CHAPTER 8

The Riverina Bioregion

1. Location

The Riverina Bioregion lies in southwest NSW, extending into central-north Vic. The bioregion is approximately 9,576,964 ha, with 7,090,008 ha or 74.03% of it lying in NSW (IBRA 5.1). The NSW portion of the bioregion occupies approximately 8.86% of the State (Eardley 1999 and IBRA 5.1).

The Riverina Bioregion extends from Ivanhoe in the Murray Darling Depression Bioregion south to Bendigo, and from Narrandera in the east to Balranald in the west. Within its boundaries lie the towns of Hay, Coleambally, Deniliquin, Leeton, Mossgiel, Hillston, Booligal and Wentworth, while Griffith, Ivanhoe, Narrandera and Albury lie just outside its boundary in neighbouring bioregions. The bioregion also includes outlying remnants of the Murray Darling Depression Bioregion in its western boundary, and the Victorian Midlands Bioregion in the south.

The Murray and Murrumbidgee Rivers and their major tributaries, the Lachlan and Goulburn Rivers, flow from the highlands in the east, westward across the Riverina plain.

2. Climate

The Riverina Bioregion is one of 6 NSW bioregions lying in a central band of the state dominated by a persistently dry semi-arid climate, and characterised by hot summers and cool winters (Stern *et al.* 2000). Seasonal temperatures vary little across the bioregion, although in the north both summer and winter temperatures tend to be higher (Eardley 1999).

The highest levels of rainfall in the Riverina Bioregion occur in May and September (Eardley 1999). Summer rainfall tends to occur mainly from localised thunderstorms, with more consistent rainfall occurring in the winter months. Annual rainfall tends to increase from west to east and from north to south. The occurrence of rainfall is unpredictable toward the northwest of the bioregion, and drought periods are not unusual (Dalton 1988, cited in Eardley 1999). Minor areas of the Riverina extend into climatic zones other than the hot semi-arid climate at the core of the bioregion. The northern tip characterises a warm semi-arid climate while the southeastern edge of the bioregion at the boundary of the neighbouring South Western Slopes Bioregion lies in the subhumid climatic zone (Stern *et al.* 2000).

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
15 – 18°C	2.2 – 4.6°C	30.6 – 33.7°C	238 – 617mm	13 – 36mm	26 – 70mm

3. Topography

The Riverina covers the alluvial fans of the Lachlan, Murrumbidgee and Murray Rivers west of the Great Dividing Range and extends down the Murray. Much of the geology and geomorphology of the region is similar to that of the Darling Riverine Plains Bioregion. The upper catchment landscape is a series of overlapping, low gradient alluvial fans. The lower tract of the river is a floodplain with overflow lakes. Discharge from past and present streams control patterns of sediment deposition, soils, landscapes and vegetation.

4. Geology and geomorphology

This bioregion is dominated by river channels, floodplains, backplains, swamps, lakes and lunettes that are all of Quaternary age. The region comprises three overlapping alluvial fans centred on the eastern half of the Murray Basin. Features of each fan differ slightly because of differences in the discharge of the streams. The Lachlan fan is mainly clay as this smaller stream does not have the competence to carry sand. The other two fans are similar except that the Murray is more confined and has more active anabranch channels where it is forced to flow around the obstacle of the Cadell fault near Echuca. At times of extreme flood flow, water from the different streams can cross the fan surfaces and enter channels of another system.

The evolutionary story of these fans is one of decreasing discharge through time that parallels the story of the Darling Riverine Plain. Different phases of stream discharge have been linked to prior and ancestral stream patterns each with different form and different bed load characteristics. Between 15-30,000 years ago, prior streams carried sand far onto the clay plains in wide channels with long meanders. Ancestral streams are more like the modern channels, with tighter meanders and carrying only clay. Alluvial sediments become deeper and older in the western half of the basin, reaching a maximum thickness of about 500m. Basement rocks are the early Palaeozoic sediments and granites of the Lachlan Fold belt, but almost no outcrops exist in the Riverina.

As in the Darling Riverine Plains, three types of wetland are found: delta-like swamplands particularly on the Lachlan, terminal drainage basins and lakes on Willandra Creek and overflow lakes on the Murray. Lake beds are covered by grey cracking clays and the eastern margins of most lakes have well-formed sandy beaches and crescent-shaped dunes or lunettes up to 25m high and composed of fine cemented quartz sand with some layers of pelleted clay. Older, abandoned lakes are also widespread.

5. Geodiversity

Important features of this bioregion include the following:

- evidence of changed Quaternary environments and human history is preserved in the landscape patterns of prior streams, lake beds and lunettes;
- coarse sand in prior stream beds is an important economic resource in a region without rock outcrop; and
- the wetlands of this bioregion are very important habitats in southern inland regions of the state.

6. Soils

Modern river channels consist mostly of sandy soils and more saline heavy grey and brown clays towards the outer perimeter of the floodplains on the higher rarely flooded terraces (Eardley 1999). Sandy soils also form levees, old channels, dunes and lunettes.

As soil and water salinity increase downstream on the Murrumbidgee, saline clays become evident on lake floors.

The red-brown and grey clays in the bioregion support grassland communities that are nationally significant. Calcareous, sandy soils, that tend to be feature of adjacent bioregions are also present in the Riverina and support mallee communities (Semple 1990, Porteners 1993, cited in Eardley 1999).

7. Biodiversity

7.1 Plant communities

Modern river channels support river red gum (*Eucalyptus camaldulensis*) and river cooba (*Acacia stenophylla*) communities. Here on the sandy soils, the river red gum understorey is generally composed of herbaceous perennial, annual and post-flooding ephemeral species that alter with topography and flooding characteristics (Eardley 1999).

Nearby on the higher, more saline heavy grey and brown clays towards the outer perimeter of the floodplains, black box (*Eucalyptus largiflorens*) woodlands dominate with an understorey of salt-tolerant grasses, saltbushes and daisies (Eardley 1999).

On the highest, rarely flooded terraces, yellow box (*Eucalyptus melliodora*) communities occur along with cypress pine and grey box (*Eucalyptus microcarpa*) (Eardley 1999).

Further from the rivers, many plains are treeless and carry saltbush shrubland, composed of old man saltbush (*Atriplex nummularia*), bladder saltbush (*Atriplex vesicaria*), cotton bush (*Maireana aphylla*) and native grasslands (*Danthonia spp* and *Stipa spp*) (Eardley 1999). A formerly extensive community of myall (*Acacia pendula*) shrubland and old man saltbush on the backplains has almost vanished (Mitchell in prep).

Sandy soils on levees, old channels, dunes and lunettes have stands of white cypress pine (*Callitris glaucophylla*), sometimes with mallee and bluebush (*Maireana* sp.). Lake beds may be bare or covered by clumped lignum (*Muehlenbeckia cunninghamii*) with a fringe of black box. Next to rivers and creeks, shrublands of lignum (*Muehlenbeckia florulenta*) and nitre goosefoot (*Chenopodium nitrariaceum*) dominate the flats and low-lying swamps (Eardley 1999). Swamps have wide margins of river red gum, black box and, depending on water depth, also support the common reed (*Phragmites australis*), cumbungi (*Typha* sp.), grasses and floating water plants.

As soil and water salinity increase downstream and saline clays become evident on lake floors, salt-tolerant species such as samphire (*Arthrocnemum* sp.) become common.

Although less characteristic of the Riverina, belah (*Casuarina cristata*) – rosewood (*Alectryon oleifolius*) and mallee (*Eucalyptus socialis, E. dumosa*) communities are common on the bioregional boundary. Mallee occurs on the calcareous, sandy soils that tend to be a feature of adjacent bioregions (Semple 1990, Porteners 1993, cited in Eardley 1999).

The Riverina Bioregion includes the *Acacia loderi* shrublands endangered ecological community listed under the TSC Act 1995.

7.2 Significant flora

The Riverina grassland communities that occur on red-brown and grey clays are nationally significant because the lowland grasslands of southeastern Australia are significantly threatened and also poorly conserved (Eardley 1999). These communities support a number of threatened plant species such as the endemic red Swainson pea (*Swainsona plagiotropis*) as well as

Swainsona murrayana, Sclerolaena napiformis, Brachycome chrysoglossa and *Lepidium monoplocoides* (Eardley 1999).

Twenty-eight threatened species from the Riverina Bioregion are listed in the schedules of the TSC Act (NSW NPWS 2001). Twelve of these are listed as endangered, 15 are listed as vulnerable and one species, *Tetratheca pilosa ssp. pilosa,* is considered extinct in the bioregion.

A member of the chenopod family, *Maireana cheelii* or chariot wheels, is listed as threatened in the NSW TSC Act as well as the Commonwealth EPBC Act. This species is restricted to the riverine plain of NSW, generally in the vicinity of Deniliquin and Hay, and therefore can be considered endemic to the Riverina Bioregion. The main areas of shrublands in NSW occur on the riverine plain (Cunningham *et al.* 1981).

7.3 Significant fauna

Significant fauna known to occur in the riverine forests of the Riverina Bioregion include the superb parrot (*Polytelis swainsonii*), sugar glider (*Petaurus breviceps*), feathertail glider (*Acrobates pygmaeus*), squirrel glider (*Petaurus norfolcensis*), brush-tailed phascogale (*Phascogale tapoatafa*), koala (*Phascolarctos cinereus*), carpet python (*Morelia spilota*), freckled duck (*Stictonetta naevosa*) and peregrine falcon (*Falco peregrinus*) (Eardley 1999).

Black box woodlands provide significant habitat to a diversity of bird species including the bush thickknee (*Burhinus magnirostris*) and the superb parrot, which will only nest where box woodland occurs within 10 km of selected nest trees (usually river red gum) (Eardley 1999).

Species including the plains-wanderer (*Pedionomus torquatus*), bush thicknee, striped legless-lizard (*Delmar Impar*) and fat-tailed dunnart (*Sminthopsis crassicaudata*) are found in the shrublands and grasslands of the Riverina Bioregion (Eardley 1999).

The northern hairy-nosed wombat (*Lasiorhinus krefftii*) was once found throughout southwestern NSW, particularly in the Riverina Bioregion. However, competition with cattle, sheep and rabbits has led to the rapid decline of the species (Strahan 1983) and the wombat is now presumed extinct, listed in Schedule 1 part 4 of the TSC Act.

As with other areas of western NSW, birds of the chenopod shrublands in the bioregion seem to be at risk of decline (Reid and Fleming 1992, cited in Morton *et al.* 1995).

The plains-wanderer (*Pedionomus torquatus*) is listed as endangered in the TSC Act and vulnerable in the EPBC Act, and although it is also found in the Murray Darling Depression Bioregion, the core of the range of this ground bird falls in the Riverina Bioregion. The species is largely confined to patches of sparse grassland and areas with low, open vegetation, often where the light topsoil is affected by wind erosion (NSW NPWS 1999). Conservation of this species is dependent on effective habitat management so as to avoid intensive cultivation, burning or overgrazing (Morton *et al.* 1995).

The endangered trout cod (*Maccullochella macquariensis*) is endemic to the section of the Murray-Darling system that lies in the Riverina Bioregion. The distribution of the Macquarie perch (*Macquaria australasica*) has declined to such an extent that its range is now restricted to the Murrumbidgee and Lachlan Rivers in the Riverina Bioregion (Morton *et al.* 1995) where previously it was widespread across the Murray-Darling River system. This decline is a

Photo: NPWS

common trend among the 29 species of fish found within the Murray-Darling system (Morton *et al.* 1995), including the two-spined blackfish (*Gadopsis bispinosus*), Murray jollytail (*Galaxias rostratus*), Australian rainbowfish (*Melanotaenia fluviatilis*), Murray cod (*Maccullochella peeli*) and silver perch (*Bidyanus bidyanus*).

The effect of clearing and grazing, coupled with competition from introduced herbivores such as sheep and rabbits and the impact of carnivores such as foxes and cats, has resulted in a general decrease in the number and species of flora and fauna in the bioregion. Small mammals such as the now rare bridled nail-tail wallaby (*Onychogalea fraenata*) and the extinct eastern hare-wallaby (*Lagorchestes leporides*) are obvious victims of both habitat modification and competition (Eardley 1999).

7.4 Significant wetlands

Important wetlands, which can support more than 20,000 waterbirds, occur in the Murrumbidgee-Lachlan confluence, Barmah-Millewa Forest, and Edward and Murrumbidgee River floodplains (Kingsford *et al.* 1996, cited in Eardley 1999). Many of these waterbirds are migratory and several, such as the Australasian bittern (*Botaurus poiciloptilus*), freckled duck and painted snipe (*Rostratula benghalensis*), are listed as vulnerable under the TSC Act (Eardley 1999).

Eight wetlands have been identified as having bioregional significance in the Riverina (Australian Terrestrial Biodiversity Assessment 2002).

Lake Urana provides habitat for the endangered winged peppercress (*Lepidium monoplocoides*) which is mainly found on the shores of the lake. Both the vulnerable freckled duck (*Stictonetta naevosa*) and the vulnerable brolga (*Grus rubicundus*) have been recorded here (NSW NPWS 2001a). Modelling has suggested that the Lake could support 11,000 waterbirds (Kingsford *et al.* 1997).

Loorica Lake supported almost 17,000 waterbirds in 1987, including the grey teal (*Anas gracilis*), hardhead (*Aythya australis*) and whiskered tern (*Sterna hybrida*) (Australian Terrestrial Biodiversity Assessment 2002). In 1983, Loorica Lake provided nesting habitat for the black swan (*Cygnus atratus*) (Australian Terrestrial Biodiversity Assessment 2002). The vulnerable freckled duck, blue-billed duck (*Oxyura australis*) and black-tailed godwit (*Limosa limosa*) have also been recorded (NSW NPWS 2001). The black-tailed godwit, found at the Lake, is listed on the China-Australia Migratory Bird Agreement (CAMBA) and the Japan-Australia Migratory Bird Agreement (JAMBA) (NSW NPWS 2001).

An unnamed swamp southeast of Lake Tala supported more than 20,000 waterbirds in 1983, including the grey teal (*Anas gracilis*), pink-eared duck (*Malacorhynchus membranaceus*) and Eurasian coot (*Fulica atra*). In 1986 and 1987, 7,000 waterbirds were present in the swamp. In 1983 and 1988, the black swan (*Cygnus atratus*) used the swamp as a nesting site. The freckled duck has also been recorded here.

Gol Gol Lake is significant to this bioregion and also extends into part of the Murray Darling Depression Bioregion. The lake provides habitat for the endangered southern bell frog (*Litoria raniformis*) as well as many vulnerable species including the painted snipe (*Rostratula benghalensis*), freckled duck and square-tailed kite (*Lophoictinia isura*) (NSW NPWS 2001).

Another significant wetland in the bioregion is the Edward River Floodplain, with wetland modelling predicting that it could support 54,000 waterbirds (Kingsford *et al.* 1997). The vulnerable brolga (*Grus rubicundus*) and Major Mitchells cockatoo (*Cacatua leadbeateri*) have been recorded at the wetland as has the painted honeyeater (*Grantiella picta*) (NSW NPWS 2001a).

The Tuppal Creek Floodplain supports a range of threatened species including the vulnerable koala (*Phascolarctos cinereus*), superb parrot (*Polytelis swainsonii*) and Australian bustard (*Ardeotis australis*) (MSW NPWS 2001a). The endangered bush stone-curlew (*Burhinus grallarius*) and the vulnerable square-tailed kite (*Lophoictinia isura*) have also been recorded here. Modelling has predicted that this floodplain could support 19,000 waterbirds (Kingsford *et al.* 1997).

Morrisons Lake is reserved within the Morrisons Lake Nature Reserve. The Lake provides habitat for a range of threatened species including the vulnerable Major Mitchells cockatoo, square-tailed kite, blue-billed duck (*Oxyura australis*), grey falcon (*Falco hypoleucos*), freckled duck (*Stictonetta*

Photo: NPWS

naevosa), Australasian bittern (*Botaurus poiciloptilus*) and painted snipe (*Rostratula benghalensis*).

Barrenbox Swamp has also been described as significant to the Riverina Bioregion. The swamp provides habitat for the vulnerable freckled duck, blue-billed duck, Australasian bittern (*Botaurus poiciloptilus*), painted snipe (*Rostratula benghalensis*) and magpie goose (*Anserenas semipalmata*) (NSW NPWS 2001). The painted snipe is protected under CAMBA. The endangered bush stone-curlew (*Burhinus grallarius*) (NSW NPWS 2001a) and the southern bell frog (*Litoria raniformis*) have also been recorded here.

The Booligal wetlands have also been recognised as a refuge for biodiversity in the bioregion (Morton *et al.* 1995).

The NSW Central Murray State Forests, together with the listed Ramsar wetlands in Victoria (Barmah and Gunbower forests), form the largest complex of tree-dominated floodplain wetlands in southern Australia. The site contains wetland types that are rare within the Riverina bioregion, particularly types floodplain lakes and floodplain meadows and reed swamps and regularly supports more than 20,000 waterbirds (eg. Mattingley 1908, Barrett 1931, Chesterfield *et al.* 1984, Maher 1993, Leslie and Ward in press).

The site plays a substantial role in the functioning of the Murray River, particularly in terms of hydrology flood mitigation, water quality sediment deposition and river health and has recently been nominated for Ramsar listing.

It provides a habitat network for at least 8 globally threatened fauna listed by the World Conservation Union in 2000. The Australasian bittern (*Botaurus poiciloptilus*), superb parrot (*Polytelis swainsonii*), silver perch (*Bidyanus bidyanus*) and flat-headed galaxias (*Galaxias rostrata*) are listed as "vulnerable", and the regent honeyeater (*Xanthomyza phrygia*), swift parrot (*Lathamus discolor*), Murray hardyhead (*Craterocephalus fluviatilis*) and trout cod (*Maccullochella macquariensis*) are listed as "endangered" on the IUCN Red List (2000).

The Central Murray State Forests are ecologically linked through an unbroken riparian corridor along the Murray and Edward Rivers. They are in high ecological condition and provide arboreal and wetland habitat in landscapes extensively cleared of trees and developed for agriculture. As such, the site contributes significantly to the conservation of globally and nationally threatened species. The site is immediately adjacent to other wetlands included in the Ramsar List of Wetlands of International Importance in the neighbouring state of Victoria, and thus, further enhances the viability of threatened flora and fauna species that occur at these Ramsar sites.

The area provides a habitat network for 13 species listed in migratory bird agreements between Australia, and Japan (JAMBA) and China (CAMBA). These species are painted snipe (*Rostralula benghalensis*), great egret (*Ardea alba*), cattle egret (*Ardea ibis*), sharp-tailed sandpiper (*Calidris acuminata*), greenshank (*Tringa nebularia*), marsh sandpiper (*Tringa stagnatilis*), Latham's snipe (*Gallinago hardwickii*), white-throated needletail (*Hirundapus caudacutus*), forked-tailed swift (*Apus pacificus*), glossy ibis (*Plegadis falcinellus*), Caspian tern (*Hydropogne caspia*), red-necked stint (*Calidris ruficollis*) and white-bellied sea-eagle (*Haliaeetus leucogaster*).

The wetlands of the Riverina Bioregion have been described as being in fair to degraded condition. Changed hydrology is a key threat to all of these wetlands, but there are also impacts from feral animals, exotic weeds, water extraction, regulation and diversion, altered nutrient levels, salinity, grazing pressure, reduced flows and use for water storage.

8. Regional history

8.1 Aboriginal occupation

It is thought that Aboriginal people have been present in the Murray-Darling Basin for at least 40,000 years (Hope 1995, cited in Eardley 1999). The Riverina Bioregion was the original homeland for many large Aboriginal communities that lived on the Hay Plain and around the rivers. These communities include the Wiradjuri, Nari-Nari, Mudi-Mudi, Gurendji and the Yida-Yida, while the Bangerang, Yorta-Yorta, Baraba-Baraba, Wamba-Wamba, Wadi-Wadi and Dadi-Dadi communities were found along the Murray River (NSW Department of Lands 1987, cited in Eardley 1999).

The rivers of the bioregion were central to the local Aboriginal lifestyles, especially as a source of food (Hope 1995, cited in Eardley 1999). It has been suggested that access to the water and its resources was a privilege inherited by generation after generation of certain groups (Pardoe 1988, cited in Eardley 1999). Unlike Europeans that have tended to use major rivers as administrative boundaries, the Aboriginal communities of the Riverina did not view the rivers as boundaries between language groups. Wiradjuri country straddled the Murrumbidgee, Bangerang country lay west from Albury to Moama on both sides of the Murray, and the Narinari occupied the land west of this.

The Bangerang people used the Murray River extensively, travelling the river in bark canoes. Many trees by the river today still show evidence of bark cut from them in at least the early nineteenth century (HO and DUAP 1996). Other relics of Aboriginal presence are common along the Riverina river systems, including human burial sites, camping sites and middens (NSW NPWS 2001b and Donovan 1997, cited in Eardley 1999).

The extensive use of the Murray by the Bangerang has been compared to the way early settlers used the Hawkesbury in the Sydney Basin Bioregion as a means of communications and trade and as a source of food (HO and DUAP 1996). Near what is now Corowa near Albury there is a line of rocks across the river that the Aboriginal people used to aid the spearing of fish. The Murray supplied the Bangerang with Murray cod and shellfish, while nuts, fruit and tubers were found in the river's surrounds. It is likely that the Bangerang joined the Wiradjuri and Monaro groups at the summer feasts of bogong moths in the alpine country, although they had less of a nomadic lifestyle than these communities (HO and DUAP 1996).

By the 1830s, European settlers had made their presence clear when diseases such as influenza, smallpox and syphilis ravaged the Wiradjuri and Bangerang communities (HO and DUAP 1996). The 1840s saw a worsening of the damage to these communities as they began to let go of their traditional practices that were now made so difficult by European presence. A census of Aborigines in 1845 estimated there were about 2,000 living in the Murrumbidgee Pastoral District, including 100 at Thomas Mitchell's station near what is now Albury, 300 near Deniliquin, and 200 at Urana on the eastern boundary of the Riverina Bioregion. Middens, which reflected the high usage and high population density of the eighteenth century, were deserted, and midden material was used in place of gravel by the Europeans (HO and DUAP 1996). Some traditional life of the Aborigines continued through the 1840s and 1850s but by the 1870s important ceremonies such as corroborees began to attract the interest of settlers who encouraged them as a form of entertainment by paying groups of Bangerang to perform them.

The 1870s also saw social problems arise in Aboriginal communities. Having been forced out of their traditional practices of fishing and being ill treated and unappreciated by the settlers, the men were forced into employment on local stations or went to live in towns such as Albury. The women of the Wiradjuri and Bangerang communities were forced to work as domestic servants and often bore settlers' children (HO and DUAP 1996).

More recently, the reinstatement of marriage practices in the Wiradjuri community has helped them to retain and encourage a sense of identity (HO and DUAP 1996).

8.2 European occupation

John Oxley first explored the Riverina in 1817, following the Lachlan River downstream southwest of Booligal in the centre of the bioregion (Eardley 1999). Oxley was followed almost 20 years later by Thomas Mitchell, who arrived at the junction of the Lachlan and the Murrumbidgee Rivers in 1836, and by Charles Sturt, who explored the Murrumbidgee and lower Murray in the years between 1828 and 1831 (Eardley 1999).

Graziers followed soon after, establishing pastoral runs near Yanco and on the Murrumbidgee and Murray Rivers as far west as Hay between 1835 and 1839 (Eardley 1999). In the 1840s, cattle were the primary industry but by the 1860s sheep were the predominant stock (Eardley 1999).

The river steamer trade was important for the development of Darlington Point (HO and DUAP 1996) from 1858 when the first steamer came past and local entrepreneurs realised the business potential of selling local timber for fuel. Inns opened at Darlington Point in the 1860s and in 1876 McCulloch and Co began trading in a general store and wool-store. The town was successful, continuing in the steamboat trade for a further 50 years.

In 1915 the River Murray Waters Agreement allowed 26 weirs to be constructed with locks, providing permanent riverboat access to Echuca in Victoria. When riverboats were no longer used, the primary focus was on the provision of water for irrigation (Eardley 1999). The Murrumbidgee Irrigation Area was established in the Riverina in 1912, created by the diversion of water from the Murrumbidgee near Narrandera.

Construction of several dams followed in the ensuing years, with the Hume Dam built between 1919 and 1931 on the Murray near Albury, Burrinjuck Dam built on the Murrumbidgee in 1928 and Blowering Dam on the Tumut River built in 1968 (Eardley 1999). Since rice growing is highly dependent on water supply, these dams, along with irrigation schemes endorsed by the state, allowed rice production to grow into an important industry for the region (Eardley 1999). Large-scale rice farming, particularly in the central and south of the bioregion, and the technology used to produce rice, are largely driven by the Japanese export market (Eardley 1999). Water availability in the bioregion due to dams, bore water and increased agricultural technology has allowed the irrigated area to extend its range, enabling the cultivation of irrigated crops in the plains around Darlington Point, Deniliquin and Hay (Eardley 1999).

Cotton crops, which are also highly reliant on water supply, were established in the Riverina Bioregion more recently. Sheep grazing still occurs on land not suitable for cropping, and potatoes are farmed on fast-draining sand hills (Eardley 1999). Orchards and vineyards are also a common land use in the east of the bioregion (HO and DUAP 1996).

The high soil fertility and abundance of water in the Riverina floodplain has made the area highly productive for plant growth. This has influenced land use in the region in the past 150 years, causing extensive changes in the natural distribution and condition of the vegetation cover (Eardley 1999).

The use of the Murrumbidgee River for irrigation and greater crop production has led to Aboriginal poet Iris Clayton lamenting the fate of the Murrumbidgee, especially if it continues to be treated as it has been for the last 200 years:

> *'No one knows how long he's been there*
> *Twisted, old ravaged beyond repair*
> *Father to many, too many to count.*
> *His dying will be a terrible account*
> *Perhaps if the damage is quickly mended*
> *His shores and banks strongly defended*
> *Old River Bidgee need never be*
> *Another lost legend of the Warrajarree.'*
>
> "River Bidgee" by Iris Clayton in *Inside Black Australia: an anthology of Aboriginal Poetry*, Kevin Gilbert (ed) 1988. Penguin, Ringwood, Victoria.

9. Bioregional-scale conservation

The current area of the Riverina Bioregion managed under tenures that achieve some level of conservation is about 124,944 ha or 1.76% of the bioregion, the smallest proportion of all the NSW bioregions.

While the major contributor to conservation in the Riverina Bioregion is land managed under the NPW Act 1974, wildlife refuges currently make the largest contribution in terms of land area managed for conservation.

There is only one national park in the bioregion, Willandra National Park, managed under the provisions of the NPW Act 1974. There are 6 nature reserves (5 of which are wholly contained within the bioregion). Together the national park and nature reserves occupy 23,041 ha or 0.32% of the bioregion. None of the reserves in the bioregion is also managed as wilderness under the Wilderness Act 1987.

Koonadan Historic Site (NPW Act 1974) falls in the bioregion and occupies 21.48 ha or 0.0003% of the bioregion. Of the other tenures provided for under the NPW Act 1974, there are no Aboriginal areas, no state recreation areas and no regional parks in the bioregion.

Some landholders have entered into private land conservation under the provisions of the NPW Act 1974 or NVC Act 1997. These comprise one voluntary conservation agreement (NPW Act 1974) occupying almost 18 ha or 0.0003% of the bioregion, 24 wildlife refuges (this figure is likely to expand to at least 51, once the updated mapping, being undertaken at the time of writing, is complete) on properties occupying 91,254.54 ha or 1.29% of the bioregion, and 24 property agreements (under the NVC Act 1997) which together occupy 2,553 ha or 0.04% of the bioregion. The area of private land conservation totals almost 99,228 ha or 1.40% of the bioregion.

Nine flora reserves (managed under the provisions of the Forestry Act 1916) occupy 2,653 ha or 0.04% of the bioregion and contribute towards biodiversity conservation. SFNSW manages 151,638.75 ha or 2.14% of the bioregion, of which 84,000 ha will be added to the Ramsar convention for the protection of wetlands, more than doubling the area of Ramsar wetlands in NSW.

10. Subregions of the Riverina Bioregion

(Morgan and Terrey 1992)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Lachlan	Quaternary alluvial sediments. Clay dominant. Groundwater lakes present. Lower river discharge than other streams.	Complex alluvial fan with numerous distributary channels and floodplains, depression plains, and abandoned lake beds with lunettes. Limited source-bordering dunes.	Red and brown clays, red brown texture contrast soils on levees and terraces, minor deep sands.	Black box and river red gum on channels. Black box, lignum and cane grass in swamps. Saltbush and bluebush with old man saltbush, cottonbush, myall and grasses on the plains. White cypress pine on sandhills.
Murrumbidgee	Quaternary alluvial sediments. Clay and sand with source bordering dunes and lakes.	Alluvial fan with distributary channels and floodplains, undulating plains with depressions. Source-bordering dunes common.	Red brown earths, grey and brown clays and deep siliceous sands on dunes.	River red gum and river cooba on channels. Black box, lignum and old man saltbush on floodplains. Myall and old man saltbush with other saltbush and grasses formerly widespread on backplains. White cypress pine on dunes.
Murray Fans	Quaternary alluvial sediments. Clay and sand with source bordering dunes, lakes and swamps.	Relatively confined alluvial fan constrained by sediments from northern Victorian rivers, the Murrumbidgee fan and the Cadell fault. Meandering channels, floodplains, source-bordering dunes, overflow lakes and swamps.	Red brown earths, grey clays and deep sands.	Extensive river red gum forests with river cooba on channels and low floodplains. Yellow Box and black box with saltbush on high floodplains and terraces. White cypress pines on dunes, sandy levees and lunettes. Common reed, cumbungi and grasses in swamps.
Robinvale Plains	Quaternary alluvial sediments. Clay dominant. Small overflow lakes.	Narrow floodplain with meandering channels, billabongs, levees and low dunes. Overflow lakes with lunettes.	Red brown earths, grey clays, deep sands and yellow texture contrast soils.	River red gum on channels. Black box, river cooba, oldman saltbush, belah and lignum on floodplains. White cypress pine, mallee acacias and bluebush on lunettes and sand dunes.
Murray Scroll Belt	Quaternary alluvial sediments. Clay dominant, wider plains with larger overflow lakes and salinas. Affected by higher water salinity and summer floods from the Darling River.	Wider floodplain with meandering channels, billabongs, levees and low dunes. Large overflow lakes with large lunettes.	Red brown earths, grey clays, deep sands and yellow texture contrast soils.	River red gum on channels and lake margins. Black box, river cooba, oldman saltbush, belah and lignum on floodplains. White cypress pine, mallee acacias and bluebush on lunettes and sand dunes.

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Riverina Biogeographic Region (IBRA) - Location

Emmdale
Silverton
Broken Hill
Nymagee
Tottenham
Menindee
Ivanhoe
Condobolin
Mossgiel
Lake Cargelligo
Manilla
Hillston
Rankins Springs
Booligal
West Wyalong
Wentworth
Griffith
Temora
Hay
Leeton
Balranald
Coleambally
Narrandera
Lockhart
Wagga Wagga
Jerilderie
Deniliquin
Corowa
Albury
Moama
South Australia
Victoria

Key

- Towns
- Roads
- Rivers
- Waterbodies
- Riverina
- IBRA regions in NSW
- IBRA regions interstate

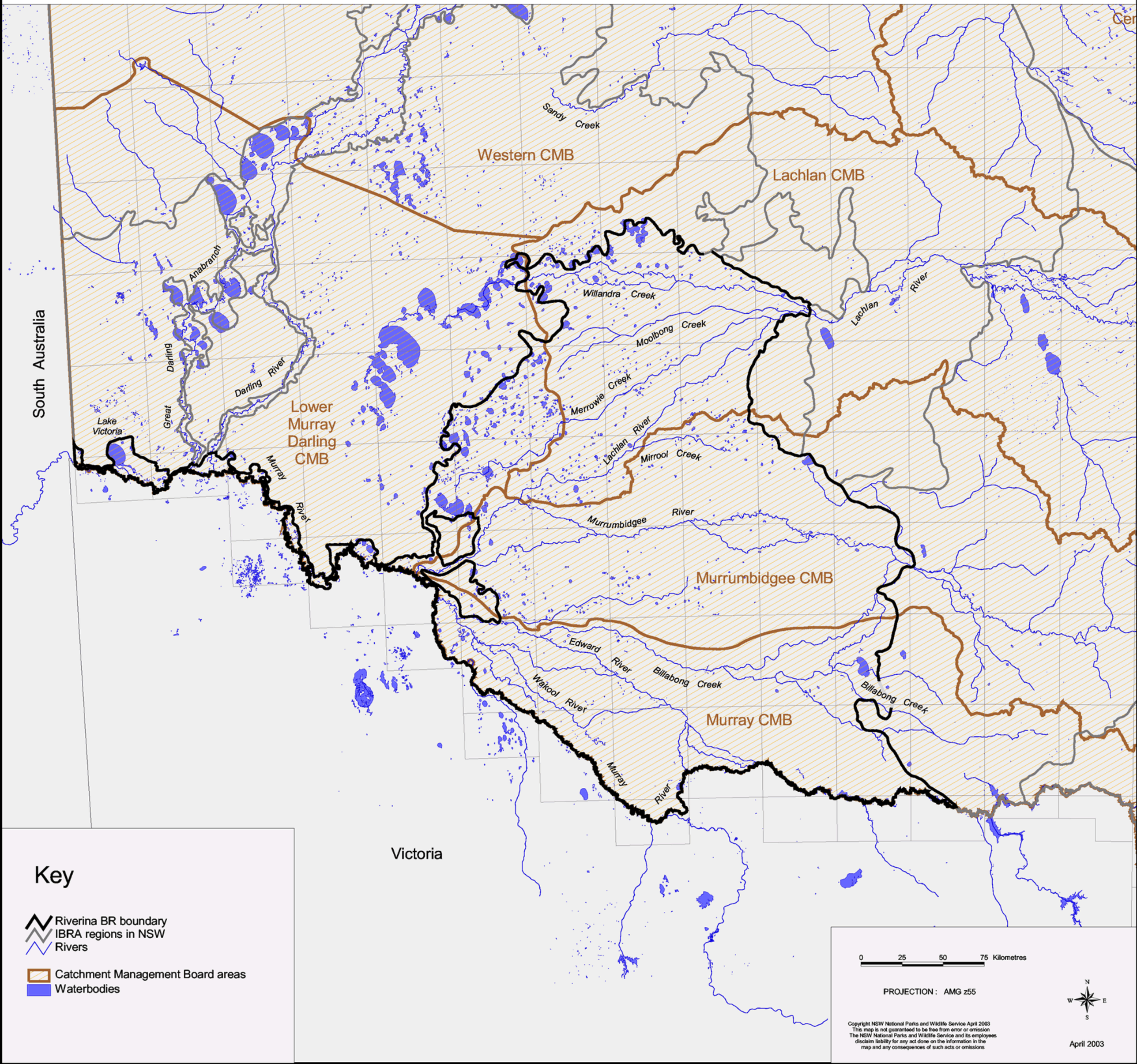
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

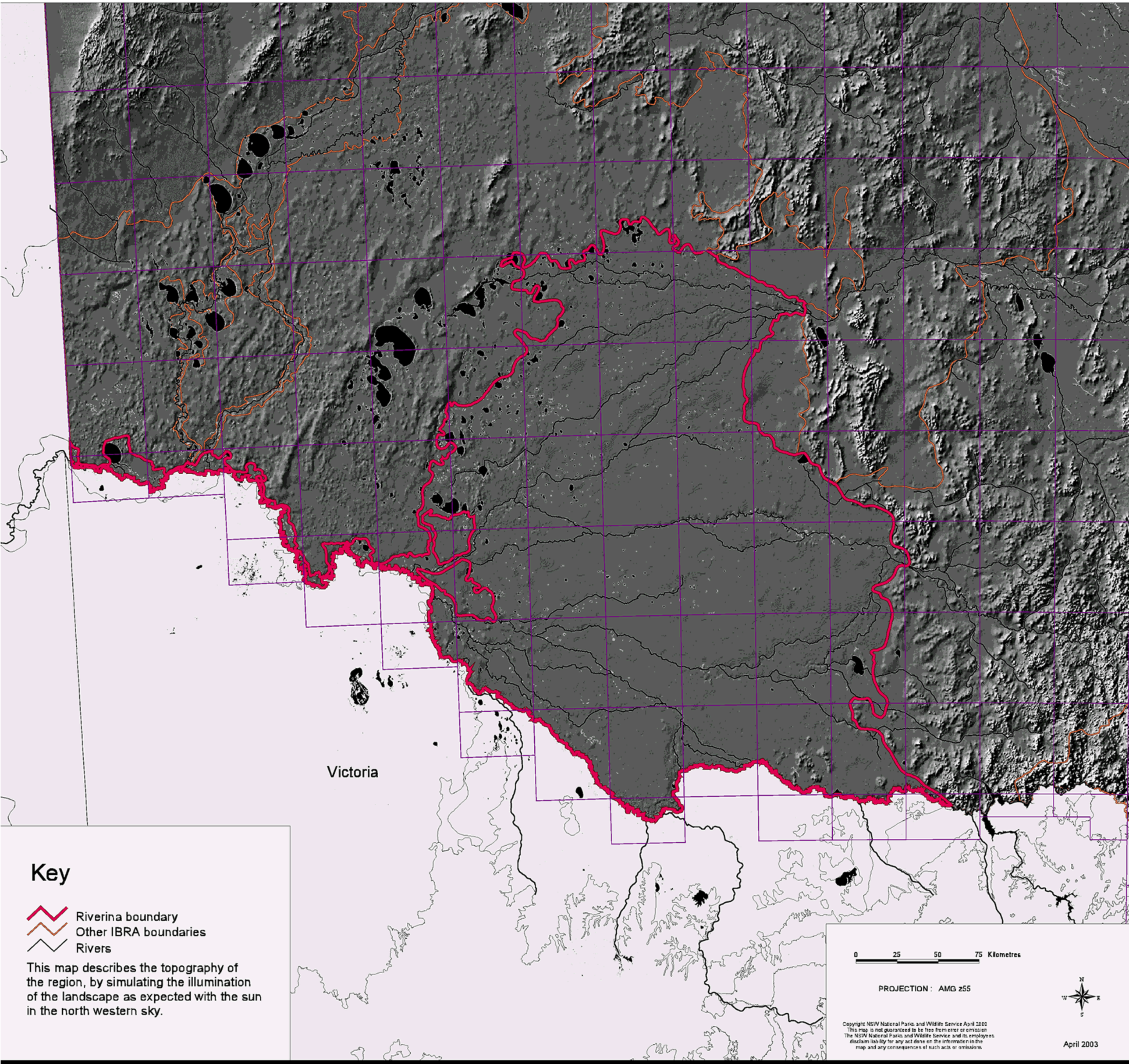
April 2003

Riverina Biogeographic Region (IBRA) - Rivers

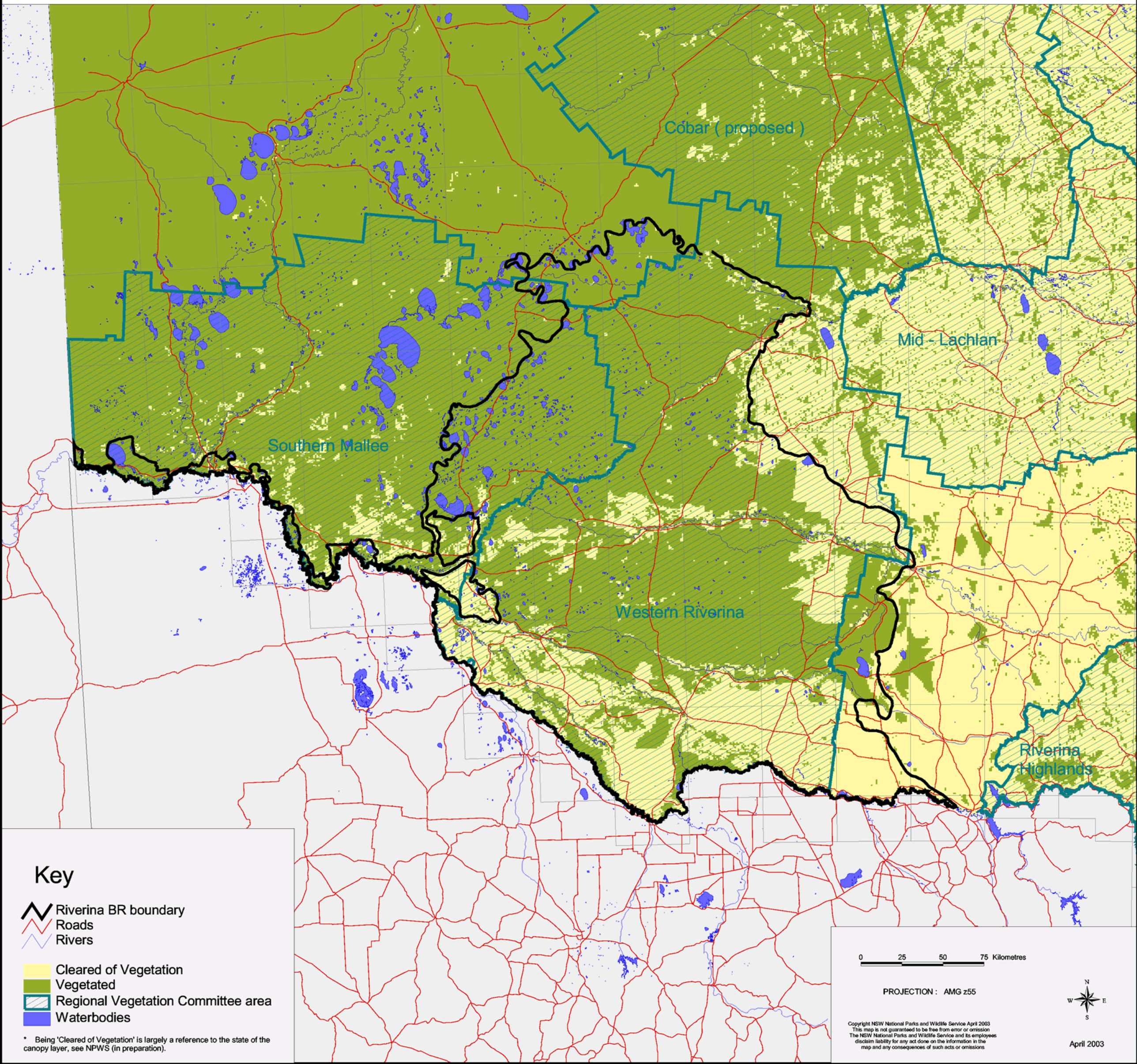


April 2003

Riverina Biogeographic Region (IBRA) - Topography



Riverina Biogeographic Region (IBRA) - Vegetation



Key

- Riverina BR boundary
- Roads
- Rivers

- Cleared of Vegetation
- Vegetated
- Regional Vegetation Committee area
- Waterbodies

* Being 'Cleared of Vegetation' is largely a reference to the state of the canopy layer, see NPWS (in preparation).

0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

Riverina Biogeographic Region (IBRA) - Tenure/Reserves

South Australia

Victoria

Key

- Riverina BR boundary
- IBRA regions in NSW
- Roads
- Rivers

- Waterbodies

Wilderness (declared)
- on NPWS Estate
- on other tenure

NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area

Other tenure
- Marine Park (MPA)
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

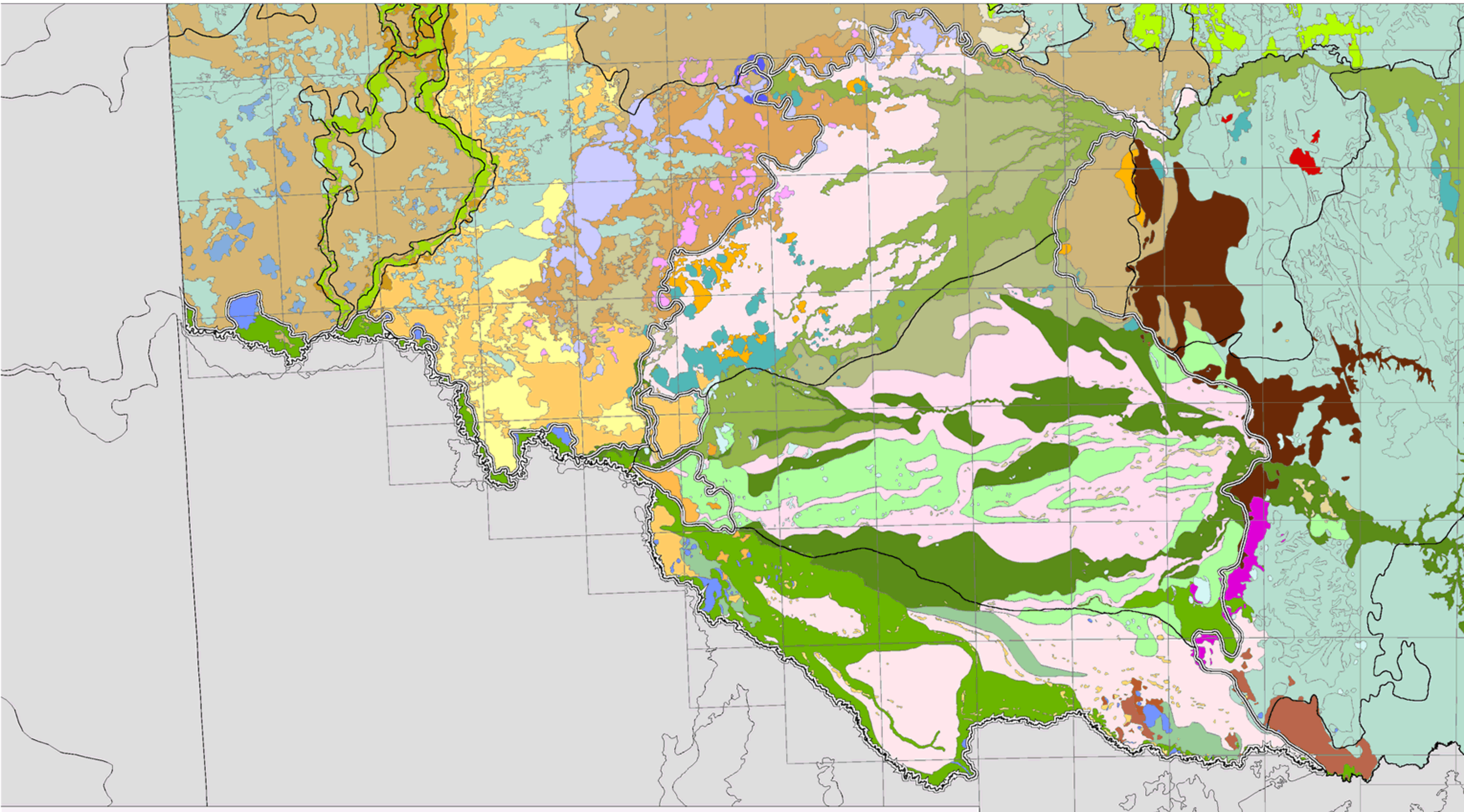
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

Riverina Biogeographic Region (IBRA) - Subregions and Landscapes (Mitchell, in preparation)



Key

Subregion boundaries (IBRA)

Riverina (IBRA)

Landscapes of the Riverina

- Albury-Oaklands Hills and Footslop
- Buckingong Gravels
- Cocoparra Basalt Hills
- Cocoparra Ranges and Footslopes
- Ivanhoe-Nangara Linear Dunes
- Ivanhoe-Nangara Sandplains
- Lachlan Channels and Floodplains
- Lachlan Depression Plains
- Lachlan Lakes, Swamps and Lunettes
- Lachlan Sandplains
- Lachlan Scalded Plains
- Lachlan Source-bordering Dunes
- Lower Darling Alluvial Plains
- Lower Darling Channels and Floodplains
- Mallee Cliffs Linear Dunes
- Mallee Cliffs Sandplains
- Mungo Lakes Complex
- Mungo-Marona Lakes and Swamps
- Mungo-Marona Linear Dunes
- Mungo-Marona Relic Lakes
- Mungo-Marona Sandplains
- Murray Channels and Floodplains
- Murray Depression Plains
- Murray Lakes, Swamps and Lunettes
- Murray Sandplains
- Murray Scalded Plains
- Murray Source-bordering Dunes
- Murrumbidgee Channels and Floodplains
- Murrumbidgee Depression Plains
- Murrumbidgee Lakes, Swamps and Lunettes
- Murrumbidgee Sandplains
- Murrumbidgee Scalded Plains
- Murrumbidgee Source-bordering Dunes
- Nymagee Downs
- Oaklands Hills and Footslopes
- Riverina Dunefields
- Riverina Sandplains
- Scotia Groundwater Basins
- Scotia Sandplains

Other Landscapes

IBRA regions interstate

0 25 50 75 Kilometres

PROJECTION : AMG z55

April 2003