2 ACT Rivers and Riparian Vegetation

Rivers, streams and their associated riparian zones are special and distinctive parts of the landscape. Some definitions of the riparian zone along with a discussion of the difficulty in defining its boundary are contained in section 1.3. Ecologically, riparian zones are areas where the assemblages of flora and fauna are often quite different to those in the surrounding country. They often also contain particular types of habitat, for example, river gorge sections with rocky cliffs that provide nesting sites for raptors and refuges for plants, and dynamic streambed and river terrace environments that are reworked by seasonal and episodic flooding. Riparian zones provide linear connectivity, demonstrated by their use in annual bird migrations. These paralleled the upstream spawning migrations of fish in the rivers, before dams and weirs blocked their passage. In the Southern Tablelands the river valleys are sheltered environments. The Murrumbidgee River, for example, tracks the deep incision of the Murrumbidgee Geological Fault hundreds of metres below the mountain ranges to the west and is a refuge from the open treeless grasslands and grassy woodlands to the east, an exposed environment in winter.

It is not surprising, therefore, that archaeological evidence points to these riparian areas in the Southern Tablelands as being the main occupation sites for Aboriginal people. The earliest known site is from Birrigai, ACT, dated at 21 000 years BP (Flood *et al.* 1987). The more sheltered river valleys provided year-round occupation sites, with some montane valley camps and high summer camps probably associated with exploitation of the Bogong Moth (*Agrotis infusa*) and associated social and ceremonial activities. The river valleys and associated lowland grasslands and woodlands provided mammals, reptiles, ducks and other birds, plant foods and a seasonal abundance of fish (Flood 1980, pp. 61–82, 97–100).

The first record of European exploration to the current ACT portion of the Murrumbidgee River was by Charles Throsby and Joseph Wild in 1821 in the vicinity of the present town centre of Tuggeranong (Ingwersen 2001). By the mid-1820s after Captain Mark Currie had ridden south of the Limestone Plains and discovered the high plains of the Monaro (Hancock 1972), the grasslands of the Southern Tablelands were known to Europeans and the pastoral advance followed. As squatters took up land, the colonial government decreed the Murrumbidgee River to be the local limit of settlement within the 'nineteen counties'. The accessible river valleys structured the pattern of this early pastoral settlement, which through the 1830s extended both across the Limestone Plains and into the upper valleys of the Cotter, Gudgenby, Orroral, Naas and Tidbinbilla rivers. Aboriginal people soon lost their lands and succumbed to disease and the effects of armed conflict. The establishment of the pastoral economy over subsequent decades brought a number of changes to the riparian zones. Valley floors were cleared, fire regimes were altered, grazing and domestic animals were introduced, new plant species were introduced both deliberately and inadvertently (some becoming weeds), soil erosion and stream sedimentation followed clearing, and gully erosion developed in streams. Bridle tracks followed the river valleys in a network connecting areas east and west of the Murrumbidgee River and districts south and west of the current ACT border in New South Wales (King 1946). This general description, however, masks many uncertainties in detail. The nature of the vegetation in the 1820s and how it changed, and Aboriginal and early European burning regimes are two examples.

Surveyors' descriptions and other historical records, remnant vegetation, and modelling based on environmental parameters for the growth of particular species or communities may all contribute to developing an approximation of past vegetation. Along the Murrumbidgee River in the Lanyon area, for example, remnant Ribbon Gum (*Eucalyptus viminalis*) is an indicator of what was a more extensive riparian community on these river flats. In the upper Gudgenby River, at the site of the former Gudgenby Station, whether the grassy valley floors were largely open and grassy at the time of European occupation or

contained much more open forest and woodland (as indicated by surveyors' descriptions of land portions) remains uncertain. Locally high water tables may have contributed to the presence of naturally treeless areas (Ingwersen 2001).

It is not possible to establish with any certainty the nature of Aboriginal and lightning induced fire regimes in the grasslands, grassy woodlands and dry forests of the Southern Tablelands including the associated river valleys. Early European explorers recorded Aboriginal fires and botanist Alan Cunningham provided an account of burning at Tuggeranong ACT in 1824 (ACT Government 2005a). However, there is no evidence that allows a construction of Aboriginal burning regimes in environments such as the former Gudgenby Station, if indeed, they burnt such areas at all. It is likely that Aborigines burnt the grasslands and grassy woodlands that flanked the riparian areas at lower elevations e.g. the plains adjacent to the Murrumbidgee and Molonglo rivers. Fire regimes were probably a combination of deliberate burning (possibly cool spring or autumn fires that favoured the maintenance of a diverse herbaceous cover) and lightning generated summer 'wildfires' that occasionally swept across the landscape under extreme conditions and predated the arrival of Aborigines in Australia (Benson 1994; Benson and Wyse Jackson 1994; Lunt *et al.* 1998). It is likely that riverine areas were less frequently burnt, deliberately or naturally, and areas such as gorges, exposed rocks and gravel terraces provided a refuge for species less resistant to, or not adapted to, high fire frequency and/or high fire intensity.

2.1

ACT Rivers

In the context of the Murray–Darling Basin, ACT rivers and streams are defined as upland drainages. In the Basin, 300 metres (asl) is sometimes used to separate upland and lowland river sections.
A characteristic of lowland sections is extensive floodplains. These are absent from upland sections; however, narrow upland riparian zones occasionally include a small floodplain geomorphic unit (Evans 2003). The following are the main characteristics of upland rivers and streams in a natural condition (adapted from Evans 2003, Young *et al.* 2001).

- They contain the steepest gradients in the river channel, though channel slope varies from boulder–step (uppermost reaches) to riffle–run–pool (lower reaches).
- Cross-sectional areas of river channels are small, reflecting low total discharge, and channels are narrow and usually fairly straight.
- Banks are commonly steep or vertical, often undercut, and held together by root mats of vegetation.
- Vegetation shades much of the in-stream environment, limiting the amount of solar energy reaching the water to drive biological production. However, water tends to be clear allowing high sunlight penetration where shading is absent.
- The flow is maintained by groundwater drainage from the upper catchment, and flow rarely drops below a relatively high base level. Water is typically cool, with daily and seasonal fluctuations.
- Because upland sections are well connected to their small catchments, run off reaches the channel quickly and discharge increases rapidly after precipitation. This rapid rise in water level is an important characteristic of upland in-stream habitats.
- In the upper reaches, a river's riparian zone merges directly into the valley slopes, and the zone of different vegetation may be quite narrow. Vegetation near the channel must be resilient to frequent flooding and high water velocities.

The Murrumbidgee River and its tributaries is a key geomorphic, hydrological and ecological feature of the ACT. The main tributaries are the Molonglo, Cotter and Gudgenby rivers. A number of creek lines also enter the river, but only a few (Guises, Tuggeranong, Bulgar and Swamp creeks) have relatively large catchments extending into the undulating terrain and hills beyond the river valley.

2.1.1 Murrumbidgee River

From its main headwaters (now Tantangara Reservoir in Kosciuszko National Park), the Murrumbidgee River flows south-east before turning north, being joined by the Numeralla River, and following a strikingly linear path to enter the ACT at Angle Crossing. Extending for about 60 km in the ACT, the river re-enters New South Wales north of Uriarra Crossing. The main ACT tributary rivers and creeks (south to north) are:

- **Guises Creek:** Drains the eastern Rob Roy Range area.
- **Gudgenby River** (tributaries: Orroral and Naas rivers): Headwaters in Namadgi National Park, joins the Murrumbidgee River south of Tharwa.
- **Tuggeranong Creek:** Dammed to form Lake Tuggeranong, significantly changed as part of the development of urban Tuggeranong and for water quality control.

- **Bulgar Creek:** Has a rural catchment south of the Cotter Road and enters the river opposite the Bullen Range and south of Casuarina Sands.
- **Cotter River:** Major water supply for Canberra with three dams. Close to its confluence with the Murrumbidgee River near Casuarina Sands, the Cotter is joined by Paddys River (tributary: Tidbinbilla River) (see s. 2.1.3).
- **Molonglo River:** Joins the Murrumbidgee River near Uriarra Crossing. The river has a relatively large catchment extending east to Captains Flat with the Queanbeyan River, and Jerrabomberra, Woolshed, Sullivans, Yarralumla and Weston creeks being major tributaries. Streams have been extensively modified related to the urban development of Canberra (see s. 2.1.2). Flow in the Molonglo River has been significantly altered by the construction of both Scrivener Dam and Googong Dam (on the Queanbeyan River tributary).
- **Swamp Creek** (tributary: Uriarra Creek): Joins the Murrumbidgee River north of Uriarra Crossing.
- **Ginninderra Creek:** Joins the Murrumbidgee River about 3.5 km north of the ACT border, but most of its catchment is in the ACT. Much of its former rural catchment is now included in the Belconnen and Gungahlin urban areas. The creek has been impounded to form Lake Ginninderra (Belconnen) and the Gungahlin Lakes (Yerrabi Pond and Gungahlin Pond).

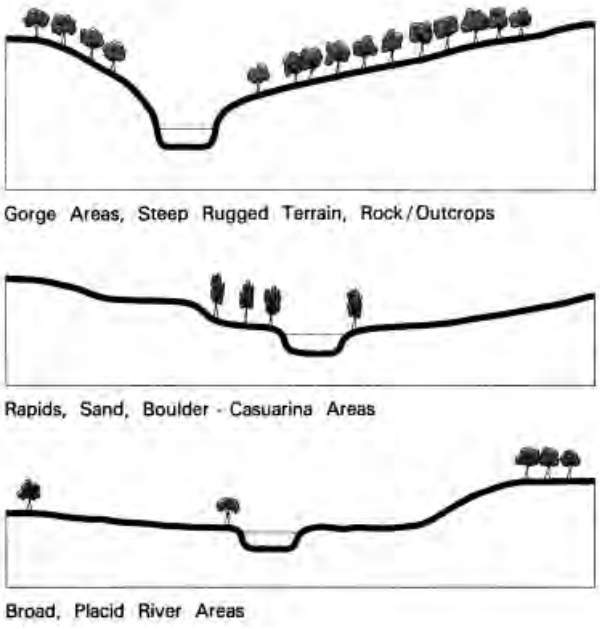
The Murrumbidgee River lies in a valley that has its orientation controlled for a considerable distance by the Murrumbidgee Fault. The valley rim has its highest elevation in the Bullen Range rising to over 300 m above the riverbed. Volcanic rocks dominate the geology but other types occur, such as the sedimentary rocks between Lambrigg and Tuggeranong Creek that form rock bars and rapids. The river falls from an elevation of 600 m at Angle Crossing to 425 m at the northern ACT border. This represents a considerable degree of downcutting below the Canberra Plain, which is generally at an elevation of about 600 m (NCDC 1981).

The topographic pattern of the valley is one of steep dissected slopes bordering the river, except in the sections through Tuggeranong. The valley is most rugged in the gorge areas between Angle Crossing and the Gudgenby River confluence (Gigerline Gorge) and through Red Rocks Gorge downstream of Pine Island. The broad floodplains around Lanyon and Lambrigg contrast with the rest of the valley with their gently sloping undulating terrain and small hills. They are old elevated river terraces, developed on alluvial (riverine) and colluvial (hill-slope) material. Here, the riverbed is deeply entrenched below the terraces (NCDC 1981).

The form and characteristics of the river channel relate to underlying geology, river flows, erosion and deposition. Where undulating land closely adjoins the river, the stream meanders within the confines of a broad channel with wide gently sloping margins on the channel floor. In the steep valley and gorge sections, the river is confined to a narrower channel with frequent falls in level, rapids, narrow streams and turbulent water. Massive rock outcrops commonly line the channel. The channel floor varies, including rock, boulders, sand and gravel, pebbles and silty material. In some reaches the riverbanks are poorly defined, terraced or may drop vertically for several metres (NCDC 1981). These variations in the channel and adjacent landforms outlined above, result in a diversity of aquatic and riparian habitats, however, three basic types of riverine and riparian landform can be recognised (Figure 2.1) (NCDC 1988a).

Highest flows in the Murrumbidgee River occur from July to October with lowest flows in February and March. The combination of extended dry periods and major floods results in large ranges of flow, including days without flow. Tantangara Dam, which captures Murrumbidgee headwater inflows for diversion to Eucembene Reservoir, has had a significant impact on downstream flows. Since 1927, there have been 52 days on which there has been no flow in the Murrumbidgee at Cotter Crossing (ACT Government

Figure 2.1: Generalised Categories of Riverine Landforms along the Murrumbidgee River in the ACT (from NCDC 1988a)



2004d, Vol. 3 pp. 3–4). The ACT has an effect on water quality in the Murrumbidgee River due to the inputs from Tuggeranong Creek, the Molonglo River and Ginninderra Creek (joins the Murrumbidgee north of the ACT border). For example, turbidity, bacteria, phosphorus and salinity all show increases, though to levels still well within guidelines (ACT Government 2004d, Vol. 1 pp. 41–42). Most of the river valley was burnt in the January 2003 bushfires, with severe impacts on the riparian *Casuarina cunninghamiana* woodland and the upslope *Callitris endlicheri* open forest and woodland (see s. 2.2.2).

GUDGENBY RIVER

The Gudgenby River and its tributaries, principally the Orroral and Naas rivers, drains 700 km^2 of mountain country in the southern ACT. The altitudinal range is from 576 m at the Gudgenby–Murrumbidgee confluence to 1777 m in the ranges. The tributary streams in particular, follow linear courses created by deep weathering along tectonically defined lineations. The landscape is characterised by deep open valleys and small streams that meander through flood plains in the granite country. Granite, derived from the Murrumbidgee batholith, forms the valley floors, slopes and ridgelines over most of the area (Ingwersen 2001).

The rivers and creeks are relatively small in dimensions and flow. Mean annual discharge of the Gudgenby River at Mt Tennent is 72.4 gigalitres (1964–85) and streamflows for all three rivers are seasonal, with maximum discharge occurring from August to October. The Naas River dries up in extreme dry seasons over substantial sections of its length. The Gudgenby may shrink to low volume flow but is more reliable. The area does not receive a high rainfall, though there is an increase with elevation (e.g. Canberra airport (571 m) receives 631 mm annually while Corin Dam (965 m) receives 1068 mm) (Ingwersen 2001).

There are significant wetland areas. An extensive morass has formed in the Gudgenby area at the junction of Middle, Bogong and Hospital creeks. There is a large area of fen on Nursery Creek, and the upper Naas River contains the largest area of fen in the ACT. Other wetland areas include small fens in the Orroral River catchment, Nursery Swamp (Nursery Creek), and seasonally filled open water ponds in the upper Rendezvous Creek catchment (Ingwersen 2001).

Approximately 75% of the Gudgenby–Naas catchment is in Namadgi National Park, the remainder is rural land. Though the upper valleys were used for grazing in the past, withdrawal of grazing, natural regeneration, and protection within Namadgi National Park has resulted in these areas retaining high natural values. Open forest and woodland cover much of the catchment with native tussock grassland and wetlands in the valleys. In the lower reaches of the Gudgenby and Naas rivers, establishment of problem willow species has resulted in displacement of native species and accelerated bank erosion following colonisation of the streambeds (Lang 1999). A substantial willow removal program has been undertaken in this section (Environment ACT 2005c). The lower (rural) part of the catchment is undulating to hilly with a mixture of improved and native pasture and scattered trees. Topsoils are sandy and subsoils thick clay. Land management practices have resulted in sheet and gully erosion and stream bank erosion (ACT Government 2004d, Vol. 3 pp. 24–26).

2.1.2 Molonglo River

The Molonglo River has a relatively large catchment extending east to Captains Flat and south to the Tinderry Range. It rises at an altitude of approximately 1100 m and flows for about 50 km through predominantly grazing land until it enters the ACT at Burbong. Mean annual discharge is 55 gigalitres with seasonal streamflows peaking between September and November. Aquatic life was almost totally eliminated from the river as a consequence of heavy metal pollution from the Captains Flat mine. Mining for copper, gold, lead and zinc first commenced at Captains Flat in 1882, but was abandoned at about the turn of the century. Full-scale mining recommenced in 1939. Collapse of mine waste dumps at Captains Flat in 1939 and again in 1942 and 1945 resulted in mine waste contamination of the stream and floodplain (Weatherley *et al*. 1967; Joint Government Technical Committee on Mine Waste Pollution of the Molonglo River 1974). Prior to the collapse of these waste dumps, the river had supported good numbers of ‘cod’ and ‘perch’. Heavy metal contamination of the stream and floodplain persists, even after extensive remediation works at Captains Flat (Norris 1986; Dames and Moore 1993).

The Queanbeyan River is the largest tributary of the Molonglo River. The main tributary creeks of the river are (west to east):

- **Weston Creek:** Has the smallest catchment of the tributaries listed and is almost completely urbanised. It retains few natural features.
- **Yarralumla Creek:** Drains the urbanised Woden Valley. For most of its course, it has been converted to a concrete drain. The lower reaches (from near the Cotter Road to the Molonglo River) retain the semblance of the natural channel and are deeply incised by gully erosion.

- **Sullivans Creek:** Drains from the Gungahlin area and through urbanised North Canberra suburbs where it has been converted to a concrete drain with one pollution control structure (gross pollutant trap) to protect Lake Burley Griffin. Associated with the waterway is small, recently constructed, artificial wetland in O'Connor.
- **Jerrabomberra Creek:** Has a fairly large catchment extending south to the Royalla area. The catchment is mainly rural but includes urban areas of Queanbeyan (Jerrabomberra) and the Hume industrial area in the ACT. The channel form has been affected by soil erosion following clearing and grazing in the catchment, and by gully incision. The sequence of degradation of Jerrabomberra Creek was described by Sebire (1991) and is typical of ACT and region lowland catchments:

  > In the 1840(s) it (Jerrabomberra Creek) was described in terms of a swampy flat, particularly suitable for agricultural purposes, well watered, mostly level, part of it wet and rushy. In an 1878 report it was described as comprising deep stormwater gullies, and in 1910 as a small canyon cut into the soft alluvial plain. In 1944 there was channel incision throughout the catchment.

  Erosion control in the Jerrrabomberra Creek catchment was the first project undertaken under the Commonwealth–New South Wales Lake Burley Griffin Catchment Protection Scheme, with work commencing in 1966 (NSW DLWC 2000). A silt trap constructed on the creek near its entry into Lake Burley Griffin has contributed to the ecological values of the lake backwaters. This area is now protected in Jerrabomberra Wetlands Nature Reserve and includes the prior channels of the Molonglo River.
- **Woolshed Creek:** Joins the Molonglo River (Molonglo Reach) at Pialligo. The creek drains the broad flat Majura Valley bounded by Mt Ainslie and Mt Majura (west), Greenwood Hill and low rises forming the watershed with Reedy Creek (east). In the northern part of the catchment, many tributaries lose coherent channels and disperse in the colluvial/fan slopes along the valley margins. Most streambeds are deeply incised as a result of gully erosion, though there is evidence of stabilisation of erosion gullies in recent decades (Taylor *et al.* 1999).

QUEANBEYAN RIVER

The Queanbeyan River rises at an altitude of approximately 1300 m in the Tinderry Range southeast of Canberra and flows for some 90 km before entering the ACT just before its confluence with the Molonglo River. The total catchment area of the river is approximately 96 000 ha (Queanbeyan City Council 1998). The river flows through predominantly dry sclerophyll forest in the upper catchment, with grazing becoming more common as the stream approaches Queanbeyan. The mean annual flow of the river is approximately 114 gigalitres. The construction of a number of weirs in the Queanbeyan township in the 1920s and 1930s has restricted upstream fish passage from the Molonglo River. The Queanbeyan River was originally known as the Fish River and supported good numbers of 'cod' and 'perch' (National Trust of Australia 1980). The river was impounded in 1978 by the construction of Googong Dam, approximately 5 km upstream of Queanbeyan. Googong Reservoir forms part of the water supply for Canberra and Queanbeyan.

MOLONGLO RIVER SECTIONS

This *Strategy* includes: (a) the section of the Molonglo River from the ACT border at Burbong to where it enters Lake Burley Griffin and, (b) the section from Scrivener Dam to the confluence with the Murrumbidgee River (lower Molonglo).

MOLONGLO RIVER: BURBONG TO LAKE BURLEY GRIFFIN

From its source in the Captains Flat area, the Molonglo River enters the ACT near Burbong. Native vegetation in this section has been highly modified or removed by previous pastoral use and the establishment of pine plantations. The narrow and steep sided Molonglo Gorge is a feature of this river section with the steep slopes susceptible to erosion (Anway *et al.* 1975). Ordovician sediments form the underlying geology for the whole of the river course in the ACT. These rocks outcrop in Molonglo Gorge and form the structure of the channel with pools, boulders and rapids. Downstream of the gorge, the river is incised below the Canberra Plain, but only to about 20 m, and this incision progressively disappears as the river merges into Molonglo Reach upstream of Lake Burley Griffin.

Water quality below Molonglo Gorge is adversely affected by local catchment land uses. Reedy Creek contributes sediment from forestry activities at Kowen. Pialligo Creek drains a small area including the airport and a fertile floodplain with small agricultural holdings that contribute to water quality problems such as high nutrient and organic levels. Turf production, stock grazing, urban and industrial uses also impact on this river section. There is extensive willow invasion along the riverbanks (ACT Government 2004d, Vol. 3 pp. 42–44).

LOWER MOLONGLO RIVER

In the lower section (downstream of Lake Burley Griffin), the river is well incised below the surrounding topography and displays a variety of geomorphic forms. Volcanic rocks (Walker Volcanics and Mount Painter Volcanics) dominate the geology and outcrop in the riverbed and banks (Henderson 1981). Bordering the river channel are terraces from two to five metres above the normal (low) flow level. Above the rock and boulder terraces at the lower level are sandy terraces, usually narrow with open grassy areas between River Oak (*Casuarina cunninghamiana*) and sparse Black Cypress Pine (*Callitris endlicheri*). These terraces were formed during previous high discharge floods, but following the construction of Scrivener Dam have become relict features upon which vegetation such as Burgan (*Kunzea ericoides*) has become established (NCDC 1988b). Riparian vegetation in this section is highly modified with only fragments of native vegetation remaining. Adjacent land uses have been primarily pastoralism and pine plantation until the latter was destroyed in the 2001 and 2003 bushfires. Some of the area is proposed for future urban development (ACT Government 2004b).

The Molonglo River becomes more deeply incised toward its confluence with the Murrumbidgee River near Uriarra Crossing. The Lower Molonglo Gorge (about 1.5 km from the confluence and approximately 2 km in length) is incised about 80 m below the surrounding land surface. Protected in the gorge environment, vegetation in this section displays high floristic diversity. Upstream of the gorge, cliffs and rock faces are a feature of the southern bank, usually facing gentler slopes on the northern side. Further upstream, exposed rock faces are less common (Environment ACT 2001b). Shallow or skeletal soils and partially embedded surface rocks are a feature of the riparian zone. About 2.5 km north-west of Coppins Crossing on the northern side of the river is an important geological feature comprising fossiliferous limestone and shale. This has been described as one of the best-documented fossil fauna assemblages from the Middle Silurian in south-eastern Australia, and of extremely high palaeontological value (NCDC 1988b). Protection of this site is identified as a management objective in the *Lower Molonglo River Corridor Management Plan* (Environment ACT 2001b).

The topography, vegetation, rock outcrops and surface rocks in the incised Molonglo River valley and riparian zone provide important wildlife habitat and connectivity in an otherwise sparsely treed and open landscape lacking in sheltered or enclosed habitat (Anway *et al*. 1975; NCDC 1988b). Downstream of Coppins Crossing, surrounding land is mainly in pastoral use. Near the confluence with the Murrumbidgee River, treated effluent from the Lower Molonglo Water Quality Control Centre is released to the river, modifying streamflow and water quality (ACT Government 2004d, Vol. 3 p. 52). Pastoral use and pine plantations were the main land uses between Scrivener Dam and Coppins Crossing prior to the December 2001 and January 2003 bushfires, when the pine plantations were destroyed. Part of this area is planned for urban development and other land uses (e.g. International Arboretum), but long-term land use for the remaining former pine plantation area is yet to be determined.

2.1.3 Cotter River

The Cotter River joins the Murrumbidgee River near Casuarina Sands. Close to the confluence, Paddys River joins the Cotter River from the south. The Cotter River catchment is all within the ACT except for the north-western area near Mt Coree. The river valley is defined by the Brindabella, Bimberi and Scabby ranges on the western border of the ACT and the Tidbinbilla Range, Mt McKeahnie, Coronet Peak and the Mt Kelly Spur to the east.

The Cotter River originates in the granitic Scabby Range at an altitude of 1760 m and flows north for about 70 km along the Cotter Fault before entering the Murrumbidgee River at an altitude of 460 m. Mean annual discharge for the Cotter River above Corin Reservoir is 46.9 gigalitres (1963–1987) with maximum discharges occurring from August to September, and minimum discharge in February/March. The Cotter catchment supplies approximately 85–90% of Canberra's domestic water supply. Mean annual rainfall at Cotter Hut in the upper catchment is 945 mm (1932–1987) with maximum rainfall occurring from August to October. The waters of the upper catchment are clear, slightly alkaline and of low conductivity.

Landforms and soils in the Cotter River catchment are related to the geological structure, which is dominated by Ordovician sediments in the central parts of the valley, granite along most of the ridges and slopes in the southern half of the catchment, and volcanics in the far north (NCDC 1986). The river is confined within a deep narrow valley defined primarily by the Cotter Fault. Steep rugged terrain falls directly to the river except in the upper reaches, which contain the only extensive gently sloping land in the catchment. The river valley is characterised by steep to very steep slopes, in some places becoming precipitous. Very steep slopes occur on the sedimentary rock

formations, while the granites are less uniformly steep. Moderately steep slopes occur on the volcanic rocks of the northern area (NCDC 1986).

There is a broad fertility gradient in the catchment, from low fertility at dry low altitudes to higher fertility in the moister uplands. Shallow earths, kraznozems and podsolic soils occur on the steep slopes and are relatively infertile, but fairly stable, while the eucalypt forest cover remains intact. Soils on the sedimentary rocks tend to be the least erodible, followed by the granites, with the less permeable soils on the northern volcanics being most susceptible to erosion. Features of the catchment are the alpine humus soils and peat bogs in high basins and on gentle slopes mostly near the crest of the Brindabella Range (Lintermans 2001a; NCDC 1986; Resource and Environment Consultant Group 1973).

Most of the Cotter catchment was burnt in the January 2003 bushfires, with fire severity ranging from low to very high. In the Bendora sub-catchment, 78% of the canopy was scorched or destroyed, while 42% of the canopy in the Corin sub-catchment was damaged. A decrease in runoff, and therefore water yield, is expected in the Cotter catchment between 2005 and 2020, related to vigorous regrowth of vegetation (ACT Government 2004d, Vol. 1 p. 16). All of the larger wetlands and bogs in the upper Cotter River catchment were burnt in the fires, with the proportion burnt ranging from about 70 to 100 per cent (Carey et al. 2003, p. 57). The fires destroyed large areas of Sphagnum Moss (*Sphagnum cristatum*) important for flow regulation and catchment stability in an area with erosion prone granitic soils.

The primary use of the upper and middle Cotter catchment since 1912 has been supply of domestic water to Canberra. Much of the Cotter catchment is covered with native forest with the ridgetop vegetation consisting mainly of sub-alpine woodland dominated by Snow Gum, *Eucalyptus pauciflora*. Montane and sub-alpine heaths and grasslands, herb fields, sphagnum bogs, fens and swamps are also found. (Helman *et al*. 1988; Lintermans 2001a). Some land clearing was undertaken in the upper catchment for early grazing leases in the 1830s, but there has been virtually no stock grazing in the catchment since its acquisition by the Commonwealth government. Approximately 3600 ha of the lower Cotter catchment have land use dominated by pine plantations, dating from 1926. These plantations were destroyed in the January 2003 bushfires. Hardwood logging was carried out in the lower catchment from 1930 to 1938 and 1947 to 1962 (Resource and Environment Consultant Group 1973).

PADDYS RIVER

The Paddys River catchment covers 24 712 ha and is drained by the Paddys and Tidbinbilla rivers. The Paddys River originates in the Mt Tennent area at an altitude of approximately 1400 m and flows northwest through predominantly rural land for about 40 km before joining the Cotter River just before its confluence with the Murrumbidgee River, at an altitude of about 460 m. The Paddys River is a small stream draining a broad valley characterised by rounded hills and ridges derived from the extensive granitic Murrumbidgee batholith (Strusz 1971). Streamflow is seasonal with maximum discharges occurring in spring. Riverbanks tend to be low and largely unmodified. The streambed contains pools, extensive sand and gravel areas (often vegetated), and stretches of boulders.

The headwaters of the Paddys River are forested and contained within Namadgi National Park and Tidbinbilla Nature Reserve (40% of catchment). About 30% of the catchment is rural land and the remaining 30% is pine plantations. These were destroyed in the January 2003 bushfires. Wetland areas in the upper reaches of the Tidbinbilla River are important for habitat and as a source of potable water for Tidbinbilla Nature Reserve.

With clearing and grazing, the presence of duplex soils (sandy topsoils and clay sub-soils) resulted in sheet and gully erosion in this catchment. There is localised soil erosion in the lower reaches associated with forestry activities (logging, tracks and firebreaks) (ACT Government 2004d, Vol. 3 p. 36).

2.2

Vegetation in the Riparian Zone

This section outlines and describes ACT riparian vegetation communities, assigning these to a revised classification of ACT vegetation communities currently being developed (Sharp *et al.*) forthcoming. There is a brief summary of existing surveys of riparian vegetation (s. 2.2.1) and short descriptions of the communities listed in Table 2.1 (s. 2.2.2).

2.2.1 ACT Riparian Vegetation Communities

Description and discussion of ACT riparian vegetation communities is limited by two constraints:

- ACT riparian areas as a whole have not been the subject of a systematic vegetation survey.
- Existing surveys cover particular rivers or river sections, use different methodologies, vary in level

of detail, and most are now dated having been undertaken between 1975 and 1992.

The priority in vegetation survey since 1993 has been systematic survey of the two ecological communities that are listed as endangered in the ACT: Yellow Box–Red Gum Grassy Woodland (ACT Government 2004a) and Natural Temperate Grassland (ACT Government 2005a).

Riparian vegetation in the ACT has been assessed as part of the nation-wide National Land and Water Resources Audit. The assessment is based on river lengths of varying sizes and uses remote sensing to indicate presence/absence of riparian vegetation. The results are at a significantly coarser scale than the vegetation surveys discussed below and the level that is needed for management. However, they provide a useful comparative figure and an overall picture of riparian condition. The riparian vegetation sub-index for the ACT shows 61% of river length to be largely unmodified, 12% moderately modified, 4% substantially modified and 23% severely modified. More detail can be found in Norris *et al*. (2001) and map information at <http://audit.ea.gov.au/mapping/index.cfm?topic=water&region_code=AUS&infoproduct=water&region=Country>.

In preparing this Action Plan, previous reports, mapping and descriptions of ACT riparian vegetation communities were examined. The various vegetation types identified were assigned, as closely as the descriptions allow, to a revised classification of vegetation communities developed with Natural Heritage Trust funding as part of the *ACT Natural Resource Management Plan* (ACT NRM Board 2004; Sharp *et al.* forthcoming). As shown in Table 2.1, the riparian vegetation communities found in the ACT have been related to a 'new broad-scale classification and map of the native vegetation of New South Wales that brings together the recent regional mapping' (Keith 2004, p. 21). The ACT classification provides the basis for consistent description of vegetation communities in the ACT riparian zone.

The most detailed survey and description is that of Barrer (1992a) for the lower reaches of the Molonglo River. The 'associations' described by Barrer have been assigned to the ACT vegetation communities in Table 2.1. Detailed classification of vegetation in the Naas–Gudgenby catchment has been undertaken by Ingwersen (2001), however, this work is not specifically a study of riparian vegetation. Ten tree-dominated and seven other vegetation 'units' (community, association, alliance) are recognised, only a few of which are characteristic of the riparian zone (Ingwersen 2001, pp. 10-6 to 10-9).

Vegetation along the ACT section of the Murrumbidgee River was surveyed in a more general way by P. Kendall as part of an ecological survey between 1976 and 1980 in which the vegetation communities were mapped (NCDC 1981). This is still the best description of riverine vegetation communities along the Murrumbidgee River. The later environmental analysis of the Cotter River catchment by NCDC (NCDC 1986), mapped 'vegetation communities' based on the 'forest types' categorised in an earlier environmental study of the catchment (Resource and Environment Consultant Group 1973). Neither document contains specific mapping of riparian vegetation, but there are descriptions of tree species associated with cold, wet flats. Helman *et al.* (1988) undertook a more comprehensive ecological survey of the upper Cotter River catchment. They defined five major vegetation groups and 17 'Site classification groups' including the woodland vegetation of river flats and lower reaches of larger creeks (Helman *et al*. 1988, Group 3, p. 44).

The classification of vegetation communities used in the NCDC reports accords with that in the 1984 NCDC publication on the ecological resources of the ACT based on the work of D. Shorthouse (NCDC 1984). The latter incorporates data from a range of published and unpublished studies (NCDC 1984, p. 11). Updating and refinement of the classification and description of plant communities in the 1984 NCDC report was undertaken by Hogg (1990). The riparian communities identified in these reports (NCDC 1981, 1984; Hogg 1990) have also been assigned to the ACT vegetation communities in Table 2.1.

Anway *et al.* (1975) provided a generalised vegetation description of the Molonglo River valley in the ACT, noting typical or common species over nine river sections. Vegetation information in this report can only be used to identify where sub-formations occur. Also at a general level was mapping of the Murrumbidgee River valley in the late 1970s by F. Ingwersen (Ingwersen and Johnson 1992). The dominant species and floristic composition were qualitatively defined from air photos with some recognition of woodland density in eucalypt areas. There was some field checking of the accuracy of air photo interpretation (unpubl. records, Wildlife Research and Monitoring, Environment and Recreation).

The other type of vegetation information available for this *Strategy* is for particular sites. For example, the Murrumbidgee River Ecological Study (NCDC 1981) identifies the dominant species at particular locations on the river. The dominant riparian vegetation has been described at 81 fish survey sites in the ACT

Table 2.1: Vegetation Communities Occurring in ACT Riparian Zones

ACT Vegetation Community	Class (Keith 2004)	Characteristic Species	Typical Location
1. *Eucalyptus macrorhyncha–Eucalyptus rossii* Tableland Forest	Southern Tableland Dry Sclerophyll Forests	*E. macrorhyncha* *E. rossii*	Dry footslopes to mountain foothills
2. *Eucalyptus dalrympleana* Montane Forest	Southern Tableland Wet Sclerophyll Forests	*E. viminalis* *E. dalrympleana* *E. robertsonii* *E. pauciflora*	On humic soils in riparian zones within Namadgi Nat. Park
3. *Eucalyptus melliodora–Eucalyptus blakelyi* Tableland Grassy Woodland	Southern Tableland Grassy Woodlands	*E. melliodora* *E. blakelyi* *E. bridgesiana*	Low hills and plains
4. *Eucalyptus dives Eucalyptus bridgesiana* Tableland Woodland	Southern Tableland Grassy Woodlands	*E. dives* *E. nortonii* *E. bridgesiana*	Dry hillslopes
5. *Eucalyptus pauciflora–Eucalyptus rubida* Tableland Woodland	Southern Tableland Grassy Woodlands	*E. pauciflora* *E. rubida* *E. dives*	Open lowland valleys on plains and frost-hollows
6. *Callitris endlicheri* Tableland Woodland	Eastern Riverine Forests	*Callitris endlicheri* *E. nortonii* *E. macrorlyncha* *E. blakelyi*	Dry hillslopes
7. *Casuarina cunninghamiana* Tableland Riparian Woodland	Eastern Riverine Forests	*Casuarina cunninghamiana*	River fringes
8. *Eucalyptus viminalis* Tableland Riparian Woodland	Southern Tableland Wet Sclerophyll Forests	*E. viminalis* *E. radiata*	River fringes
9. Tableland Shrubland	Not identified	*Kunzea ericoides* *Bursaria lasiophylla* *B. spinosa*	Dry hillslopes, river fringes
10. Tableland Dry Tussock Grassland	Temperate Montane Grasslands	*Themeda triandra* *Poa sieberiana* *Austrostipa scabra ssp. falcata* *Austrostipa bigeniculata* *Austrodanthonia spp.* *Bothriochloa macra*	Lowland plains, valleys
11. Tableland Moist Tussock Grassland	Temperate Montane Grasslands	*Themeda triandra* *Carex inversa* *Poa labillardieri*	Lowland plains, valleys
12. Tableland Wet Tussock Grassland	Temperate Montane Grasslands	*Carex appressa* *Poa labillardieri*	Drainage lines in lowland plains, valleys
13. Montane Dry Tussock Grassland	Temperate Montane Grasslands	*Themeda triandra* *Poa sieberiana*	Montane valleys
14. Montane Wet Tussock Grassland	Temperate Montane Grasslands	*Poa sieberiana* *Poa labillardieri* *Carex gaudichaudiana*	Montane valleys
15. Montane and Subalpine Fen	Montane Bogs and Fens	*Carex gaudichaudiana* *Restio australis*	Montane swamps
16. Tableland Riparian Fringing Vegetation	Montane Lakes	*Phragmites australis* *Schoenoplectus validus* *Typha spp.* *Juncus australis*	River fringes
17. Tableland Riparian Floating and Submerged Vegetation	Montane Lakes	*Vallisneria gigantea* *Myriophyllum spp.*	Submerged macrophytes in deep pools (to 4 m)

Vegetation Community: A community is an assemblage of organisms occurring in one place, usually as a recognisably distinct group (NCDC 1984). A vegetation community has been defined by Costin (1954) as a climax plant community of which the dominant stratum has a qualitatively uniform floristic composition and which exhibits a uniform structure as a whole; and by (Specht *et al.* 1995) as a plant community based on structural attributes and floristic dominance in the various strata. The vegetation communities in Table 2.1 are derived from a revised classification of vegetation communities in the ACT and sub-region that is subject to further review.

Class: As applied by Keith (2004), vegetation classes are groups of vegetation defined mainly by overall floristic similarities (i.e. shared species), although they may also share structural and habitat characteristics.

Characteristic Species: An abbreviated list for the purposes of this table.

(M. Lintermans pers. comm.). Fifteen of these sites in the upper Cotter valley have been documented in more detail, with major species of the overstorey, understorey and ground cover, as well as site characteristics (Ingwersen and Ormay 1988).

The vegetation communities occurring in ACT riparian zones covered by this *Strategy* and their structural relationships are shown in Table 2.1, based on the surveys and descriptions mentioned above. These communities are briefly described in section 2.2.2 below. Factors influencing efforts to improve the knowledge of riparian vegetation include:

- Riparian vegetation is diverse, changing frequently along the length of the river in response to changes in gradient, rock outcrops, river flows and other factors.
- There has been no uniform approach to mapping riparian vegetation, in particular, defining the limits of the riparian zone. This may be difficult to standardise, even within the ACT (F. Ingwersen, pers. comm.).

This review of existing sources of information on riparian vegetation indicates that there is a need for more detailed, accurate and consistent survey. Therefore, a key action in the implementation of this Strategy is to undertake vegetation surveys, develop more accurate vegetation models, and ground truth the results of modelling throughout the riparian zone (see s. 5.3.2, Table 5.1 and Table 6.1).

2.2.2 Descriptions of Riparian Vegetation Communities in the ACT

The following is a brief description of each of the vegetation communities listed in Table 2.1. The distribution of these vegetation communities in ACT riparian zones is shown in Figures 2.2 to 2.4 (pages 27–29).

1. *Eucalyptus macrorhyncha–Eucalyptus rossii* Tableland Forest (Red Stringybark–Scribbly Gum)

This ecological community has been described previously as Scribbly Gum Dry Forest (NCDC 1981; NCDC 1984; Hogg 1990). The community is widespread on sedimentary soils on exposed aspects in lowland areas of ACT. It occurs in the riparian areas along the Molonglo River (Anway *et al.* 1975; Barrer 1992a), the Murrumbidgee River north of Red Rocks and parts of the lower Cotter catchment (Hogg 1990). A number of associations have been identified within the riparian zone. Included in this community are relict stands of *Allocasuarina luehmannii* (Bulloak) in the area below Molonglo Gorge in the upper Molonglo River valley (Anway *et al*. 1975; NCDC 1984).

Characteristic tree species include *E. macrorhyncha* (Red Stringybark), *E. rossii* (Scribbly Gum), *E. mannifera* (Brittle Gum) and *E. dives* (Broad-leaved Peppermint), with *Daviesia leptophylla* understorey and *Joycea pallida* (Redanther Wallaby Grass) groundcover.

2. *Eucalyptus dalrympleana* Montane Forest (Mountain Gum)

This community occurs on humic soils in riparian zones within Namadgi National Park and Kosciuszko National Park. It is common in the upper Cotter River and tributaries.

Characteristic species include *E. robertsonii* (Robertson's Peppermint), *E. dalrympleana* (Mountain Gum), *E. viminalis* (Ribbon Gum) and *E. pauciflora* (Snow Gum).

3. *Eucalyptus melliodora–Eucalyptus blakelyi* Tableland Grassy Woodland (Yellow Box–Red Gum)

This woodland community is declared endangered in the ACT (ACT Government 2004a). It is generally found on the middle and lower slopes of hills (600–900 m) and in gently undulating topography that is less susceptible to cold-air drainage (ACT Government 2004a; NCDC 1984). It occurs throughout the central Southern Tablelands on deep colluvial soils on lower slopes and hilly to undulating terrain with loamy soils of moderate fertility. There may be a sparse mid-layer of shrubs. The ground cover comprises a continuous layer of perennial grasses and there may be a diversity of native forbs (ACT Government 2004a; Keith 2004). In the ACT the community fringes the riparian zones on the Murrumbidgee and Molonglo rivers. It also extends to the rivers where valleys are not steep and soils are deeper, for example, on the west bank of the Murrumbidgee River at Pine Island and between Tharwa and Lambrigg (NCDC 1981). In the lower Molonglo River valley, Barrer (1992a) recorded occasional individuals of *E. melliodora* (Yellow Box) and in one section of the gorge, a small, scattered population of stunted and sometimes mallee-form of *E. blakelyi* (Blakely's Red Gum) at and above maximum flood level.

Characteristic tree species of this community are *E. melliodora, E. blakelyi* and *E. bridgesiana* (Apple Box), with groundcover of *Austrodanthonia racemosa* var. *racemosa* (Wallaby Grass), *Austrostipa scabra* ssp. *falcata* (Rough Spear Grass), *Themeda triandra* (Kangaroo Grass), *Poa sieberiana* (Poa Tussock) and a wide range of orchids, lilies and daisies (ACT Government 2004a).

4. *Eucalyptus dives–Eucalyptus bridgesiana* Tableland Woodland (Broad-leaved Peppermint–Apple Box)

This community occurs on hillslopes and on foothills of rocky slopes. It covers extensive areas in the southern ACT, in the sub-montane stream valleys and hillslopes flanking the Murrumbidgee River, generally at

elevations from 700 m to over 1200 m (NCDC 1984). It intergrades with *Eucalyptus melliodora–Eucalyptus blakelyi* Tableland Grassy Woodland on lower exposed slopes (ACT Government 2004a).

Characteristic tree species include *E. dives, E. nortonii* and *E. bridgesiana*, with *Bursaria spinosa* (Native Blackthorn) a common shrub.

5. *Eucalyptus pauciflora–Eucalyptus rubida* Tableland Woodland (Snow Gum–Candlebark)

This woodland containing *E. pauciflora* (Snow Gum) occurs in low-lying frost-prone areas and is only localised in extent. It usually fringes *Eucalyptus melliodora–Eucalyptus blakelyi* Tableland Grassy Woodland where cold-air drainage restricts the growth of less frost tolerant tree species (ACT Government 2004a). In the riparian zone, it occurs as open forest or woodland and replaces *Eucalyptus macrorhyncha–Eucalyptus rossii* Tableland Forest in a few areas such as Red Rocks Gorge. *E. rubida* (Candlebark) is found to a limited extent with this community or as pure stands (NCDC 1981). *E. pauciflora* has been recorded from the upper Molonglo River (Burbong) (Anway *et al.* 1975) and a few sites in less rugged parts of the lower Molonglo River valley (Barrer 1992a).

The characteristic tree species are *E. pauciflora* and *E. rubida*, with a grassy ground cover of *Poa sieberiana*, *Austrodanthonia caespitosa* and *Themeda triandra*.

6. *Callitris endlicheri* Tableland Woodland (Black Cypress Pine)

Callitris endlicheri Tableland Woodland/Open Forest occurs on dry rocky slopes adjacent to river corridors and on some hillslopes (e.g. Mt Tennent and northern slopes of the Billy Range). It is present on granite in the northern end of the Gudgenby–Naas catchment below 820 m on warm, westerly tending aspects where it was considerably disturbed in the past (Ingwersen 2001), most likely by grazing and clearing. The community occurs within the steeper gorge-like sections of the Gudgenby and Murrumbidgee rivers (NCDC 1981). In the northern section of the Murrumbidgee River (Cotter River confluence to ACT border) scattered stands of *Callitris endlicheri* (Black Cypress Pine) occur amongst extensive areas of *Kunzea ericoides* (Burgan). Relatively dry, rocky, steep slopes close to the river now dominated by shrub species such as *Bursaria spinosa* (Native Blackthorn) and *Grevillea juniperina* may have carried more extensive stands of *Callitris* in the past (Mallen 1986). *Callitris endlicheri* also occurs in Molonglo Gorge and steep valley areas of the lower Molonglo River, dominating spurs, ridgelines and hot, dry slopes (Anway *et al.* 1975; Barrer 1992a).

Much of this community was severely burnt in the January 2003 bushfires. However, *Callitris* along the Murrumbidgee River below its junction with the Molonglo River was not burnt. Three sites were established in 2004 for long-term post-fire monitoring of the recovery of the community. Two of these are at Mt Tennent (outside the riparian zone), the other in the Lower Molonglo River Corridor (s. 2.3.1). *Callitris endlicheri* is fire sensitive and trees that were 100% scorched in the fires have died. In the one site revisited in 2005 at Mt Tennent, there was some seedling recovery (six seedlings 10–20 cm in a 0.1 ha plot). The main threats to the re-establishment of this species are grazing by rabbits and another fire.

The characteristic tree species in the community are *Callitris endlicheri, E. macrorhyncha, E. blakelyi, E. nortonii, Allocasuarina verticillata* (Drooping She-oak), *E. dives* and *E. melliodora*. There is a sparse understorey of *Acacia rubida* (Red-leaved Wattle), *Cassinia quinquefaria, Bursaria spinosa, Dodonaea viscosa* ssp. *angustissima* (Hop Bush), *Daviesia mimosoides* (Bitter Pea), *Cassinia longifolia* and *Kunzea ericoides*, over a sparse to open herbaceous ground cover of *Joycea pallida*, *Pimelea curviflora* (Curved Rice Flower), *Wahlenbergia* spp. (Bluebells), *Xerochrysum viscosum* (Sticky Everlasting), *Chrysocephalum semipapposum* (Clustered Everlasting).

Previous studies have identified the following associations of *Callitris endlicheri* Tableland Woodland within ACT riparian zones:

(a) Lower Molonglo: *C. endlicheri–E. macrorhyncha* with occasional *E. bridgesiana* and less frequently *E. melliodora*; *C. endlicheri–E. blakelyi* (at higher elevations in the valley and transitional to (former) surrounding lowland woodland) (Barrer 1992a);

(b) Upper Molonglo (Molonglo Gorge): *C. endlicheri–E. macrorhyncha* (Anway *et al.* 1975);

(c) Steeper gorge-like sections of the Gudgenby and Murrumbidgee Rivers: *C. endlicheri–E. nortonii*; may also include *Allocasuarina verticillata* and/or *E. dives* (Ingwersen 2001).

7. *Casuarina cunninghamiana* Tableland Riparian Woodland (River She-oak)

This vegetation community has been described previously as *Casuarina cunninghamiana* (River Oak) community (NCDC 1981, 1984; Hogg 1990; Barrer 1992a).

The community occurs on alluvial soils along rivers and streams in the central, northern and western parts of the Southern Tablelands and throughout Eastern Australia (Keith 2004). It grows on streambanks between normal water levels and maximum flood levels, in particular, on sandy and shingle terraces. Characteristically, it forms almost pure stands in narrow belts along the watercourses. In the ACT it occurs along the Murrumbidgee River north of Point

Hut Crossing, Paddy's River, the lower Molonglo River, and along Uriarra and Swamp Creeks (north of Uriarra crossing on the Murrumbidgee River) (NCDC 1984).

Most of the community was severely burnt in the January 2003 bushfires. However, *Casuarina* along the Murrumbidgee River below its junction with the Molonglo River was not burnt. Three sites were established in 2004 for long-term post-fire monitoring of the recovery of the community. Two sites are near Murrays Corner (Paddys River), the other at Pine Island (Murrumbidgee River) (s. 2.3.1). *Casuarina cunninghamiana* is a fire sensitive species and the majority of mature trees will die if 100% scorched by a fire. At Murrays Corner, some of the mature trees initially resprouted but the majority of these have subsequently died. Monitoring in 2005 showed seedling regrowth, which is facing competition from weed species, especially Blackberry. No seedlings were evident at Pine Island in 2004 but some larger plants (3–12 m) were recorded.

The characteristic species of the community are *Casuarina cunninghamiana, Acacia mearnsii* (Black Wattle), *Acacia dealbata* (Silver Wattle), *Callistemon sieberi, Kunzea ericoides* and *Microlaena stipoides* (Weeping Grass). Pryor and Moore (1955) described the *Casuarina cunninghamiana* association to be of special interest, noting that the trees have a relatively short life, probably less than 100 years, appearing to give way to either *E. viminalis* or *E. bridgesiana* in the absence of disturbance. This vegetation cycle recommences following floods or changes in river course, as *Casuarina cunninghamiana* colonises the new banks. Willows (*Salix* spp.) are found as occasional individuals within the community (NCDC 1981). Riparian She-oak Woodlands and associated mistletoe species are important faunal habitat (see s. 3.2.5 and s. 3.3.1).

Maintenance and re-establishment of the She-oak Woodland in ACT riparian areas following the 2003 bushfires is a long term conservation issue for the river corridors. This woodland provides habitat for a variety of native birds.

8. *Eucalyptus viminalis* Tableland Riparian Woodland (Ribbon Gum)

This community occurs on alluvial soils on river flats and lower broad creek-lines between the upper Shoalhaven and Numeralla river valleys. In the riparian zone in the ACT, *E. viminalis* occurs as scattered individuals or small groups along the Murrumbidgee River between Kambah Pool and Angle Crossing and along part of Condor Creek. These appear to be remnants of a former climax community developed on old river terraces (NCDC 1981).

The characteristic tree species are *Eucalyptus viminalis, E. radiata* ssp. *radiata* and *Acacia melanoxylon* (Blackwood), with an understorey of *Prostanthera lasianthos* (Victorian Christmas Bush), *Cassinia aculeata* (Dolly Bush), *Hakea dactyloides* (Broad-leaved Hakea), *Coprosma quadrifida* (Prickly Currant Bush), *Pteridium esculentum* (Bracken) and *Dianella tasmanica* (Blue Flax Lily), and a groundlayer of *Microlaena stipoides* var. *stipoides*, *Poa meionectes* (Snow Grass), *Clematis aristata* (Old Man's Beard) and *Billardiera scandens* var. *scandens* (Appleberry).

9. Tableland Shrubland

The Tableland Shrubland community in the ACT riparian zone is dominated by *Kunzea ericoides* (formerly *Leptospermum phylicoides*) and is associated particularly with river fringes, rocky riverbanks and gravel beds adjoining rapidly flowing water. It is frequently an early colonizer and stabilizer of riverbanks and may form extensive thickets up to 3 m high (NCDC 1981). Although not a typical climax vegetation type in the ACT, the shrub community that has developed on steep slopes and along gullies is similar to the shrub dominated structural formations of the Southern Tablelands comprising the *Leptospermum phylicoides–Leptospermum flavescens* alliance described by Costin (1954) (Hogg 1990; NCDC 1981).

Kunzea shrublands are also commonly dominant away from the riparian zone on previously cleared hillslopes. In many situations this is a disclimax community, which is maintained at an early seral stage when trees have been cleared and are unable to replace the shrubs (Kirschbaum and Williams 1991).

Eucalypts are either sparse or absent but *Callitris endlicheri* commonly occurs within the shrub community and extends into adjacent open forest. Along the valley slopes of the Murrumbidgee, Molonglo and Cotter rivers, *Kunzea ericoides* occurs with a range of other species, including *Leptospermum obovatum* (Anway *et al.* 1975), *C. endlicheri* (Barrer 1992a; Hogg 1990; NCDC 1981), *Callistemon sieberi* (River Bottlebrush) (Barrer 1992a) and *Acacia dealbata* (Hogg 1990).

Anway *et al.* (1975) and Barrer (1992a) have identified other shrubland associations along the Molonglo River that do not contain *K. ericoides*:

- *Bursaria lasiophylla* shrublands;
- *Pomaderris angustifolia* shrublands;
- *Cryptandra propinqua* (Silky Cryptandra) shrublands;
- *Dodonaea viscosa* and *Acacia rubida* shrublands; and
- *Acacia rubida, A. mearnsii, Bursaria spinosa* shrublands.

Shrubland along the river valleys provides important habitat and movement corridors for birds (NCDC 1984).

10. Tableland Dry Tussock Grassland
Tableland Dry Tussock Grassland includes the endangered Natural Temperate Grassland (ACT Government 2005a) and Stipa spp. Tussock Grasslands (Chan 1980; Barrer 1992a; NCDC 1984).

The community is naturally treeless or contains up to 10% projective foliage cover of trees, shrubs or sedges (Environment and Recreation 2005a). The community is characterised by a diverse flora dominated by tussock grasses and containing many native forb species. The community is found in valleys influenced by cold air drainage and on open plains, within the Southern Tablelands of NSW and ACT (Environment ACT 2005a). Within the ACT, the community usually occurs up to an elevation of 625 m (Sharp 1997) but may occur as high as 900 m (Sharp *et al.* forthcoming). Small areas within frost hollows occur along the riparian system in the Molonglo and Murrumbidgee rivers (Anway *et al.* 1975; Barrer 1992a). Generally this community merges into *Eucalyptus melliodora–Eucalyptus blakelyi* Tableland Grassy Woodland or *Eucalyptus pauciflora–Eucalyptus rubida* Tableland Woodland.

The community has been greatly fragmented and disturbed since European settlement (ACT Government 2005a; Barrer 1992a; Environment ACT 2005a). Where it occurs within the riparian zone, it is frequently difficult to distinguish between naturally treeless grassland and cleared *Eucalyptus melliodora–Eucalyptus blakelyi* Tableland Grassy Woodland (NCDC 1981).

Characteristic species are *Themeda triandra, Poa sieberiana, Austrostipa scabra* spp. *falcata, Austrodanthonia* spp., *Bothriochloa macra* (Redleg Grass), *Chrysocephalum apiculatum* (Common Everlasting), *Convolvulus erubescens* (Pink Bindweed), *Vittadinia muelleri* (Narrow-leaved New Holland), *Desmodium varians* (Slender Tick-trefoil) and *Carex inversa* (Knob Sedge).

Three dry tussock associations have been identified in the ACT (Sharp 1997):

- *Austrostipa* grassland;
- *Austrodanthonia* grassland;
- Dry *Themeda* grassland.

11. Tableland Moist Tussock Grassland
Tablelands Moist Tussock Grassland is included in one of five floristic associations defined for the endangered Natural Temperate Grassland in the ACT (ACT Government 2005a). The community has been previously referred to as Wet Tussock Grassland (*Poa caespitosa*) (Costin 1954), Tablelands Grassland (Specht, Roe and Boughton 1974), and Poa Grasslands (NCDC 1984). The community occurs in moist and periodically wet drainage areas on valley floors in native grassland areas generally below 625 m elevation (Sharp 1997) but may occur as high as 900 m (Sharp *et al.* forthcoming).

Characteristic species include *Poa labillardieri* (Common Tussock Grass), *Themeda triandra, Carex appressa* (Small Sedge), *Juncus australis* (Australian Rush), *Asperula conferta* (Common Woodruff), *Geranium solanderi* var. *solanderi* (Native Geranium), *Hydrocotyle laxiflora* (Stinking Pennywort).

One moist tussock association has been identified in the ACT (Sharp 1997):

- Wet *Themeda* grassland;

12. Tableland Wet Tussock Grassland
Tableland Wet Tussock Grassland is included in one of five floristic associations defined for the endangered Natural Temperate Grassland in the ACT (ACT Government 2005a). It occurs in the ACT as small, often degraded remnants that are part of larger grassland sites. It is found in poorly drained areas and along seepage lines, drainage lines and creeks generally below 625 m elevation but may occur as high as 900 m (Sharp *et al.* forthcoming). In the riparian zone it is confined to damp, level situations, such as near flats, springs and creeks and can be found as small fringing zones of wet areas and creeks (NCDC 1984).

Characteristic species are *Carex appressa* and *Poa labillardieri* as well as *Juncus australis, Poa sieberiana* var. *sieberiana*, and *Themeda triandra*.

One wet tussock association has been identified in the ACT (Sharp 1997):

- *Poa labillardieri* grassland.

13. Montane Dry Tussock Grassland
Montane Dry Tussock Grassland occurs in the ACT at an elevation of 900 m to 1300 m in frost hollows where cold air drainage impedes tree establishment (Benson 1994, Ingwersen 2001). As with Tableland Dry Tussock Grassland, it is frequently difficult to distinguish between naturally treeless grassland and secondary grassland.

Characteristic species are *Poa sieberiana, Asperula conferta, Epilobium hirtigerum* (Hoary Willow-herb) (Ingwersen 2001) and *Acaena ovina* (Sheep's Burr) (Benson 1994).

14. Montane Wet Tussock Grassland
Montane Wet Tussock Grassland occurs between 900 and 1300 m, on flats in valley floors where extreme local cold results in treeless conditions and soils are usually moist. This grassland occurs in the upper sections of the Naas, Gudgenby (Ingwersen 2001) and Cotter rivers (Helman *et al.* 1988).

Characteristic species are *Poa sieberiana, Carex gaudichaudiana* and *Poa labillardieri*.

15. Montane and Subalpine Fen
This community commonly occurs at high altitudes associated with swamps. The habitat is on soils with impeded drainage on flat valley floors (Ingwersen 2001).

Characteristic species are *Carex gaudichaudiana, Myosotis discolor* (Forget-me-not), *Restio australis, Bolboschoenus medianus* (Marsh Club-rush), *Eleocharis plana* (Spike-rush), *Eleocharis acuta* (Common Spike-rush), *Carex appressa, Glyceria australis* (Australian Sweetgrass), *Ranunculus inundatus* (River Buttercup), *Hydrocotyle tripartita* (Pennywort) and *Ranunculus amphitrichus*.

16. Tableland Riparian Fringing Vegetation
Hogg and Wicks (1989) listed the aquatic vascular plants, semi-aquatic and wetland plants found in the ACT, noting that there are no clear boundaries between these communities, as transitional ecotones blend one into the other. Hogg and Wicks' report provides general information on habitat requirements and distribution of aquatic vascular species, noting that there have been no systematic field studies of plants associated with water bodies in the ACT. This situation remains largely unchanged.

There is some general information in existing reports. Anway *et al.* (1975) recorded the main semi-aquatic and wetland species in each of their six terrain types (river sections) for the length of the Molonglo River. Reedlands, sedgelands and rushlands were recorded by Barrer (1992a) for the lower Molonglo river valley. A general discussion of aquatic and semi-aquatic vegetation in the Murrumbidgee River is included in NCDC (1981, p. 146). Ingwersen and Ormay (1988) include aquatic and semi-aquatic vegetation in their description and photographic record of vegetation at 15 fish sampling sites in the upper Cotter River.

The following associations have been described:

- *Salix* spp., *Phragmites australis* (Common Reed) reedland (Anway *et al.* 1975);
- *Schoenoplectus validus* (Sedge) closed sedgeland (Barrer 1992a);
- *Isolepis fluitans* (Floating Club-rush) closed sedgeland (Barrer 1992a);
- *Eleocharis acuta* (Common Spike-rush) sedgeland (Barrer 1992a);
- *Cyperus* spp. closed sedgeland (Barrer 1992a);
- *Carex appressa* sedgeland (Barrer 1992a);
- *Typha* spp. (Cumbungee) closed rushland (Barrer 1992a);
- *Juncus* spp. rushland (Barrer 1992a); and
- *Typha* spp., *Phragmites australis, Juncus australis, Scirpus validus* rushland (Anway *et al*. 1975).

17. Tableland Riparian Floating and Submerged Vegetation
In this category are those plants that are entirely dependent on the presence of permanent water and are adapted to growing in or on permanent water, either completely submerged or emergent and having a definite life-form (habit, structure) related to this aquatic environment (Aston 1977 in Hogg and Wicks 1990). Briggs (1981) described these as *Swamp Herblands*, which include both floating and free-floating herblands and submerged and emergent herblands. A list of aquatic plants found in the ACT is contained in Hogg and Wicks (1989).

Aquatic vegetation provides habitat and food sources and traps sediment. It is most developed in permanent waters to a depth of about 4 m, as occurs in the ACT urban lakes and backed up river waters. Submerged plant species such as *Vallisneria gigantea* (Ribbon Weed) and *Myriophyllum* spp. (Water Milfoil) also occur along the Murrumbidgee River in mud in semi-stagnant backwaters and the margins of quiet pools (NCDC 1981).

2.3

Vegetation Change and Condition

Where riparian zones contain areas of lowland native grassland or lowland woodland, discussion of changes to these communities since European settlement and on-going threats are contained in Action Plan 27, the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a) and Action Plan 28, the *ACT Lowland Native Grassland Conservation Strategy* (ACT Government 2005a).

2.3.1 Changes to Riparian Zone Vegetation Since European Settlement and Ongoing Threats

The main changes to riparian zone vegetation since European settlement and ongoing threats are discussed below in relation to factors causing changes. Aquatic vegetation has also been affected by these factors.

- **Pastoral and agricultural development:** From the 1820s the Southern Tablelands, including the land that became the Australian Capital Territory, was occupied by Europeans who established a pastoral economy. This continued after the establishment of the Territory in 1911 and through to the present day, though it is now reduced in area and economic importance.

Figure 2.2: Vegetation Communities in the Gudgenby, Naas and Orroral River Catchments, ACT

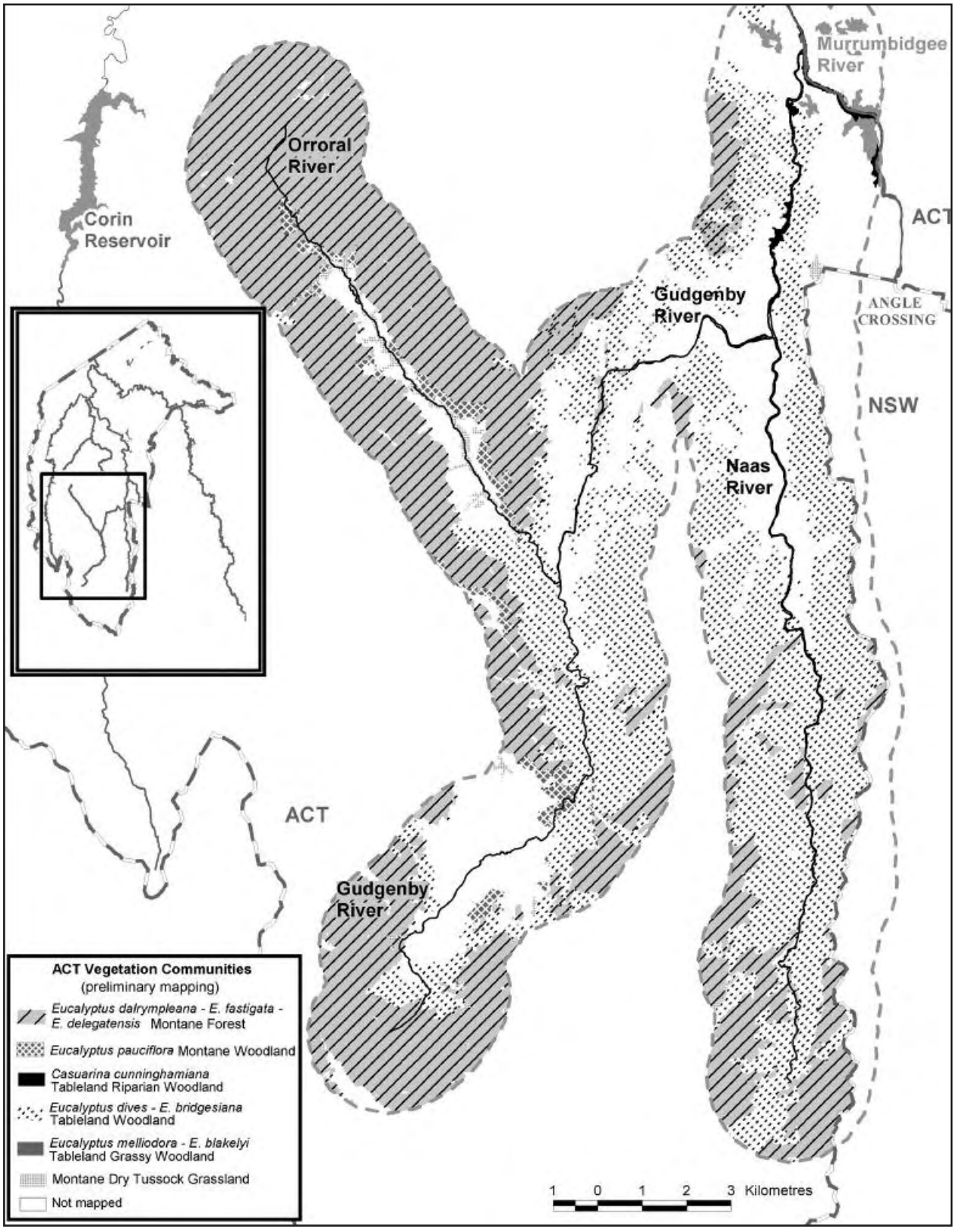


Figure 2.3: Vegetation Communities in the Cotter, Paddys and Tidbinbilla River Catchments, ACT

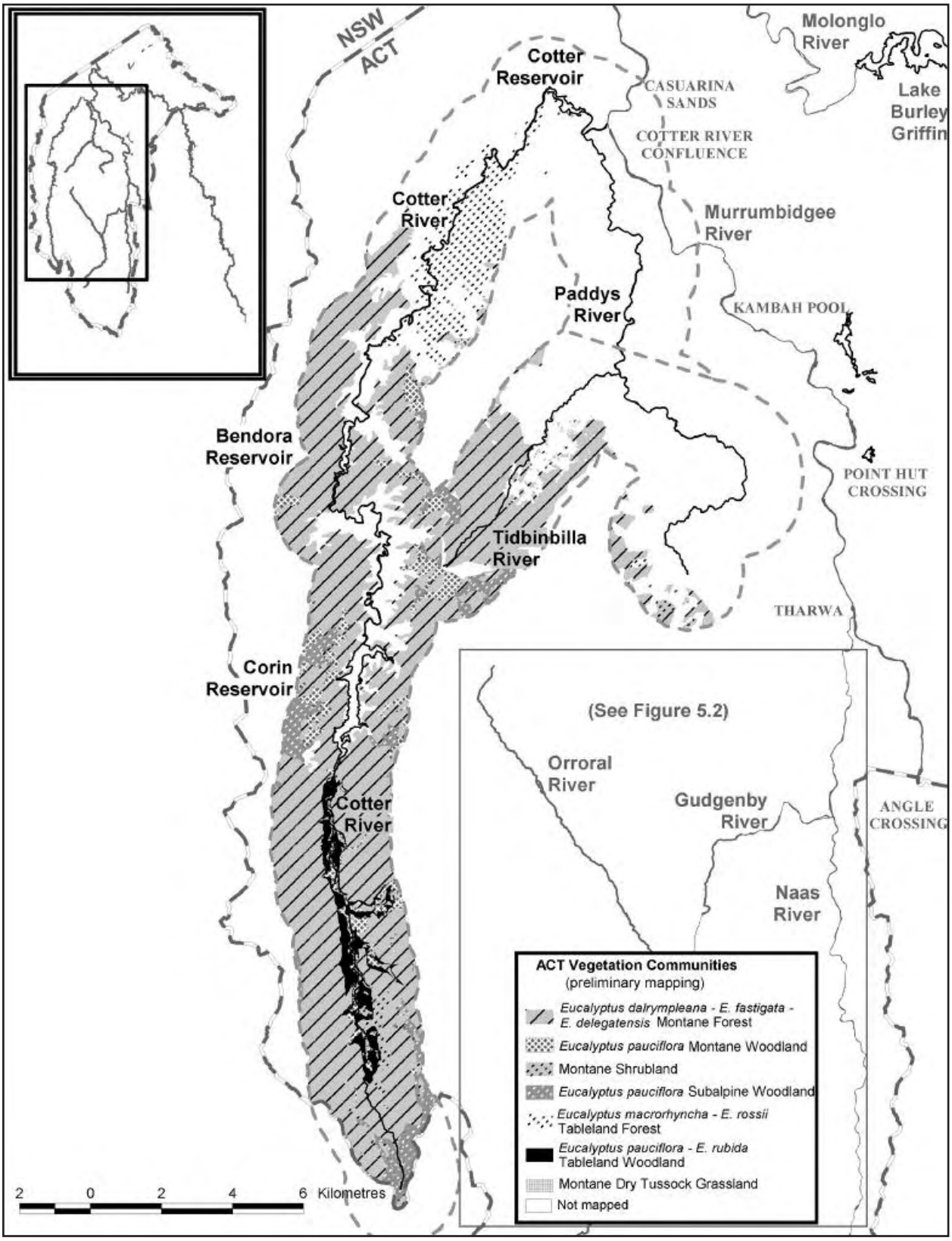
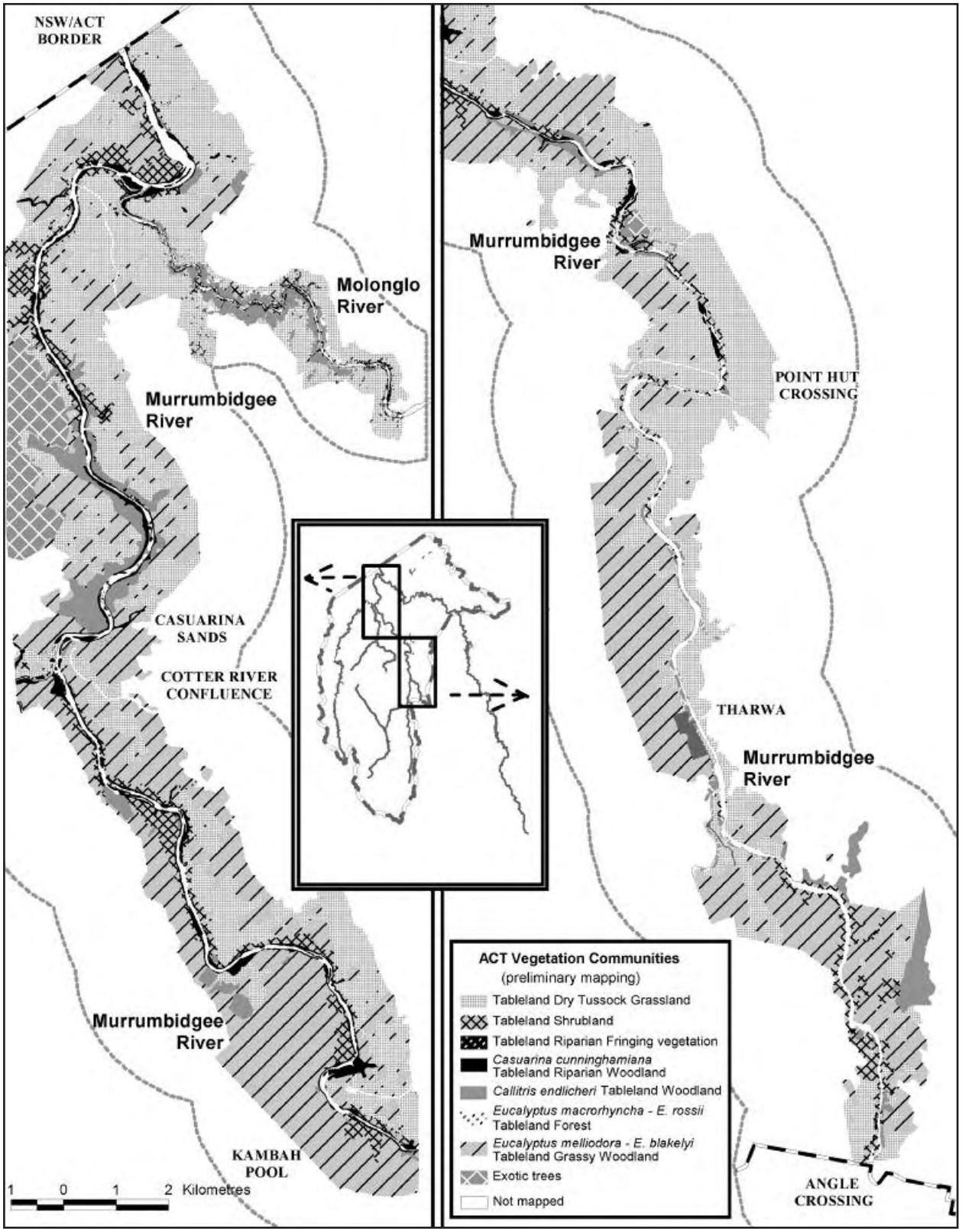


Figure 2.4: Vegetation Communities along the Murrumbidgee and Lower Molonglo Rivers, ACT



The mainstay of this industry has been sheep and cattle grazing for wool and meat production, the growing of cereal and fodder crops, and a limited amount of dairying and small cropping (Department of the Interior 1965). In this rural economy the rivers were important as sources of water for stock and domestic purposes, and the riparian zones for cultivation of crops and for dairying. King (1946) described the 'hayrick' pastures (characterised by haystacks), which combined sheep-raising and fodder-crop growing, as the optimum sheep lands of the Territory. As well as being present in gently undulating and low-lying northern and north-eastern parts of the Territory, these pastures occurred along and around the Murrumbidgee and Molonglo rivers, Ginninderra, Sullivans and Jerrabomberra creeks, with smaller areas in the lower parts of the valleys of the Naas and Gudgenby rivers. Growing of cereal and fodder crops is now an insignificant part of rural land use in the ACT.

Past and continuing rural use form a major part of the European cultural heritage of ACT riparian zones. Most significant is the Lanyon–Lambrigg area between Tharwa and Point Hut Crossing. The Lambrigg property, where William Farrer carried out his wheat-growing trials, continues to operate as an ACT rural lease and includes the homestead built by Farrer, his laboratory, trial plots and grave (Environment ACT 1998). East of the river, the Lanyon property also continues as a grazing enterprise. The historic homestead, associated buildings, gardens and landscaping is managed as a museum, which is open to the public (Environment ACT 1998). The Lanyon–Lambrigg area is protected by heritage legislation, and planning and management controls.

Pastoral and agricultural activity has had a major impact on riparian vegetation in the ACT, including:

- —Clearing, selective clearing and ringbarking of grassy woodland, open forest and other tree communities. Cultivation of some areas with introduced crops.
- —Removal of fringing riparian vegetation.
- —Trampling of streambank vegetation by stock, resulting in loss of streambank stability, erosion, greater susceptibility to weed invasion, and destruction of habitat.
- —Plant introductions, both deliberate and inadvertent, some of which have become weed species of riparian areas (see below).
- —Changes in species composition and loss of floral diversity in native grassland and grassy woodlands. Grazing affects grassy communities through removal of biomass, trampling, nutrification, increased weediness, destruction of faunal habitat, soil erosion, loss of soil moisture, and prevention of seedling recruitment of overstorey species (Askey-Doran and Pettit 1999; Sharp 1994). For the Murrumbidgee River downstream of the ACT, Roberston and Rowling (2000) have documented the deleterious effects of grazing on riparian vegetation and the quantity of ground surface detrital material (litter and woody debris), both of which have a significant influence on the ecological functioning of riparian zones (see s. 3.1.3 and s. 5.6.4).

- **Urban and infrastructure development:** Urban and infrastructure development for the city of Canberra has had a substantial impact on riparian zones. As well as urban areas, dams and bridge crossings, river corridors contain a wide variety of sewerage, electricity, telecommunications and water supply infrastructure.

  The major change on the Molonglo River has been the construction of Scrivener Dam, the filling of Lake Burley Griffin and associated lakeshore development. Future urban development along the Molonglo River in the Stromlo and Kowen areas will potentially result in impacts on water quality, including increased erosion and sedimentation, and urban edge threats. These include predation and disturbance by cats and dogs, removal of bush rock, removal of fallen timber by local residents or for fire hazard fuel reduction, dumping of garden waste, planting out into riparian reserves from adjacent backyards, and spread of invasive pest plants.

  Tributary creeks of the Molonglo River are briefly described in s. 2.1.2. These have been substantially altered by past land uses and as part of the stormwater drainage and pollution control engineering for urban Canberra. The lower Molonglo River valley near its confluence with the Murrumbidgee River is the site of the Lower Molonglo Water Quality Control Centre (Canberra's sewage treatment works) with treated effluent being discharged to the river.

  The Cotter River and its riparian zone have been changed by the construction of three water storage reservoirs. Water storage infrastructure affects not only the streamflow and channel morphology but the riparian zones as well. For example, in regulated rivers there is usually a reduction in the levels and frequency of high volume over-bank flows. The effects of this include lack of regular

addition of alluvial material to river flats and terraces, stabilization of river terraces, channel constriction, and permanent establishment of vegetation (including weed species) that would normally be unable to survive in such an unstable environment.

The Murrumbidgee River Corridor contains the semi-rural settlement of Tharwa and nearby Cuppacumbalong, and has been affected by the urban development in Tuggeranong (e.g. sedimentation to the river, and increase in peak runoff during rainfall events).

- **Recreational facility development:** Riparian areas in the ACT have a long history of recreational use with locations along the Murrumbidgee River (e.g. Kambah Pool), and the Cotter River near its Murrumbidgee River confluence being most important (NCDC 1988a). Other riparian areas used for recreation include the lower reaches of Paddys River, Molonglo Gorge (Kowen) and sections of the Molonglo River valley downstream of Scrivener Dam. Recreational facilities such as roads, parking areas, and toilets have impacts in the riparian zone as do associated visitor use (e.g. trampling, weed introduction and spread, litter, dogs, fire). In the Murrumbidgee – lower Cotter area, recreation activity has been concentrated at accessible nodes near sought after features (e.g. swimming holes, flat low areas near the stream suitable for picnics, and attractive scenery). Low-key, non-motorised access based on walking tracks is provided over longer riparian sections. Control over access is an important means of avoiding undesirable impacts over a wide area.

  Relevant planning considerations for the Murrumbidgee and Molonglo river corridors are contained in the *National Capital Plan* (NCA 2005) and the *Territory Plan* (ACTPLA 2005) while more detailed management objectives and activities are set out in the plans of management e.g. Environment ACT 1998, 2001b. Recreation and tourism use in the Murrumbidgee, Molonglo and Cotter river areas, including future opportunities, have been investigated following the bushfires of January 2003 (Non-Urban Study Steering Committee 2003). Impacts on riparian zone vegetation, in particular, areas or communities recovering from the fires, need careful consideration in any new development or redevelopment in these areas.

- **Weed Invasion:** Management of riparian areas of Australian rivers over the last 200 years, combined with the natural cycle of disturbance involving the regular raising and lowering of water tables, periodic flooding and dispersal of seeds and propagules by water, have provided conditions conducive to weed invasion. The abundance and diversity of environmental weeds increases with increasing soil moisture. Drainage lines, watercourses and associated habitats have the greatest infestations of locally prevalent exotic species and are the habitats at greatest risk Australia-wide (Humphries *et al.* 1991). The weed species of riparian zones are of two broad types: those of the surrounding terrestrial ecosystems (e.g. Briar Rose (*Rosa rubiginosa*) found in grasslands and woodlands including land under pastoral use); and those whose survival and spread is related to the presence of the watercourse (e.g. Noogoora Burr (*Xanthium occidentale*)). Many riparian weeds are both terrestrial species and those whose spread has been enhanced by watercourses (e.g. African Lovegrass (*Eragrostis curvula*)). Willows (*Salix* spp.) and Blackberry (*Rubus fruticosus* spp.) are major weeds of riparian areas. There are a number of factors that make riparian zones in the ACT susceptible to the establishment and spread of weeds:

  —Some riparian areas have a long history of pastoral use including stock access to streams, with associated plant introductions.

  —Native tree cover has been cleared, exposing the ground surface to plant invasions.

  —Exotic species have been deliberately or accidentally introduced e.g. planting of willows (*Salix* spp.) and poplars (*Populus* spp.) for ornamental or riverbank stabilisation purposes; planting of softwood plantations adjacent to riparian zones.

  —Streambed environments are naturally unstable being reworked on a regular basis by water flows. Newly exposed or disturbed surfaces provide an opportunity for establishment of weed species. This potential has increased over time with both the larger number and population sizes of weed species and their wider distribution, and river regulation, which has resulted in few high level flows to limit weed establishment. Results of a weed survey of the Murray River indicated that sites that are regularly flooded have a low proportion of weed species, suggesting a need for specialisation to survive in these more difficult environments (Margules and Partners Pty Ltd *et al.* 1990 in Askey-Doran *et al.*1999).

—Riparian areas are usually wetter and more fertile, often allowing exotic species to out-compete native species, especially where there is disturbance. Cultivation and fertiliser addition further encourage establishment of weed species.

—Riparian zones are movement corridors for animals, particularly birds, which are important in transporting seeds of plants.

—The watercourse itself is a route by which seeds and other plant material are transported to new locations.

Common weeds of riverine habitats and drainage lines in the ACT are listed in Berry and Mulvaney (1995, pp.14–15). Their study of ACT environmental weeds showed that near-urban and riverine areas had the greatest weed diversity, though all lowland plant communities were invaded by a large number of weeds. Seventy-six species (or groups of species) have been declared pest plants in the ACT in the *Pest Plants and Animals (Pest Plants) Declaration 2005* under the *Pest Plants and Animals Act 2005* (see s.1.5.2). Some of these are major problems in riparian areas (e.g. African Love Grass (*Eragrostis curvula*), Serrated Tussock (*Nassella trichotoma*), St Johns Wort (*Hypericum perforatum*), Blackberry (*Rubus fruticosus* agg.), Scotch Broom (*Cytisus* spp.), privet (*Ligustrum* spp.), willows (*Salix* spp.), Noogoora Burr (*Xanthium occidentale*)). The list includes water-weeds that are widely used in aquaria and have potential to spread into the ACT. The following briefly outlines the more important weed species and groups of weed species occurring in ACT riparian zones. Some have the potential to substantially expand their distribution:

(a) **Woody trees and shrubs of horticultural or silvicultural origin:** There is a variety of these species occurring across ACT lowland environments including riparian areas (Environment ACT 2002a). Uncontrolled, they can form dense and impenetrable thickets, especially when thorny, restricting access and impacting on landscape and environmental values. The nutrient flush produced by large stands of deciduous species growing next to streams can disrupt natural stream nutrient cycles (Environment ACT 2002a).

—White Poplar (*Populus alba*) and Lombardy Poplar (*Populus nigra*) occur along the Murrumbidgee and Molonglo rivers in particular locations.

—Briar Rose (*Rosa rubiginosa*) and Hawthorn (*Crataegeus monogyna*) have spread from sites of early rural settlement and are major woody weed species west of the Murrumbidgee River. Hawthorn commonly invades riparian areas.

—Radiata or Monterey Pine (*Pinus radiata*) is widespread especially in areas adjacent to plantations. This species is particularly common along the Murrumbidgee River between Kambah Pool and Uriarra Crossing.

—Other species include: Box Elder (*Acer negundo*), Service Tree (*Sorbus aucuparia* and *S. domestica*), Black Alder (*Alnus glutinosa*), Tree of Heaven (*Ailanthus altissima*), African Boxthorn (*Lycium ferocissimum*), Scotch Broom (*Cytisus scoparius*), Firethorn (*Pyracantha* spp.) and Cotoneaster (*Cotoneaster* spp.).

(b) **Grasses:** Major grassy weeds of lowland grassland and grassy woodland are also prevalent in the riparian zones. It is common for introduced grasses, in association with introduced annual and perennial herbs to completely dominate riverine areas

—African Lovegrass (*Eragrostis curvula*) is an aggressive, tenacious, drought and frost tolerant species capable of dominating the ground flora on lighter low-nutrient soils (Muyt 2001). It is widespread in the Murrumbidgee River Corridor, and may form almost the complete groundcover in disturbed sites (Environment ACT 2002b; Mallen 1986).

—Serrated Tussock (*Nassella trichotoma*) is a major weed of the Southern Tablelands but may have occupied only 20% of its potential range (Environment ACT 2002c). It has a broad site tolerance and is highly invasive. There are major riparian infestations in the ACT in the Naas district, Point Hut and Stranger paddocks in the Bullen Range and Woodstock Nature Reserve.

—Other grass species include Phalaris (*Phalaris aquatica*), Brome grasses (*Bromus* spp.), Paspalum (*Paspalum dilatatum*), Yorkshire Fog (*Holcus lanatus*) and Wild Oats (*Avena* spp.).

(c) **Annual, biennial and perennial herbs:** This category includes both widespread species and those confined to wet areas or stream edges.

—Noogoora Burr (*Xanthium occidentale*) is a noxious weed with a wide distribution in eastern and northern Australia (Parsons and Cuthbertson 1992). The species is capable of developing dense thickets on the water's edge completely suppressing any other vegetation. It is dependent upon water contact for seed germination and only survives in close proximity to streams. In the ACT, it occurs along the Murrumbidgee River from Point Hut Crossing downstream to the New South Wales border (Environment ACT 2002d).

—St Johns Wort (*Hypericum perforatum*) forms extensive infestations excluding most other ground flora and impeding overstorey regeneration. It is widespread in the ACT.

—Jointed Rush (*Juncus articulatus*) is a tufted perennial widespread in damp areas (Eddy *et al.* 1998).

—Paterson's Curse (*Echium plantagineum*) is widespread in riverine areas of the ACT including the Gudgenby–Naas rivers. Infestations exhibit annual variation related to seasonal conditions, but seeds can remain dormant in the soil for at least five years (Parsons and Cuthbertson 1992).

—Sorrel (*Acetosella vulgaris*) is widespread including at higher altitudes. Also widespread in damp, riverine and creek areas are Clustered Dock (*Rumex conglomeratus*) and Curled Dock (*Rumex crispus*) (Berry and Mulvaney 1995).

—Clovers (*Trifolium* spp.) are widespread. Common species in riverine environments are Haresfoot Clover (*T. arvense*), Hop Clover (*T. campestre*) and White Clover (*T. repens*).

—Other plants include Great Mullein (*Verbascum thapsis*), Saffron Thistle (*Carthamus lanatus*), Spotted Burr Medic (*Medicago arabica*), Lucerne (*Medicago sativa*), and Hemlock (*Conium maculatum*) (Berry and Mulvaney 1995).

(d) **Other woody weeds (exotic species):**

—Willows are a major woody weed species of streambanks and streambeds in the ACT. All willow species except Weeping Willow (*Salix babylonica* var. *babylonica*) and the hybrid Pussy Willow (*S. x calodendron*) and *S. x reichardtii* are declared pest plants in the ACT. Originally introduced for amenity and riverbank stabilisation in southern Australia, major concern has arisen over their spread, ecological impacts and effects on stream morphology. As well as vegetative reproduction, many willow species are now reproducing from seed and by hybridisation (Cremer 1996; Cremer 1999; Cremer *et al.* 1995). A survey of willows along ACT streams by Lang (1999) identified Black Willow (*S. nigra*) and Crack Willow (*S. fragilis*) as particular problem species, with seedling willow establishment and hybridisation occurring. A particularly aggressive species Broadleaf Willow (*S. glaucophylloides*), a female shrub willow imported from New Zealand in 1958 and planted in Commonwealth Park, is now spreading locally below Scrivener Dam probably with pollen from *S. x reichardtii*. This species has been the subject of a control program.

—Blackberry (*Rubus fruticosus* agg.) comprises a number of closely related species of which *R. discolor, R. fruticosus* and *R. ulmifolius* are considered to be present in the ACT (Environment ACT 2002e). Blackberry is common in woodlands, pine plantations, riverine areas and creek lines where it forms dense impenetrable thickets and may completely smother riparian habitat. It is a threat to some frog species (Gillespie and Hollis 1996).

(e) **Weedy indigenous species:**

—Burgan (*Kunzea ericoides*) is an indigenous species that occurs along riverbanks as an early coloniser following floods and may be considered a flood disclimax community. It is also an early coloniser of cleared areas on slopes where it has formed extensive thickets (NCDC, 1984; Hogg 1990; Kirschbaum and Williams 1991; Barrer 1992a). In this way the species appears to behave as an environmental weed, out of ecological balance due to past or continuing disturbance to its environment (Berry and Mulvaney 1995). Burgan also occurs naturally as an association with Black Cypress Pine (*Callitris endlicheri*) and Silver Wattle (*Acacia dealbata*).

As well as the species noted above, there are many other introduced and some native species with potential to invade ACT riparian areas. These include Olives (*Olea* spp.), *Prunus* spp., Sweet Vernal Grass (*Anthoxanthum odoratum*), Cootamundra Wattle (*Acacia baileyana*) and *Grevillea rosmarinifolium*.

- **Changed and inappropriate fire regimes:** The natural temperate grasslands, lowland woodlands and dry sclerophyll forests that bordered or were part of lower elevation riparian zones in the ACT were adapted to a fire regime derived from lightning strike and Aboriginal burning. The latter may have played a pivotal role in controlling the ecological structure and functioning of these grassy ecosystems (Hobbs 2002; Lunt and Morgan 2002). At higher elevations (e.g. the upper Naas and Gudgenby rivers), it is not known if Aborigines burnt the open valley floors (Ingwersen 2001). Locally high water tables and cold frost-hollow conditions may have kept these areas free of tree growth. In the lower elevation riparian areas, the presence of River Oak (*Casuarina cunninghamiana*) and Black Cypress Pine (*Callitris endlicheri*), both of which succumb to high intensity fires and/or frequent burning, points to the riparian areas as refuges from the fires that may have regularly burnt across the adjacent grassy ecosystems in pre-European times. The understoreys of the River Oak

and Cypress Pine communities typically contain limited biomass to carry fires.

With European settlement, the dominant disturbance agent in grassy ecosystems changed from burning under low grazing pressure by native species to grazing by stock with little burning (Lunt and Morgan 2002). In the higher elevation valleys, however, there was a tendency for pastoralists to light valley floor fires and allow these to run into the lower slopes (Ingwersen 2001). This was part of an increased fire frequency in the higher altitude areas in the ACT generally, which is shown in the results of dendrochronological research (Banks 1989). Deliberate burning has not been part of the management of these valleys in the more recent period, though they are still subject to the effects of lightning generated wildfire (e.g. in 1939, 1983, 2003). In the lowland riparian areas, the emphasis has been on fire suppression and biomass control, mainly by grazing. However, the proximity of the Murrumbidgee and Molonglo valleys to urban development, and the spread of introduced grasses that mature in the summer period and create a large fuel load, has seen an increase in fire frequency (Environment ACT 1998). The frequency of fire in the Pine Island area may be assisting the spread of African Lovegrass in the area.

The riparian zone also remains susceptible to the effects of uncontrolled fires as shown by the impact of the high intensity bushfires of January 2003 (Carey *et al.* 2003). It may be some decades before the effects of this event, especially on fire-sensitive species and communities are known. Environment ACT is undertaking monitoring in selected vegetation communities affected by the 2003 bushfires. Some of the sites are within the riparian zone. These include:

—Site M14 Murrays Corner (Paddys River): *Casuarina cunninghamiana–Acacia dealbata*;

—Site M15 Upstream Murrays Corner (Paddys River): *Casuarina cunninghamiana–Eucalyptus macrorhyncha*;

—Site M19 Pine Island (Murrumbidgee River): *Casuarina cunninghamiana– Acacia dealbata*;

—Site M36 Bendora Dam (Cotter River): *Eucalyptus viminalis–Eucalyptus robertsonii*; and

—Site M37 Lower Molonglo River: *Eucalyptus macrorhyncha–Callitris endlicheri*.

(Site numbers refer to the database for post-2003 bushfire monitoring held by Environment ACT.)

- **Extractive industry (sand and gravel extraction):** For many years the Murrumbidgee River was an important source of sand and gravel for the ACT building industry. The locations of this extraction were documented in NCDC (1981) and mainly occurred between Angle Crossing and the Lanyon–Lambrigg area (ceasing in the 1970s), and below the Molonglo river confluence near the northern ACT border (continuing into the 1980s). The impacts of these operations included disturbance to banks, destruction of vegetation, disturbance to in-stream habitat, increased turbidity, and construction of access tracks and roads, buildings and machinery. Former sites have been invaded by weeds. Sand and gravel extraction involving deepening of the channel results in scouring of upstream sections as bedload moves to fill the extraction point. Rehabilitation of former quarry sites was identified as a likely management requirement in the *Murrumbidgee River Corridor Management Plan* (Environment ACT 1998, p. 50). Both the Management Plan and the *Territory Plan* (Part B13: River Corridors Land Use Policies) provide for sand and gravel extraction to occur as part of habitat rehabilitation. The potential to utilise commercial extractive industries in removing in-stream sand and gravel deposits, as part of a well-managed habitat enhancement program in the ACT is noted in s. 5.6.11. Any future extraction operation should be required to undertake site rehabilitation and revegetation following cessation of operations.

2.3.2 Condition of Riparian Zone Vegetation in the ACT

As previously noted (s. 2.2.1), there is no recent systematic vegetation survey of ACT riparian zones. Broad-scale assessment of riparian vegetation condition in the ACT is included in the National Land and Water Resources Audit (see s. 2.2.1). It is an objective of the Strategy that the type, location and condition of all aquatic and riparian ecological communities in the ACT are described and the information kept current by means of an appropriate monitoring program (Table 6.1.1). The previous sections (s. 2.2.1 and s. 2.2.2) have briefly described vegetation communities occurring in ACT riparian zones and the broad changes that have occurred since European settlement. Based on the sources outlined in s. 2.2.1, a brief description of the dominant vegetation of defined river sections, with an indication of vegetation condition, is contained in Table 2.2 (see also Figures 2.2 to 2.4).

Table 2.2: Riparian Zones by River Sections: Brief Description of Dominant Native Vegetation Communities and Vegetation Condition

Current Planning and Management	Description	Dominant Native Vegetation Communities	Threatened/ Uncommon Flora/ Communities*	Threats to Species and/or Communities
Murrumbidgee River (Murrumbidgee River Corridor (MRC)) (*Special Requirements* apply to the MRC and Lanyon Bowl Area under the *National Capital Plan*.)				
MU 1: Angle Crossing to Tharwa				
Territory Plan ■ Gigerline Nature Reserve ■ Special Purpose Reserve (Tharwa) ■ Rural leasehold ***Management*** MRC Management Plan 1998	Southern and northern ends of this section have been extensively cleared for pastoral use. Central part including Gigerline Gorge retains native vegetation. There is no *Casuarina cunninghamiana* in this section (NCDC 1981). Weed cover is more prevalent outside the gorge section adjacent to grazing land. Most of this section was burnt in the January 2003 bushfires.	■ *E. dives–E. bridgesiana* Tableland Woodland ■ *Callitris endlicheri* Tableland Woodland ■ *E. viminalis* Tableland Riparian Woodland ■ Tableland Shrubland	■ Relict *E. viminalis* Tableland Riparian Woodland	■ Weeds including Willows and African Love Grass ■ Uncontrolled grazing
MU 2: Tharwa to Point Hut Crossing				
Territory Plan ■ Special Purpose Reserve (including Lanyon Landscape Conservation Reserve) ■ Rural leasehold ***Management*** MRC Management Plan 1998	Former *E. melliodora–E. blakelyi* Tableland Grassy Woodland has been extensively cleared and replaced by improved pasture and cropping, especially on the eastern floodplain area. Areas of lowland woodland remain, varying from severely modified to partially modified (endangered ecological community on the western side of the river). Willows dominate riverbank vegetation. There is no *Casuarina cunninghamiana* in this section (ACT Government 2004a; NCDC 1981).	■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland	■ Relict *E. viminalis* Tableland Riparian Woodland ■ *Discaria pubescens*	■ Weeds including Willows and African Love Grass ■ Uncontrolled grazing
MU 3: Point Hut Crossing to Kambah Pool				
Territory Plan ■ Special Purpose Reserve (Point Hut Crossing to Pine Island, Pine Island, Kambah Pool) ■ Bullen Range Nature Reserve (Pine Island to Kambah Pool) ■ Rural leasehold ***Management*** MRC Management Plan 1998	There is a diversity of vegetation related to topography and past land use. Former Yellow Box–Red Gum Grassy Woodland has been extensively cleared and replaced by improved pasture and cropping. Areas of lowland woodland remain, varying from severely modified to partially modified (endangered ecological community on the western side of the river near Red Rocks Gorge) (ACT Government 2004a). *Callitris endlicheri* is common on rocky slopes. *Casuarina cunninghamiana* occurs on sandy river margins to just north of Point Hut Crossing (its southern limit on the Murrumbidgee River). Bullen Range vegetation is less disturbed and comprises open forest and shrub thickets. Most of this section was burnt in the January 2003 bushfires.	■ *E. macrorhyncha–E.rossii* Tableland Forest ■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland ■ *E. pauciflora–E. rubida* Tableland Woodland ■ *Callitris endlicheri* Tableland Woodland ■ *Casuarina cunninghamiana* Tableland Riparian Woodland ■ Tableland Shrubland ■ Tableland Dry Tussock Grassland	■ *Muehlenbeckia tuggeranong* (endangered) ■ *Thesium australe* ■ *Discaria pubescens* ■ *Bossiaea bracteosa* ■ *E. pauciflora–E. rubida* Tableland Woodland	■ Weeds including Willows and African Love Grass ■ Recreational use ■ Unauthorised fires (deliberately lit)
MU 4: Kambah Pool to Cotter River Confluence/Casuarina Sands				
Territory Plan ■ Bullen Range Nature Reserve ■ Special Purpose Reserve (upslope areas on eastern side of Murrumbidgee R. above nature reserve) ■ Special Purpose Reserve (Cotter Reserve/ Casuarina Sands) *(Continues next page)*	The Bullen Range and steep valley slopes in this section have retained their vegetation cover, mainly dry forests, Callitris Pine woodland and shrublands. Dry forest and lowland woodland of flatter areas and undulating terrain above the valley slopes have been cleared for pasture. North of Kambah Pool (west bank) there is an area of partially modified *E. melliodora–E. blakelyi* Tableland Grassy Woodland (endangered ecological community). This community, *(Continues next page)*	■ *E. macrorhyncha–E. rossii* Tableland Forest ■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland ■ *E. dives–E. bridgesiana* Tableland Woodland *(Continues next page)*	■ *Discaria pubescens* ■ *Desmodium brachypodum* ■ *Pomaderris pallida*	■ Weeds including Willows and African Love Grass ■ Recreational use

Table 2.2: *(Continued)*

Current Planning and Management	Description	Dominant Native Vegetation Communities	Threatened/ Uncommon Flora/ Communities*	Threats to Species and/or Communities
MU 4: Kambah Pool to Cotter River Confluence/Casuarina Sands *(continued)*				
Management MRC Management Plan 1998	modified to varying degrees, extends northward, mainly on the eastern side of the river. River Oaks and shrub vegetation dominate the riverbanks. Radiata pine wildings are common in this area. This section was severely burnt in the bushfires of January 2003.	■ *Casuarina cunninghamiana* Tableland Riparian Woodland ■ Tableland Shrubland ■ Tableland Dry Tussock Grassland		
MU 5: Cotter River Confluence/Casuarina Sands to ACT/NSW Border				
Territory Plan ■ Stony Creek Nature Reserve ■ Swamp Creek Nature Reserve ■ Woodstock Nature Reserve ■ Special Purpose Reserve (upslope areas above nature reserves) ■ Special Purpose Reserve (Uriarra Crossing) ***Management*** MRC Management Plan 1998	Riverbanks and valley slopes are in parts densely vegetated with Tableland Dry Shrubland dominated by *Kunzea ericoides* and emergent *Callitris enlicheri*. Dry forest is also common in this section. Above the valley, lowland woodland has been extensively cleared for pasture and west of the river, near Mt McDonald, planted to pine plantation (destroyed in the January 2003 bushfires). North of Uriarra Crossing some moderately modified areas of lowland woodland remain west of the river (ACT Government 2004a). Riverine vegetation consists of *Casuarina cunninghamiana* with shrubs in rocky areas (NCDC 1981). Radiata pine wildings, willows, blackberry and other weeds are scattered along this section. This section was severely burnt in the bushfires of January 2003.	■ *E. macrorhyncha–E. rossii* Tableland Forest ■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland ■ *Callitris endlicheri* Tableland Woodland ■ *Casuarina cunninghamiana* Tableland Riparian Woodland ■ Tableland Shrubland	■ *Bossiaea bracteosa* ■ *Muellerina bidwillii* ■ *Diurus punctata* ■ *Pomaderris pallida*	■ Weeds including Willows and African Love Grass ■ Recreational use

Gudgenby River
(Tributaries: Naas and Orroral rivers)

(*Special Requirements* apply to the Namadgi National Park Area under the *National Capital Plan*. This 'Area' is the Park and adjacent areas in the Gudgenby and Cotter catchments.)

GU 1: In Namadgi NP				
Territory Plan ■ Namadgi National Park ***Management*** Namadgi National Park Management Plan 2005	Open valley floors in the Naas–Gudgenby catchment contain a range of grassy vegetation communities as well as limited areas of shrubland and wetland complexes. Grassy vegetation includes natural, semi-natural and pasture-improved areas. Naturally open areas are often low and moist with wet native grassland and swampy communities. There is a diversity of tree cover from open forest to open woodland with woodland usually the result of previous clearing (Ingwersen 2001). A wide range of exotic species, many associated with pastoralism, occur in the catchment (Ingwersen 2001).	■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland ■ *E. dives–E. bridgesiana* Tableland Woodland ■ *Callitris endlicheri* Tableland Woodland ■ Montane Dry Tussock Grassland ■ Montane Wet Tussock Grassland ■ Montane and Subalpine Fen	■ *Viola caleyana* ■ *Discaria pubescens*	■ Willows (including willow re-establishment following control) ■ Other weeds

Table 2.2: *(Continued)*

Current Planning and Management	Description	Dominant Native Vegetation Communities	Threatened/ Uncommon Flora/ Communities*	Threats to Species and/or Communities
GU 2: Namadgi NP to Murrumbidgee River				
Territory Plan ■ Special Purpose Reserve (possible Tennent Dam site) ■ Rural leasehold	Vegetation has been extensively modified by pastoral use including introduction of exotic pasture species and thinning of tree cover. Areas of lowland woodland remain, varying in condition from severely modified to partially modified (Yellow Box–Red Gum Grassy Woodland endangered ecological community) (ACT Government 2004a). Other tree and shrub communities are present in the steep, rocky valley of the Gudgenby River near Mt Tennent (e.g. *Callitris endlicheri–Eucalyptus nortonii* community) (Ingwersen 2001). Lang (1999) reported a complex population of hybrid willow species below the Naas–Gudgenby confluence (recently, the subject of a major control program).	■ *E. macrorhyncha–E. rossii* Tableland Forest ■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland ■ *E. dives–E. bridgesiana* Tableland Woodland ■ *Callitris endlicheri* Tableland Woodland		■ Weeds including willows ■ Uncontrolled grazing

Cotter River
(Tributary: Paddys River)

(*Special Requirements* apply to the Namadgi National Park Area under the *National Capital Plan*. This 'Area' is the Park and adjacent areas in the Gudgenby and Cotter catchments.)

CO 1: Paddys River (Tributary: Tidbinbilla River)				
Territory Plan ■ Tidbinbilla Nature Reserve ■ Rural leasehold ■ Plantation forestry ***Management*** Tidbinbilla Nature Reserve Management Plan 1999	Vegetation in this catchment has been substantially altered by pastoral and forestry use. The large area of pine plantation in the lower part of the catchment was destroyed in the January 2003 bushfires. *Casuarina cunninghamiana* occurs along the lower reaches of the river. The valley contains some areas of lowland woodland, varying in condition from severely modified to partially modified (Yellow Box–Red Gum Grassy Woodland endangered ecological community) (ACT Government 2004a). There are also areas of *Themeda grassland* (Environment ACT 1999). *Kunzea ericoides* has colonised valley slopes in the area. There is a wide variety of weed species e.g. thistles, Briar Rose, Hawthorn, Blackberry, St John's Wort, pine wildings and willows.	■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland ■ *Casuarina cunninghamiana* Tableland Riparian Woodland ■ Tableland Shrubland ■ Tableland Dry Tussock Grassland	■ *Drabastrum alpestre* ■ *Pomaderris pallida* ■ *Bossiaea bracteosa* ■ *Thesium australe*	■ Weeds including willows ■ Uncontrolled grazing ■ Degradation of riparian areas (erosion, forestry activities, recreational use)
CO 2: Cotter River (Headwaters to Corin Dam)				
Territory Plan ■ Namadgi National Park ***Management*** Namadgi National Park Management Plan 2005	Vegetation of the river flats comprises Black Sally (*Eucalyptus stellulata*), Candlebark (*E. rubida*) and Snow Gum (*E. pauciflora*) open woodland, *Poa labillardieri* tussock grassland, wetland and bog communities. Grassland areas may contain many weed species mostly derived from past pastoral use (Helman *et al.* 1988). Dense shrub vegetation is typical at stream edges. Characteristic species include Dagger Wattle (*Acacia siculiformis*), Native Raspberry (*Rubus parvifolius*), Woolly Teatree (*Leptospermum lanigerum*), Common Shaggy Pea (*Oxylobium ellipticum*) and *Epacris breviflora* (Helman *et al.* 1988; Ingwersen and Ormay 1988). This area was moderately and patchily burnt in the January 2003 bushfires.	■ Montane Dry Tussock Grassland ■ Montane Wet Tussock Grassland	■ *Discaria pubescens* ■ *Blechnum fluviatile*	■ Weeds

Table 2.2: *(Continued)*

Current Planning and Management	Description	Dominant Native Vegetation Communities	Threatened/ Uncommon Flora/ Communities*	Threats to Species and/or Communities
CO 3: Cotter River (Below Corin Dam to Bendora Dam)				
Territory Plan ■ Namadgi National Park ***Management*** Namadgi National Park Management Plan 2005	In this section, the vegetation communities characteristic of higher altitude valley areas usually extend down to the river. Variations in tree species present are related to site conditions and aspect. Between Corin Dam and the upper part of Bendora Reservoir, dry forest and variable shrub cover occupies the more deeply incised river valley. Characteristic tree species are Brittle Gum (*E. mannifera*), Ribbon Gum (*E. viminalis*), Broad-leaved Peppermint (*E. dives*) and Robertson's Peppermint (*E. robertsonii*) (NCDC 1984; NCDC 1986). Flanking Bendora Reservoir is a transitional wet sclerophyll forest containing Mountain Gum (*E. dalrympleana*), Broad-leaved Peppermint and Narrow-leaved Peppermint (Keith 2004; NCDC 1984). This area was severely burnt in the January 2003 bushfires.	■ *E. macrorhyncha–E. rossii* Tableland Forest ■ *E. dalrympleana* Montane Forest		
CO 4: Cotter River (Below Bendora Dam to Cotter Dam)				
Territory Plan ■ Namadgi National Park ■ Special Purpose Reserve (upstream from Cotter Dam to boundary of Namadgi National Park) ***Management*** ■ Namadgi National Park Management Plan 2005 ■ Lower Cotter Catchment Strategic Management Plan 2006	Below Bendora Dam, dry forest and variable shrub cover occupies the river valley. Closer to Cotter Reservoir, the riparian vegetation is flanked by pine plantation. The riparian area is heavily infested with Blackberry. This area was severely burnt in the January 2003 bushfires. A change in land use is proposed for the Lower Cotter Catchment from pine plantation to catchment protection for water supply, with native vegetation cover (natural regeneration and planting).	■ *E. macrorhyncha–E. rossii* Tableland Forest		■ Weeds
CO 5: Cotter River (Below Cotter Dam to Murrumbidgee River				
Territory Plan ■ Special Purpose Reserve	Native riparian vegetation in this area has been largely replaced by planted exotic species. Casuarina cunninghamiana lines the streambed and there is native shrub cover near the Murrumbidgee River confluence. The Casuarinas were severely burnt in the January 2003 bushfires.	■ *Casuarina cunninghamiana* Tableland Riparian Woodland	■ *Pomaderris pallida*	■ Weeds ■ Recreational use ■ Fire

Molonglo River

(*Special Requirements* apply to the Molonglo River Corridor under the *National Capital Plan*.)

MO 1: Burbong to Blue Tiles (Immediately Upstream of Molonglo Gorge)				
Territory Plan ■ Nature Reserve ■ Rural leasehold ■ Pine plantation	Native vegetation in this section has been affected by previous pastoral use and the establishment of adjacent pine plantations. Upstream of Molonglo Gorge, there are some areas of moderately modified lowland woodland (Yellow Box–Red Gum Grassy Woodland endangered ecological community) and secondary grassland. Near Burbong there is a small, modified remnant of Snow Gum Woodland (ACT Government 2004a).	■ *E. macrorhyncha–E. rossii* Tableland Forest ■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland ■ *E. pauciflora–E. rubida* Tableland Woodland ■ *Callitris endlicheri* Tableland Woodland ■ Tableland Moist Tussock Grassland	■ *Eucalyptus pauciflora* ■ *Allocasuarina luehmannii*	■ Weeds ■ Recreational use ■ Urban edge (potential impact if urban development occurs in Kowen)

Table 2.2: *(Continued)*

Current Planning and Management	Description	Dominant Native Vegetation Communities	Threatened/ Uncommon Flora/ Communities*	Threats to Species and/or Communities
MO 2: Molonglo Gorge to Lake Burley Griffin				
Territory Plan ■ Nature Reserve ■ Rural leasehold ■ Other leasehold	The steep, rocky slopes of Molonglo Gorge support dry forest with *Callitris* and a scattered shrub understorey. Blackberries and willows are particular problem weed species in this section. Below Molonglo Gorge there are some isolated stands of *Allocasuarina luehmannii* and native shrubs. However, willows and other weed species dominate most of the riverine environment down to Lake Burley Griffin	■ *E. macrorhyncha–E. rossii* Tableland Forest ■ *Callitris endlicheri* Tableland Woodland	■ *Allocasuarina luehmannii* ■ *Discaria pubescens*	■ Weeds including willows ■ Urban/industrial runoff (poor results in macroinvetebrate sampling)
MO 3: Scrivener Dam to Coppins Crossing				
Territory Plan ■ Urban Open Space (Scrivener Dam to Tuggeranong Parkway) ■ Special Purpose Reserve (Tuggeranong Parkway to Coppins Crossing) ■ Rural leasehold	Riparian vegetation in this section is highly modified with only fragments of native vegetation remaining. Prior to the January 2003 bushfires, most of the riparian zone was fringed on one or both sides by pine plantation. There is dense woody weed growth below Scrivener Dam including willows, poplars, hawthorn and blackberry.	■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland ■ *Casuarina cunninghamiana* Tableland Riparian Woodland ■ Tableland Shrubland ■ Tableland Dry Tussock Grassland		■ Weeds including willows ■ Recreational use ■ Urban edge effects
MO 4: Coppins Crossing to Murrumbidgee River				
Territory Plan Lower Molonglo River Corridor Nature Reserve ***Management*** Lower Molonglo River Corridor Management Plan 2001	Protected in the gorge environment, vegetation in this section of the river displays high floristic diversity. Barrer (1992a) recorded 225 plant species in 62 families. The tree cover comprises a number of communities. Valley slopes are dominated by a *Callitris endlicheri–Eucalyptus macrorhyncha* association. Other tree species include *Eucalyptus dives, E. bridgesiana* and an unusual occurrence of *Eucalyptus blakelyi*. *Casuarina cunninghamiana* dominates the riverine areas and deeper gullies. There is a diverse shrub cover, including some uncommon species. Also present are grassland remnants including *Poa labillardieri* (now uncommon in the ACT). Near the river and in damp sites are sedges and rushes. Ferns are found in protected locations in the gorge. Weeds typical of the ACT riparian zone are found in this section including *Pinus radiata* wildings, *Ailanthus altissima*, willows, Briar Rose, Blackberry, St Johns Wort (*Hypericum perforatum*), Phalaris (*Phalaris aquatica*) and African Love Grass (*Eragrostis curvula*).	■ *E. macrorhyncha–E. rossii* Tableland Forest ■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland ■ *E. dives–E. bridgesiana* Tableland Woodland ■ *E. pauciflora–E. rubida* Tableland Woodland ■ *Callitris endlicheri* Tableland Woodland ■ *Casuarina cunninghamiana* Tableland Riparian Woodland ■ Tableland Shrubland ■ Tableland Dry Tussock Grassland	■ *Pomaderris pallida* ■ *Bossiaea bracteosa* ■ *Desmodium brachypodum* ■ *Adiantum hispidulum* ■ *Eucalyptus pauciflora* ■ *Discaria pubescens*	■ Weeds including willows and African Lovegrass ■ Recreational use ■ Urban edge effects ■ Uncontrolled grazing

* **Threatened/uncommon flora/communities:** Indicative only until comprehensive survey undertaken.

2.4

Riparian Zone Flora

Riparian environments may act as refugia for plants especially where they are steep, rocky, infertile and deeply incised below the surrounding land surface. Gorges and steep valley environments do this in two ways: first, by retaining a mosaic of physically protected habitats over time and allowing the floristic relicts of past conditions to survive; second, by their rugged nature such areas are usually unsuitable for agricultural and urban development and therefore avoid the habitat destruction typical of those activities. Because of this, they may exhibit high floristic diversity and contain a relatively high proportion of regionally or nationally significant species (Barrer 1992a). The following areas are of particular floral interest in the ACT:

- **Murrumbidgee River:** Gigerline Gorge, Red Rocks Gorge, Bullen Range.
- **Gudgenby–Naas rivers:** The riparian zone within Namadgi National Park and the steep, rocky valley of the Gudgenby River near Mt Tennent.
- **Cotter River:** All of the riparian zone upstream of Cotter Reservoir.
- **Molonglo River:** Molonglo Gorge (Kowen) and the lower Molonglo Gorge.

The following sections outline conservation objectives and actions for the one plant species in the ACT riparian zone declared threatened under ACT legislation (Tuggeranong Lignum *Muehlenbeckia tuggeranong*), uncommon ACT plant species declared threatened under Commonwealth or State legislation, and other uncommon plant species. The studies used to compile the information in s. 2.2 contain lists of plants that are uncommon and/or new records for the ACT, in particular:

- **Murrumbidgee River Corridor:** NCDC (1981: App. C4, pp. 147–149) lists plant species of particular interest. These are species nominated by Gray (1970) as requiring study for conservation, as they are relatively uncommon in the ACT, have a range restricted to only a few localities, or are endangered by reduction in habitat.
- **Upper Cotter Catchment:** Helman *et al.* (1988: Ch. 3.3.2, pp. 71–79) include annotated lists of rare plants (based on Briggs and Leigh 1985), first records of plant species for the ACT, and uncommon species (based on a number of previous studies).
- **Lower Molonglo River Corridor:** Barrer (1992a: Ch. 10.3 and Table 1, pp. 32–43) discusses nationally rare and regionally uncommon or rare flora, with an associated table. Information on plant species status is based on Hogg (1990).
- **Naas–Gudgenby Catchments:** Ingwersen (2001: Ch. 1.2 and Table 1.2, pp. 1-11 to 1-13) discusses uncommon species and includes a list based on the ROTAP (Rare or Threatened Australian Plants) list (Briggs and Leigh 1995).

Assessment of the conservation status of plant species is an action for this *Strategy* associated with the systematic survey of riparian areas (Table 6.1.)

2.4.1 Threatened Flora Species: Threats, Conservation Objectives and Actions

Consistent with the requirements for threatened species in the *Nature Conservation Act 1980*, protection goals of this Strategy are to:

- **Conserve in perpetuity viable, wild populations of all aquatic and riparian native flora and fauna species in the ACT.**
- **Conserve in perpetuity aquatic and riparian native vegetation communities in the ACT as viable and well-represented ecological communities.**

The goal applies also to uncommon plant species discussed in s. 2.4.2. There is only one plant species in the ACT riparian zone that is declared as threatened under ACT legislation (Tuggeranong Lignum *Muehlenbeckia tuggeranong*). The following actions for the species supersede those in the original Action Plan (ACT Government 1999e).

Threatened Species: Tuggeranong Lignum (*Muehlenbeckia tuggeranong*)

Tuggeranong Lignum was declared an endangered species in the ACT in 1998 under the *Nature Conservation Act 1980* (ACT) and is also declared endangered nationally under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth). Tuggeranong Lignum is a sprawling or procumbent shrub growing to about 1 m and is known from only one location, near the Murrumbidgee River, Tuggeranong, ACT. It grows on flood terraces of the river. The known population is only eight plants, of which only one is female. The species is similar to *M. axillaris* that has a much wider distribution at higher altitudes in Australia and New Zealand. Further details are contained in Appendix 1.1.

THREATS

Threats (or potential threats) to the survival of Tuggeranong Lignum are:

- **Lack of natural reproduction:** The greatest threat to the survival of the species is its very small population and the presence of only one female plant. The population does not currently support seed production, as the female plant has not developed mature ovaries (D. Mallinson pers. comm.). It is possible that the population could be sterile (see 'Erosion of genetic diversity' below).
- **Habitat loss or degradation:** Deliberate or unintended actions associated with visitor and/or land management activities in the local area are a potential threat to the population.
- **Grazing:** It is not clear whether grazing animals such as kangaroos may also pose a threat to survival of remaining plants, or whether such grazing may benefit the species by keeping competing grass tussocks and other plant growth short and open.
- **Fire:** The response of the species to fire was not recorded until 2001 when a fire burnt one plant and this recovered from basal shoots. A fire of very high intensity burnt the area in January 2003. A subsequent survey showed the recovery of all plants from basal shoots (Carey *et al.* 2003). This experience indicates that a single fire is not a threat to the species, however, the effect of a changed fire regime (e.g. frequent burning) is not known.
- **Erosion of genetic diversity and increased inbreeding:** This may compromise both short and long-term population viability by reducing individual fitness and limiting the gene pool on which selection can act in the future. The small population of this species (eight plants) means that genetic variation will be very low. In addition, the skewed sex ratio of the plants (seven male, one female) further enhances the potential genetic bottleneck and will lead in the medium term either to strong mate limitation or to significant biparental inbreeding. These two factors may be at the base of the lack of seed production observed in the wild (Young, A. 2001). There is also concern that the one female plant is not producing viable seed. The wild female plant and cuttings that are at the National Botanic Gardens need to be monitored for production of ovaries and seed, and any seed produced, tested for viability. If over time no seed is produced, the species would have to be considered sterile, and the only way of conserving the species would be to maintain a population of clones produced from cuttings.

CONSERVATION OBJECTIVES

1. Preserve the existing ACT population of *Muehlenbeckia tuggeranong* as it is the only known population of the species.
2. Conserve and manage the habitat of *Muehlenbeckia tuggeranong* so that natural ecological processes continue to operate.

The previous Action Plan for the species included an action to seek expert advice on best practices with regard to management of the species including the need and potential for *ex-situ* conservation measures to be undertaken (ACT Government 1999e). In a report commissioned by Environment ACT, A. Young (2001) has examined issues and options for the genetic conservation of *M. tuggeranong*. Given the small population and skewed sex ratio, the main genetic conservation issue for the species is the generation of new genetic variation. Young (p. 29) considers that this would be best achieved through controlled pollination among all possible combinations of male and female plants. Such a strategy would maximise the effective population size of the next generation. Seed produced could then be used to increase the size of the current population and equilibrate its sex ratios. They could also be used as a basis for an *ex-situ* breeding population as well as being out-planted to make new wild populations so as to spread the risk of extinction through habitat loss. However, this would no longer be possible if the population is sterile.

Propagation work undertaken at the Australian National Botanic Gardens has shown that the species strikes extremely well from cuttings, with a success rate around 80%. This could form the basis for *ex-situ* conservation of the species. Using this clonal material for reintroductions is of little value to genetic conservation given the limited genetic sample, however, *ex-situ* clone collections can be used to spread the risk of genetic loss due to accidental site disturbance (Young, A. 2001, p. 29).

CONSERVATION ACTIONS

Conservation actions for this species (mostly undertaken by Environment ACT) are adapted from the previous Action Plan and take into consideration the recommendations of A. Young (2001). They also are in accordance with the actions in the National Recovery Plan for the species prepared by Environment ACT for the Commonwealth Department of Environment and Heritage (Environment ACT 2005b).

Information (Survey, Monitoring, Research)

As it is unlikely that the species exists anywhere else in the ACT, surveys beyond its immediate location are not economically justified. However, awareness of the

species by field workers and others is important for potentially locating other sites.

- Maintain alertness to the possible presence of *Muehlenbeckia tuggeranong* while conducting surveys in appropriate habitat.
- Advise field workers, interested naturalists and conservation groups of the presence of the species to increase the potential that any other existing populations are identified.
- Liaise with the NSW Department of Environment and Conservation to encourage surveys of potential habitat outside the ACT.
- Monitor the existing population annually.
- Undertake the following with regard to the reproduction of the species:
  (a) Monitor the one wild female plant and the cuttings at the National Botanic Gardens for production of ovaries and seed, and if any seed is produced, test for viability.
  (b) If over time no seed is produced and the species is considered sterile, maintain a population of clones produced from cuttings.
  (c) If viable seed is produced, undertake controlled pollination among all possible combinations of male and female plants as a first step to increasing population size. Take cuttings also for regeneration purposes. (After plants have fully recovered from the effects of the January 2003 bushfires).
- Encourage further research into the species.

Protection

The eight plants are located the Murrumbidgee River Corridor (MRC) (Public Land (Special Purpose Reserve) under the *Territory Plan*). Seven are in one cluster near the river and the remaining plant is in the Bullen Range Nature Reserve of the MRC. Management responsibility rests with Environment and Recreation (Territory and Municipal Services).

- Protect the existing specimens of *Muehlenbeckia tuggeranong* in accordance with the specific management objective in the Murrumbidgee River Corridor Management Plan (p. 21) 'to protect the habitats of rare and threatened plant and animal species' (Environment ACT 1998).

Management

Due to the nature and small size of the sites containing the species, management actions will be directed towards maintaining the existing conditions and ensuring that adjacent activities do not adversely affect the sites.

- Facilities, such as walking tracks, will not be developed near the sites, with the aim of discouraging visitor access to the area.
- No attention will be drawn to the sites where the species is located, and no signs or fencing will be erected.
- Statements of conservation objectives and intended management actions for the species will be placed in relevant management plans and strategies.

Community/Landholder Involvement

Given the characteristics of the population of this species (very small population on two sites within a Nature Reserve) no direct community involvement in management actions is envisaged in the foreseeable future.

Regional and National Co-operation

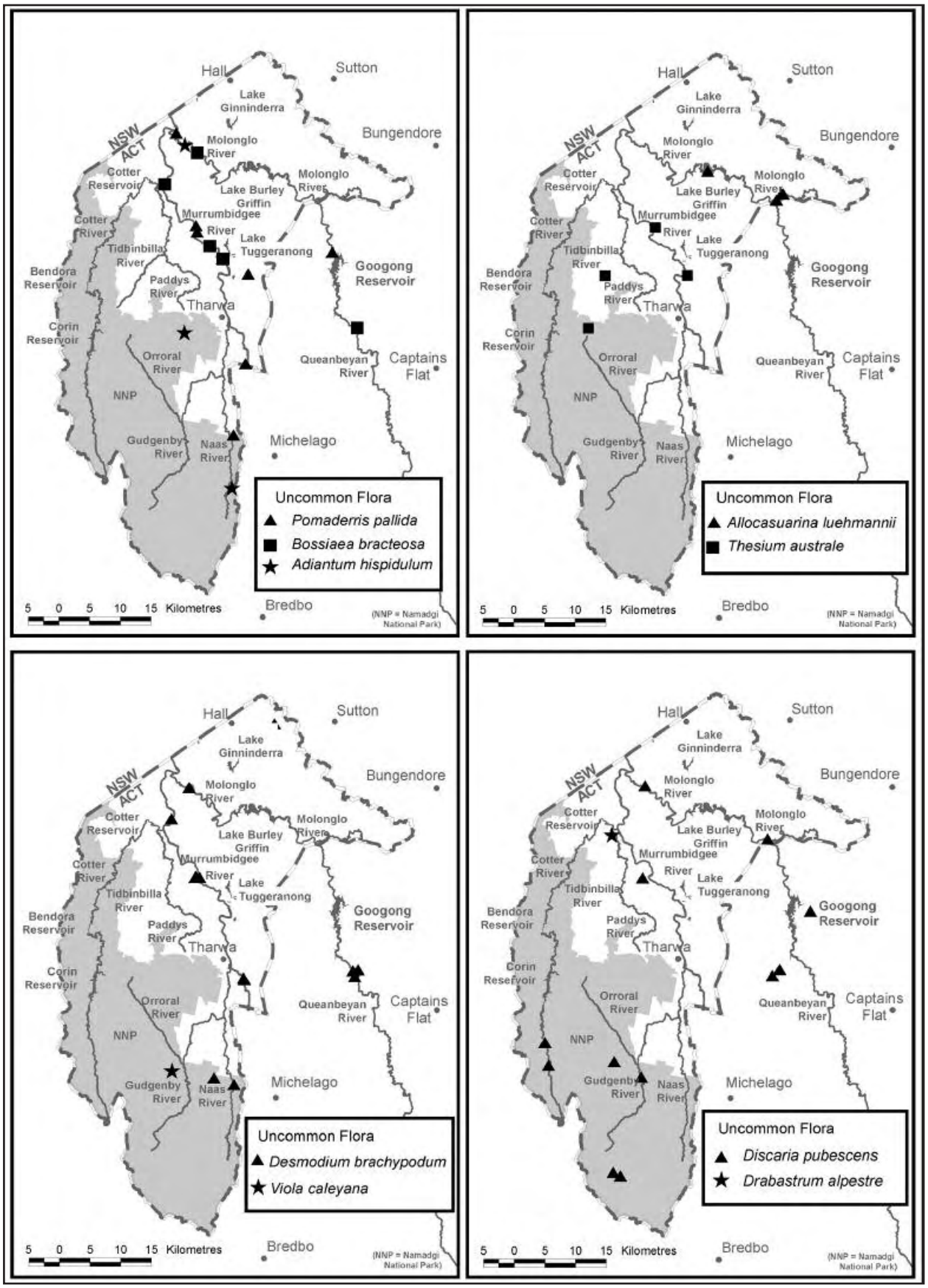
Preparation by Environment ACT of the National Recovery Plan (Commonwealth) and liaison regarding surveys (NSW) are noted above. No further actions are required at this stage.

2.4.2 Conservation of Uncommon Plant Species in the ACT

Many species not listed under ACT legislation as vulnerable or endangered may be also of conservation concern, especially those species declared as threatened under other State or Commonwealth legislation. It is important that their status be monitored over time and threats minimised. Some plant species in riparian zones are naturally rare or have become uncommon elsewhere due to clearance or disturbance. Some species may also be considered to be 'declining' if there is a suspected or recorded decrease in numbers. For reasons such as the inconspicuous habit of some species, seasonal variation, and lack of historical knowledge of abundance and distribution, considerable uncertainty may surround these assessments. The conservation status of species needs to be considered in a regional or national context. Lowland woodlands and grasslands in the ACT have been comprehensively surveyed (ACT Government 2004a, 2005a), but as previously noted, the riparian zone has not been systematically surveyed. Known locations in the ACT of uncommon plant species are shown in Figure 2.5.

Four uncommon species occurring in the riparian zone are of particular interest. These are briefly described below. None of these plants are declared threatened in the ACT. Their conservation status in other jurisdictions is shown in Table 2.3.

Figure 2.5: Locations of Uncommon Flora Species in ACT Riparian Zones and Googong Foreshores



- *Discaria pubescens* (Australian Anchor Plant) is a rigid shrub 0.4–2.5 m high, with stems dominated by spines and leaves often falling early. The small flowers are clustered in groups of 10–50 at the base of the spines. It is found in woodland and forest, often in rocky areas, on slopes and near watercourses. The species is widespread but rare. Its distribution is Queensland, eastern NSW, ACT, Victoria and Tasmania. In the ACT it is found in the Bullen Range Nature Reserve (Murrumbidgee River Corridor) (Briggs and Leigh 1995), the Naas–Gudgenby area (Ingwersen 2001), the Lower Molonglo River Corridor (Barrer 1992a), the Molonglo River valley at Oaks Estate (Crawford 1998), and the upper Cotter River catchment (Helman *et al*. 1988), in addition to other non-riparian locations.
- *Drabastrum alpestre* (Mountain Cress) is a herb or sub-shrub 10–30 cm high with a woody base and rhizome and erect branched stems. The flowers have white or lavender petals. The species is confined to higher altitudes south of Bathurst in NSW including the ACT and Victoria. It is known from only one site in the ACT near Paddys River, close to its junction with the Cotter River. This population numbered 142 plants in 2004 (unpublished records, Wildlife Research and Monitoring, Environment and Recreation) (Burbidge and Gray 1970; Harden 2000; NCDC 1988c).
- *Pomaderris pallida* is a narrow-leaved shrub 1–2 m high with cream coloured flowers. It is found in open forest. It is known from the Paddys–Cotter rivers area (location of the type specimen), the lower reaches of the Molonglo River in the ACT, McQuoids Creek near Kambah Pool (Murrumbidgee River), some other ACT non-riparian locations and from Victoria (Barrer 1992a; Burbidge and Gray 1970; Harden 2000; NCDC 1988c).
- *Thesium australe* (Austral Toadflax) is a semi-parasitic perennial herb to 40 cm high that appears to be strongly associated with Kangaroo Grass (*Themeda triandra*) dominated groundcover. It is found in the Kambah Pool Reserve of the Murrumbidgee River Corridor and at Point Hut. The species is included in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a).

OTHER UNCOMMON PLANT SPECIES

There are other uncommon plant species found in the riparian zones that may be rare nationally, or locally rare and uncommon in the ACT. In the latter case, the species are restricted to only a few localities or represent relict populations on the edge of their range, which is mainly in coastal or inland (drier) parts of New South Wales. Of all the species recorded in the Lower Molonglo River Corridor, for example, 28 per cent are considered to be either regionally uncommon or rare, or nationally rare or threatened (Environment ACT 2001: based on data in Hogg (1990) and Briggs and Leigh (1988)). Proposed vegetation surveys (Table 6.1.1) will provide a basis for reviewing the status of species that occur in the riparian zone.

The following species occurring in parts of the riparian zone are thought to be uncommon plants in the ACT. As there has been no systematic survey of riparian

Table 2.3: Conservation Status Nationally of Uncommon Plant Species of ACT Riparian Zones

Species	Cwlth	NSW	Vic.	Qld	Tas.
Discaria pubescens	—	—	T (R)	R	E
Drabastrum alpestre	—	—	T (V)	—	—
Pomaderris pallida	V	V	—	—	—
Thesium australe	V	V	T (V)	—	X

E: Endangered; **R:** Rare; **T:** Threatened; **V:** Vulnerable; **X:** Extinct.

LEGISLATION:

Commonwealth: *Environment Protection and Biodiversity Conservation Act 1999*

NSW: *Threatened Species Conservation Act 1995*

Vic: *Flora and Fauna Guarantee Act 1988* (Note that under this Act, species are listed as 'threatened' and specific conservation status (e.g. endangered) is applied in lists prepared by the Victorian Department of Sustainability and Environment (VDSE 2006).)

Qld: *Nature Conservation Act 1992*; *Nature Conservation (Wildlife) Regulation Act 1994*; threatened species lists are included in *Nature Conservation and other Legislation Amendment Regulation (No. 1) 2000*

Tas: *Threatened Species Protection Act 1995*

areas, the list is not definitive and the species have not been well documented nor properly assessed for their abundance.

1. *Viola caleyana* (Swamp Violet). This perennial herb with stems to 30 cm high and white to pale violet flowers grows in wet situations in forest, woodland and near swamps. Its distribution is eastern New South Wales and Tasmania (Harden 2000). It is known to occur downstream of the road crossing at the Orroral campground in the Orroral River valley (Hogg 1990; P. Ormay pers. comm.; L. Adams pers. comm.).
2. *Adiantum hispidulum* (Rough Maidenhair Fern). This species has a wide distribution in eastern Australia, New Zealand and the Pacific, occurring in rainforest and open forest amongst rocks (Harden 2000). It has been recorded from the gorge in the lower Molonglo River (Barrer 1992a; P. Ormay pers. comm.) and rock slabs near Booroomba Rocks (Hogg 1990).
3. *Bossiaea bracteosa* is a multi-stemmed shrub to 2.5 m high on which the leaves are reduced to tiny scales. It has golden-yellow flowers. The species grows on riverbank sand between boulders, south from Abercrombie Caves (NSW) to Victoria and is considered to be rare (Harden 1991). In the ACT it is recorded from the lower Molonglo River valley upstream from the gorge (P. Ormay pers. comm.). Barrer (1992a) recorded four populations, three of which were at or above the high flood level. In 1992, one population burnt in 1990 was showing evidence of seedling regeneration. Other records are from Casuarina Sands (NCDC 1981) and near Red Rocks Gorge on the Murrumbidgee River (P. Ormay pers. comm.).
4. *Desmodium brachypodum* (Large Tick Tre-foil). This is an erect or climbing perennial herb to 60 cm high with mauve to red or tan flowers and a hairy seed pod 20–40 mm long. The species is common and widespread in sclerophyll forest with a distribution in eastern and southern Australia and New Guinea (Harden 1991). In the ACT, it has been recorded from McQuoids Creek (near Kambah Pool, Murrumbidgee River), the lower Molonglo River (Barrer 1992a) and the lower eastern slope of Mt Tennent (Gilmour et al. 1987).
5. *Eucalyptus camphora* (Mountain Swamp Gum). This small to medium-sized tree occurs on open swampy flats and gently sloping valley floors in mountainous country (NPA ACT 1983). In the ACT it is known only from the Blundells Flat area (Shannons Flat and Wombat Creek-Condor Creek junction). Outside of the ACT it has a scattered distribution in the tablelands and mountains of eastern Victoria and south-eastern New South Wales, and the central and northern tablelands of New South Wales as far north as the Queensland border.

THREATS

Threats to uncommon plant species are mostly the same as those discussed for riparian zone vegetation in s. 2.3.1. An additional threat is the lack of botanical and ecological knowledge of these species, as they do not have the same 'profile' as listed threatened species.

CONSERVATION OBJECTIVES

1. Populations of uncommon plant species in the ACT riparian zone are identified through systematic survey and their conservation status is assessed.
2. Uncommon plant species in ACT riparian zones are conserved as viable populations in perpetuity.
3. The full range of riparian habitat diversity is conserved in order to maintain a range of species in suitable habitat.

CONSERVATION ACTIONS

Conservation actions for uncommon plant species occurring in the riparian zone (mostly undertaken by Environment and Recreation) are framed within the actions for the *Strategy* as a whole in Table 6.1.

Information (Survey, Monitoring, Research)

- Maintain alertness to the possible presence of uncommon plant species when undertaking surveys in appropriate habitat.
- Maintain a database of known occurrences and abundance of uncommon plant species to enable analysis of changes in distribution and abundance.
- Maintain a watching brief on ACT populations of uncommon plant species and evaluate their conservation status in a regional context.
- Facilitate and encourage research that will provide information on the status of uncommon plant species and management requirements.

Protection

- Assess the conservation status of uncommon plant species, identified in survey and monitoring.
- Ensure known populations of uncommon plant species are protected from inadvertent damaging actions (e.g. by advising landholders and managers of their presence).

Management

- Prepare management guidelines for uncommon plant species for use by landowners and managers where necessary.
- Manage sites, and provide advice to other landowners and managers, to maintain optimum habitat (where known) for uncommon plant species.
- Consider nomination for ACT listing if uncommon plant species show evidence of local decline in extent and abundance.

Regional and National Co-operation

Liaise with interstate agencies involved in protection and management of uncommon plant species with the aim of increasing knowledge of their biology, and habitat and conservation requirements.