson (1994) list 205 open eucalypt forest communities and Floyd (1990) describes 44 rainforest communities from the region in five formations: cool temperate, warm temperate, subtropical, dry and littoral. The largest areas of rainforest in the Bioregion are protected in national parks and most are listed as a World Heritage Area. The rainforests and coral reefs of Lord Howe Island 1000 km off the north coast are also listed as a World Heritage Area.

    The escarpment contains a complex range of wet and dry eucalypt plant communities in state forests or national parks. The foothills and coastal plain contain generally drier forests on medium to poor soils with subtropical rainforest patches remaining on better soils and lining watercourses. Grassy woodlands of the lower valleys containing tree species such as Forest Red Gum (*Eucalyptus tereticornis/Eucalyptus scias*) and Grey Box (*Eucalyptus moluccana*) have mainly been cleared and are threatened and poorly conserved.

    The vegetation has been well sampled using a stratified sampling system with about 10 500 floristic plots. These are a composite of data from the natural resources of north-eastern NSW (NPWS 1995) funded by the then Natural Resource Audit Council (now Resource and Conservation Assessment Council RACAC); the recent CRA process; previous data collected by NSW State Forests for environmental impact statements;

past rainforest surveys and other surveys. About 8000 of these plots contain full floristic data, mainly collected on public land. About 2500 plots contain canopy data only and many of these are from roadsides or on private land. These data have been used to model pre-European vegetation across the Bioregion. Analyses were also undertaken to relate these site data and forest type mapping (State Forests 1989).

The present and pre-European vegetation has been mapped using a combination of modelling the floristic data and by using 1:25 000 scale aerial photographs (NPWS pers. comm.). Over 200 forest ecosystems in the Bioregion are mapped. Private land was not fully surveyed or mapped. Aerial photographic interpretation was undertaken in the north of the bioregion to map forest growth stages (NPWS pers. comm.). While the modelling methodology is very advanced, it will not always be accurate at finer scales. In a botanical survey of the western additions of Washpool National Park, Hunter (1998) found that some predicted vegetation classes (including Spotted Gum *Eucalyptus maculata*) were not present.

Littoral rainforest has been reduced to only 1300 ha (Pople and Cowley 1982) by sandmining and urban development between 1950 and 1980. The invasive weed Bitou Bush (*Chrysanthemoides monilifera*) now threatens it. Subtropical rainforest has been mainly cleared from the lowlands where, for example, only 400 ha (0.74%) of an original 75 000 ha of the Big Scrub remains in the Richmond/Tweed valleys (Lott and Duggin 1993). Rapid urbanisation is threatening bushland and wetlands on the coast - including pollution through the disturbance of acid sulphate soils. Weeds are a major problem on coastal dunes, in rainforest remnants and in wetlands. About 17% of the bioregion is reserved, taking into account the November 1998 CRA decision on forests, but the ecosystems on private land in valleys and on floodplains are threatened and poorly protected.

12. **NSW South Western Slopes (SWS)** This is the most cleared of all Bioregions in NSW with 85% of the vegetation having been removed and much of this having been replaced with introduced pasture or crops. The remnant vegetation in the northern section of the Bioregion in the vicinity of Forbes is described by Howling (1997) and is partly mapped at 1:250 000 scale by Sivertsen and Metcalfe (1995). More detailed vegetation maps at 1:100 000 scale have been produced on a GIS for the Mid-Lachlan Regional Vegetation Management Plan in central-western NSW (Mid-Lachlan Regional Vegetation Committee, 1999). The southern section of the Bioregion (east of the Hume Highway), centred on Tumut, is being mapped and classified by the NPWS for the CRA for forests. NPWS has also used API to map vegetation in the Shires of Cootamundra and Young (R. Good pers. comm.) but this is not supported by detailed ground sampling. West of the Hume Highway around Wagga Wagga several local studies have taken place but broad-scale vegetation mapping is lacking.

The vegetation remnants present in the Bioregion include grassy box woodland communities most of which have been substantially cleared and are threatened on both national and state perspective. These include communities composed of White Box of which less than 1% remain in good condition (Prober 1996); Inland Grey Box (*Eucalyptus microcarpa*), Fuzzy Box (*Eucalyptus conica*) and Yellow Box, Blakely's Red Gum and Apple Box. None of these box woodlands are common, most have been substantially cleared and all are poorly conserved (Benson 1989). Fuzzy Box is probably the most poorly represented box woodland in conservation reserves in NSW.

In 1998 Young Shire Council entered into a Voluntary Conservation Agreement with the NPWS to protect a small area of box woodland and native grassland in the Monteagle Cemetery. This area contains an outstanding patch of native grasses and herbs that probably resemble the species composition of pre-European ground cover in the region.

Stands of White Cypress Pine occur in state forests in the Bioregion. Their regeneration occurs spasmodically in response to a sequence of high rainfall years and lower grazing pressures on seedlings, particularly by rabbits. The structure and species dominance in cypress pine forests have changed over 200 years due to logging practices and altered grazing and fire regimes (Allen 1998). River Red Gum lines the watercourses in the Bioregion and open woodlands of Myall (*Acacia pendula*) grow on clay soils but have mainly been cleared and are now rare. Dwyer's Red Gum (*Eucalyptus dwyeri*), Mugga Ironbark (*Eucalyptus sideroxylon*) along with Currawang (*Acacia doratoxylon*) grow on stony rises in the Bioregion (Norris and Thomas 1991). This hilltop vegetation is less threatened and better conserved than the box woodlands of the valleys and lower slopes. Along with the Riverina Bioregion the NSW South-western Slopes is least represented in the conservation reserve system.

13. **Riverina (R)** Two thirds of this Bioregion is in NSW, the remainder is in Victoria. It has a dry climate receiving most rainfall in winter with hot dry summers. Several major rivers, including the Murrumbidgee and Murray, dissect the region. The soil is predominantly red clay or grey cracking clay. There are large irrigation developments for rice and horticultural crops. Rising salinity is threatening agriculture and remnant vegetation in the Bioregion. Over 60% of the area has been cleared but all of it was overgrazed last century leading to severe soil erosion and a loss of an extensive area of chenopod (saltbush) shrubland. Derived native grassland (Benson *et al*. 1997) covers the southeastern half of the Bioregion, while various types of chenopod shrublands, particularly bladder saltbush (*Atriplex vesicaria*), cover the Hay Plain on the northwestern part of the Bioregion (Porteners 1993).

    Acacia shrublands including Myall (*Acacia pendula*) occur across the eastern half of the Bioregion. However, these have mainly been cleared. River Red Gum lines major watercourses and forms extensive floodplain forests along the Murray River. The largest of these are in state forests and trees have been cut for timber over the last 150 years, so there are now fewer large trees and more smaller regrowth trees. Black box (*Eucalyptus largiflorens*) woodlands occur on the floodplains and along drainage lines but much of this woodland has been cleared. White Cypress Pine, Belah and Rosewood occur on sandier soils associated with prior stream channels. Degraded stands of Murray Pine (*Callitris gracilis*) and Bulloak (*Allocasuarina leuhmannii*) occur on source-bordering sand dunes along the Murray River. The vegetation of the western two thirds of the Bioregion in NSW is mapped by the RBG (Porteners 1993), while the eastern third is only coarsely mapped by NPWS as part of its Riverina Bioregional Conservation Strategy (Eardley 1999). Detailed mapping is required on this eastern third. A 1:500 000 vegetation map has been produced by NPWS for the whole Bioregion incorporating data from Victoria (Eardley 1999).

    The Bioregion contains some highly threatened plant communities and fauna species such as the Plains Wanderer and Superb Parrot. Less than 1% of the Bioregion is sampled in conservation reserves. Along with the NSW South-western Slopes Bioregion, the Riverina is least represented in the conservation reserve system.

14. **Simpson-Strzelecki Dunefields (SSD)** Most of this Bioregion is in South Australia and the Northern Territory. A small part occurs in far northwestern NSW. It is dominated by sand dune vegetation containing Spinifex grassland (*Triodia* spp.) and sparse acacia and chenopod shrublands. None has been cleared and only 6% of the Bioregion is in conservation reserves (Sturt National Park). The main threats are from over-grazing by stock, native and feral animals. Bore water has led to unnaturally high populations of kangaroos in some areas.

15. **South Eastern Corner (SEC)** This Bioregion covers the south coast of NSW and east Gippsland in Victoria. Most of the Bioregion is composed of native forests on steep escarpment and undulating foothills. Only 19% has been cleared - mostly for farming in coastal valleys and for urban expansion on the coast. The vegetation in state forests has been mapped using forest type classification (State Forests 1989). Numerous localised botanical surveys have occurred over the last two decades, often in response to the debate about forestry

practice in the region, particularly woodchipping (see references in Keith and Bedward in press). The southern section of the NSW portion of the Bioregion, covering the Eden and Bega areas, has been comprehensively surveyed and ecologically mapped at 1:25 000 scale on GIS to be published at 1:100 000 in a hard copy form by Keith and Bedward (in press). They describe and map 79 plant communities including escarpment eucalypt forests, rainforests, swamps, lowland dry forests and coastal heath. Their classification is based on the analysis of over 1600 full floristic sample plots. The mapping used traditional API and modern computer modelling techniques. The current and pre-European vegetation of the northern section of the Bioregion in NSW is being mapped and modelled by the NPWS as part of the NSW Southern Region CRA for forests. The vegetation is to be sampled in several thousand floristic plots coordinated by the NPWS. Other data, such as 9000 canopy tree species plots by the CSIRO Division of Wildlife and Ecology, is also available and useful in modelling canopy species. NPWS is using API of woody vegetation down to 10 ha in size to map the vegetation and classify vegetation structure. The most threatened ecosystems are coastal wetlands and lowland forests located in the coastal valleys, for example Forest Red Gum communities in the Bega Valley. 37% of this Bioregion is in reserves but this is biased towards steep escarpment lands.

16. **South Eastern Highland (SEH)** This Bioregion extends along the Great Dividing Range from Bathurst in the north to near Melbourne in Victoria in the south. It includes undulating plateaux and steep dissected ranges. About 60% has been cleared - mainly on the plateaux for grazing. The vegetation consists of a range of eucalypt forest and woodlands, native grasslands and montane swamps. Blakely's Red Gum, Yellow Box and other box woodland species such as Apple Box (*Eucalyptus bridgesiana*) and Long-leaved Box (*Eucalyptus goniocalyx*) are widespread on clay soil in valleys but most of this landform has cleared and isolated trees are affected by dieback and are not regenerating (Landsberg & Wylie 1988). Forests of Red Stringybark (*Eucalyptus macrorhyncha*), White Gum (*Eucalyptus mannifera*) and scribbly gum (*Eucalyptus rossii*) grow on lower nutrient siliceous ridges. Prior to European settlement, native grasslands were present in valleys such as those near present-day Bathurst, Goulburn and Canberra. Approximately 250 000 ha of native grasslands covered the Monaro Tableland south of Canberra (Benson 1994). Over 95% of these grasslands have been destroyed or highly modified. Vegetation survey and mapping cover parts of the Bioregion at different scales and quality. Most of the private land has not been mapped or sampled to the same degree as public land. The NPWS (Southern Region) has mapped the native vegetation of the Yass Shire using aerial photographs. As part of the NSW Southern Region CRA for forests, woody vegetation (>10% canopy cover) down to 10 ha in size is being mapped by the NPWS using API. Also, it has been sampled in over 1000 full floristic plots. Computer modelling is being undertaken by the NPWS to produce a pre-European and current vegetation maps at a scale of 1:100 000.

17. **Sydney Basin (SB)** This Bioregion centres on Sydney and central coast of NSW extending from the Hunter Valley, Blue Mountains to the south coast near Nowra. Most of the area is composed of Triassic sandstone and shales. Over 2000 plant species occur in the area and D. Benson and McDougall (1993) are publishing summaries of their ecology over a 10-year period. The vegetation of the Sydney (D. Benson & Howell 1994), Gosford and Lake Macquarie (D. Benson 1986) Penrith (D. Benson 1992), Wallerawang (D. Benson & Keith 1990), Katoomba (Keith & D. Benson 1988), Burragorang (Fisher *et al*. 1995), Merriwa (McRae & Cooper 1985) and St Albans (Ryan, Fisher and Shaeper. 1996) 1:100 000 map sheets have been mapped by the RBG. The Wollongong, Mittagong and Mount Pomany map sheets are currently being mapped by the RBG.

More detailed mapping covers Ku-ring-gai Chase, Royal, Dharug, Heathcote, Brisbane Water and Morton National Parks and also many of the nature reserves in the Bioregion. The 450 000 ha Wollemi National Park is currently being surveyed and mapped at 1:25 000 scale by the NPWS. During 1996-7 the NPWS surveyed the flora and mapped, at a fine scale, the vegetation remnants on the Cumberland Plain in western Sydney (NPWS 1997). These remnants mainly occur on shales and gravel substrates and are threatened by urban development. What remains of the riparian vegetation of the Hawkesbury-Nepean River and proposals for its rehabilitation are documented by D Benson and Howell (1993). A range of studies cover the Illawarra rainforest and dry woodlands. 30% of this Bioregion has been cleared but this is heavily skewed towards high nutrient soils on the Illawarra Plain and Cumberland Plain. While 39% of the Bioregion it protected in conservation reserves, there is an under-representation of box woodlands and wetlands. The main threats to vegetation are urban expansion, weed invasion and pollution.

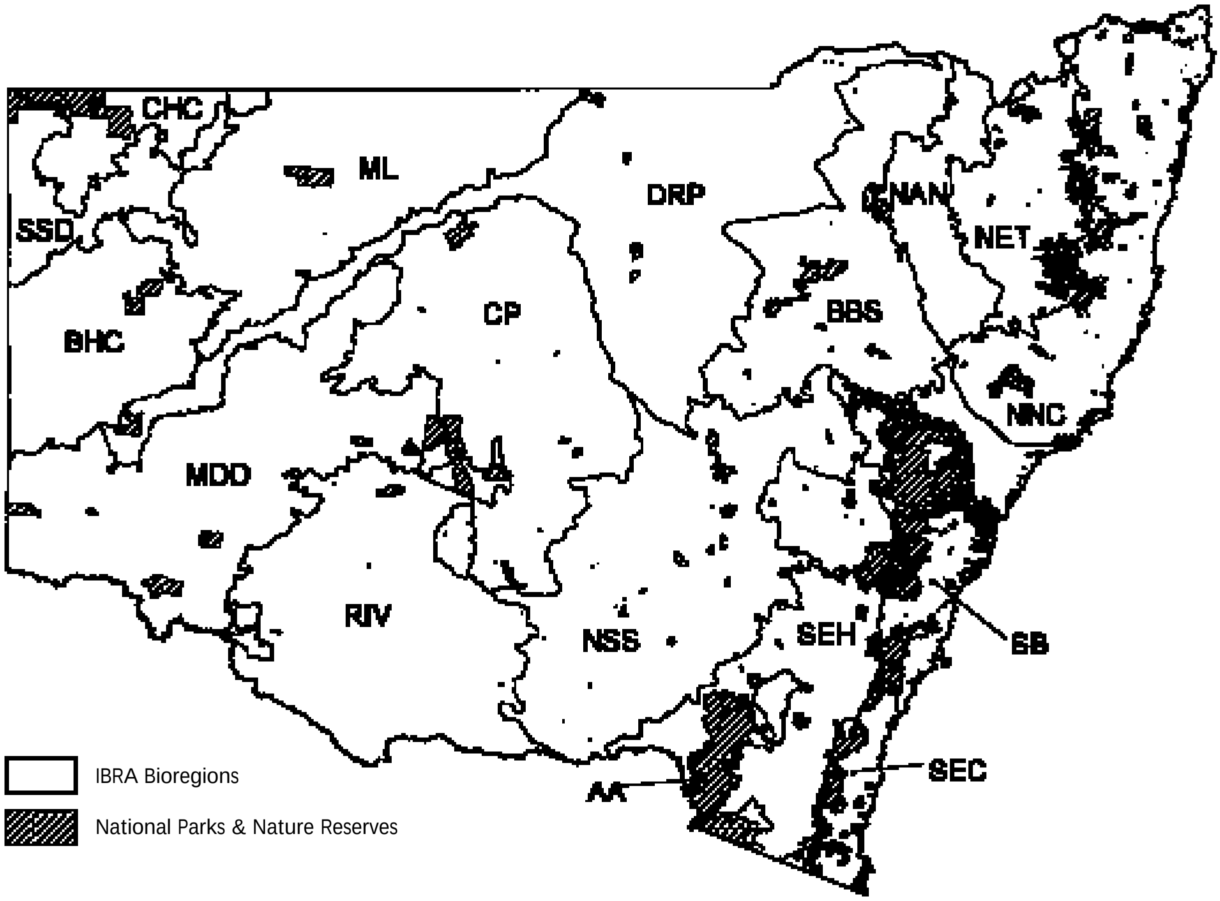

Figure 2. 17 of the 80 Interim Biogeographic Regionalisation of Australian Bioregions (IBRA) partly or wholly occur in NSW. The classification of the IBRA Bioregions is primarily based on substrate, climate and vegetation (Thackway and Cresswell 1995). Conservation reserves, that cover 6.2% of NSW, are shaded. Eastern NSW contains a greater number and aerial extent of reserves than western NSW. The recent addition of 400 000 ha of reserves on the North Coast is not shown (data supplied by the NSW National Parks and Wildlife Service, GIS Division).

Table 1. Degree of clearing and reservation, and the priorities for native vegetation protection and management for each IBRA Bioregion of New South Wales

IBRA Regions	Area in NSW	Cleared of native vegetation ha and (%)	% in cons. reserves	Major threatening processes	Vegetation types most threatened	Examples of management activities
Australian Alps	468300	15400 (3.29)	82.5	fire regime, climate change, tourism	Alpine	fire management, visitor management, weed control, eg., exotic pine infestations in native vegetation, restoration of riparian vegetation
Brigalow Belt South	5243600	3194800 (61)	2.5	clearing/cropping, grazing, salinity	brigalow, vine thickets, box woodlands, riparian, *Austrostipa* grasslands	fencing of remnants, identification of key grassland sites, corridors and connectivity, enhancement of significant remnants, fire management, eg., in dense *Callitris* pine regrowth - enhancement of riparian vegetation, restoration of riparian vegetation
Broken Hill Complex	3812900	0 (0)	2.2	total grazing pressure	all	grazing management strategies, feral grazing control, control of feral predators, restoration of riparian vegetation
Channel Country	1428900	0 (0)	14.4	total grazing pressure	Mitchell grasslands and riparian floodplain	feral predator control, grazing management strategies and artificial watering point management, restoration of riparian vegetation
Cobar Peneplain	7334800	2380200 (32.5)	1.7	total grazing pressure, clearing	Bimble Box woodland, Belah/Rosewood, Leopardwood	fencing of remnants in fragmented areas, enhancement of significant remnants, grazing management strategies, feral grazing control, feral predator control, restoration of riparian vegetation
Darling Riverine Plains	9474500	3444400 (36.3)	0.9	clearing cropping, water quantity/quality	box woodlands, riparian, native grasslands, wetlands	floodplain hydrology restoration, weed control especially *Lippia* in forested wetlands, fencing of significant remnants, enhancement of significant remnants, restoration of riparian vegetation
Mulga Lands	6577900	30600 (0.5)	1.1	total grazing pressure, clearing	Coolabah woodlands, mulga, brigalow	feral predator control, grazing management strategies, artificial water point management, restoration of riparian vegetation
Murray-Darling Depression	8021100	619700 (7.7)	3.6	total grazing pressure, clearing, stream regulation	riparian vegetation and source-bordering dunes, rosewood/belah, chenopod shrublands, wetlands	feral predator control, grazing management strategies, artificial water point management, restoration of riparian vegetation

Table 1. Continued

IBRA Regions	Area in NSW	Cleared of native vegetation ha and (%)	% in cons. reserves	Major threatening processes	Vegetation types most threatened	Examples of management activities
Nandewar	2099200	1380800 (66)	1.9	clearing, total grazing pressure, invasive weeds	box woodlands and ironbark box	identification and fencing of significant remnants, enhancement of significant remnants, re-vegetation, restoration of riparian vegetation, enhanced grazing management
New England Tableland	2796700	1613000 (58)	7.5	clearing, invasive weeds, pasture improvement, firewood cutting, drainage of wetlands	New England peppermint, yellow box, red gum, ribbon/mountain gum, montane wetlands	identification and fencing of significant remnants, enhancement of significant remnants, enhancement of existing corridors to improve connectivity, regeneration and replanting of understorey species, enhanced grazing management, restoration of riparian vegetation
NSW North Coast	5767800	21800700 (38)	17.5	subdivision and urbanisation, weed invasion, water pollution and wetland drainage, fire, total grazing pressure, inappropriate logging	riparian vegetation especially rainforests, wetlands (marine and freshwater) coastal box woodlands, mangroves	weed control, restoration of floodplain and valley bottom vegetation communities, identification and fencing of significant remnants, protection of old growth forest areas, restoration of floodplain wetland hydrology. Enhancement of rainforest remnants particularly areas adjoining Big Scrub and riparian rainforest remnants, restoration of riparian vegetation
NSW South-western slopes	8075300	6898800 (85)	1.2	clearing, firewood cutting, total grazing pressure, acid and salt	grassy white box woodlands, red gum, yellow box, riparian, box woodlands especially white box woodlands	identification fencing and enhancement of significant remnants, enhancement of existing corridors and improvement of connectivity between remnants, restoration of riparian vegetation
Riverina	6891966*	2131842 (31)* Central Division section mainly cleared while Western Division section mainly vegetated	0.4	clearing cropping, salinity, irrigated cropping and horticulture	native grasslands, chenopod shrublands, myall woodlands, grey box woodlands, riparian, wetlands, black box woodlands, Callitris mixed woodlands (including yellow box) and belah/rosewood	identification enhancement and fencing of significant remnants, restoration of floodplain wetland hydrology, restoration of riparian vegetation

Table 1. Continued

IBRA Regions	Area in NSW	Cleared of native vegetation ha and (%)	% in cons. reserves	Major threatening processes	Vegetation types most threatened	Examples of management activities
Simpson-Strzelecki Dunefields	2082900	0 (0)	6	total grazing pressure	all, particularly lignum	artificial water point management, feral animal grazing control, feral predator control, grazing management, restoration of riparian vegetation
South Eastern Corner	1280000	238600 (19)	37.3	subdivision and urbanisation, clearing, inappropriate logging, fire, invasive weeds	coastal communities especially lagoons, estuaries, dunes, wetlands, forest red gum/box forests	identification fencing and enhancement of significant remnants, restoration and enhance-ment of floodplain and valley bottom vegetation communities, weed control especially Bitou Bush on dunes and willows on floodplains, restoration of riparian vegetation
South Eastern Highlands	5066700	2958800 (58.4)	9.8	clearing, total grazing pressure, invasive weeds, pasture improvement, acidification, salinity, peat mining	native grasslands, box woodlands, especially yellow box/red gum woodlands, montane wetlands, riparian	identification of significant grassland sites, identification fencing and enhancement of significant remnants, enhancement of existing corridors and restoring connectivity, restoration of riparian vegetation
Sydney Basin	3694100	1209300 (33)	39.1	urbanisation and subdivision, pollution, fire, weeds, resource extraction	riparian, grey box forest/red gum woodlands, wetlands, subtropical and dry rainforest	protection and restoration of extensively cleared communities, eg., Cumberland plain woodlands, blue gum high forest, weed control in grassy woodlands, restoration of riparian vegetation

Notes

Data on clearing was provided by the NSW National Parks and Wildlife Service Geographical Information Section 1998. It is derived from the Eastern Bushland database, Murray Darling mapping, RBG mapping, DLWC clearing data (for Western Division) and visual LANDSAT interpretation of woodland on the Western Slopes in the gap between the EBD and the Murray Darling mapping. Data on reservation is from Pressey et al (in prep).

Some types of vegetation in each IBRA Bioregion have been more cleared than others. For example, 95% of the Cumberland Plain on the shale soils of western Sydney is cleared, whereas most of the sandstone vegetation is protected in reserves - thus the clearing statistic of this region is only 30%. Clearing is also correlated with land tenure. For example, the Central Division section of the Darling Riverine Plain Bioregion is mostly private land and is mostly cleared (>60%), whereas the leasehold lands of the Western Division section is composed of native vegetation.

Preliminary mapping of native grassland (Moree-Walgett, Liverpool Plains and the Monaro) was also undertaken by NPWS. This used LANDSAT TM imagery. Within these grassland regions, any areas of visible pasture improvement were classed as cleared. Where a definitive decision could not be made, the classification of potential native grassland was used. This category was considered to be native vegetation.

*Data for clearing in the Riverina Bioregion is taken from the NSW NPWS Bioregional assessment (Eardley 1999 and NPWS pers. comm.). 76% of the Murray Province in the Central Division is cleared compared to only 4% of the Lachlan Province in the Western Division. These figures ignore the loss of chenopod shrublands over the last 100 years with their replacement of native grasslands and they also probably over-estimate the area of native grasslands in the Bioregion.

Native grasslands

Over the last decade more attention has been paid to studying, managing and protecting native grassland for production and conservation purposes. The Native Vegetation Conservation Act does not define a "native grassland" but it defines ground cover as being native when more than 50% of the canopy cover of the ground cover vegetation at a site is composed of native species, and when there is a least 10% vegetation ground cover (living or dead) at a site. Native grasslands occur in open treeless areas with <10% cover of trees or shrubs. Derived native grasslands occur in areas where the tree or shrub cover has been removed by clearing or due to other factors. Grassland can also occur as an understorey layer in woodlands.

The non-woody nature of native grasslands makes it difficult to monitor change or clearing using remote sensing. It is also difficult to assess the quality of native grassland without sampling it at various times of the year. In Spring, numerous native herbs may appear including some that may be rare, but so do annual weeds such as wild oats and rye grass. Summer is a good time to record what perennial native grasses persist. Grasslands require periodic disturbance, either through grazing, fire or mowing. Management guidelines for native grasses under the NVCA have been released by DLWC.

The main types of native grasslands in NSW are:

1. Mitchell Grass (*Astrebla* spp.) grasslands of the semi-arid inland plains of far northwestern NSW and southwestern Queensland;
2. Sections of the Darling Riverine Plain around Moree and Walgett where Mitchell grass (*Astrebla* spp.), *Leptochloa, Panicum*, love grass (*Eragrostis* spp.) and wire grass (*Aristida* spp.) commonly dominate;
3. Liverpool Plains near Breeza, southern section of the New England Tableland, dominated by Plains Grass, *Austrostipa aristiglumis*;
4. Small areas on poorly drained flats and in valleys subject to cold air drainage on the New England Tableland where snow grass (*Poa* spp.) is dominant;
5. The Monaro region of the South Eastern Highlands where originally approximately 250 000 ha of native grasslands was present dominated by Kangaroo Grass (*Themeda australis*), corkscrew grasses (*Austrostipa* spp.), wallaby grasses (*Austrodanthonia* spp.), snow grasses (*Poa* spp.) and forbs (see Benson 1994 for a description of the Monaro native grasslands);
6. About one million hectares of the Riverina Bioregion were covered by native grassland dominated by *Austrodanthonia* spp and *Austrostipa* spp. Four main grassland types are described by Benson *et al*. (1997). These have been derived from an original chenopod shrubland-grassland mix that disappeared in the 1880s due to grazing by rabbits and stock combined with drought;
7. Alpine and sub-alpine regions of Kosciuszko and Namadgi National Parks in the Australian Alps dominated by snow grasses (*Poa* spp.) and forbs;
8. Coastal clayey headlands dominated by Kangaroo Grass (*Themeda australis*).

Floristic associations vary across each of these regions as an indicator of environmental differences. Therefore, several grassland communities may be present in each region. For example, on the Monaro, Benson (1994) classified eight types of native grassland communities that grow in response to different environments. Also, in any region, some grassland communities will be more restricted and threatened than others will.

The native grassland communities in regions 2-6 above have been severely depleted due to 150 years of intense European land use and some are highly threatened. In contrast, the alpine and subalpine native grassland communities are well conserved and are generally in good condition, many recovering after the removal of stock grazing after World War II. The coastal headland Kangaroo Grass dominated grasslands are well conserved in reserves but some are threatened with the invasive weed, Bitou Bush.

Nadolny (1998) has questioned the economic and environmental benefits of replacing more of the native pastures in the hillier and poorer soil landscapes of the New England Bioregion with exotic pasture.

CURRENT KNOWLEDGE OF THE VEGETATION OF NSW

Describing, mapping and modelling vegetation

The spatial and temporal variation of organisms in nature is complex but recurring patterns occur across a landscape. These patterns are often described, classified and mapped as ecosystems, landsystems, plant communities or ecological communities.

The term "ecosystem" has been loosely interpreted in both the scientific and popular literature. It has often been applied to map units that have been derived from combinations of climate, geology and vegetation. However, this contrasts with an accepted definition of an ecosystem as being: *an aggregate of plants, animals and other organisms, and the non-living parts of the environment with which these organisms interact* (Odum 1971). This definition concentrates on the concepts of interactions and processes that link organisms to the environment, rather than describing ecosystems as spatial entities. Therefore, when mapping spatial distributions of landscape patterns, it is probably best to use terms such as plant community, ecological community or map unit rather than "ecosystem". Incidentally, the NSW Threatened Species Conservation Act 1995 (TSCA) defines an “ecological community” as simply *an assemblage of species occupying a particular area*.

The NSW National Parks and Wildlife Service (NPWS) has prepared a discussion paper on defining "ecosystems" in NSW (NPWS 1998). This outlines factors that could be used in their definition and suggests that hierarchical approaches can be used to mesh large and small map units. At present there is no uniform map coverage of NSW depicting ecological or plant communities at scales larger than one to one million.

There are some good examples of landscape classification overseas. Over the last 20 years in British Columbia, Canada, both the Forest Service and Parks Service have defined environmental units using climate, substrate and vegetation and mapped the whole province at 1:250 000 scale (Banner *et al*. 1996). About 10% of the province has been mapped at 1:20 000 using a standardised plant community classification system containing about 1000 “site series” vegetation types. This ongoing mapping program relates the fine scale vegetation classification to coarser scale ecosystem classifications through an integrated coding system attached to each individual mapped unit. The vegetation classification was derived from plot data and other field assessments and all mapping is loaded on a standardised geographical information system that is used by all government agencies in the Province. This system has the advantage of providing a uniform mapping classification that allows comparisons to be made from one area to another. Its drawback is that it lacks flexibility of adapting to new and improved classification systems should they arise.

So what kind of classification of landscapes would be most useful in protecting and managing native vegetation and in administering the Native Vegetation Conservation Act?

Since the NVCA deals with managing vegetation, the most useful classification of an ecological community would be one based on the structure (density, height, number of layers) and floristic composition (plant species presence and abundance) of vegetation. This type of classification is being used for defining and mapping forest ecosystems for the Comprehensive Regional Assessment of Forests in NSW (CRA). Keith *et al*. (1997) recommended that classification of floristic assemblages in native forests should be based on analyses of field sample plots, environmental variables such as substrate, and patterns discerned from remote sensing of aerial photographs or satellite images.

The acquisition of floristic plot data, that sample environmental variation in the landscape, allows vegetation communities to be classified more objectively. This data also forms a basis for modelling the likelihood of a species or a classified community being present in an area. With the advent of more sophisticated computers and GIS/database software it is now possible to model likely distributions of species and species assemblages across a landscape. Modelling is most reliable when there is sufficient plot data or quality mapping in a region to underpin extrapolation to other parts of the region.

A discussion of the various modelling approaches is provided in Austin *et al*. (1994). Generalised additive modelling (GAM) is a robust statistical method currently in favour.

There are four levels of modelling that can be developed after the collection of sufficient primary data. Landscape models can evaluate the impact of fragmentation on habitat and populations of species of concern. Habitat models use spatial layers of information (soils, geology, landform, etc) to predict the location and extent of habitat for species and communities. Meta-population models deal with species that occur in isolated patches but have connections through dispersal mechanisms. Population demographic models determine the viability of populations at a location and evaluate the impacts of changes in the habitat at those locations. Populations of recently isolated plant species may not be able to connect with other populations because of poor dispersal of pollen or seeds. This can lead to inbreeding depression and localised extinctions over the longer term.

Modelling the distribution of plant communities can be used as a means for selecting areas to protect all species, but only up to a point (Ferrier & Watson 1997). Recent examples of vegetation and plant species modelling are Keith and Bedward (in press) for the southeast forests of NSW, and the NSW NPWS CRA forest assessments in northeastern NSW. These techniques are likely to be used more in the future and their effectiveness will be further tested.

In addition to quality of data, scale of mapping is also important in meeting the requirements of managing vegetation at a regional scale. Ideally, classified communities should be mapped at scales of 1:100 000 in western NSW and 1:25 000 in eastern NSW (see discussion on "standards of data" below).

Most landscape mapping in NSW has tended to use vegetation as a primary basis, but unlike British Columbia or some other states of Australia, there has not been a consistent approach to broad-scale landscape or vegetation classification, making it difficult to gain a state or regional perspective. This should be a key objective for the future.

When using vegetation maps there are two main notes of caution:

- Individual species are distributed along environmental gradients. Therefore, vegetation maps summarise this complexity by mapping intuitively or computer-derived clusters of species. Some assemblages are floristically distinct and are easy to discern, classify and map. Examples may be a swamp or a patch of rainforest. Other vegetation, such as many of the *Eucalyptus* forests in eastern NSW, is difficult to classify and map as it contains a high proportion of overlapping species.
- Classified units of the landscape are purported to act as "surrogates" for biodiversity as a whole. This may be true for some organisms but for not others. For example, it appears that invertebrate assemblages do not vary to a significant degree across a distinct vegetation boundary in Sturt National Park in far northwestern NSW (Dangerfield *et al*. 1998). More research is required on the correlation of landscape classifications based on vegetation with the existence of other organisms.

Irrespective of these limitations, having vegetation communities mapped on a regional basis helps with planning decisions about conservation management. This includes setting priorities for LANDCARE projects, protecting areas in regional plans and selecting areas for conservation reserves or property agreements.

Status of vegetation mapping and floristic data

Species records and vegetation mapping provide information suitable for vegetation assessment and vegetation management. Species records are either in the form of voucher specimen records in herbaria, such as the NSW Herbarium which holds about 500 000 records of plants for NSW, or from botanical field surveys. The quality of field data varies markedly from standardised plot data to general species lists for a location. The former can be used in developing numerical classifications and modelling species distributions, while the latter cannot.

Botanical field surveys record the presence or abundance of species in a given area or sampling plot. Vegetation mapping extrapolates discernible patterns of species assemblages or structures across the landscape using remote sensing such as aerial photographs or computer modelling, or both. The number of vegetation units described from an area relates to the degree of heterogeneity of the landscape (climate, soils, topography), the scale of the mapping and the degree that the mapper classifies the vegetation - either intuitively or using numerical analyses.

A review of the major vegetation classifications and mapping systems in Australia is provided in Sun *et al*. (1996). This highlights the benefits of quantitative measurements and the need for the collection of mandatory data in the field. Sampling is expensive but it provides flexibility in the use of the data over the long term (Benson 1995).

There has not been a well-funded and consistent vegetation survey and mapping program in NSW. The need for one led to the NPWS establishing a Biodiversity Survey Program as a subset of the NSW Biodiversity Strategy. However, guidelines for surveys have not been produced, although procedures were established for surveying and mapping vegetation in the CRA for the forests of eastern NSW. Consequently, NSW does not have a standard set of vegetation maps covering it, or an associated agreed classification of plant communities. This contrasts with vegetation mapping programs in other states in Australia. For example, Queensland has a standardised vegetation survey conducted by the Queensland Herbarium. This has partly been funded by the CRA for forests but is extending into north central Queensland under State funding. To date, over 40 1:100 000 maps have been mapped using API and ground survey. In South Australia all botanical surveys comply with State guidelines (Heard and Channon 1997) and much of the vegetation in the southern part of that state has been surveyed and mapped into a geographical information system in order to administer vegetation retention laws.

The vegetation of NSW has not been adequately sampled in plots using stratified sampling methods. Figure 3 shows that the vegetation of eastern NSW has been better sampled than inland areas. Public forested land on the east coast and escarpment has been most intensively sampled, largely due to the recent and ongoing regional assessments of these forests. Private lands remain relatively poorly sampled.

Early vegetation mapping in NSW was conducted by the Soil Conservation Service in western NSW (Beadle 1948) at a coarse scale or resolution. From the 1950s - 1990s the NSW Forestry Commission produced forest type maps concentrating on commercial timber in state forests at a fine scale of 1:25 000. The Department of Land and Water Conservation is currently mapping the canopy cover of the New England and Nandewar Bioregions and the Walgett-Moree section of the Darling Riverine Plains.

In the mid-1970s the National Herbarium embarked on a program to map the State's native vegetation at a regional scale. That organisation has completed 1:250 000 maps for the south-western corner of NSW, has mapped much of the Sydney Basin Bioregion at 1:100 000, has mapped the north-western section of the state at 1:1 million (Pickard and Norris 1995) and has commenced detailed 1:25 000 mapping (to be published at 1:100 000 scale) in the New England Tableland Bioregion.

The NSW NPWS has mapped the northern and central sections of the NSW wheatbelt at 1:100 000 scale on GIS. The southern most map sheets of this survey (Forbes and Cargelligo) have been published at 1:250 000 scale (Sivertsen & Metcalfe 1995). The forests and the wetlands of the Murray River Valley have been surveyed and mapped at 1:50 000 scale (Margules and Partners 1990). One of the most thorough vegetation surveys and ecological mapping exercises is by Keith and Bedward (in press) covering the Eden forest management section of the South Eastern Corner Bioregion. This used over 1600 sample plots to define 79 plant communities. These were mapped using a combination of computer modelling and remote sensing to produce a vegetation map at 1:25 000 (reduced to 1:100 000 for publication) for the region. The NPWS has, or is in the progress of surveying and mapping the vegetation in many national parks and nature reserves in NSW at a fine scale (see for example Hunter 1998). The NPWS is also assisting in local government scale mapping using LANDSAT and SPOT imagery and aerial photographs, for example for the Yass, Cootamundra and Young Shires in southern NSW. A number of local governments are mapping vegetation in their jurisdictions, including surveys of roadside vegetation for State of the Environment reporting. Only a few of the above-mentioned mapping programs are supported by sufficient plot data to enable numerical classification of vegetation.

There has not been a comprehensive statewide synthesis of all botanical survey data or vegetation classifications although this was partly achieved in a synthesis by the DLWC for the Vegetation Forum in 1996 (DLWC 1996). Vegetation mapping for the Barwon region of north central NSW is documented in Blair (1998). Some spatial data are registered in the annual publication of the NSW Mapping and Spatial Data produced by the Land Information Centre, Bathurst. The NSW Natural Resources Data Directory was a meta-database initiated by DLWC in 1994. Its records are being translated to the Australian and New Zealand Land Information Council (ANZLIC) standard meta-data set that has been established to bring conformity to natural resource dataset records across Australian and New Zealand. It contains a large number of survey and vegetation map records and is the key meta dataset servicing government and the wider community.

A uniform, government-wide gap analysis of vegetation survey and mapping information in NSW is urgently required. This should use the ANZLIC database and link these records as points or polygons, via GIS, to a NSW map base of the Surveyor General's topographic maps. This central database would serve all agencies and all community groups, including regional vegetation committees, in NSW.

There are difficulties in bringing together disparate information on vegetation due to inconsistency in vegetation surveys, mapping techniques and scales used. Vegetation survey methods were agreed on at a national workshop in 1991 (Bolton 1992). However, consistent standards for vegetation survey and mapping have not been applied by all organisations, although in NSW the NPWS, State Forests and the National Herbarium use similar (interchangeable) proformas for recording floristic data from sample plots. This contrasts with the situation in South Australia where detailed guidelines for native vegetation survey have been prepared (Heard and Channon 1997). Such guidelines not only serve to standardise data collection within government but also assist consultants, community groups and lay members of the public to collect information in a way that can be incorporated into State databases for wider uses.

The National Land and Water Audit, funded by the Commonwealth Government, is attempting to produce pre-European and present vegetation maps of Australia at a regional scale (100 000-250 000 scale) by the end of 1999. The Audit proposes to produce a national database of vegetation maps and surveys, set national standards and identify gaps at regional scales. This will not, therefore, necessarily record local scale vegetation mapping or survey, but it may provide a national overview. It is estimated that it will cost $26 million over 10 years to produce a quality 1:100 000 mapping and survey layer of NSW (pers. Comm. Environment Australia and Royal Botanic Gardens Sydney). This cost estimate includes gap filling with field survey and vegetation mapping, updating previous work to required standards and stitching all of this together in databases and GISs.

Computer databases, such as the NPWS Wildlife Atlas, have been developed to store species locality data and there are about 20 000 floristic plot records databased for NSW. Approximately half of these plots record all plants present, the remainder record canopy species only. Recently, floristic survey has been driven by the comprehensive regional assessment of forests in eastern NSW. This should deliver sound botanical data for public and some private lands on the coast and tablelands. The NPWS is undertaking Bioregional assessments of the Cobar Peneplain (Creaser and Knight 1996) and Riverina Bioregions (Eardley 1999). These reports collate data on vegetation and produce analyses of the conservation status of the ecosystems in those Bioregions.

Standards of data

Ideally, sound vegetation management planning requires adequate plot data, vegetation classification and mapping of that classification over a region (Keith *et al* 1997, Benson 1995). Finer scale vegetation mapping is easier to relate to property planning and usually provides a more detailed vegetation classification. In addition to mapping, scientific studies on the functioning of species and ecosystems assist decisions about vegetation management especially in relation to disturbance regimes such as fire and grazing.

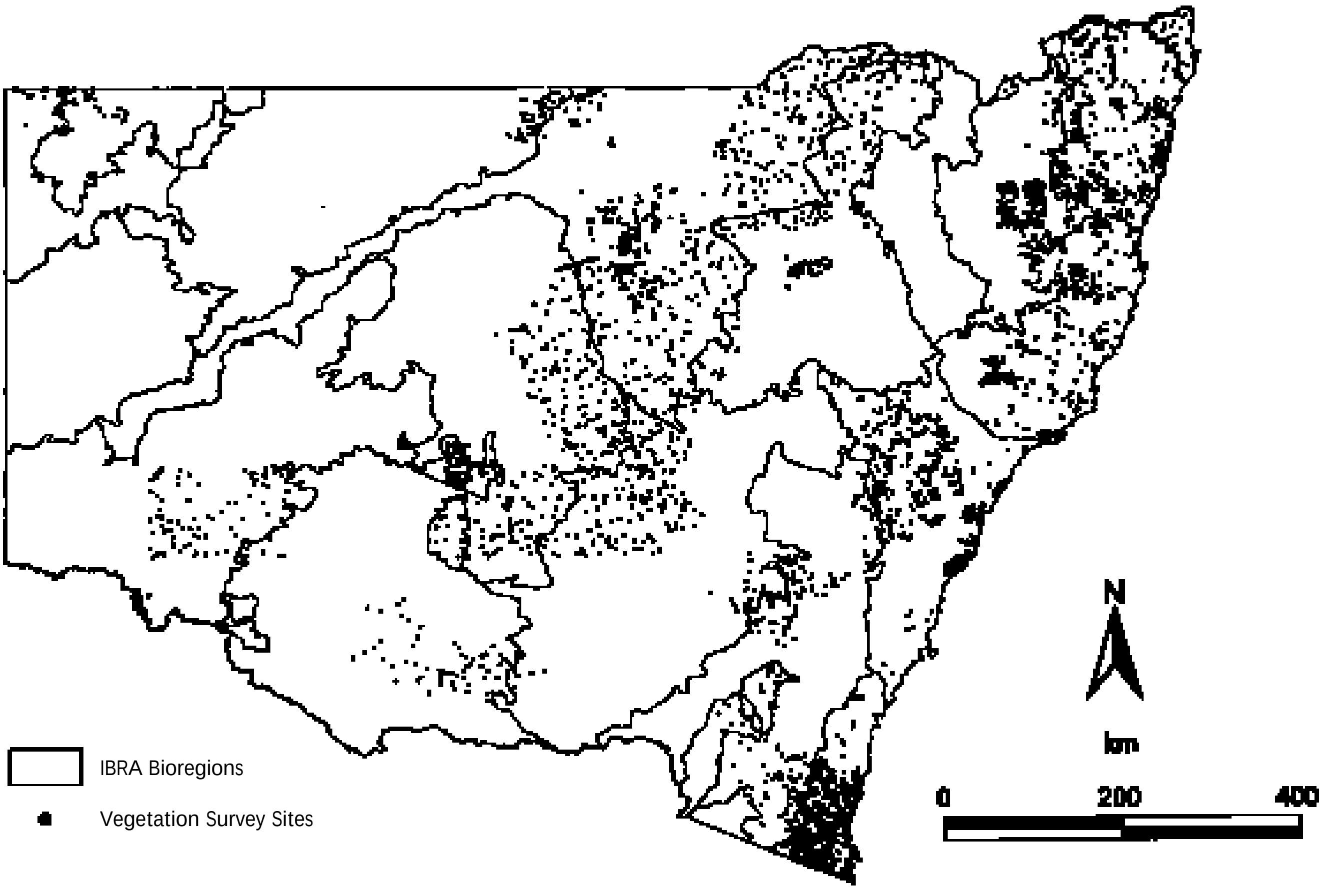

Figure 3. Location of native vegetation sample plots in New South Wales. Over 20 000 plots are databased from different surveys. Public lands of eastern NSW are well sampled compared to private lands. Western regions are poorly sampled, with the exception of the northern and central wheatbelt, the Pooncarie area, some conservation reserves and some state forests (modified from data supplied by the NSW National Parks and Wildlife Service, GIS Division).

In NSW there has been less consistency in mapping vegetation than in accumulating floristic data from field survey plots. Map unit definitions are greatly influenced by scale and over the years different projects have mapped vegetation at different scales. These inconsistencies make it difficult to edge-match or overlay vegetation maps that have been derived from different projects. This is why plot data are so important. Variables recorded at a particular place and time can be used to define vegetation patterns in the future. In contrast aerial photographic interpretation of vegetation patterns is highly subjective and difficult to standardise. API is best used in conjunction with adequate sampling of the vegetation, as the sampling provides a sound basis for extrapolating photo patterns that reflect structure and floristic variation across the landscape.

Depending on the purpose of the study and its scale, the level of detail of vegetation mapping and survey will vary. Scale does not necessarily relate to quality because different scale vegetation maps may have different purposes. However, projects that map vegetation at a fine scale (say 1:25 000) and adequately sample the vegetation in survey plots are more likely to produce high standard data suitable for local and regional planning. Several categories of quality and their usefulness are summarised below:

1. **High Standard - Full floristic, stratified plot sampling and fine scale mapping:** Scale of 1:25 000 in Eastern Division, 1:50 000 in Central Division and 1:100 000 scale in Western Division; vegetation sampled in standard-sized plots, using stratified sampling methods (Benson 1995); all vascular plant species recorded in plots; vegetation numerically classified and analysed against environmental variables; mapping of vegetation units by aerial photographic interpretation with ground traverses and/or using modelling; vegetation units should be linked to numerical analysis as much as possible; capacity for modelling ecosystems and species across the landscape to produce pre-European vegetation maps.

Examples: Keith and Bedward (in press) for Eden region (South East Corner Bioregion), Benson and Ashby (in prep.) for Guyra 1:100 000 map sheet (New England Bioregion), South Australian southern mallee survey and mapping project, some of the recent surveys of conservation reserves in eastern NSW, eg Clarke *et al*. (1997). The CRA survey of public lands on NSW North Coast Bioregion (unpublished NPWS) qualifies for the quality of its plot data and modelling capacity, but its vegetation mapping may fall into a lower category.

Uses: regional vegetation planning, property planning, species and ecosystem recovery planning, identify sites of significance, species and ecosystem modelling for rehabilitation.

2. **High-medium standard - full or part floristic, stratified or non-stratified plot sampling, medium scale mapping:** Scale of 1:100 000 in Eastern Division, 1:100 000 - 1:250 000 in Central and Western Divisions, with plot data less than required for high quality analyses; limited number of plot data recording all vascular plant species, or large number of canopy species plot data; vegetation numerically or subjectively classified; remote sensing by API and/or SPOT satellite images; thorough ground truthing; limited capacity to model species from data except canopy species.

   Examples: Wheatbelt mapping of Sivertsen and Metcalfe (1995), Pooncarie 1:250 000 vegetation map by Porteners *et al*. (1997), Queensland's vegetation mapping program, some older vegetation maps of reserves that mapped vegetation at fine scales.

   Uses: Provide regional perspective for regional vegetation planning, basis for more detailed survey, identified sites of significance.

3. **Medium standard - part floristic survey - often canopy only, medium to coarse scale mapping:** scale of 1:100 000 in Eastern Division, 1:250 000 or smaller in Central and Western Divisions, with limited non-stratified plot data often only canopy species noted; data not subjected to numerical analysis; vegetation subjectively classified; remote sensing by API, SPOT or LANDSAT imagery; moderate ground truthing; poor capacity to model species from data except canopy species.

   Examples: RBG mapping at 1:100 000 scale of Sydney region, RBG mapping of S/W NSW (excluding Pooncarie sheet).

   Uses: Setting regional perspective, overview for regional vegetation planning, identifying some sites of significance.

4. **Coarse standard - limited field plots and/or coarse scale, structural rather than floristic classification:** Scale > 1:100 000 in eastern NSW, generally > 1: 250 000 in western NSW; no stratified sampling, few plots, emphasis on noting canopy species; subjective classification of floristics or only structure measured remotely; remote sensing by LANDSAT or API but often for structure only; no capacity to model species.

   Examples: Pickard and Norris (1994) 1: 1,000, 000 map of north-western NSW, Eastern Bushland data base, BASINCARE M305 data (Ritman 1995) which shows woody/non woody vegetation at 1:100 000 scale but is does not provide a sound floristic classification and is not supported by plot data.

   Uses: State or regional overview can show extant vegetation by structural classes such as woody/non-woody.

Gaps in data

There are regions of NSW where reasonable vegetation maps have been produced but plot data is lacking and visa versa. Other regions have no data at all. The main gaps in floristic plot and vegetation mapping data are in the private land of the coast along with the Nandewar, New England Tableland, South Western Slopes, Broken Hill Complex and South Eastern Highlands Bioregions. No Bioregion of NSW has had its native vegetation completely mapped at a fine scale supported by sound floristic plot data. Some Bioregions such as the Murray Darling Depression have had their vegetation mapped but lack plot data, while others such as the NSW North Coast contain much plot data but lack ecologically based vegetation mapping.

With the exception of some regions covered by the CRA and far western regions, there is no uniform, detailed pre-European vegetation map of NSW. Even where extant vegetation has been mapped, site data are often lacking. It is suggested that by the year 2015 the native vegetation of NSW should be surveyed and mapped to the "high quality" standard as described above. This will require a gap analysis, followed by a well-planned and coordinated botanical survey program. Priorities for new survey and mapping should be a function of existing data and the degree of threat faced by vegetation in different regions. Table 1 provides a coarse comparative overview of the degree of threat to native vegetation in each Bioregion.

It would be beneficial to regional planning and vegetation management if there was more consistency in the collection and analysis of botanical data along with more consistent methods of classifying plant communities across the landscape. This will require improved cooperation and protocols for data transfer between government agencies, local government and the public.

As mentioned previously, it is crucial that a meta-database on vegetation survey and mapping, and research studies, be established to facilitate bibliographic studies by government agencies, regional vegetation committees, local government or the public. This would reduce the chance of duplication of survey and mapping.

THREATS TO NATIVE VEGETATION

Clearing

The main causes of change to Australia's vegetation since European settlement have been large-scale clearing and cultivation of land (Benson 1991). Between 1788 and 1921, 35 million hectares, or 44% of NSW, were ringbarked and partially cleared, peaking at a rate of 2515 hectares per day between 1893 and 1921 (Reed 1990). It is estimated that 15 billion trees (15,000,000,000) have been cleared in the Murray-Darling Basin since European settlement (Walker *et al*. (1993).

From the early years of European settlement up until recent times, there have been economic incentives to clear land. For example, up to 1985 when the tax laws were changed, there were tax concessions for clearing native vegetation.

The cumulative impact of 200 years of clearing in NSW has resulted in over 70% of the native vegetation having been removed from the Central Division wheat/sheep zone (Wells *et al*. 1984). Similar reductions have occurred at lower elevations in the coastal valleys and parts of the tablelands (Figure 1). The largest native vegetation remnants occur on poor soils on sandstones, granites, coastal sand plains, steep slopes and rugged mountain ranges. For example, in the South Eastern Highland Bioregion most of the forests and woodlands that occurred on medium to high nutrient soils on undulating topography have been cleared. Bushland remains on siliceous ridges and in rugged mountain ranges including the Snowy Mountains.

Clearing of the northern floodplains occurred later than the southern slopes and plains. However, over the last few decades most of these northern floodplains in the Central Division have been cleared as wheat and cotton cropping has expanded in response to higher commodity prices - relative to lower prices for products derived from sheep and cattle. Sivertsen (1996) reveals that there was an annual clearing rate of about 4% of native vegetation in the northern wheatbelt between 1977 and 1984. Extrapolated over a larger area of the wheatbelt this amounted to hundreds of thousands of hectares being cleared during this period.

While clearing rates vary from place to place and from year to year the key point is that clearing is cumulative over time. Only 28% of the St George 1:250 000 map sheet area in the northern wheatbelt of NSW was naturally vegetated in 1994 compared to 61% 20 years earlier in 1974 (Sivertsen 1996). Between 1974 and 1989 there was a 61% (54 400 ha) reduction in native vegetation in the area of the Condobolin 1:100 000 map sheet in the central NSW wheatbelt (Sivertsen and Metcalfe 1995) (Figure 4).

On a smaller scale, between 1955 and 1990 there was a 185% increase in cropping of previously grazed land on rich soils in the Goran Basin near Gunnedah (Gray 1995). This increased clearing of deep-rooted native vegetation in favour of annual crops is leading to a rising saline watertable in the Basin. The extent of this clearing and cropping not only effects biodiversity conservation but will also impact on-farm incomes and land values over the long term. Similar scenarios to Goran Basin apply to other parts of rural NSW.

Rates of clearing in the 1980s

It was not until 1980 that it became possible to estimate rates of clearing using satellite image technology. Using MSS satellite images, D. Graetz (CSIRO pers. comm.), detected 50 000 ha of woody vegetation (with a canopy cover of >20%) being cleared annually in NSW during the 1980s, and 520 000 ha/year throughout Australia. However, this calculation probably underestimate the amount of clearing because:

- of the coarse resolution of MSS satellite imagery used (LANDSAT TM with its improved resolution was not available), therefore some areas of clearing may not have been detected;
- the methodology did not consider woody vegetation with <20% canopy cover, therefore it would have underestimated the clearing of sparse woodlands and shrublands on the inland plains;
- the methodology did not attempt to detect the clearing of native grasslands that are herbaceous vegetation with a canopy cover of <10% of woody species;
- improved detection methodologies such as those developed by the Environmental Research and Investigation Consortium (ERIC 1998) have detected more clearing compared to other methodologies (see discussion below).

Given the above considerations, it is likely that the total clearing rate of woody vegetation, with a canopy cover of >12-15%, during the 1980s, would have been as much as 100 000 ha/year. If the clearing of native grasslands could be estimated, the total clearing rate of all native vegetation in the 1980s would be higher.

Rates of clearing in the 1990s

Clearing decreased in the 1990s due to the 1992-4 drought, because much of the arable land had been cleared, and commodity prices fell for grazing enterprises. However, clearing continued for crops, notably for wheat, cotton and rice. Currently, commodity prices for crops are high compared with those for production based on grazing. Expected rates of return for the 1997-8 season were 4.4% for wheat and other crops, compared with 0.8% for sheep and -0.2% for beef (Martin 1998).

Average clearing rates of woody vegetation in NSW between 1991 to 1997 have been studied by the Bureau Resource Sciences (BRS)(1998) for the period 1991-1995 and ERIC (1998) for the period 1995-1997.

The BRS study was restricted to detecting clearing in vegetation with a canopy cover of >20%. Thus it excluded large areas of native vegetation including sparse woodlands and shrublands. It calculated that about 24 600 ha of woody vegetation were being cleared annually in NSW between 1991 and 1995. This included about 7000 ha/year for forestry operations, 2300 ha/year for urban expansion and mining operations and about 15 000 ha for agriculture.

In its study of clearing during 1995-1997, ERIC (1998) showed that total clearing was approximately 30 000 ha/year for the 1995-1997 period. This used improved detection methods that measured clearing of woody vegetation down to 12-15% canopy cover.

When ERIC applied the BRS method for the 1995-1997 period, the total clearing detected fell by half compared to their method, ie to 15 000 ha/year.

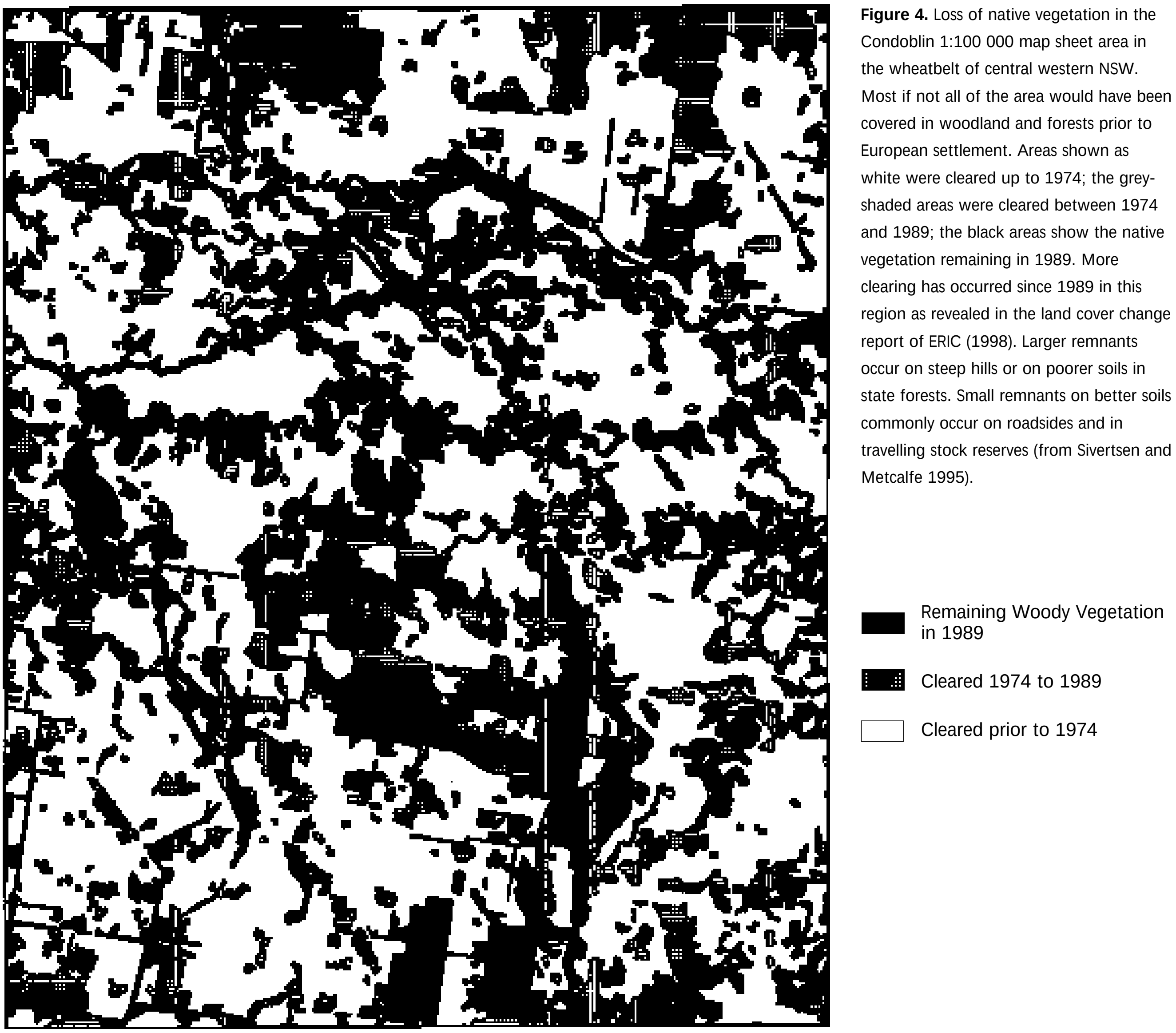

Figure 4. Loss of native vegetation in the Condoblin 1:100 000 map sheet area in the wheatbelt of central western NSW. Most if not all of the area would have been covered in woodland and forests prior to European settlement. Areas shown as white were cleared up to 1974; the grey-shaded areas were cleared between 1974 and 1989; the black areas show the native vegetation remaining in 1989. More clearing has occurred since 1989 in this region as revealed in the land cover change report of ERIC (1998). Larger remnants occur on steep hills or on poorer soils in state forests. Small remnants on better soils commonly occur on roadsides and in travelling stock reserves (from Sivertsen and Metcalfe 1995).

Therefore, if the ERIC method was applied to the 1991-1995 period there is a high probability that it would detect twice as much clearing as that detected by the BRS (1998) approach. Given that areas less than three hectares were not reliably detected (ERIC pers. comm.), these figures probably underestimate clearing rates.

The current information suggests that clearing of native woody vegetation (including forestry, and with canopy cover greater than 12-15%) during the 1991-1995 period, was close to 50 000 ha/year. This fell to about 30 000 ha/year after the introduction of vegetation clearing controls (SEPP 46 in August 1995 followed by the NVCA in January 1998). Therefore, it is possible that regulation has worked to reduce clearing - at least in some parts of NSW.

This reduced rate of clearing remains well above the targets set by the Commonwealth Government for revegetation and reduction of greenhouse emissions.

Currently in NSW, clearing is mainly occurring in the Coolabah-Black Box woodland of the Darling Riverine Plains Bioregion (Moree-Walgett-Nyngan regions) for wheat and cotton, and Riverina Bioregion for rice. Smaller scale clearing occurs elsewhere, for example for urban development and subdivision on the coast, for pine plantations on the southwestern slopes, eucalypt plantations on the north coast and for opportunistic cropping in the Western Division.

Overgrazing by domestic stock and feral animals

The influx of millions of sheep and cattle, along with feral animals such as the goat and rabbit, and increases in populations of larger macropods, led to an increase in "total grazing pressure". Over 100 years of this grazing pressure over much of NSW has reduced the biomass of native vegetation - particularly palatable plant species. Large parts of NSW were over-grazed last century and early this century. This led to sheet and gully soil erosion, as many of the soils were sandy or otherwise erodible once ground cover was removed. Numerous papers are published in the rangeland literature about grazing regimes and their impacts on the environment. Although grazing is better managed today than in previous decades, most vegetation remnants west of the Great Dividing Range have been affected by past and present stock grazing and this is likely to continue to be a problem. Continuous grazing prevents the regeneration of plants from suckers or the recruitment of new individuals from seedlings. In response to the impacts of grazing, LANDCARE, Save the Bush and Natural Heritage Trust programs are funding the fencing of remnants from stock.

Weed invasion

Approximately 15% (1000) of the plant species in NSW have been introduced since European settlement. A small proportion of these have become weeds impacting on agriculture or natural ecosystems or both. A review of the main weed species in Australia was undertaken by Humphries *et al*. (1991). The major environmental weed species in NSW are listed in Table 2. These include several aquatic plants, trees, shrubs and grasses. Only a few of the many weed species of pastures are listed here as these are generally less invasive of native vegetation.

Other weed species in NSW. These include: *Rubus discolor* (Blackberry) that forms thickets in disturbed pastures and along rivers in southern NSW; *Cardiospermum grandiflorum* (Balloon Vine), *Ipomoea cairica* and *I. indica* (morning glory) that invade rainforest and other forests on the central and north coasts; the vines *Lonicera japonica* (Honeysuckle) and *Hedera helix* (English Ivy) and *Protasparagus* spp. (Asparagus Fern) that invade urban bushland on the coast; *Lycium ferocissimum* (African Boxthorn) that dominates the shrub layer of some inland floodplains; *Ludwigia peruviana* (introduced Water Primrose) which is spreading in wetlands around Botany Bay and elsewhere; the garden shrub *Polygala mytifolia* (Polygala) which is invading bushland along the coast; several *Cotoneaster* species that are spreading on the tablelands and coast; *Ageratina* spp. (Crofton Weed) that invades disturbed higher nutrient sites on central and north coast; and the native species *Acacia baileyana* (Cootamundra Wattle) which occurs in disturbed urban areas outside its natural range, including around Sydney. Auld and Medd (1987) illustrate many of the weeds of Australia.

Table 2. Major Environmental Weeds in NSW (excluding pasture weeds such as thistles, rye grass or wild oats) ("integrated control" = judicious use of herbicides, weeding, grazing management)

Species/common name/lifeform	Habitat	Impacts	Actions
Salvinia molesta Salvinia: aquatic forb	high nutrient, slow moving water	invades open water and alters aquatic systems	biological control, monitoring
Eichhornia crassipes Water Hyacinth: aquatic forb	Standing water with high nutrients	invades open water and alters aquatic systems	integrated controls and biological control
Alternanthera philoxeroides Alligator Weed: aquatic and terrestrial forb	Stoloniferous aquatic or semi-aquatic able to live in low nutrients water bodies	invades water systems and has potential to spread to many areas	biological and integrated controls, monitor
Salix spp Willows (5 spp in NSW): tree	stream banks and dams	shades out native species, not hollow forming so poor habitat for fauna	integrated controls including wholesale removal
Chrysanthemoides monilifera subsp. *rotunda* (Bitou Bush) and subsp. *monilifera* (Boneseed): shrub	occurs on over 60% of NSW coast, dominating in places - on dunes, headlands and in adjacent forests	displaces native species, prolific seed set and rapid spread	biological and integrated controls including weeding
Myrisphyllum asparagoides Bridle Creeper: vine	range of habitats including mallee , coastal eucalypt forests and rainforest	smothers ground and shrub layers	research of ecology and biological control
Ligustrum spp. (3 species in NSW) Privet: tree	invades forests on higher nutrient soils in eastern NSW including Sydney bushland, Dorrigo and Robertson Plateaux	shades out understorey species, alters fire regime, high seed production	integrated controls, research needed for biological control
Cinnamomum camphora Camphor Laurel: tree	colonises disturbed sites Major weed on north coast	suppresses other species, some forms are toxic to fauna	taxonomic research on forms, integrated control, monitoring
Cytisus scoparius Broom: shrub	forms thickets on better soils - Barrington Tops, Blue Mountains, and Snowy Mtns	Shades out native species, invades native vegetation, prolific production of long-lived seeds	biological and integrated control. Monitor spread
Macfadyena unguis-cati Cats's Claw Vine: vine	invades rainforest Sydney to north coast	smothers trees and shades out understorey	single species genus in Australia therefore biological control may benefit but research required
Lantana camara Lantana: shrub	colonises disturbed sites and edges of forests, major infestations on coast, particularly north	can choke out native species, but can provide cover for native regrowth and habitat for fauna	biological and integrated controls or do nothing
Nassella trichotoma Serrated Tussock	invades grasslands, particularly disturbed sites	out competes native grasses and forbs, damages production on farms	biological and integrated control. Monitor spread. Grazing management

Table 2. Continued

Species/common name/lifeform	Habitat	Impacts	Actions
Eragrostis curvula African Love Grass	invades grasslands, particularly disturbed sites	out competes native grasses and forbs, damages production on farms	biological control research required. Integrated controls. Grazing management
Hyparrhenia hirta Coolatai Grass	invades grasslands, particularly disturbed sites	out competes native grasses and forbs, damages production on farms	biological control research required. Integrated controls. Grazing management

Appropriate fire regimes

Over millions of years Australia's flora has adapted to a range of fire regimes - well before the arrival of Aboriginal people 40-60 000 years ago. Some plant species contain woody fruits that shed seed after fire; others resprout after fire from root tubers (lignotubers) or from epicormic shoots on tree trunks. Some vegetation, however, is intolerant to frequent fire including all rainforest, alpine/subalpine woodlands and herbfields, and chenopod (saltbush) shrublands. Wet sclerophyll forests burn infrequently - with fire intervals of several decades. Fire is more common in drier *Eucalyptus* forests and woodlands, grasslands, mallee shrublands and coastal heath but it varies in frequency and intensity from place to place.

There is considerable debate about the impact of Aboriginal burning on eastern Australian vegetation (summarised in Benson and Redpath 1997). Most scientists agree that the composition of Australian vegetation was determined by climate change over millions of years and that Aboriginal burning affected the rate but not the direction of that change (Clark 1983). There is no evidence that Aborigines burnt the whole landscape annually. Their burning practices would have varied depending on the type of vegetation and the food resources they sought to manage (Baker 1997).

The biological evidence suggests that the pre-European frequency of fire (Aboriginal or other) must have varied for different types of vegetation. The explorer observations, and some scientific studies, indicate that Aborigines burnt grassy woodland and grassland habitats frequently, but there is a lack of detail in the historical journals about the extent and frequency of burning. It is most likely that Aborigines burnt grassy vegetation in a mosaic fashion for "green pick" to attract game as recorded by Leichhardt (1842-1844).

Fire sensitive vegetation could not have been burnt frequently by Aborigines. In fire-prone environments, such as coastal heath, fire management is complex. For example, the scientific evidence for the Sydney sandstone flora suggests that repeated, widespread prescribed burning at intervals of less than a few years will cause the extinction of plant species and that recolonisation from unaffected sites occurs extremely slowly (Bradstock *et al*. 1998, Keith 1996). As a generalisation, these shrubby sandstone forests and woodlands require occasional intense fires between 8 and 25 years apart, but with variable inter-fire periods (Bradstock *et al*. 1995).

While the "appropriate" fire regime to maintain all species in a given area is difficult to achieve, modern bushland fire management should take a landscape approach aimed at maintaining species diversity in patches by applying varied fire regimes. A general principle concerning the management of fire in native vegetation is to implement a fire regime that maintains species diversity and populations of species over the long term. In general, fire intervals should be long enough to allow seedlings to mature and seed to be built up in the seedbank before another fire.

Habitat loss for fauna

Most animal species rely on vegetation for food and shelter. If the vegetation is lost or degraded food becomes less available and predation by foxes, cats and native predators may increase. This leads to declining populations and local or regional extinctions. There are many scientific papers and general articles about the habitat requirements of animals, particularly referring to the impacts of logging forests. These should be consulted for more details about the habitat requirements of particular species.

Vegetation structure is of over-riding importance to the maintenance of animal populations. Arboreal mammals and many bird species require old growth trees with branch and trunk hollows to provide shelter and nest sites. Recher *et al.* (1980) found hollows in 80% of eucalypts with diameters of >0.8 m. As trees get older, say over 120 years old, the hollows get larger and more numerous, as demonstrated by Mackowski (1987) in a study of Coastal Blackbutt (*Eucalyptus pilularis*). Age and size of trees also affects flower production. In a study of the flower cover of box and ironbark trees in a woodland in Victoria, it was established that large, old trees produce more floral resources than younger trees (Wilson and Bennett in press). Therefore, the loss of old-growth trees may have negative repercussions for nectar or pollen-dependent animals such as honeyeaters and possums.

If old growth trees are lost from forests or woodlands, some animal species will become locally extinct. So if a forest consists only of young regrowth trees it is likely that some animal species will not be present and will only recolonise the forest as it gains age if there are remnant old growth stands within the dispersal capability of the species.

Changes to understorey structure and floristics can also lead to loss of animal species. The endangered Long-footed Potoroo of the southeastern forests of NSW feeds on fungi and is susceptible to predation by foxes. If the dense understorey in which it survives were to be changed to a more open one, its food resource may decline and predation rates may increase. The endangered ground bird, the Plains-wanderer, requires a grassland habitat containing an open tussock structure (Baker-Gabb 1990). It is intolerant of dense grassland. Superb parrots nest in old growth River Red Gum trees on the Murray River but winter in central western NSW in box woodlands. These examples illustrates the importance of understanding species biology in conservation planning.

A more detailed background paper on the ecological values of native vegetation is to be produced by the NVAC in the future.

Other threats to native vegetation

There are many other threats to native vegetation that may be more critical in some regions than others. These include:

- rising saline water-tables due to loss of deep-rooted vegetation;
- acidification of soils due to the application of fertiliser;
- disturbance of acid sulphate soils in coastal regions;
- changes to natural drainage;
- intensive and frequent logging on both public and private lands;
- mining and quarrying, for example coastal sand mining in NSW between 1950 and 1980 destroyed large areas of coastal dune vegetation including a large proportion of littoral rainforest;
- urban expansion of cities and towns that leads to direct destruction of vegetation and secondary impacts of weed invasion;
- inappropriate planting of non-indigenous species that “pollutes” natural gene pools of species in an area;
- unsustainable firewood cutting;
- nutrification and other pollution of waterways from urban and agricultural sources;
- intensive recreational activities that disturb vegetation;
- climate change - that has long term ramifications for the survival of species across the landscape.

CONSERVATION OF NATIVE VEGETATION

Land tenure

Most of the remaining native vegetation in NSW occurs on public (Crown) land including conservation reserves, state forests, travelling stock routes and stock reserves (TSRs), vacant Crown land, various types of crown leases in eastern NSW and Western Land Leases in the Western Division of NSW.

TSRs contain the largest areas of native vegetation in some of the most extensively cleared regions of NSW (particularly in the wheatbelt of the Central Division). Because they have mostly been discontinuously grazed, TSRs often contain threatened plant species that have been eliminated by continuous grazing on private land. Some of the most important native vegetation remnants occur on TSRs (Hibberd 1978). Williams and Metcalfe (1991) document the importance of TSRs for threatened species and plant community conservation in the Armidale District in the New England Tableland Bioregion. Some of the most important native grassland remnants in NSW are in TSRs in the Monaro (Benson 1994) and in the Riverina (Benson *et al*. 1997). These values of TSRs are threatened by current requirements of the Rural Lands Protection Board to raise revenue through leasing the reserves for continuous grazing.

The one million hectares of Crown leasehold land under the Crowns Land Act in the Central and Eastern Divisions of NSW is critically important for species conservation and habitat retention, serving more or less as a defacto reserve system (Benson and Doherty 1993). Once leasehold land is freeholded it can be subdivided and it is often cleared of its native vegetation.

The naturally vegetated Western Division (40% of NSW) is primarily covered with western land leases under the Western Lands Act. This tenure allows government to limit land use activities such as grazing and clearing in a semi-arid environment that is prone to land degradation.

Until the Native Vegetation Conservation Act came into force the Government had limited control over clearing and degradation of native vegetation on freehold land.

Protection of vegetation in conservation reserves

In an ideal world we would manage the landscape "ecosystem by ecosystem" rather than by land tenure. In reality, the presence of native vegetation largely correlates to tenure as mentioned above. Publicly owned and managed conservation reserves afford the highest level of protection to natural habitats. These reserves cover approximately 6.2% of the State, taking into account recent additions resulting from the Eden and North Coast regional assessment of forests.

Most reserves are in the eastern and far western parts of the State. About 60% of the vegetation communities present in the State are reasonably well sampled in these reserves (authors estimate). However, reservation does not guarantee the conservation of many species over the long term if threatening processes affect populations inside reserves.

Table 1 shows the proportion of each Bioregion reserved in conservation reserves. Figure 2 overlays the existing conservation reserve system with the IBRA Bioregions. This is somewhat misleading because parts of the Bioregions containing lower nutrient soils are better conserved than parts with higher nutrient soils. Nevertheless, in the broad context, eight of the state's 17 Bioregions have 3% or less of their land in conservation reserves (Pressey *et al*, in prep). Most of these are west of the Great Dividing Range where the impacts of agriculture have been greatest and where most of the land is privately owned.

To address the poor conservation status in western NSW, the NPWS has conducted Bioregional assessments for the Cobar Peneplain (Creaser and Knight 1996) and the Riverina Bioregions (Eardley 1999). Using geographical information systems linked to bio-databases and applying land-selection algorithms based on the concepts of comprehensiveness, adequacy and representativeness (CAR) (Pressey *et al.* 1995), these assessments highlight ecosystems that are poorly conserved and prioritise regions for conservation action. This action may include acquiring land for conservation reserves or entering into property management agreements. Bioregional assessments are an example of a strategic approach to setting priorities in nature conservation.

The CRA for eastern forests is using the JANIS (1996) criteria for assessing conservation status of ecosystems.

JANIS requires a minimum of 15% of the pre-European extent of defined vegetation types to be protected in conservation reserves. When vegetation types are very rare or restricted in extent, as much as 90% of their extent may be targeted for reserves.

A limiting factor in establishing a fully representative reserve system is the expense of acquiring private land and managing it in regions where there is a "sea of agriculture". Most of the poorly reserved and highly threatened vegetation communities occur as small remnants on private land or small areas of public land in agricultural areas - coastal valleys, tablelands, western slopes and plains (Benson 1991). While small reserves may be established over the most important sites, landscape-wide vegetation management will most likely be realised through regional planning, property agreements and other partnership arrangements with landholders, either under the Native Vegetation Conservation Act, National Parks and Wildlife Act, or through other means. In some areas where the native vegetation and soils have been so degraded, decisions will need to be made about what kind of ecosystems should be rehabilitated - the result may be so called "designer ecosystems".

Protection of native vegetation on private land through incentives and regulation

Biologists have long realised that it is not possible to conserve all species and ecological communities in public conservation reserves. Many animals migrate, others require large ranges and many species of both plants and animals can become inbred if their populations fall below critical thresholds. Not only does the protection of vegetation remnants on private land provide critical habitat for the survival of many species, it may also protect corridors linking larger areas of natural habitat in reserves or state forests.

It is not feasible to protect thousands of vegetation remnants in reserves. In South Australia, since 1985, incentive funding has been provided for fencing, feral animal or weed control, and re-vegetation schemes on private property. More recently incentives have become available in NSW. Rate relief is available under Voluntary Conservation Agreements of the National Parks and Wildlife Act. Funding for a range of conservation activities is available from the Native Vegetation Management Fund of the Native Vegetation Conservation Act. Funding is provided from the Fund when a landholder enters into either a management or property agreement with the Department of Land and Water Conservation.

A thorough review of incentives for conserving biodiversity is provided in Young *et al.* (1996). An example of a community-based conservation program aimed at protecting a highly threatened type of vegetation, grassy White Box woodland, is described in Elix and Lambert (1998).

Monitoring change and condition

Success in vegetation management will require more than just protecting vegetation in reserves or under agreements with landholders - although this is a vital first step. Over the long term, ecosystem monitoring will detect changes that may require management intervention. Examples of intervention may include: restoring genetic variability to populations of species where there is critical loss of genetic variability due to low numbers, or, re-introducing lost pollinators or symbiotic mycorrhizal fungi. Weed and feral animal management will continue to be one of the most important management tasks in order to maintain native vegetation in good condition.

A component of the National Land and Water Audit is to monitor changes in condition. However, there is no statewide monitoring of vegetation change in NSW, except perhaps in some experimental research plots or enclosures such as those established by the Soil Conservation Service over the decades.

DLWC's land cover change project 1995-97 (ERIC 1998), reveals gross changes to vegetation cover - clearing, some thinning, fire patterns etc. However, it does not detect changes to the understorey structure or floristic composition. Methods of detecting change in the understorey include: large scale aerial photographs, video cameras attached to aircraft, fixed ground photo-points, field measurements of changes in biomass, and site-based sampling techniques to detect changes in abundance of species and in species composition. The greatest challenge in monitoring is pinpointing the likely causes of change. There are numerous variables such as rainfall, feral or stock grazing intensity, native vertebrate and invertebrate herbivory, fire and plant diseases.

Due to the complexity of monitoring and the long-term financial commitment required to yield meaningful results, it is suggested that monitoring should not be undertaken lightly. It requires sound experimental design and long term planning and resources.

CONCLUSION

We are at a critical stage for protecting native vegetation in NSW, particularly on private land in agricultural regions. Salinisation is increasing, soil continues to erode in some places, more weed species are invading, and native species are becoming rare or extinct. Even with regulation, clearing is continuing in some regions, but apparently at reduced levels compared to the past. Some regions have lost more than 70% of the original native vegetation cover and contain highly degraded landscapes compared to pre-European environments. A high degree of fragmentation of vegetation has major implications for species survival, and perhaps some forms of agriculture.

So what can be done? The first step is to protect remaining vegetation by whatever means. This will require a mixture of actions. Some key lands may be purchased and dedicated as public conservation reserves - but this will only cover a small percentage of land. More land will be protected through community educational programs, incentive schemes and property agreements. Regulation has an important role to play as it acts as a disincentive to illegal clearing of vegetation.

The second step is to actively rehabilitate landscapes that have been severely degraded. This may involve selective plantings of indigenous species along watercourses or in areas devoid of native vegetation.

Both of the above steps are best undertaken after the native vegetation in a region has been mapped and surveyed to high standards. This information will underpin the production of sound regional vegetation management plans or local environmental plans for vegetation. A thorough gap analysis of vegetation mapping and survey data should be a prerequisite to instigating a regional vegetation survey and mapping program. A centralised, standardised meta-database that lists previous relevant vegetation projects and highlights existing datasets should serve all players in vegetation management. To fill the gaps, a regional scale vegetation survey, to agreed standards, should be instigated. A long-term aim should be to develop fine scale vegetation maps of all bioregions of NSW and stitch these together to form a detailed State map. These maps should be supported by plot data to help classify the landscape, detect rare species and model species distribution.

Future management, conservation and rehabilitation of native vegetation will depend on: adequate regional survey and vegetation mapping, ecological research on species and ecosystems, research on and implementation of rehabilitation schemes, successful extension programs, and adequate incentives funding. It would be beneficial if the Native Vegetation Management Fund could be funded well beyond its initial three years. If this happened, in 20 years from now, there may be hundreds or thousands of property agreements in NSW, protecting a range of habitats or economic assets of farms, such as tree lots and water-table recharge areas.

A cultural change towards conservation and sustainable agriculture has already been initiated by LANDCARE in rural regions of Australia. The preparation of regional vegetation management plans for regions of NSW will empower local communities with knowledge about the distribution, functioning and management of native species and their habitats. Wise application of this knowledge to vegetation management will greatly assist with the conservation of what remains of the Australian natural landscape along with the array of species that depend on it for survival.

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