Australian Capital Territory

# Nature Conservation (Threatened Ecological Communities and Species) Action Plan 2007 (No 1)

**Disallowable instrument DI2007— 84**

made under the

**Nature Conservation Act 1980, s 42 (Preparation of action plan)**

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## 1 Name of instrument

This instrument is the Nature Conservation (Threatened Ecological Communities and Species) Action Plan 2007 (No 1).

## 2 Details of instrument

I have prepared Action Plan No 29 (Aquatic Species and Riparian Zone Conservation Strategy) as attached to this instrument.

This Action Plan incorporates the Action Plan requirements for the following declared items and supersedes any previous Action Plans for the following items.

- Two-spined Blackfish (*Gadopsis bispinosus*)
- Trout Cod (*Maccullochella macquariensis*)
- Macquarie Perch (*Macquaria australasica*)
- Murray River Crayfish (*Euastacus armatus*)
- Silver Perch (*Bidyanus bidyanus*)
- Tuggeranong Lignum (*Muehlenbeckia tuggeranong*)

## 3 Commencement

This instrument commences the day after notification.

## 4 Instruments revoked

This instrument revokes the following instruments for Action Plans.

- Nature Conservation (Threatened Ecological Communities and Species) Action Plan 2005 (No 2) DI2005-87
- Nature Conservation Action Plans for Protecting ACT's Threatened Species NI 1999-59.

Hamish McNulty
Conservator of Flora and Fauna
4 April 2007

Action Plan No. | **29**

# ACT Aquatic Species and Riparian Zone Conservation Strategy

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# Vision

The Murrumbidgee and Molonglo rivers in the ACT and their major tributaries make an outstanding contribution to the conservation of aquatic and riparian ecosystems of the upper Murrumbidgee River catchment.

Rivers, streams and their associated riparian zones are special and distinctive parts of the landscape. They 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.

The central focus of this *Strategy* is on biodiversity and habitat conservation for the rivers and riparian zones, with some consideration of water resource management and recreation (especially recreational fishing) because of their importance in relation to habitat and threatened species conservation. Other natural and cultural values of river sections and adjacent riparian zones include Aboriginal and European cultural heritage, other forms of recreation, aesthetic amenity, educational and special scientific features (e.g. geological sites).

The *Strategy* is an Action Plan for species that occur in ACT rivers and riparian zones and are declared threatened under the *Nature Conservation Act 1980* (ACT).

## Acknowledgements

The *Strategy* was prepared for the Conservator of Flora and Fauna by the Environment and Recreation, Department of Territory and Municipal Services (formeerly Environment ACT. The team comprised: Mark Lintermans, Murray Evans, Sarah Sharp, Mark Dunford (mapping), David Shorthouse and Marjo Rauhala.

Kevin Frawley prepared drafts of the report and managed its compilation.

Progress in preparing the *Strategy* was reported to the ACT Flora and Fauna Committee, and individual members provided expert comment and advice.

The cover illustration was prepared by Lesley Wallington.

THIS DOCUMENT SHOULD BE CITED AS:

ACT Government 2007 *Ribbons of Life: ACT Aquatic Species and Riparian Zone Conservation Strategy*. Action Plan No. 29 (Department of Territory and Municipal Services, Canberra).

**FURTHER INFORMATION**

Further information on this Action Plan or on threatened species and ecological communities can be obtained from:

The Department of Territory and Municipal Services
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# 1 Introduction

## 1.1

### A New Focus for Nature Conservation in the ACT

In 2002 the ACT Government introduced a *New Focus for Nature Conservation in the ACT*, which includes a program to establish strategies for priority species and ecological communities. This is to ensure that resources are directed to achieving maximum effect in conservation activities. To implement this program, the government initiated a three-year review of existing Action Plans for threatened species and ecological communities.

The first review in 2002–03 resulted in Action Plan 27, *Woodlands for Wildlife: ACT Lowland Woodland Conservation Strategy* covering endangered Yellow Box–Red Gum Grassy Woodland, other lowland woodlands and the species dependent upon these woodlands (ACT Government 2004a). The second review covering endangered natural temperate grassland, other native grasslands, and plant and animal species dependent upon these was undertaken in 2003–04. The resulting strategy, Action Plan 28, *A Vision Splendid of the Grassy Plains Extended: ACT Lowland Native Grassland Conservation Strategy* (ACT Government 2005a) was released in July 2005.

This *Aquatic Species and Riparian Zone Conservation Strategy*, Action Plan 29, is the third and final strategy in this sequence. The three strategies are complementary and recognise that ecological communities are dynamic, in that they change over time, intergrade with each other, and share the more mobile of their constituent fauna.

## 1.2

### Scope of the Aquatic Species and Riparian Zone Conservation Strategy

Reflecting government policy, the *Aquatic Species and Riparian Zone Conservation Strategy* takes an integrated territory-wide approach within a regional context, to the protection and management of the rivers and riparian areas in the ACT that support threatened species and ecological communities. The *Strategy* seeks to maintain and improve the natural integrity of the rivers and riparian zones. Key considerations include:

- the need for improvements in the knowledge of vegetation and habitat in riparian zones;
- recovery of riparian areas severely affected by the January 2003 bushfires;
- protection of the river corridors from the effects of existing and proposed urban development, possible expansion of recreational infrastructure, and other threats such as inappropriate grazing regimes;
- maintenance and improvement of linear and upslope connectivity;
- restoration of riparian habitat including control of weed species such as willows;
- maintenance and improvement of in-stream habitat (including streamflow) and where feasible, rehabilitation of native fish populations;
- maintenance of wildlife corridors;
- maintenance and protection of aquatic ecosystem processes and water quality.

Objectives and actions for the *Strategy* as a whole are contained in Chapter 6 (Table 6.1). Specific actions related to vegetation are in Chapter 2 (s. 2.4), to riparian fauna in Chapter 3 (s. 3.3), and to fish, crayfish and macroinvertebrates in Chapter 4 (s. 4.10 to s. 4.14).

**Action Plan for Threatened Species:** The *ACT Aquatic Species and Riparian Zone Conservation Strategy* supersedes six separate Action Plans previously published for four threatened fish species, one crustacean and one plant species-all declared threatened under the *Nature Conservation Act 1980* (ACT) (Table 1.1). The statutory requirement for the ACT Conservator of Flora and Fauna to prepare Action Plans for declared threatened species and ecological communities remains and this *Strategy* incorporates this requirement in an integrated way. While the legal authority of the *Strategy* is confined to the Australian Capital Territory, management considerations are addressed in a regional context. Should any other aquatic species, or species or ecological community associated with the riparian zone be declared threatened in the future, the *Strategy* will require amendment to incorporate the details and requirements for that species/community.

The *Strategy* also includes consideration of the Pink-tailed Worm Lizard (*Aprasia parapulchella*) and Murray Cod (*Maccullochella peelii peelii*), which are not declared threatened in the ACT. The Pink-tailed Worm Lizard has Special Protection Status in the ACT under the *Nature Conservation Act 1980*. It is declared threatened under Commonwealth, NSW and Victorian legislation (see s. 3.3.2; Appendix 1.2). Murray Cod is declared threatened under Commonwealth and Victorian legislation (see. s. 4.3). Painted Honeyeater (*Grantiella picta*), an ACT threatened species recorded from the Murrumbidgee River is referred to only briefly in s. 3.3.2, as this species is included in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a).

As well as listed threatened species, the *Strategy* is concerned generally with the conservation of aquatic fauna (e.g. Platypus *Ornithorhynchus anatinus*, Eastern Water Rat *Hydromys chrysogaster*, small spiny crayfish *Euastacus* spp., Mountain Galaxias *Galaxias olidus*, Eastern Snake-necked Turtle *Chelodina longicollis*). The *Strategy* is also concerned with the maintenance and improvement of aquatic habitat utilised by fish, invertebrates, mammals, birds, reptiles and frogs (see Lintermans and Osborne 2002).

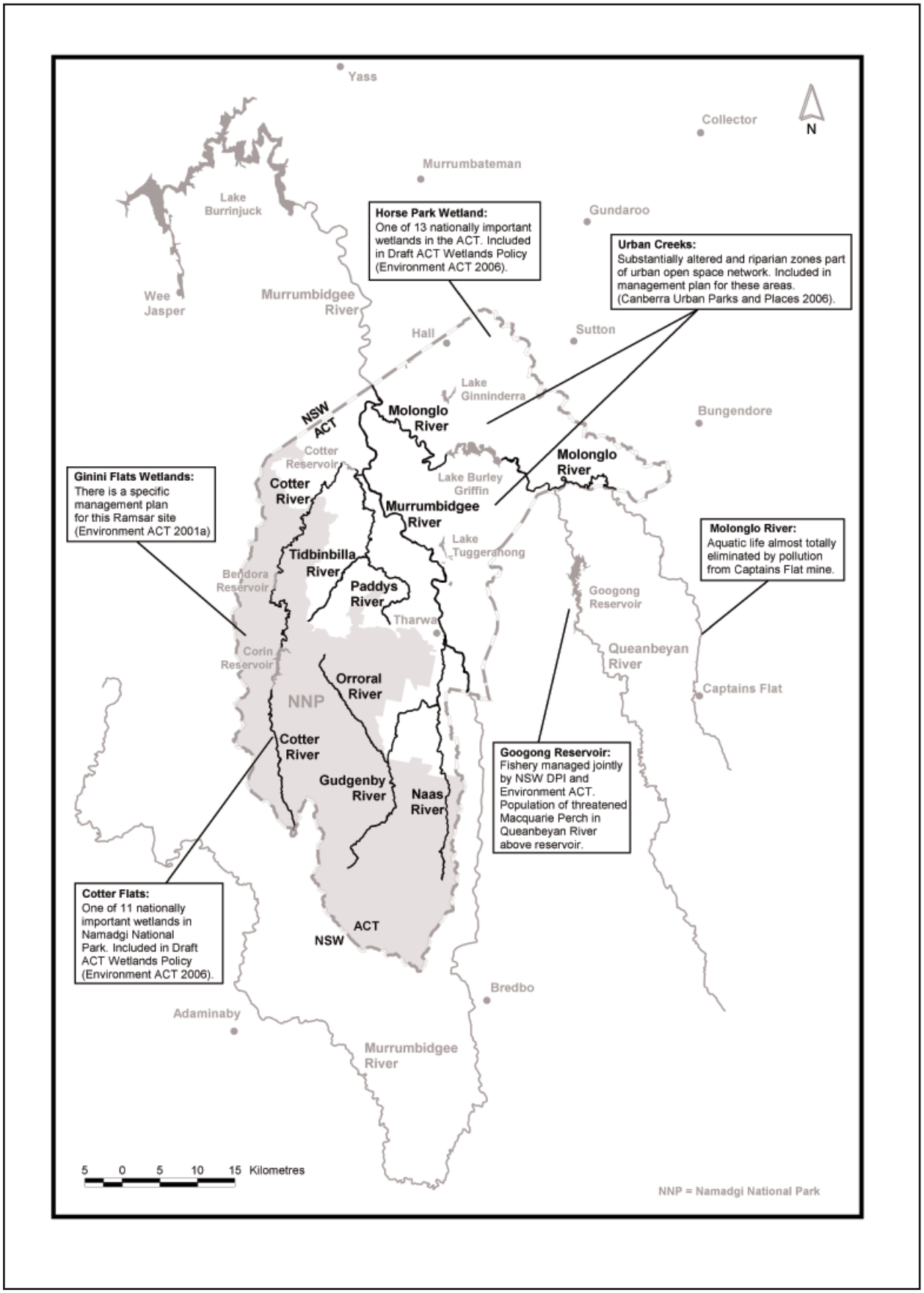
**Primary Focus of the *Strategy*:** In its role as an Action Plan for ACT threatened species, the primary focus of this *Strategy* is the rivers and larger tributary creeks and their riparian zones in the ACT, that support threatened flora and fauna species (Figure 1.1). These are the Murrumbidgee River; its major tributaries, the Molonglo and Cotter rivers; and smaller tributaries, the Paddys-Tidbinbilla rivers and Gudgenby-Naas-Orroral rivers (s. 2.1). Tributary streams of these rivers are included in the river sections outlined in following chapters (see Table 2.2) though they may not be specifically mentioned. These rivers and their riparian zones, except for Paddys River and most of the lower sections of the Naas and Gudgenby rivers, are categorised as Public Land under the *Land (Planning and Environment) Act 1991* (ACT) (see s. 1.5.2, Ch. 5). As shown in Table 5.1, a high level of statutory protection is afforded most of the river sections in the ACT e.g. almost all of the Orroral River and substantial upper sections of the Cotter, Naas and Gudgenby rivers are protected in Namadgi National Park.

**Table 1.1: ACT Declared Threatened Species Included in the *Aquatic Species and Riparian Zone Conservation Strategy* and Existing Action Plans for Those Species**

| Species/Ecological Community | Status | Action Plan No./ Date | Declaration Date[1] |
|---|---|---|---|
| Two-spined Blackfish (*Gadopsis bispinosus*) | Vulnerable | No. 11, 1999 (ACT Government 1999a) | 27 December 1996 |
| Trout Cod (*Maccullochella macquariensis*) | Endangered (Special Protection Status) | No. 12, 1999 (ACT Government 1999b) | 27 December 1996 |
| Macquarie Perch (*Macquaria australasica*) | Endangered (Special Protection Status) | No. 13, 1999 (ACT Government 1999c) | 27 December 1996 |
| Murray River Crayfish (*Euastacus armatus*) | Vulnerable | No. 14, 1999 (ACT Government 1999d) | 27 December 1996 |
| Silver Perch (*Bidyanus bidyanus*) | Endangered | No. 26, 2003 (ACT Government 2003) | 4 September 2001 |
| Tuggeranong Lignum (*Muehlenbeckia tuggeranong*) | Endangered (Special Protection Status) | No. 24, 1999 (ACT Government 1999e) | 7 August 1998 |

1. Declaration in accordance with section 21 of the *Nature Conservation Act 1980* (ACT).

**Figure 1.1: Sections of ACT Rivers Included in this *Aquatic Species and Riparian Zone Conservation Strategy***



**River Sections in New South Wales:** The *Strategy* does not include the Queanbeyan River (almost entirely in New South Wales), though reference is made to this river, including the section upstream of Googong Reservoir, with regard to threatened fish species. Similarly, the section of the Molonglo River from its headwaters near Captains Flat to the ACT border is not included. A brief summary of the impact on aquatic life in this river section of heavy metal pollution from Captains Flat is included in s. 2.1.2.

**Urban Creeks:** Tuggeranong, Weston, Yarralumla, Sullivans, Woolshed, Jerrabomberra and Ginninderra creeks are not included in the *Strategy*, but are referred to in relation to specific planning and management issues. Woolshed and Jerrabomberra creeks have substantial rural catchments, however, the other creeks are now mainly within or adjacent to the Canberra urban area. They have been substantially altered by past land uses and as part of the stormwater drainage and pollution control engineering for urban Canberra (see s. 2.1.2). Their riparian zones are part of the urban open space network and are now mostly included in management plans for those areas (Canberra Urban Parks and Places 2006).

**ACT Wetlands:** The *Strategy* does not include ACT wetlands as these are covered in a separate (draft) wetlands policy (Environment ACT 2006). ACT wetlands include naturally occurring freshwater swamps, marshes, peatlands and bogs as well as artificial lakes, dams and ponds. Of these wetlands, one is recognised as internationally important and has its own management plan (Ginini Flats Ramsar Wetland Site (343 ha)) (Environment ACT 2001a). Thirteen wetlands (covering 1257 ha, including Ginini Flats) are listed as nationally important (Environment Australia 2001). Eleven of these wetlands are in Namadgi National Park, and one, Jerrabomberra Wetlands, has its own management plan. The remaining unreserved wetland (Horse Park) is on a small ACT rural lease and a management plan has been prepared for the wetland as part of a conservation management plan for the property (Eric Martin and Associates & Peter Dowling 2006).

**Riparian Zone Vegetation Communities, Flora and Fauna:** The *Strategy* includes consideration of riparian zone vegetation communities, flora and fauna. The riparian zone in the ACT provides important habitat for several threatened or uncommon terrestrial or amphibious species that are strongly associated with riparian habitats. Threatened fauna species have been noted above. Riparian vegetation has been significantly altered since European settlement, especially in the lower elevation river valleys of the Murrumbidgee and Molonglo rivers and their tributaries. Significant stands of River She-oak (*Casuarina cunninghamiana*) community occur along the Murrumbidgee and lower Cotter and Paddys rivers. These were severely burnt in the January 2003 bushfires.

**Strategy is Not a Management Plan:** The *Strategy* differs from a management plan applied to a particular area or areas. Most of the rivers and riparian zones considered in this *Strategy* are Public Land in the *Territory Plan* for which it is a requirement under the *Land (Planning and Environment) Act 1991* that a management plan be prepared (s. 1.5.2). This process is not yet complete for the areas covered by the *Strategy* (Ch. 5, Ch. 6). A central purpose of the *Strategy* is to inform decision-making with regard to conservation of threatened species, land use planning, and the development and management of land in the ACT.

Specifically, the *Strategy*:

- identifies the vegetation communities, threatened and uncommon plant species in the riparian zones (recognizing also the lack of systematic vegetation survey in these areas), and changes to riparian zone vegetation since European settlement and ongoing threats;
- describes the riparian zone fauna, including threatened and uncommon species, the characteristics of aquatic and riparian habitat, and threats to riparian fauna;
- describes the fish and crayfish fauna of ACT rivers, including threatened and uncommon species, and discusses those factors considered to have contributed to the decline of native fish species in the Murray–Darling Basin, including the ACT, and continue to be ongoing threats;
- lists conservation goals, objectives and actions for aquatic species and flora and fauna of the riparian zone, including those species declared as threatened under the *Nature Conservation Act 1980* (ACT);
- outlines principles on which to base conservation actions;
- incorporates the Action Plans for listed species which are required by the *Nature Conservation Act 1980* (ACT);
- provides a basis for planning and land management decisions with regard to threatened aquatic species and the riparian zone;
- encourages community participation in the conservation of aquatic and riparian flora and fauna species and their habitat; and
- satisfies the requirement under section 23(2) of the *Nature Conservation Act 1980*, that an Action Plan includes proposals for the identification, protection and survival of a threatened species or ecological community, or, in the case of a threatening process, proposals to minimise its effect.

# 1.3

## Definition of the Riparian Zone

There are many definitions of the riparian zone. *How* the zone is defined often relates to *why* it is being defined (Tubman and Price 1999). For administrative or legal purposes, it may be defined by a fixed width along designated rivers or streams, or by land subject to the 100 year Average Recurrence Interval (ARI) flood level, generally referred to as the floodplain. It may also be defined by land uses; however, these may pay little heed to natural processes in the zone. Both these approaches are of limited value for riparian zone management where a functional or ecosystem approach is more appropriate, and the width that is taken into consideration needs to be related to management objectives.

In essence, the riparian zone is where an aquatic ecosystem (creek, river, lake) adjoins a terrestrial ecosystem. Ecological communities (most obviously the vegetation) in the riparian zone are affected by the adjacent water body in the form of raised water tables, flooding and associated water velocity, and micro-climate. Riparian vegetation may be distinctly different in structure and/or floristics from vegetation further away from the water and at higher elevation, but this is not universally the case. Riparian zone vegetation influences the stream and in-stream ecology in a number of ways, including supply of nutrients (leaf fall), filtering of sediments, bank stability and in-stream habitat (tree roots, fallen logs, shading).

The following are some riparian zone definitions:

(a) The riparian zone encompasses the stream channel between the low and high water marks and that portion of the terrestrial landscape from the high water mark toward the uplands where vegetation may be influenced by high water tables or flooding and by the ability of the soils to hold water (Naiman and Décamps 1997).

(b) Riparian land is any land that adjoins, directly influences, or is influenced by a body of water. It includes:
   - —land immediately alongside small creeks and rivers, including the riverbank;
   - —gullies and dips which sometimes run with water;
   - —areas surrounding lakes; and
   - —wetlands on river floodplains which interact with the river in times of flood (Tubman and Price 1999).

(c) Riparian ecosystems are those terrestrial but inundation-prone systems where plant growth is enhanced by its proximity to the adjacent running freshwaters of streams and rivers (Note: wetlands and lakes were excluded from the definition in the context of the report for which the definition was prepared) (Williams 1993).

(d) The riparian zone is that region along lakeshores, streams and rivers where the existing or original emergent vegetation has distinctly different structure and/or floristics from that of adjacent terrestrial areas (*Think water, act water*, Vol 2, Appendix B (ACT Government 2004d)).

(e) The riparian zone is the area along the bank of a river or stream; often has water-dependent vegetation (Young 2001, p. 292).

These definitions assist in understanding the location and characteristics of the riparian zone, and the difficulty in delineating it in a general definition compared with a specific location. In the latter case, particular topographic, hydrological and ecological attributes will often make the riparian–terrestrial transition apparent.

This *Strategy* adopts the well-established planning unit in the ACT of the 'River Corridor', developed as part of the National Capital Open Space System (NCOSS) by the former National Capital Development Commission (Anway et al. 1975; NCDC 1981, 1988a; see also *National Capital Plan*, s. 8.6 (NCA 2005); *Territory Plan*, Part B13 (ACTPLA 2005)). The river corridor concept provides the linking structure for a linear series of reserves and non-urban land uses, which for some river sections have been bound together in statutory management plans (Murrumbidgee River Corridor (Environment ACT 1998); Lower Molonglo River Corridor (Environment ACT 2001b)).

This *Strategy* accords with the ACT planning and management framework for river corridors in that it is *focused on the rivers and adjacent non-urban land that has close ecological, landscape and visual connections and interactions with the rivers*. There may be instances where these interactions go beyond the land use boundaries for river corridors defined in the Territory Plan. In the case of river sections contained within larger national parks or reserves (sections of the Cotter River, Gudgenby–Naas–Orroral rivers, Tidbinbilla River), the framework established for the Murrumbidgee and Molonglo rivers is not appropriate or necessary.

# 1.4

## Role of the ACT Flora and Fauna Committee

The ACT Flora and Fauna Committee is established under amendments to the *Nature Conservation Act 1980* that were enacted in 1994. It is comprised of seven members with expertise in biodiversity or ecology. It advises the ACT Minister for the Environment in relation to nature conservation.

Since its establishment in 1995, the Flora and Fauna Committee has received and assessed nominations of species or ecological communities that may be threatened with extinction. The Committee is required to make assessments on nature conservation grounds only and is guided by specific criteria set out in its publication *Threatened Species and Communities in the ACT: Criteria for Assessment* (July 1995) (ACT Flora and Fauna Committee 1995). In making its assessment of the listed plant and animal species included in this *Strategy*, the Committee concluded that each nomination satisfied these criteria.

As a group of experts in biodiversity, the Committee is asked to draw on its knowledge and experience of the region's flora and fauna during preparation by Environment and Recreation of draft and final Action Plans and to advise the Conservator of Flora and Fauna on progress in implementing them. These reviews are published in the Committee's Annual Reports. The Committee is also asked for its views on topical nature conservation issues as they apply to the ACT and it regularly provides such advice to Environment and Recreation. Thus the Committee is a valuable source of technical expertise, independent of Environment ACT and the Conservator of Flora and Fauna.

#### ACTION PLAN REVIEWS

The Flora and Fauna Committee conducts annual reviews of progress in implementing Action Plans for threatened species and communities. In 2004 the review comprised an assessment of Action Plans for the threatened species associated with ACT rivers and riparian zones (Table 1.1). The Flora and Fauna Committee reported in December 2004 to the Conservator of Flora and Fauna that significant progress had been made in implementing the aquatic species action plans and in linking fish monitoring to management activities. Other matters noted by the Committee included the potential implications of future ACT water supply options for the conservation of threatened fish species, the need for community education regarding threatened aquatic species, and the status of Trout Cod and Macquarie Perch. The Committee was of the view that riparian vegetation restoration is a key issue for the *Aquatic Species and Riparian Zone Conservation Strategy*. The Committee noted progress with the implementation of the Action Plan for Tuggeranong Lignum (ACT Government 1999e) and suggested that a higher priority be given to germination trials for the species.

The Committee agreed at its October 2004 meeting that it would be appropriate to include the Pink-tailed Worm Lizard in this Strategy, as this nationally vulnerable species is not included in the *ACT Lowland Woodland Conservation Strategy* or the *ACT Lowland Native Grassland Conservation Strategy* (ACT Government 2004a, 2005a).

# 1.5

## Relevant Legislation

### 1.5.1 ACT Planning and Land Management

The *Australian Capital Territory (Planning and Land Management) Act 1988* provides for two categories of land in the ACT:

- National Land—used by or on behalf of the Commonwealth, and managed by the Commonwealth; and
- Territory Land—all the remaining land of the ACT. The ACT Government manages this land on behalf of the Commonwealth.

All of the land included in this *Strategy* is Territory Land.

The *National Capital Plan* (NCA 2005) contains general land use policies for the Territory as a whole and may specify areas of land that have the special characteristics of the National Capital as 'Designated Areas'. The *Plan* may include detailed conditions of planning, design and development in Designated Areas. The National Capital Authority has planning responsibility for these areas, which may be either National Land or Territory Land. The *Plan* also sets out principles and policies for particular land use categories in the Territory. Permitted land uses are also prescribed. Relevant to this *Strategy* are principles and policies related to the National Capital Open Space System (NCOSS) (Ch. 8), Rural Areas (Ch. 9) and Environment (Ch. 11). The *Plan* contains 'Special Requirements' for the Murrumbidgee and Molonglo River Corridors (Chs 8.6.4 and 9.4.2). More information on planning for NCOSS and the river corridors is contained in section 5.1.1. The *Aquatic Species and Riparian Zone Conservation Strategy* accords with

these principles, policies and special requirements.

Planning for areas that are not Designated Area is the responsibility of the ACT Planning and Land Authority and planning policies are set out in the *Territory Plan* (ACTPLA 2005).

The *Canberra Spatial Plan* (ACT Government 2004b) was released in March 2004 and provides a strategic direction for the development of Canberra over the next 30 years and beyond, but with the flexibility required to respond to change. It sets the framework for spatially based decision making in the future and outlines the actions needed to achieve the strategic direction for Canberra over the next 30 years. The *Spatial Plan* does not replace the *Territory Plan*, but will inform changes to both the *Territory Plan* and the *National Capital Plan*.

The *Spatial Plan* contains key principles to guide the future growth of Canberra. Protection of the natural environment is one of these key principles. The *Plan* states that the location of future residential development will ensure that areas identified as having significant biodiversity values, such as threatened species and ecological communities and habitat for threatened species, are protected from development.

#### TERRITORY PLAN POLICIES

*The Territory Plan* (ACTPLA 2005) contains detailed land use policies for the ACT. The following are particularly relevant to this *Strategy*:

- **Territory Plan Part B13: River Corridors Land Use Policies:** Conservation of natural and cultural resources is the primary goal in a system in which recreation is the key use. The policy sets out objectives and controls; the latter covering permitted land uses, land use restrictions, special conditions for environmental protection, recreation development, development conditions, public access and trails, and bushfire protection.
- **Territory Plan Appendix 1: Water Use and Catchment Policies:** Because of competing and often conflicting demands on water resources and past diminution of water quality, it is necessary to allocate waters of the ACT in terms of the permitted water uses and protected environmental values, and to identify the water quality and streamflow criteria related to the full protection of these uses and values. Three Water Use Catchments have been defined for the ACT.

More detail on these policies is contained in s. 5.1.1. These and other *Territory Plan* policies provide the statutory planning framework for the achievement of many of the objectives of this *Strategy* (Table 6.1).

### 1.5.2 Legislation Applying to the Conservation of Flora and Fauna, and to Fisheries Management in the ACT and Region

The following legislation applies to the conservation of flora and fauna, and to management of fisheries in the ACT and region.

#### ACT LEGISLATION

***Nature Conservation Act 1980***

The *Nature Conservation Act 1980* provides authority for the Conservator of Flora and Fauna to manage Public Land reserved for conservation of the natural environment. Activities that are inconsistent with management objectives for nature conservation are controlled. Special measures for conservation of a species or community of concern can be introduced in a reserved area, including restriction of access to important habitat. Provisions of the *Nature Conservation Act 1980* are applicable to National Land (s. 1.5.1).

Part 1 of the Act establishes the ACT Flora and Fauna Committee with responsibilities for assessing the conservation status of ACT flora and fauna and the ecological significance of potentially threatening processes. Where the Committee believes that a species or ecological community is threatened with extinction or a process is an ecological threat, it is required to advise the responsible minister, and recommend that a declaration be made accordingly.

Parts 4 and 5 of the Act provide for protection of native plants and animals. Section 21 of the Act authorises the declaration of (a) a vulnerable or endangered species, (b) an endangered ecological community, and (c) a threatening process, based upon the advice and recommendation to the responsible Minister by the ACT Flora and Fauna Committee.

Native plants and animals may also be declared as 'protected' (s. 17) or as having 'special protection status'(s. 16) in recognition of a particular conservation concern that warrants additional protection. Increased controls apply to declared species and licensing constraints are specified. Species declared as endangered under the Act, or threatened with extinction, must also be declared as having special protection status. This is the highest level of statutory protection that can be conferred on a species in the ACT.

Under s. 47 of the Act, the Conservator of Flora and Fauna may give directions to the occupier of land, for protection or conservation of native plants and animals. This provision is relevant to the management

of threats to a species or ecological community of concern that occurs on leased land.

Part 9 of the Act allows the Conservator to enter into a Management Agreement with an agency where its activities have potential to conflict with nature conservation objectives. This provision is relevant to management of conservation threats on unleased land and applies to utilities (e.g. gas, electricity), navigation and communication facilities, and land development.

***Land (Planning and Environment) Act 1991***

The *Land (Planning and Environment) Act 1991* is the primary authority in the ACT for land planning and administration and establishes *The Territory Plan*. One of the goals of the *Plan* is 'to promote ecologically sustainable development, protect biodiversity, and provide for high standards of environmental amenity, urban design and landscape' (ACTPLA 2005).
The *Plan* identifies nature reserves, national parks, wilderness areas and special purpose reserves within the Public Land estate. The Act requires that management plans be prepared for areas identified as Public Land under the *Territory Plan*. The Act also provides for environmental assessments and inquiries to be initiated in relation to land use and development proposals. This is included in the *Territory Plan* environmental planning policies.

It should be noted that Part IV (Environmental Assessments and Inquiries) and Part V (Land Administration) of the *Land (Planning and Environment) Act 1991* apply to all Territory Land. This includes Territory Land within Designated Areas under the *National Capital Plan* (see s. 1.5.1) that is subject to regulations under the Act. In circumstances where the regulations do not apply, collaborative solutions are sought between the Territory and the Commonwealth.

***Pest Plants and Animals Act 2005***

The main objects of the Act are to protect the ACT's land and aquatic resources from threats from pest plants and animals; to promote a strategic and sustainable approach to pest management; to identify pest plants and animals; and to manage pest plants and animals. The Act provides for the declaration of pest plants and animals and the preparation of management plans. It also prescribes offences in relation to propagation, supply and reckless disposal of pest plants, and supply, keeping and reckless disposal of pest animals.

***Heritage Act 2004***

The *Heritage Act 2004* establishes a system for the recognition, registration and conservation of natural and cultural heritage places and objects in the ACT, including Aboriginal places and objects. A list of these places and objects is maintained on a Heritage Register. Places and objects are listed on the Register on the advice of the ACT Heritage Council and following assessment of their heritage significance using specified criteria. Under the Act, all ACT public authorities are required to identify and manage heritage places or objects for which they are responsible. The Heritage Council is empowered to require a public authority to prepare a conservation management plan for such a heritage place or object.

***Fisheries Act 2000***

The *Fisheries Act 2000* is the primary legislation for the regulation of fishing activities in the ACT. The Act provides the framework for sustaining and protecting native fish species and providing high quality fishing opportunities in the ACT. Under the Act, the public waters of the ACT are divided into three categories:

(a) **Open Waters (open to fishing all year round):** Murrumbidgee River in the ACT downstream of the junction with the Gudgenby River; Molonglo River below Scrivener Dam; urban lakes.

(b) **Closed Waters (fishing prohibited):** Tidbinbilla River within Tidbinbilla Nature Reserve; upstream section of the Orroral River, Cotter River catchment upstream of Bendora Dam wall, Cotter Reservoir and river up to the junction with Pierces Creek; Murrumbidgee River (Angle Crosssing to Gudgenby River junction).

(c) **Trout Waters:** These comprise all public waters in the ACT that are not designated open waters. Trout waters have a closed season from early June to early October.

The Fisheries Act prescribes bag limits and minimum lengths, a closed season for Murray Cod (September to November), restrictions on the number of lines used and types of fish and crayfish traps, restrictions on type of bait used, prohibition on fish translocations, and a requirement to return protected fish to the water unharmed.

There is no requirement for a fishing licence in the ACT, however fishing in Googong Reservoir is controlled by NSW Department of Primary Industries and a NSW recreational freshwater fishing licence is required to fish there.

***Animal Welfare Act 1992***

The primary purposes of this Act are to promote vertebrate animal welfare and control activities that impose suffering on animals. The Animal Welfare Advisory Committee is established to provide advice to the Minister about animal welfare matters.

***Environment Protection Act 1997***

The main purpose of the Environment Protection Act is to provide protection for the environment from

pollution and other forms of environmental harm. The Act sets water quality guidelines and establishes the Environment Protection Authority.

***Water Resources Act 1998***

The Water Resources Act provides for the management and use of the Territory's water resources in a way that sustains the physical, economic and social well being of the people of the Territory, while protecting the ecosystems that depend on those resources. The *Environmental Flow Guidelines* is a statutory instrument established under the Act (ACT Government 2006a). The guidelines specify the flows required to maintain aquatic ecosystems in the ACT and cover both surface and groundwater (see s. 4.12.2 and s. 5.6.10). The *Water Resources Management Plan* is a statutory instrument under the Water Resources Act that describes Territory water resources, proposed allocations, water allocations to various uses, and action to be taken to manage water resources.

**NEW SOUTH WALES LEGISLATION**

***Fisheries Management Act 1994***

The primary purpose of the *Fisheries Management Act 1994* is to conserve, develop and share the fisheries resources of New South Wales for the benefits of present and future generations (Fisheries NSW 1998). Objects of the Act include conservation of fish stocks and habitat, and threatened species, populations and ecological communities. The Act includes provisions covering identification, assessment and listing of endangered species, populations and ecological communities, vulnerable species and key threatening processes. The Act also provides for identification of critical habitat, mandatory impact assessment in the land use planning process and active management for habitat recovery.

***Threatened Species Conservation Act 1995***

The *Threatened Species Conservation Act 1995* provides for the protection of all threatened plants and animals native to New South Wales (with the exception of fish and marine plants which are covered by other laws). Under the Act, threatened species are classified as endangered or vulnerable. A recovery plan must be prepared for endangered species (other than those presumed extinct), endangered populations, endangered ecological communities and vulnerable species. For each key threatening process that is listed, the NSW Department of Environment and Conservation (Parks and Wildlife Division) is required to prepare a threat abatement plan.

**VICTORIAN LEGISLATION**

***Flora and Fauna Guarantee Act 1988***

The *Flora and Fauna Guarantee Act 1988* is the primary legislation for the protection of Victoria's biodiversity, native plants and animals and ecological communities on land and in water. Species and ecological communities can be listed as threatened under the Act, based on assessments by an independent Scientific Advisory Committee. Threatening processes may also be listed. The Act does not provide for categories of threat (e.g. endangered, vulnerable). The Victorian Department of Sustainability and Environment maintains an advisory list of species considered threatened, poorly known, near threatened or extinct in Victoria (VDSE 2006). Conservation status categories used in these lists (ranging from extinct to 'data deficient') are also applied to species or communities listed as threatened under the Act.

**COMMONWEALTH LEGISLATION**

***Environment Protection and Biodiversity Conservation Act 1999***

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the primary Commonwealth legislation for environment protection. Under the EPBC Act, an action will require approval from the (Commonwealth) Environment Minister if the action has, will have, or is likely to have a significant impact on a matter of national environmental significance and it is not subject to certain specified exceptions. Exceptions include actions taken in accordance with Commonwealth accredited management plans. The Act also promotes ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, the conservation of biodiversity, and a cooperative approach to the protection and management of the environment involving governments, the community, landholders and indigenous peoples.

Matters of national environmental significance trigger the Commonwealth's environmental assessment and approval responsibilities. The matters are: World Heritage and National Heritage properties, Ramsar wetlands of international importance, nationally listed threatened species and ecological communities, migratory species protected under international agreements, Commonwealth marine environment and nuclear actions.

As well as in relation to a matter of national environmental significance, approval under the Act is required for actions that are likely to have a significant impact on: the environment of Commonwealth land

(even if taken outside Commonwealth land); and the environment anywhere in the world (if the action is undertaken by the Commonwealth).

Several of the plant and animal species included in this Strategy are listed as threatened under the EPBC Act (Trout Cod, Macquarie Perch, Murray Cod, Tuggeranong Lignum, Pink-tailed Worm Lizard). There is potential application of the EPBC Act in the ACT to nationally listed threatened species, National Land, and in relation to Commonwealth actions (see <http://www.deh.gov.au/epbc/index.html>).

The Commonwealth prepares Recovery Plans for species and ecological communities listed under the EPBC Act. In situations where such Recovery Plans coincide with ACT Action Plans or ACT management responsibilities, every effort is made to ensure coordination, consistency and cooperation between the Commonwealth and ACT governments and their agencies.

# 1.6

## Implementation

The *Aquatic Species and Riparian Zone Conservation Strategy* is not a management plan prepared under the *Land (Planning and Environment) Act 1991*, nor does it propose that management plans be prepared for each area independent from existing management plans and management arrangements. The *Strategy* is a *thematic* document i.e. it deals with the conservation of aquatic and riparian species, ecological communities and habitats across all land tenures in the ACT. The goals of the *Strategy* will be achieved through a variety of means, relevant to the different tenures. The Strategy provides the strategic, ACT-wide and regional context for the consideration of aquatic and riparian species, ecological communities and habitats in planning studies for specific areas of the ACT.

Environment ACT has responsibility for coordinating implementation of this *Aquatic Species and Riparian Zone Conservation Strategy* in partnership with relevant public and private land managers and the wider community. Building upon the existing community interest will be an important part of achieving the goals of this *Strategy*. The rivers and riparian zones in the ACT are mainly on Public Land (Territory Land) reserved under the *Territory Plan*, with other areas on leased and unleased Territory Land. Achievement of the objectives of the *Strategy* will require the participation of the managers of these lands in undertaking the actions for the *Strategy* as a whole set out in Chapter 6 and more specific actions contained in Chapters 2–5.

Primary responsibility for conservation of aquatic and riparian species and ecological communities on reserved Public Land will rest with Environment and Recreation (Territory and Municipal Services), with the directions of the *Strategy* expressed through management plans. For example, the *Murrumbidgee River Corridor Management Plan* (Environment ACT 1998) includes a set of objectives related to the 'Management of Water and Channel Values' and 'Management of Terrestrial Natural Resource Values'. Memoranda of Understanding (especially with Commonwealth landholders), Land Management Agreements (with rural lessees), and directions by the Conservator of Flora and Fauna under s. 47 of the *Nature Conservation Act 1980* are also means by which the *Strategy* may be implemented. Cooperation with NSW agencies, especially the Department of Environment and Conservation (Parks and Wildlife Division) and the Department of Primary Industries (Fisheries) is an important element in implementing the *Strategy*, as part of a regional effort to conserve the biodiversity of the ACT and Southern Tablelands.

The role of the *Strategy* in land use planning and land management in relation to ACT legislation is shown in Figure 1.2.

# 1.7

## Structure of the *Aquatic Species and Riparian Zone Conservation Strategy*

The *Strategy* is structured as follows:

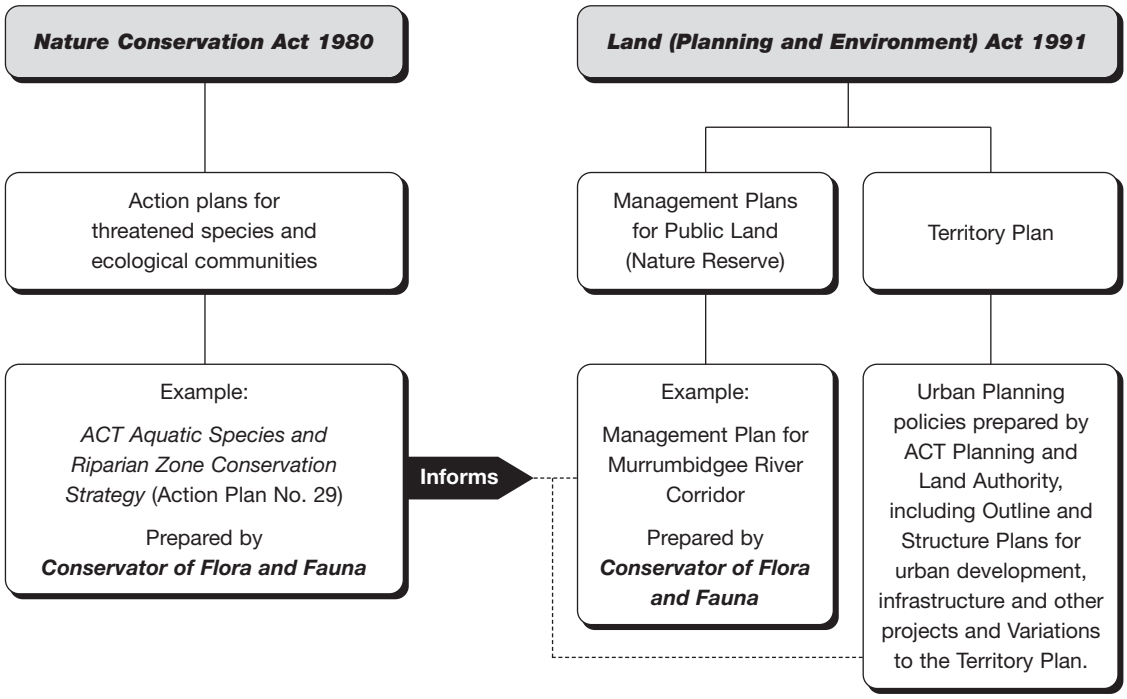
**Chapter 1:** The **Introduction** outlines the scope of the Strategy, the basis for declaring species threatened in the ACT and the role of the ACT Flora and Fauna Committee. It also includes a brief summary of the structure of ACT planning and land management, an outline of legislation applying to the conservation of flora and fauna in the ACT and region, and a section on implementation of the Strategy.

**Chapter 2: ACT Rivers and Riparian Vegetation** contains sections on ACT rivers, riparian zone vegetation, and threatened and uncommon riparian zone flora in the ACT. Changes to riparian zone vegetation since European settlement and ongoing threats are outlined as well as conservation objectives and actions. Table 2.2 contains a brief description of dominant native vegetation communities and vegetation condition for defined sections of the rivers.

**Chapter 3: Riparian Fauna** discusses riparian zone fauna, the importance of riparian habitat and threats to

**Figure 1.2: The Role of the *Aquatic Species and Riparian Zone Conservation Strategy* in Land Use Planning and Land Management in the ACT**

(A brief outline of the broader ACT planning framework including the role of the *National Capital Plan* is contained in s. 1.5.1.)




fauna. Conservation objectives and actions for threatened and uncommon fauna are outlined.

**Chapter 4: Fish, Crayfish and Macroinvertebrates in ACT Rivers** focuses in particular on the fish and crayfish species declared threatened under ACT legislation. A short section outlines the importance of macroinvertebrates to the health of aquatic ecosystems and their use as indicators for this purpose. Sections in the chapter discuss factors that have contributed to the decline of native fish and crayfish in the Murray–Darling Basin and the Upper Murrumbidgee River catchment. Conservation objectives and actions are outlined and discussed. Table 4.2 provides a brief description of stream morphology, fish and crayfish fauna including threatened species for defined sections of the rivers (corresponding to the vegetation descriptions in Table 2.2).

**Chapter 5: Aquatic Species and the Riparian Zone: Planning and Management for Conservation** briefly considers the status of planning, protection and management for ACT rivers and riparian zones. Subsequent sections discuss conservation planning including principles, planning and conservation issues for each of the rivers, best practice and adaptive management, habitat rehabilitation, management issues in the ACT, and management agreements and networks. Table 5.1 outlines planning and conservation issues and priority actions for each of the defined river sections previously detailed in Table 2.2 and Table 4.2.

**Chapter 6: The Aquatic Species and Riparian Zone Conservation Strategy** brings the elements of the *Strategy* together, placing the *Strategy* into the ACT planning and land management context and considering policy guidelines for the conservation of aquatic species and the riparian zone. The chapter evaluates the state of protection for aquatic species and the riparian zone in the ACT, outlines actions taken to improve their conservation, future actions necessary, and determines priorities. In particular, in support of the *Strategy's* goals, the chapter includes objectives, the actions necessary to achieve those objectives, and relevant performance criteria (Table 6.1).

# 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).

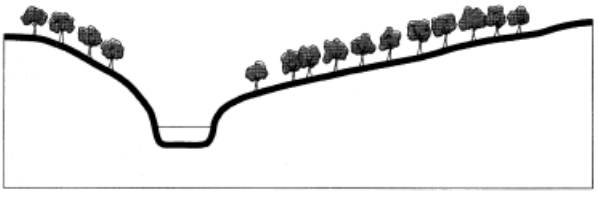
The Murrumbidgee River lies in a valley that has its orientation controlled for a considerable distance by the Murrumbidgee Fault. The valley rim has its highest elevation in the Bullen Range rising to over 300 m above the riverbed. Volcanic rocks dominate the geology but other types occur, such as the 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).

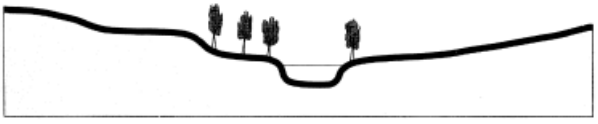
The form and characteristics of the river channel relate to underlying geology, river flows, erosion and deposition. Where undulating land closely adjoins the river, the stream meanders within the confines of a broad channel with wide gently sloping margins on the channel floor. In the steep valley and 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

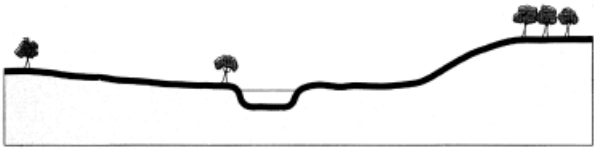
**Figure 2.1: Generalised Categories of Riverine Landforms along the Murrumbidgee River in the ACT (from NCDC 1988a)**



Gorge Areas, Steep Rugged Terrain, Rock/Outcrops



Rapids, Sand, Boulder - Casuarina Areas



Broad, Placid River Areas

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*<br>*E. rossii* | Dry footslopes to mountain foothills |
| **2.** *Eucalyptus dalrympleana* Montane Forest | Southern Tableland Wet Sclerophyll Forests | *E. viminalis*<br>*E. dalrympleana*<br>*E. robertsonii*<br>*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*<br>*E. blakelyi*<br>*E. bridgesiana* | Low hills and plains |
| **4.** *Eucalyptus dives Eucalyptus bridgesiana* Tableland Woodland | Southern Tableland Grassy Woodlands | *E. dives*<br>*E. nortonii*<br>*E. bridgesiana* | Dry hillslopes |
| **5.** *Eucalyptus pauciflora–Eucalyptus rubida* Tableland Woodland | Southern Tableland Grassy Woodlands | *E. pauciflora*<br>*E. rubida*<br>*E. dives* | Open lowland valleys on plains and frost-hollows |
| **6.** *Callitris endlicheri* Tableland Woodland | Eastern Riverine Forests | *Callitris endlicheri*<br>*E. nortonii*<br>*E. macrorlyncha*<br>*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*<br>*E. radiata* | River fringes |
| **9.** Tableland Shrubland | Not identified | *Kunzea ericoides*<br>*Bursaria lasiophylla*<br>*B. spinosa* | Dry hillslopes, river fringes |
| **10.** Tableland Dry Tussock Grassland | Temperate Montane Grasslands | *Themeda triandra*<br>*Poa sieberiana*<br>*Austrostipa scabra ssp. falcata*<br>*Austrostipa bigeniculata*<br>*Austrodanthonia spp.*<br>*Bothriochloa macra* | Lowland plains, valleys |
| **11.** Tableland Moist Tussock Grassland | Temperate Montane Grasslands | *Themeda triandra*<br>*Carex inversa*<br>*Poa labillardieri* | Lowland plains, valleys |
| **12.** Tableland Wet Tussock Grassland | Temperate Montane Grasslands | *Carex appressa*<br>*Poa labillardieri* | Drainage lines in lowland plains, valleys |
| **13.** Montane Dry Tussock Grassland | Temperate Montane Grasslands | *Themeda triandra*<br>*Poa sieberiana* | Montane valleys |
| **14.** Montane Wet Tussock Grassland | Temperate Montane Grasslands | *Poa sieberiana*<br>*Poa labillardieri*<br>*Carex gaudichaudiana* | Montane valleys |
| **15.** Montane and Subalpine Fen | Montane Bogs and Fens | *Carex gaudichaudiana*<br>*Restio australis* | Montane swamps |
| **16.** Tableland Riparian Fringing Vegetation | Montane Lakes | *Phragmites australis*<br>*Schoenoplectus validus*<br>*Typha spp.*<br>*Juncus australis* | River fringes |
| **17.** Tableland Riparian Floating and Submerged Vegetation | Montane Lakes | *Vallisneria gigantea*<br>*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**

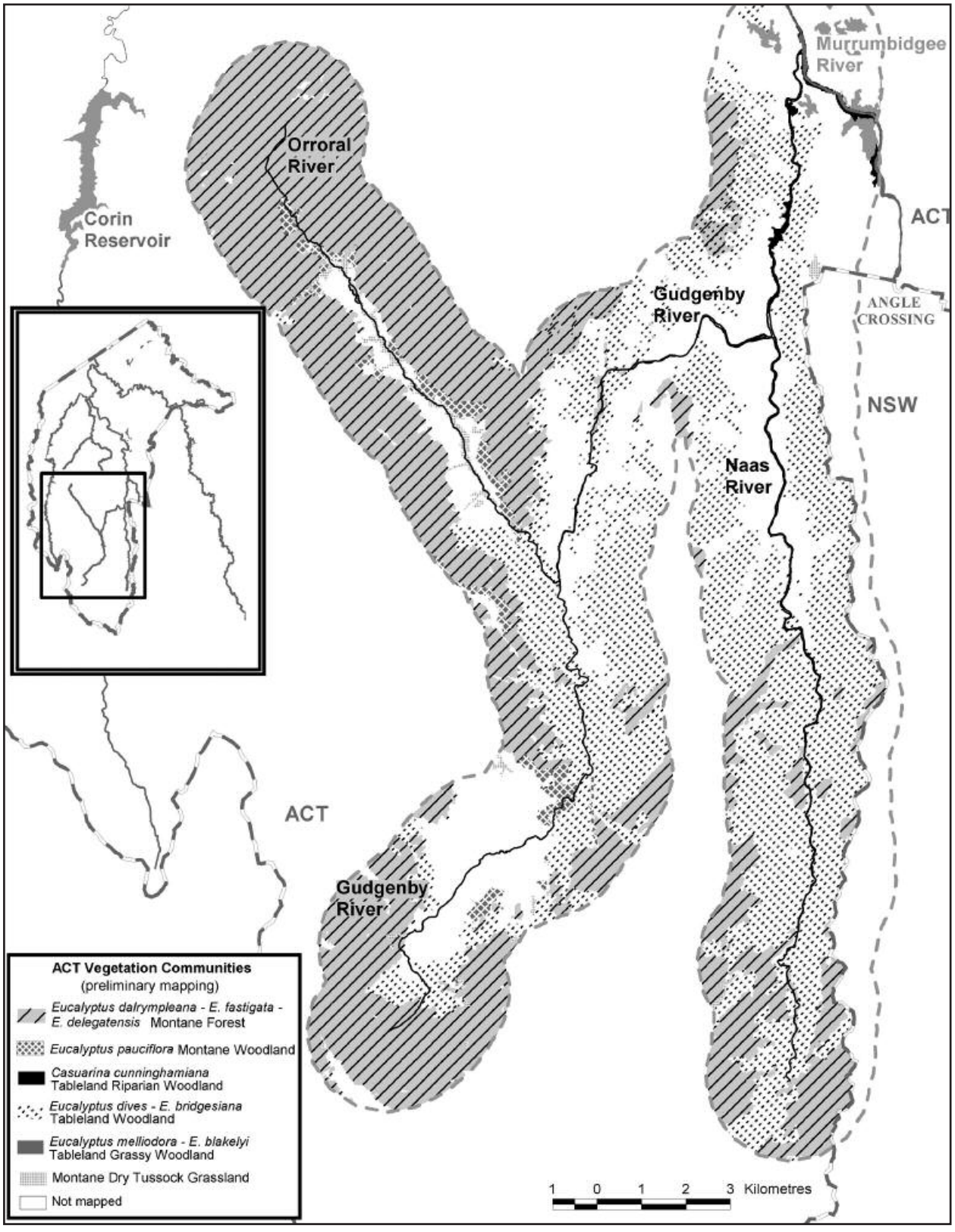


**Figure 2.3: Vegetation Communities in the Cotter, Paddys and Tidbinbilla River Catchments, ACT**

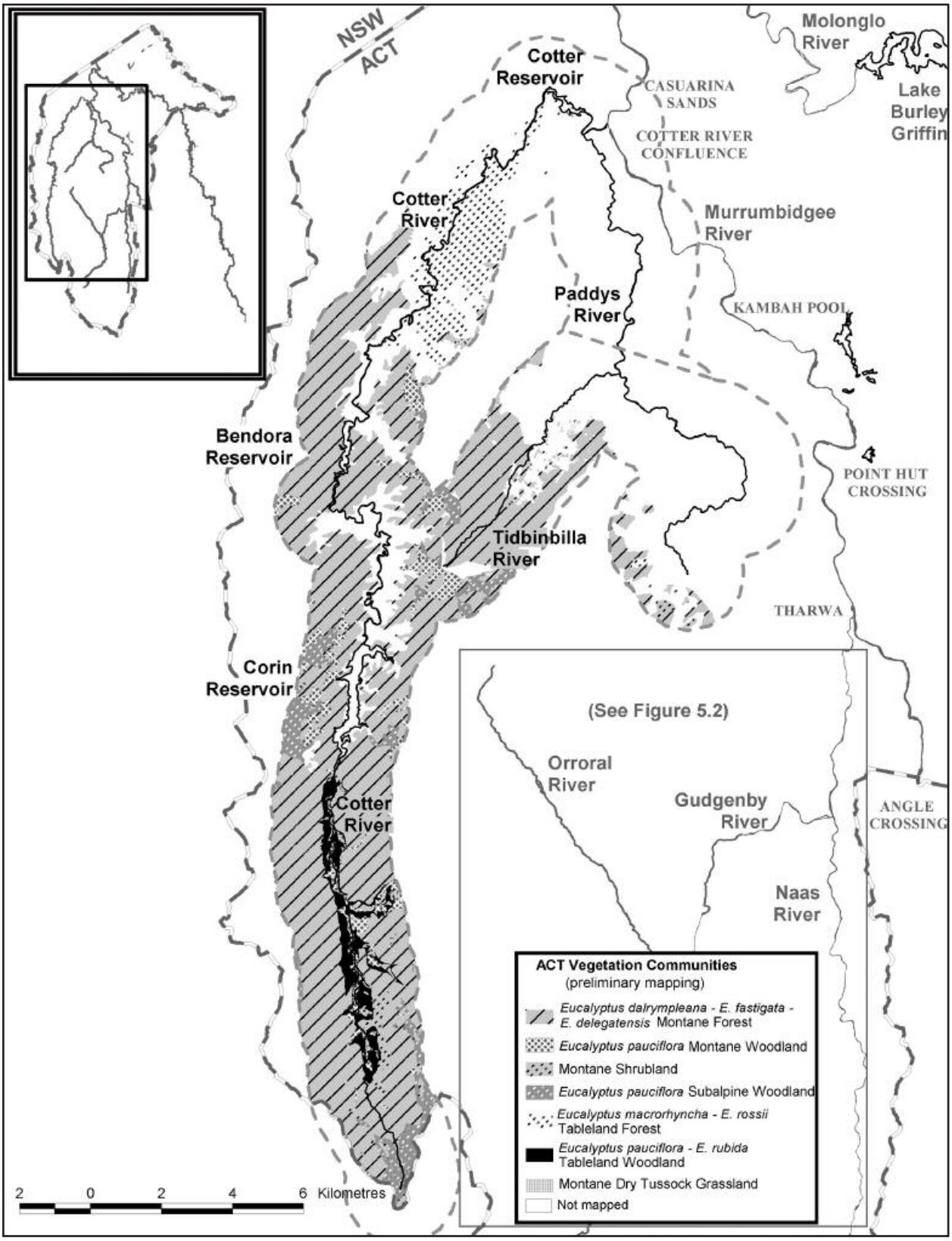
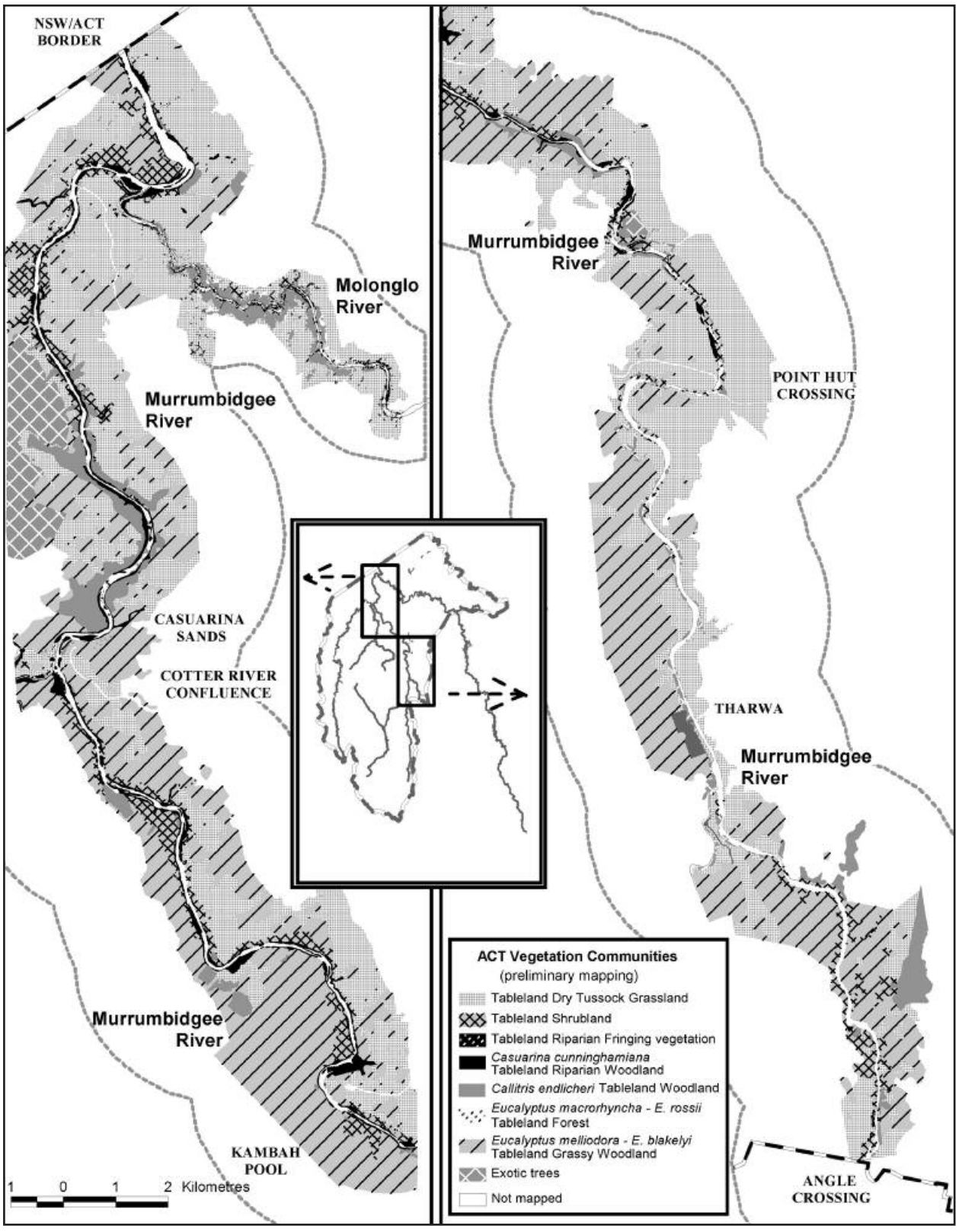


**Figure 2.4: Vegetation Communities along the Murrumbidgee and Lower Molonglo Rivers, ACT**



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***<br>■ Gigerline Nature Reserve<br>■ Special Purpose Reserve (Tharwa)<br>■ Rural leasehold<br>***Management***<br>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.<br>Most of this section was burnt in the January 2003 bushfires. | ■ *E. dives–E. bridgesiana* Tableland Woodland<br>■ *Callitris endlicheri* Tableland Woodland<br>■ *E. viminalis* Tableland Riparian Woodland<br>■ Tableland Shrubland | ■ Relict *E. viminalis* Tableland Riparian Woodland | ■ Weeds including Willows and African Love Grass<br>■ Uncontrolled grazing |
| **MU 2: Tharwa to Point Hut Crossing** | | | | |
| ***Territory Plan***<br>■ Special Purpose Reserve (including Lanyon Landscape Conservation Reserve)<br>■ Rural leasehold<br>***Management***<br>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<br>■ *Discaria pubescens* | ■ Weeds including Willows and African Love Grass<br>■ Uncontrolled grazing |
| **MU 3: Point Hut Crossing to Kambah Pool** | | | | |
| ***Territory Plan***<br>■ Special Purpose Reserve (Point Hut Crossing to Pine Island, Pine Island, Kambah Pool)<br>■ Bullen Range Nature Reserve (Pine Island to Kambah Pool)<br>■ Rural leasehold<br>***Management***<br>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<br>■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland<br>■ *E. pauciflora–E. rubida* Tableland Woodland<br>■ *Callitris endlicheri* Tableland Woodland<br>■ *Casuarina cunninghamiana* Tableland Riparian Woodland<br>■ Tableland Shrubland<br>■ Tableland Dry Tussock Grassland | ■ *Muehlenbeckia tuggeranong* (endangered)<br>■ *Thesium australe*<br>■ *Discaria pubescens*<br>■ *Bossiaea bracteosa*<br>■ *E. pauciflora–E. rubida* Tableland Woodland | ■ Weeds including Willows and African Love Grass<br>■ Recreational use<br>■ Unauthorised fires (deliberately lit) |
| **MU 4: Kambah Pool to Cotter River Confluence/Casuarina Sands** | | | | |
| ***Territory Plan***<br>■ Bullen Range Nature Reserve<br>■ Special Purpose Reserve (upslope areas on eastern side of Murrumbidgee R. above nature reserve)<br>■ Special Purpose Reserve (Cotter Reserve/ Casuarina Sands)<br>*(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,<br>*(Continues next page)* | ■ *E. macrorhyncha–E. rossii* Tableland Forest<br>■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland<br>■ *E. dives–E. bridgesiana* Tableland Woodland<br>*(Continues next page)* | ■ *Discaria pubescens*<br>■ *Desmodium brachypodum*<br>■ *Pomaderris pallida* | ■ Weeds including Willows and African Love Grass<br>■ 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***<br>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.<br>This section was severely burnt in the bushfires of January 2003. | ■ *Casuarina cunninghamiana* Tableland Riparian Woodland<br>■ Tableland Shrubland<br>■ Tableland Dry Tussock Grassland | | |
| **MU 5: Cotter River Confluence/Casuarina Sands to ACT/NSW Border** | | | | |
| ***Territory Plan***<br>■ Stony Creek Nature Reserve<br>■ Swamp Creek Nature Reserve<br>■ Woodstock Nature Reserve<br>■ Special Purpose Reserve (upslope areas above nature reserves)<br>■ Special Purpose Reserve (Uriarra Crossing)<br>***Management***<br>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.<br>This section was severely burnt in the bushfires of January 2003. | ■ *E. macrorhyncha–E. rossii* Tableland Forest<br>■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland<br>■ *Callitris endlicheri* Tableland Woodland<br>■ *Casuarina cunninghamiana* Tableland Riparian Woodland<br>■ Tableland Shrubland | ■ *Bossiaea bracteosa*<br>■ *Muellerina bidwillii*<br>■ *Diurus punctata*<br>■ *Pomaderris pallida* | ■ Weeds including Willows and African Love Grass<br>■ 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***<br>■ Namadgi National Park<br>***Management***<br>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<br>■ *E. dives–E. bridgesiana* Tableland Woodland<br>■ *Callitris endlicheri* Tableland Woodland<br>■ Montane Dry Tussock Grassland<br>■ Montane Wet Tussock Grassland<br>■ Montane and Subalpine Fen | ■ *Viola caleyana*<br>■ *Discaria pubescens* | ■ Willows (including willow re-establishment following control)<br>■ 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***<br>■ Special Purpose Reserve (possible Tennent Dam site)<br>■ 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<br>■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland<br>■ *E. dives–E. bridgesiana* Tableland Woodland<br>■ *Callitris endlicheri* Tableland Woodland | | ■ Weeds including willows<br>■ 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***<br>■ Tidbinbilla Nature Reserve<br>■ Rural leasehold<br>■ Plantation forestry<br>***Management***<br>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<br>■ *Casuarina cunninghamiana* Tableland Riparian Woodland<br>■ Tableland Shrubland<br>■ Tableland Dry Tussock Grassland | ■ *Drabastrum alpestre*<br>■ *Pomaderris pallida*<br>■ *Bossiaea bracteosa*<br>■ *Thesium australe* | ■ Weeds including willows<br>■ Uncontrolled grazing<br>■ Degradation of riparian areas (erosion, forestry activities, recreational use) |
| **CO 2: Cotter River (Headwaters to Corin Dam)** | | | | |
| ***Territory Plan***<br>■ Namadgi National Park<br>***Management***<br>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).<br>This area was moderately and patchily burnt in the January 2003 bushfires. | ■ Montane Dry Tussock Grassland<br>■ Montane Wet Tussock Grassland | ■ *Discaria pubescens*<br>■ *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***<br>■ Namadgi National Park<br>***Management***<br>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).<br>This area was severely burnt in the January 2003 bushfires. | ■ *E. macrorhyncha–E. rossii* Tableland Forest<br>■ *E. dalrympleana* Montane Forest | | |
| **CO 4: Cotter River (Below Bendora Dam to Cotter Dam)** | | | | |
| ***Territory Plan***<br>■ Namadgi National Park<br>■ Special Purpose Reserve (upstream from Cotter Dam to boundary of Namadgi National Park)<br>***Management***<br>■ Namadgi National Park Management Plan 2005<br>■ 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.<br>This area was severely burnt in the January 2003 bushfires.<br>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***<br>■ 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<br>■ Recreational use<br>■ 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***<br>■ Nature Reserve<br>■ Rural leasehold<br>■ 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<br>■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland<br>■ *E. pauciflora–E. rubida* Tableland Woodland<br>■ *Callitris endlicheri* Tableland Woodland<br>■ Tableland Moist Tussock Grassland | ■ *Eucalyptus pauciflora*<br>■ *Allocasuarina luehmannii* | ■ Weeds<br>■ Recreational use<br>■ 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***<br>■ Nature Reserve<br>■ Rural leasehold<br>■ 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<br>■ *Callitris endlicheri* Tableland Woodland | ■ *Allocasuarina luehmannii*<br>■ *Discaria pubescens* | ■ Weeds including willows<br>■ Urban/industrial runoff (poor results in macroinvetebrate sampling) |
| **MO 3: Scrivener Dam to Coppins Crossing** | | | | |
| ***Territory Plan***<br>■ Urban Open Space (Scrivener Dam to Tuggeranong Parkway)<br>■ Special Purpose Reserve (Tuggeranong Parkway to Coppins Crossing)<br>■ 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<br>■ *Casuarina cunninghamiana* Tableland Riparian Woodland<br>■ Tableland Shrubland<br>■ Tableland Dry Tussock Grassland | | ■ Weeds including willows<br>■ Recreational use<br>■ Urban edge effects |
| **MO 4: Coppins Crossing to Murrumbidgee River** | | | | |
| ***Territory Plan***<br>Lower Molonglo River Corridor Nature Reserve<br>***Management***<br>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<br>■ *E. melliodora–E. blakelyi* Tableland Grassy Woodland<br>■ *E. dives–E. bridgesiana* Tableland Woodland<br>■ *E. pauciflora–E. rubida* Tableland Woodland<br>■ *Callitris endlicheri* Tableland Woodland<br>■ *Casuarina cunninghamiana* Tableland Riparian Woodland<br>■ Tableland Shrubland<br>■ Tableland Dry Tussock Grassland | ■ *Pomaderris pallida*<br>■ *Bossiaea bracteosa*<br>■ *Desmodium brachypodum*<br>■ *Adiantum hispidulum*<br>■ *Eucalyptus pauciflora*<br>■ *Discaria pubescens* | ■ Weeds including willows and African Lovegrass<br>■ Recreational use<br>■ Urban edge effects<br>■ 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**

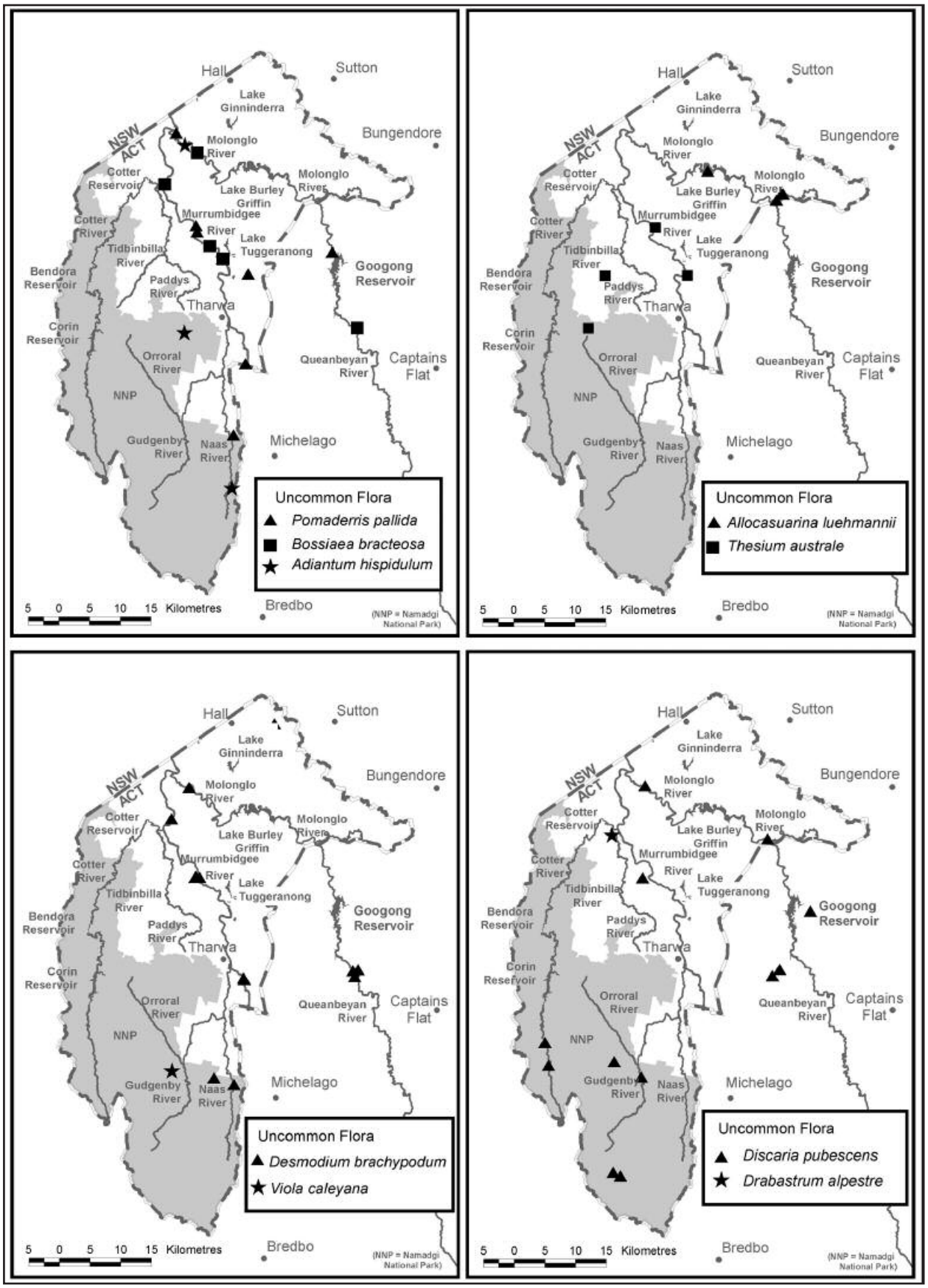
Preparation by Environment ACT of the National Recovery Plan (Commonwealth) and liaison regarding surveys (NSW) are noted above. No further actions are required at this stage.

### 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.

# 3 Riparian Fauna

## 3.1

## Riparian Zone Fauna and Habitat

This section includes consideration of animals that use the riparian zone exclusively or in conjunction with a range of terrestrial habitats. It also includes a smaller number of animals that are mainly aquatic but use the riparian zone, particularly riverbanks for important parts of their life cycles e.g. Platypus (*Ornithorhynchus anatinus*) and the Eastern Water Rat (*Hydromys chrysogaster*). Fish, crayfish and aquatic macroinvertebrates are discussed in Chapter 4.

### 3.1.1 Aquatic and Riparian Habitats

#### AQUATIC HABITATS

Aquatic habitats in the region have been grouped by Lintermans and Osborne (2002) broadly according to altitude: upland bogs, fens, seepages, creeks and rivers; lakes and reservoirs at varying altitudes; and lowland rivers, creeks, backwaters, billabongs, swamps and farm dams.

There has been an increase in some types of aquatic habitat since European settlement because of the construction of farm dams, water storages and urban lakes; however, the habitat value of many natural environments has been dramatically reduced (Lintermans and Osborne 2002):

(a) Small lowland wetlands have been drained for various purposes and/or invaded by weeds.
(b) Creeks in urban areas have been straightened, piped, or converted into concrete-lined drains.
(c) Large streams and rivers have flows altered by dams, temperatures lowered by cold-water pollution or raised following the clearing of riparian vegetation, and water quality affected by sedimentation due to erosion or catchment degradation (see s. 4.4, s. 4.12).
(d) Ephemeral wetlands have been drained or permanently flooded by lakes and/or invaded by weeds.
(e) A variety of habitats have been invaded by introduced aquatic species.

#### RIPARIAN HABITATS

There is a diversity of habitat in riparian areas which may include fringing aquatic vegetation, boggy areas or wet grassland, various riparian vegetation communities, the ecotone between riparian and upslope vegetation, riverbanks, flood terraces and steep, rocky gorge areas. In general, the condition or level of disturbance of the vegetation is the most critical factor for riparian habitat with the presence of understorey species an important biodiversity consideration. The importance of riparian vegetation for wildlife habitat has been shown in a number of studies e.g. Crome *et al.* 1994; Fisher and Goldney 1997; Recher and Lim 1990. In extensively cleared areas, where riparian vegetation may form the majority of the remnant native vegetation, it may be considered a critical landscape component in maintenance and restoration programs (Fisher and Goldney 1997). Riparian areas and their associated watercourses are 'keystone' ecosystems, with the health of ecological communities elsewhere in the landscape dependent upon the health of riparian areas (MacLeod 2002a). They are particularly important drought refuges and it is during these periods that conflict with livestock is most acute, as native fauna are restricted to patches of favourable habitat typically found in riparian areas (Morton 1990 in Macleod 2002a). Riparian areas wind their way through a variety of ecosystems, form natural corridors linking habitats, and provide routes for dispersal or migration of terrestrial and aquatic animals. For example, riparian zones are used as movement corridors by honeyeaters migrating between the southern highlands (including the ACT) and coastal areas. The role of riparian areas as corridors has become increasingly important as surrounding ecosystems are modified for urban and agricultural purposes.

Vegetation in the ground and shrub layers, rocks and fallen timber all provide habitat for invertebrates, frogs, lizards, snakes and small ground dwelling mammals. Some waterbirds (such as herons, rails and bitterns) and warblers use thick reed beds and other vegetation

fringing watercourses for shelter, foraging and nesting. Shallow, lentic water with vegetation provides habitat for frogs and their tadpoles and for aquatic macroinvertebrates (see Chapter 4). Outcropping rocks and river cobbles provide important habitat for reptiles, including a number of species confined to riparian areas. Emergent trees and snags provide perching places for waterbirds. Vegetation with a complex structure (herb, shrub and tree layers), which often occurs in the riparian zone, is important nesting and foraging habitat for many bird species. Large trees in or beside watercourses provide nest sites for raptors or nesting hollows for possums, bats and birds such as cockatoos, kingfishers and some duck species.

Rocky gorges and cliffs provide habitat for raptors, martins, swallows and bats and may have added significance where other habitat, such as large trees, have been lost from the landscape. Migratory Rainbow Bee-eaters (*Merops ornatus*) build their nests by tunnelling into sandy riverbanks and a number of areas along the Murrumbidgee River, including Point Hut and Gigerline Nature Reserve, are important habitat. The *Murrumbidgee River Corridor Management Plan* notes that special attention will be given to protection of riverbanks used by the species (Environment and Recreation 1998, p. 24). This type of habitat is particularly affected by trampling from stock (Fisher and Goldney 1997).

The riparian zone is intrinsically linked to the surrounding catchment through material flows (water, soil, nutrients, chemicals), an extensive ecotone, and animal movement. Compared to the surrounding landscape, riparian zones can be relatively nutrient rich environments and hence higher quality habitat. Soil and nutrients are transported from surrounding areas and deposited in riparian zones. These fertile alluvial soils and often-moister conditions result in productive environments for both plants and animals. Variable flood duration and frequency, and concomitant changes in water table depth and plant succession, create an environment that is a complex of shifting habitats, established and destroyed on different spatial and temporal scales (Naiman and Décamps 1997).

Riparian zones are long and thin, and consequently have an extensive interface with adjacent ecosystems. These ecotones are often more structurally complex and hence contain more animal species than the vegetation communities they separate. They are also the lowest lying (drainage) areas in the landscape. This physical connectivity means that activities occurring in adjacent ecosystems or elsewhere in the catchment (e.g. land clearing, agriculture, pasture improvement (including fertiliser application) and urbanisation) can also affect habitats in the riparian zone, either directly or through effects arising from changes to sediment loads, water quality or flow patterns. The narrow width of riparian zones leaves little to buffer them against impacts occurring in adjacent ecosystems. Indeed, the riparian zone itself is important in buffering aquatic environments against erosive or polluting land uses. Connections between the riparian zone and other ecosystems also occur through animal use and movement. For example, the home ranges of many animals include areas of both the riparian zone and adjacent habitats, and so habitat modification to either area will affect these species. Many riparian zones are now characterised by the loss of linear and upslope connectivity.

### 3.1.2 Fauna as Part of the Riparian Zone

Animals are intrinsic to the overall functioning of ecosystems, including riparian systems. Animals are essential for pollination and dispersal of many plants and are involved in nutrient recycling and maintenance of soil condition and water quality. Whilst some animals are largely restricted to the riparian zone, other animals living in the surrounding landscape use the riparian zone and associated rivers or streams as a source of food, water, shelter or nesting sites. Other animals move mainly between the water and adjacent riparian areas. Reference to riparian zone fauna in this sub-section is to all three categories. Loss of native animal species or establishment of introduced animal species can alter ecosystem processes and may lead to a change in the composition of fauna or flora. There may be adverse affects also on the health of the ecosystem (such as the decline of native plants following loss of their insect pollinator or increased erosion of banks resulting from removal of vegetation cover by heavy grazing).

#### 3.1.3 Threats to Riparian Zone Fauna

Threats to the terrestrial or aquatic fauna of the riparian zone stem largely from habitat removal or modification; either to the riparian zone itself or arising from land-uses in adjacent ecosystems. Other threats include changes in water quality or flows (which also affect riparian habitats and fauna), increased predation from introduced predators, and human disturbance. These threats to riparian zone fauna and other, mainly aquatic fauna are described in more detail in the following sections. Threats to fish and crayfish are discussed in Chapter 4 (sections 4.4 to 4.9).

### HABITAT REMOVAL, FRAGMENTATION AND MODIFICATION

Clearance of native vegetation, including riparian vegetation, still remains the most significant threat to terrestrial biodiversity despite apparently tight legislative controls and is recognised as a key threatening process in NSW and nationally. Expanding urban development increases pressure on catchments, aquatic and wetland habitats, and remnants of native vegetation, whereas construction of roads and other urban infrastructure leads to increased fragmentation of habitat. Fragmentation of riparian zone habitat reduces the value of these zones as corridors connecting different areas and habitats. The Australian State of the Environment Committee (ASOEC 2001) documented the Australia-wide degradation of riparian areas, riverbanks and wetlands. It also estimated that river and stream salinities are likely to increase substantially over the next 50 years resulting in additional stress on flora and fauna.

Loss of habitat diversity in the riparian zone has a major impact on riparian fauna. Ecosystems with a complex 'architecture' support more species than ecosystems that have been simplified, and many species require a complex vegetation structure to meet their habitat requirements (Mac Nally 1995). Structural complexity is created by the presence of trees of different ages, tree hollows, standing dead trees, a patchy shrub layer, a species-rich understorey of grasses and forbs, fallen timber and water, all of which provide shelter, food or nesting sites for animals (Martin and Green 2002). A reduction in habitat complexity (or quality) occurs through removal of mature trees, fallen timber and rocks, grazing by stock at an intensity that reduces floral diversity of the ground layer and prevents tree and shrub regeneration, inappropriate fire regimes, invasion by weeds and soil erosion. For example, invasion by weeds and removal of bush rock from habitat of the Pink-tailed Worm Lizard (*Aprasia parapulchella*) are both likely to have severe impacts on this species.

Grazing by domestic stock (cattle particularly) is a major cause of disturbance to Australian riparian habitats (Commonwealth of Australia 2002b; MacLeod 2002a) (see s. 5.6.4). Feral animals (especially rabbits) have also had a significant impact (Smith and Smith 1990). Grazing has altered and continues to alter the structure and function of the riparian landscape of the Murrumbidgee River and its tributaries. In a study of the riparian landscape downstream of the ACT, Robertson and Rowling (2000) found that seedlings and saplings of the dominant *Eucalyptus* tree species were up to three orders of magnitude more abundant in areas with no stock access compared with grazed areas. Similarly, the biomass of groundcover plants was an order of magnitude greater in areas with no stock access compared with grazed areas. Differences between stocked and unstocked areas were most pronounced where the riparian zone had been excluded from stock for more than 50 years.

Fallen timber, leaf litter and other ground cover provides important habitat for a range of invertebrates, many of which depend on dead wood and leaves for their survival. These invertebrates, together with microbial organisms and fungi, are important in the breakdown of timber (Araya 1993) and recycling of nutrients back into the soil. In turn, invertebrates provide the main food source for a range of birds, reptiles, amphibians and some mammals. Land uses such as clearing and intensive grazing result in loss of riparian vegetation, which leads to a reduction in leaf litter deposition, streambank stability and consequential impacts to water quality and stream health.

### ALTERATION OF NATURAL FLOWS

The modification of 'natural' flow regimes in river systems is considered to be one of the most significant impacts on Australian inland aquatic ecosystems (ASOEC 2001). The impact of altered flow regimes on fish and crayfish is discussed in s. 4.4.4. Altered flow regimes can have a major effect on habitat for both terrestrial and amphibious fauna. Natural flow regimes in the ACT have been altered by dam construction and upstream water abstraction. Riparian areas have been affected by the reduced incidence of high flow events. The establishment of urban lakes with relatively stable water levels has favoured some waterbirds and resulted in the creation of additional wetland areas such as those in the Jerrabomberra Wetlands Nature Reserve.

### PREDATORS

Foxes, cats and dogs are known to prey on a range of native animals, many of which occur in riparian habitats, and can form a substantial proportion of the diet of these introduced predators. The native prey of foxes and feral, stray and domestic cats includes mostly ground-dwelling small mammals, reptiles, frogs and birds commonly found on the ground or in lower understorey, and occasionally bats and small arboreal mammals (Coman 1995; Newsome 1995; Dickman 1996). The impact of this predation on population sizes of fauna has not been well quantified. It is evident, however, that some species have been highly vulnerable to predation by introduced predators. Feral cat and fox predation on native wildlife are listed as key threatening processes in NSW and nationally. The uncontrolled roaming of domestic cats, and in some

cases dogs, in riparian zones close to urban areas is likely to contribute to increased predation on wildlife. Conservation of susceptible fauna in these areas will depend on responsible pet ownership or stronger controls. New urban development close to the lower Molonglo River may result in an increased threat from these causes.

Terrestrial vertebrate pests identified of most concern in the Murrumbidgee and Molonglo River Corridors are wild pigs, wild dogs, European fox, rabbits, and feral cats (Environment ACT 1998, 2001a). Fallow Deer are widely distributed throughout the lower elevation riparian areas (D. Fletcher, pers. comm.) and whilst currently in low density, may represent an emerging threat. As well as these species, feral goats (populations of which have been reduced by aerial culling) and feral horses (which seasonally re-invade from Kosciuszko National Park and are culled) are also potential threats in the Cotter catchment (ACT Government 2002i; ACT Government 2005c).

#### OTHER HUMAN IMPACTS

As well as the impacts of pastoralism and farming, threats to riparian habitat and riverbank morphology derive from construction of infrastructure (dams, weirs, bridges), recreational use and facilities, road and river traffic, and dumping of rubbish. Human disturbance to habitat is exacerbated in riparian areas close to population centres. These impacts are discussed in more detail in Chapters 4 and 5.

# 3.2

## Riparian Zone Fauna in the ACT

A variety of data sources were used to compile composite information on fauna in riparian areas of the ACT region. These sources included scientific papers and books; reports and/or records of observations by government staff, consultants, other government agencies including the NSW Department of Environment and Conservation, and community groups such as the Canberra Ornithologists Group (COG). The detail and accuracy of these data vary within the region, depending upon the locations and methods of surveys and the inclusion of opportunistic observations.

Some terrestrial or amphibious animal species in the ACT region are restricted to, or highly dependent upon the riparian zone. Other animals that frequent riparian areas also occur in adjacent ecosystems such as forests, woodlands and grasslands. Riparian areas are important drought refuges for many of these species.

### 3.2.1 Birds

(Bird names are based on Barrett *et al*. 2003)

Riparian zones, particularly the Murrumbidgee and Molonglo river corridors, are noted for their high bird diversity (Taylor and COG 1992). Over 200 bird species have been recorded in the ACT and at least three-quarters of these have been recorded in the riparian zone. Few of the bird species occurring in the riparian zone are restricted to this habitat. Many bird species typically found in forests, woodlands and grasslands also use riparian areas and some birds strongly associated with riparian zones, such as waterbirds, also occur in wetlands outside the riparian zone (such as lakes and farm dams). Whereas individuals of some species may live entirely within the riparian zone (such as wrens, thornbills, some honeyeaters and other small, non-migratory passerines), individuals of other bird groups (such as raptors, ravens, currawongs, cockatoos and parrots) may satisfy their foraging, shelter and breeding requirements by having home-ranges that include a mix of riparian and other habitats. Riparian areas are an important component of the habitats used in seasonal altitudinal migrations by some species.

Compared to the rest of the ACT region, the Murrumbidgee and Molonglo river corridors have a higher diversity and abundance of raptors (birds of prey), with at least 12 species recorded. The Molonglo Valley provides critical hunting and breeding habitat for birds of prey due to the mosaic of habitats in the area (rural lands, woodlands, grasslands and river corridor). Commonly seen raptors in the river corridors include Wedge-tailed Eagle (*Aquila audax*), Little Eagle (*Hieraaetus morphnoides*), Whistling Kite (*Haliastur sphenurus*), Black-shouldered Kite (*Elanus axillaris*), Nankeen Kestrel (*Falco cenchroides*) and Brown Falcon (*Falco berigora*).
At least ten of these species are known to nest in the riparian zone, including the Wedge-tailed Eagle, White-bellied Sea Eagle (*Haliaeetus leucogaster*) and Peregrine Falcon (*Falco peregrinus*). For most of these species, especially the eagles and larger kites, the surrounding rural areas provide essential foraging habitat.

Other landbirds strongly associated with the riparian zone in the ACT region include Yellow Thornbill (*Acanthiza nana*) and Mistletoebird (*Dicaeum hirundinaceum*) (both of which use River Oaks and Mistletoe), Rainbow Bee-eater (*Merops ornatus*), Sacred Kingfisher (*Todiramphus sanctus*), Yellow-tufted Honeyeater (*Lichenostomus melanops*), Fairy Martin (*Hirundo ariel)*, Tree Martin (*Hirundo nigricans*), Welcome Swallow (*Hirundo neoxena*) and Clamorous

Reed-Warbler (*Acrocephalus stentoreus*). Vegetated riparian areas are also important habitat and movement corridors for small passerine species for which cover is important e.g. Mistletoe Bird (*Dicaeum hirundinaceum*), Silvereye (*Zosterops lateralis*), Western Gerygone (*Gerygone fusca*) and White-browed Scrubwren (*Sericornis frontalis*). Yellow-tailed Black-Cockatoos (*Calyptorhynchus funereus*) are common along the Murrumbidgee River, but historically have been rare in areas to its east (Taylor and COG 1992). Loss of the extensive pine plantations in the lower Cotter and Paddys River areas in the bushfires of 2003 has resulted in the species becoming a common sight in urban Canberra (COG 2006). Sulphur-crested Cockatoos (*Cacatua galerita*) have a strong association with the Murrumbidgee River corridor.

Waterbirds are attracted to a range of waterbodies in the ACT region that include lakes, ponds, rural dams, streams and rivers. Australian waterbirds are largely nomadic, their movements triggered by flooding and drought. They are also capable of moving large distances, providing the potential for numerous species to visit the ACT on a regular or vagrant basis. Because of the presence of permanent waterbodies in the ACT region, many waterbird species are residents that stay year-round and breed. Lake Burley Griffin and Molonglo Reach are important breeding locations for a significant population of the Darter (*Anhinga melanogaster*) and three species of cormorants: Great (*Phalacrocorax carbo*); Little Black (*Phalacrocorax sulcirostris*); and Little Pied (*Phalacrocorax melanoleucos*) (Allan 2003). The most commonly seen species in the riparian zone and associated streams and rivers include the Great Cormorant (*Phalacrocorax carbo*), Little Pied Cormorant (*Phalacrocorax melanoleucos*), White-faced Heron (*Egretta novaehollandiae*), Pacific Black Duck (*Anas superciliosa*), Australian Wood Duck (*Chenonetta jubata*), Australasian Grebe (*Tachybaptus novaehollandiae*) and to a lesser extent Dusky Moorhen (*Gallinula tenebrosa*), Purple Swamphen (*Porphyrio porphyrio*), Eurasian Coot (*Fulica atra*) and Nankeen Night Heron (*Nycticorax caledonicus*). Latham's Snipe (*Gallinago hardwickii*), a migrant between Australia and Japan, occurs in wetlands and riparian areas of the ACT.

Not all water bodies are equally suitable habitat for waterbirds. The upper reaches of rivers and streams, which are fast-flowing and rocky, or deep cold water in dams such as Corin Dam, are not ideal habitat. Most waterbird species prefer shallow, still or slow-flowing water bodies with abundant emergent or fringing vegetation.

**HONEYEATER MIGRATION**

First documented in the early 1950s, the autumn exodus of many thousands of honeyeaters from the Canberra region to lower elevations nearer the coast is a special phenomenon (Taws 1999; Wilson 1999). The birds mass together and move from the higher ranges in a general west to east direction following various land features, especially the river systems including the Murrumbidgee Valley. Honeyeaters using riparian zones for migration are mostly the Yellow-faced Honeyeater (*Lichenostomus chrysops*) and White-naped Honeyeater (*Melithreptus lunatus*), and to a lesser extent Fuscous Honeyeater (*Lichenostomus fuscus*), Red Wattlebird (*Anthochaera carunculata*), Noisy Friarbird (*Philemon corniculatus*) and White-eared Honeyeater (*Lichenostomus leucotis*).

The availability of tree cover along the Murrumbidgee River is a particular issue, as the migrating honeyeaters prefer to make short distance flights between cover rather than crossing extensive open areas. Historically, Point Hut Crossing was a major location for exiting the river corridor but the Angle Crossing area has emerged as a major gathering and exit point in recent years. East of the river at Angle Crossing, the Ingeldene pine plantations used to provide a corridor of cover before the 2003 bushfires. Urban development close to Point Hut and lack of vegetation cover may be the reason for the shift in movement patterns. Revegetation with trees and shrubs at strategic nodes along the Murrumbidgee River is likely to assist movement along and exit from the corridor.

### 3.2.2 Mammals

Native mammals occurring in riparian zones of the ACT region include large grazing marsupials, smaller ground dwelling mammals, arboreal marsupials and bats. Two mammal species (Platypus *Ornithorhynchus anatinus* and Eastern Water Rat *Hydromys chrysogaster*) are largely restricted to waterbodies and the adjacent riparian zone. These species are somewhat cryptic and not often readily observed, but neither is particularly rare. Both species were hunted in the past for fur to make rugs and coats, and given that a rug required 60–80 Platypus pelts, the impact on populations was probably considerable (Lintermans and Osborne 2002).

The range of the Platypus is eastern Australia including Tasmania, but its distribution is discontinuous and related to the presence of suitable bodies of fresh water (Carrick 1995). Features of suitable habitat are: (a) water depth of less than about 5 m as the species must be able to dive to the bottom to feed, (b) suitable

banks for resting burrows (3–5 m long) and nesting burrows (3–8 m, but up to 30 m long), and (c) a substrate not smothered in sediment which results in declining abundance of freshwater invertebrates, the main food for Platypus (Lintermans and Osborne 2002). Threats to platypus are sedimentation of pools, clearing of riparian vegetation and stock trampling (resulting in slumping of riverbanks and their unsuitability for burrows), and human disturbance (domestic dogs, entanglement in plastic litter, and entrapment in illegal gill nets) (Lintermans and Osborne 2002). Platypus are still regularly recorded from the Cotter, Murrumbidgee and Molonglo rivers, and are commonly observed in the waterfowl dams at Tidbinbilla Nature Reserve.

The Eastern Water Rat is an active swimmer creating a distinctive 'V' shaped wake on a calm water surface. Individuals often have a favourite surface used for feeding, such as a flat rock, where food remains are left. They feed on a wide range of other animals, including large insects, fish, crustaceans, mussels, frogs, lizards, small mammals and even waterbirds, mostly taken in the water. The species lives in burrows in the banks of rivers and lakes. Drainage of wetlands has reduced some of their habitat and they appear to be sparse along rivers, however, they have adapted to drainage swamps in irrigated areas and to urban lakes in the ACT. Hunting until the 1940s seriously reduced their numbers, but they have subsequently recovered, and are considered to be common and widespread in the ACT and region. Clearing of riparian vegetation and stock trampling may result in slumping of riverbanks and their unsuitability for burrows (Lintermans and Osborne 2002). Water rats are commonly found in the urban lakes such as Lake Burley Griffin and Lake Ginninderra and have been recorded from the Molonglo, Cotter, Paddys, Orroral, Naas, Tidbinbilla and Murrumbidgee rivers and Sullivans and Ginninderra creeks.

The other mammals occurring in the riparian zone in the ACT region are also found in a range of non-riparian ecosystems such as forests, woodlands or grasslands. Some of these species have adapted well to pastoral and urban areas, particularly where mature native trees have been retained.

Larger native mammals include Common Wombat (*Vombatus ursinus*), the ubiquitous Eastern Grey Kangaroo (*Macropus giganteus*), Red-necked Wallaby (*Macropus rufogriseus*), Swamp Wallaby (*Wallabia bicolor*) and, less commonly, Wallaroo (*Macropus rubustus*). The small mouse-like insectivorous Agile Antechinus (*Antechinus agilis*) and the Dusky Antechinus (*Antechinus swainsonii*) have been recorded in riparian areas and it is likely that the other Antechinus species in the ACT region, the Yellow-footed Antechinus (*Antechinus flavipes*), also occurs in riparian areas. There are some records of the vulnerable Spotted-tailed Quoll (*Dasyurus maculatus*) from riparian areas in the Orroral Valley in Namadgi National Park (ACT Government 2005b). Other native ground mammals frequenting riparian zones include the Bush Rat (*Rattus fuscipes*), the Broad-toothed Rat (*Mastacomys fuscus*) and Echidna (*Tachyglossus aculeatus*). Arboreal marsupials include the Common Brushtail Possum (*Trichosurus vulpecula*), Common Ringtail Possum (*Pseudocheirus peregrinus*) and Sugar Glider (*Petaurus breviceps*). The Koala (*Phascolarctos cinereus*) is rare in the ACT region, but there are historical records from riparian areas.

Bats occur in a range of habitats in the ACT region including riparian areas, which are used for feeding on insects flying above water or for roost sites in tree hollows. Bat species known to occur in riparian areas of the ACT region are the Eastern False Pipistrelle (*Falsistrellus tasmaniensis*), Lesser Long-eared Bat (*Nyctophilus geoffroyi*), Gould's Long-eared Bat (*N. gouldi*), White-striped Freetail Bat (*Tadarida australis*), Chocolate Wattled Bat (*Chalinolobus morio*), Gould's Wattled Bat (*C. gouldii*), Common Bentwing Bat (*Miniopterus schreibersii*), Little Forest Bat (*Vespadelus vulturnus*), Southern Forest Bat (*V. regulus*), Large Forest Bat (*V. darlingtoni*) and Southern Freetail Bat (*Mormopterus planiceps*) (Menkhorst and Knight 2001).

### 3.2.3 Reptiles

(Reptile common names are based on Lintermans and Osborne (2002) with common names used locally in brackets.)

The riparian zone in the ACT region provides habitat for many species of reptiles, most of which are also found in other habitats. Snakes typically associated with riparian areas are the Red-bellied Black Snake (*Pseudechis porphyriacus*), Highland Copperhead (*Austrelaps ramsayi*) (usually found above 700m) and Eastern Tiger Snake (*Notechis scutatus*). The Eastern Brown Snake (*Pseudonaja textilis*) is common in the ACT and occasionally seen in riparian areas.

The Eastern Snake-necked Turtle (Long-necked Tortoise) (*Chelodina longicollis*) is the most truly aquatic reptile species and is common and widespread throughout the ACT, occurring wherever there is a water source such as a creek, river, swamp or farm dam. The species is distributed throughout eastern continental Australia along coastal and inland waterways (Cogger 2000). It is an active freshwater predator capturing a wide range of

invertebrates, snails and frogs. Preferred habitat is swamps and well-vegetated farm dams, but the species is also found in slow moving rivers and lakes. Turtles sometimes undertake extensive overland migrations in summer when many are run over by motor vehicles. Mechanised disturbance to river channels and banks may destroy nesting sites (Lintermans and Osborne 2002).

The Murray River Short-necked Turtle (Murray Turtle) (*Emydura macquarii*) occurs in the Murrumbidgee River downstream of the ACT and is relatively common in Lake Burrinjuck. However, the northern ACT border is close to the upstream limit of this species in the Murrumbidgee Catchment and it is rare in the ACT (Lintermans and Osborne 2002).

At least 41 lizard species have been recorded in the ACT region and many of these are present in riparian areas where there is suitable substrate such as rocks, fallen timber, leaf litter and grass tussocks. The Gippsland Water Dragon (*Physignathus lesueurii howittii*) and Heatwole's Water Skink (*Eulamprus heatwolei*) are riparian species typically associated with watercourses. The Gippsland Water Dragon is common along streams and rivers in the lowland parts of the ACT and region. The dragons forage along banks for invertebrates, fruits and flowers and may also take small lizards, crustaceans and fish. They are often noticed as they leap from tree branches or logs into the water. Vegetation, logs and other debris along watercourses are important habitat for this species (Lintermans and Osborne 2002). The Nobbi Dragon (*Amphibolurus nobbi*) is uncommon and in the ACT has only been recorded from dry, rocky woodlands close to the Murrumbidgee River. Rosenberg's Monitor (*Varanus rosenbergi*), a species rarely seen in the ACT, has been recorded near the Orroral, Murrumbidgee and Queanbeyan rivers (Lintermans and Osborne 2002) and there is one record from the Kowen escarpment near Molonglo Gorge. Stony hillsides within riparian areas of the Murrumbidgee and Molonglo rivers contain key habitat for the threatened Pink-tailed Worm Lizard (*Aprasia parapulchella*) (see section 3.3.2). Much of the known habitat for this species is within these river corridors.

### 3.2.4 Amphibians

Frogs occur in a range of wetter habitats in the ACT region. Riparian zones tend to contain moist terrestrial areas (under rocks, logs and leaf-litter and in thick vegetation) that provide habitat for frogs. Most species of frog live on land, although free water is required for their aquatic stages (eggs and tadpoles) and for rehydration. Streams, rivers and large dams or lakes generally provide poor habitat for the aquatic stages of most frog species, as they tend to be fast-flowing or deep and have aquatic predators such as fish and Dragonfly (Odonata) larvae. Many species prefer aquatic habitats that are shallow, still, or slow-flowing, have few predators and contain abundant aquatic vegetation (such as swampy areas, temporary pools and farm dams). Nevertheless, there is a component of the frog fauna that occurs along rivers and streams. These are collectively referred to as 'riverine frog species' (Hunter and Gillespie 1999). Trout are considered to be significant predators on some of these species, resulting in low population densities in upland streams. It is likely that fish are able to exert their greatest impact on frog populations by preying upon larval stages rather than adults (Gillespie and Hero 1999; Gillespie and Hines 1999).

In the ACT this riverine group includes the rare Southern Leaf-green Tree Frog (Cotter River form) (*Litoria nudidigitus*), Lesueur's Frog (*Litoria lesueuri*) and Broad-palmed Frog (*Litoria latopalmata*), all of which are strongly associated with riparian areas. The Southern Leaf-green Tree Frog is rare in the ACT region, being known only from the Cotter River in the ACT and the Goodradigbee and Geehi rivers in NSW. Lesueur's Frog is widely distributed across the ACT region and is strongly associated with rocky streams. The Broad-palmed Frog is largely restricted to riparian areas of the lower Murrumbidgee and Molonglo rivers and adjacent creeks and farm dams. Other species known or likely to be found in riparian areas in the ACT region include Peron's Tree Frog (*Litoria peronii*), Whistling Tree Frog (*Litoria verreauxii*), Plains Froglet (*Crinia parinsignifera*), Common Eastern Froglet (*Crinia signifera*), Eastern Banjo Frog (*Limnodynastes dumerilii*), Brown-striped Frog (*Limnodynastes peronii*), Spotted Grass Frog (*Limnodynastes tasmaniensis*), Smooth Toadlet (*Uperoleia laevigata*) and the uncommon Brown Toadlet (*Pseudophryne bibronii*) (Cogger 2000; Lintermans and Osborne 2002; Rauhala 1997).

The threatened Northern Corroboree Frog (*Pseudophryne pengilleyi*) occurs in pools and seepages in *Sphagnum* bogs, wet tussock grasslands and wet heath in the Brindabella and Bimberi ranges in the ACT. This species is not included in this *Strategy* but is the subject of a separate Action Plan (ACT Government 1997).

### 3.2.5 Invertebrates

Insects, other macro-invertebrates and microbiota account for more than 90 per cent of biodiversity and are vital for healthy ecosystem function. They are essential for pollination and reproduction of many

woodland plants, are involved in nutrient recycling through the breakdown of dead plant and animal material and are the main food of many aquatic and terrestrial animals. Terrestrial invertebrates are more diverse and abundant in habitats with mature trees (loose bark) and a well-developed ground cover of leaf litter, rocks, logs, branches or tussock grasses. Less information, however, exists on the composition, biodiversity and ecological requirements of invertebrates in most ecosystems (including riparian) than for other faunal groups. Consequently, conservation of most invertebrate species falls under the umbrella of habitat protection for vertebrates and vegetation communities.

There is increasing recognition of the importance of mistletoe in woodland ecosystems and as a 'keystone' resource for some fauna (Watson 2001). For example, Needle-leaf Mistletoe (*Amyema cambagei*) on *Casuarina cunninghamiana* in ACT riparian zones is the food plant for the larvae of the small brilliant blue butterfly Amaryllis Azure (*Ogyris amaryllis amata*) mainly found flying high in the canopy of mature trees. The larvae of the Wood White butterfly (*Delias aganippe*) also feed on this species (Common and Waterhouse 1981). Mistletoe offers food, shelter, nest sites and protection from predation for a wide variety of bird species from raptors to fairy-wrens (Watson 2001).

Aquatic macroinvertebrates are discussed in Chapter 4.

# 3.3

## Threatened and Uncommon Riparian Zone Fauna Species in the ACT

The riparian zone in the ACT region provides important habitat for several threatened or uncommon terrestrial or amphibious species that are strongly associated with riparian habitats. Threatened species include the Painted Honeyeater (*Grantiella picta*) and the Pink-tailed Worm Lizard (*Aprasia parapulchella*). These species are discussed in section 3.3.2.

Many threatened or uncommon species typically associated with the adjacent woodlands or grasslands also use the riparian zone to varying extents. Riparian vegetation is important for birds in partially cleared landscapes. Eight woodland bird species are declared as threatened in the ACT under the *Nature Conservation Act 1980* (ACT Government 2004a). In addition to these threatened species, there is a suite of woodland bird species that is in apparent decline based on evidence from Taylor and COG (1992), Reid (1999), Traill and Duncan (2000), and data from both COG and NSW Atlasers group. This suite includes the Diamond Firetail (*Stagonopleura guttata*), Speckled Warbler (*Chthonicola sagittata*), Flame Robin (*Petroica phoenicea*), Crested Shrike-tit (*Falcunculus frontatus*), Scarlet Robin (*Petroica multicolor*), Jacky Winter (*Microeca fascinans*), Dusky Woodswallow (*Artamus cyanopterus*) and White-fronted Chat (*Epthianura albifrons*). The White-bellied Sea-Eagle, an uncommon species in the ACT, has been recorded nesting in the riparian zone of the lower Molonglo River. Cliffs along the Molonglo and Murrumbidgee rivers provide some of the few suitable nesting sites in the ACT for Peregrine Falcons. This species is thought to use the same cliff nest sites, in some cases for hundreds of years. The Little Eagle, an uncommon species in the ACT (COG 2006), appears to be declining possibly due to habitat loss and competition with the Wedge-tailed eagle.

The uncommon Nobbi Dragon (*Amphibolurus nobbi*) is largely confined to eucalypt and cypress pine woodlands with a northerly or westerly aspect flanking the Murrumbidgee River. Rosenberg's Monitor (*Varanus rosenbergi*) is rarely seen in the ACT (s. 3.2.3) and is listed as vulnerable in New South Wales.

The rare Southern Leaf-green Tree Frog (Cotter River form) is known only from the Cotter River in the ACT (see s. 3.2.4). The Brown Toadlet has disappeared from bushland in the vicinity of Canberra and is now known only from a few scattered sites in riparian areas in the foothills of the southern ACT.

Key's Matchstick Grasshopper (*Keyacris scurra*), an uncommon grassland invertebrate, has been recorded from several sites in the ACT including areas adjacent to the Murrumbidgee River.

### 3.3.1 Conservation of Riparian Zone Fauna in the ACT

Consistent with the requirements for threatened species in the *Nature Conservation Act 1980*, protection goals adopted for the *Aquatic Species and Riparian Zone Conservation 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.**

As noted in s. 3.1.1, riparian zones are important as habitat in their own right, as ecological or linking corridors, and as a distinctive part of a wider habitat mosaic with special features such as access to water and often structurally complex vegetation.

The major threat to riparian zone fauna in the ACT and

region and the apparent reason for decline of some species is the loss, modification and fragmentation of riparian habitat (s. 3.1.3). The premise of this *Strategy* is that protection in nature reserves and off-reserve conservation management of riparian habitat provides the foundation for long-term conservation of riparian zone fauna, including threatened species. For this reason, objectives and actions in the *Strategy* for conservation of fauna relate largely to habitat protection and management. In general, the *Strategy* takes an ecosystem approach to the conservation of riparian zone fauna rather than treating each species separately. Exceptions are threatened species, for which there is a legislative requirement to prepare Action Plans. In addition, some threatened species have specific recovery requirements.

From the general threats previously discussed (s. 3.1.3), it is evident that all riparian zone fauna will be advantaged by the conservation of the linear connectivity of riparian zone vegetation communities and streambank condition, as well the connectivity to upslope terrestrial ecosystems. Previous and ongoing land uses have impacted severely on this connectivity.

Actions undertaken to conserve threatened, declining or uncommon animal species and their habitats will also benefit the more abundant animal species. For example, maintenance of the *Casuarina cunninghamiana* community (especially large trees with mistletoe) is important for a number of birds and invertebrates. Any key conservation requirements for non-threatened species that do not fall under the umbrella of protection of the riparian zone or habitat protection for threatened species need to be explicitly identified.

Objectives and actions for the *Strategy* related to riparian zone fauna, including threatened species, are shown in Table 6.1. The actions are not designed to prescribe every detailed task needing to be undertaken. Detailed actions will be developed by responsible agencies, often with community involvement and will be refined over time as more information is gained (as part of 'adaptive management'). With regard to threatened species, objectives and actions in this *Strategy* must be integrated with state and national conservation efforts. Information in the next section provides a guide to more detailed or specific actions related to the conservation of threatened species.

Conservation of riparian habitat in the ACT contributes to the regional conservation of several threatened (e.g. Painted Honeyeater) or uncommon (e.g. Nobbi Dragon) animal species and to those species that regularly use riparian zones as migration routes (e.g. Yellow-faced Honeyeater). The long-term viability of threatened and uncommon species across their range at regional or national levels is dependant on appropriate conservation measures both within and outside the ACT.

### 3.3.2 Conservation Actions: Threatened Riparian Zone Fauna Species in the ACT

Two listed threatened species are strongly associated with riparian zones in the ACT. These are the Painted Honeyeater *Grantiella picta* and the Pink-tailed Worm Lizard *Aprasia parapulchella* (Table 3.1).

#### Threatened Species: Painted Honeyeater (*Grantiella picta*)

The Painted Honeyeater is one of the bird species included in the *ACT Lowland Woodland Conservation Strategy*, which contains conservation actions for the

**Table 3.1: Conservation Status Nationally of Threatened Animal Species Occurring in ACT Riparian Zones**

| Species | ACT | NSW | Cwlth | Other |
|---|---|---|---|---|
| Painted Honeyeater | V | V | — | V(Vic), R(Qld) |
| Pink-tailed Worm Lizard | SPS | V | V | E(Vic) |

**V:** Vulnerable; **SPS:** Special Protection Status; **E:** Endangered; **R:** Rare.

LEGISLATION:

**Commonwealth:** *Environment Protection and Biodiversity Conservation Act 1999*

**ACT:** *Nature Conservation Act 1980*

**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*

species (ACT Government 2004a, pp. 53–54). The most significant of these is the conservation of its woodland habitat, comprising Yellow Box–Red Gum grassy woodland and *Casuarina cunninghamiana* riparian woodland.

This species was recorded from River She-oak (*Casuarina cunninghamiana*) along the Murrumbidgee River in 1948 and 1950 (Lamm and Calaby 1950) and occasionally in subsequent years. Wilson (1984) noted the large trees near Uriarra Crossing as a breeding area. However, since these earlier reports there have been no records of large numbers of Painted Honeyeaters associated with River She-oaks. The breeding distribution of *G. picta* is dictated by the presence of mistletoes, which are largely restricted to older trees, and by the seasonality of mistletoe fruiting (Garnett and Crowley 2000). River Oaks in the riparian zone of the Murrumbidgee River are host to the Needle-leaf Mistletoe (*Amyema cambagei*).

The Painted Honeyeater has been described as a 'very rare vagrant making a spectacular influx to the region' (COG 2003). In 2002–2003, an influx of at least 35 birds was reported (Bounds 2003). Most records were from Yellow Box–Red Gum grassy woodlands away from the riparian zone (COG 2003). This followed four decades with few reported sightings (Wilson 1999). The species was again present in the Canberra region in spring and early summer of 2004, with most records from a woodland remnant north of Gundaroo (Bounds 2004).

### Threatened Species: Pink-tailed Worm Lizard (*Aprasia parapulchella*)

The Pink-tailed Worm Lizard has a restricted and patchy distribution in south-eastern Australia. Most of the known population occurs in the ACT, where the species has a fairly wide distribution and is locally common. Outside the ACT it is known from only scattered and isolated sites, including Tarcutta, Cootamundra, Cooma, Queanbeyan, Bathurst, Albury and Yass in NSW and near Bendigo in Victoria (NSW NPWS 1999).

Within the ACT, the species is largely restricted to the Murrumbidgee and Molonglo river valleys and nearby hillslopes (in particular Mt Taylor). Major populations in the ACT occur in the lower Molonglo River corridor from upstream of Coppins Crossing to the junction with the Murrumbidgee River, Mount Taylor and Cooleman Ridge, Woodstock, Stony Creek, Bullen Range and Gigerline reserves in the Murrumbidgee River Corridor. There are also some records from Googong foreshores (Figure 3.1) (Barrer 1992b; Osborne and McKergow 1993; Osborne and Jones 1995, Osborne *et al.* 1991, Osborne pers. comm.). The Molonglo and Murrumbidgee river corridors are particularly important, because they provide extensive corridors of habitat that potentially allow for dispersal and hence gene flow between localised populations.

The Pink-tailed Worm Lizard is a small, thin, legless lizard that lives a largely subterranean existence. It apparently spends considerable time beneath partly embedded rocks in ant tunnels. It is a dietary specialist feeding on the eggs and larvae of various ant species, mainly *Iridomyrmex 'rufoniger'* (Webb and Shine 1994; Jones 1999). Its habitat is open grassland communities, usually dominated by Kangaroo Grass (*Themeda triandra*), with numerous partially embedded rocks. These areas typically have not been pasture improved and still have a moderate to extensive cover of native grasses (Osborne and Jones 1995). Soils at these locations include infertile skeletal soils and darker, deeper, finely grained soils with a porous or sandy fabric (Barrer 1992b). The Pink-tailed Worm Lizard has specialised habitat requirements in that it lives beneath partly embedded rocks in burrows formed initially by ant colonies. In the ACT region, suitable habitat for the lizard occurs in open (treeless) rocky areas on hillsides, and, particularly, on slopes of the Molonglo and Murrumbidgee river valleys (Osborne and Coghlan 2004). It is this particular land surface and associated ant biota that is critical habitat for the species rather than a riparian location, *per se*. A more detailed description of the species and its ecology is given in Appendix 1.2.

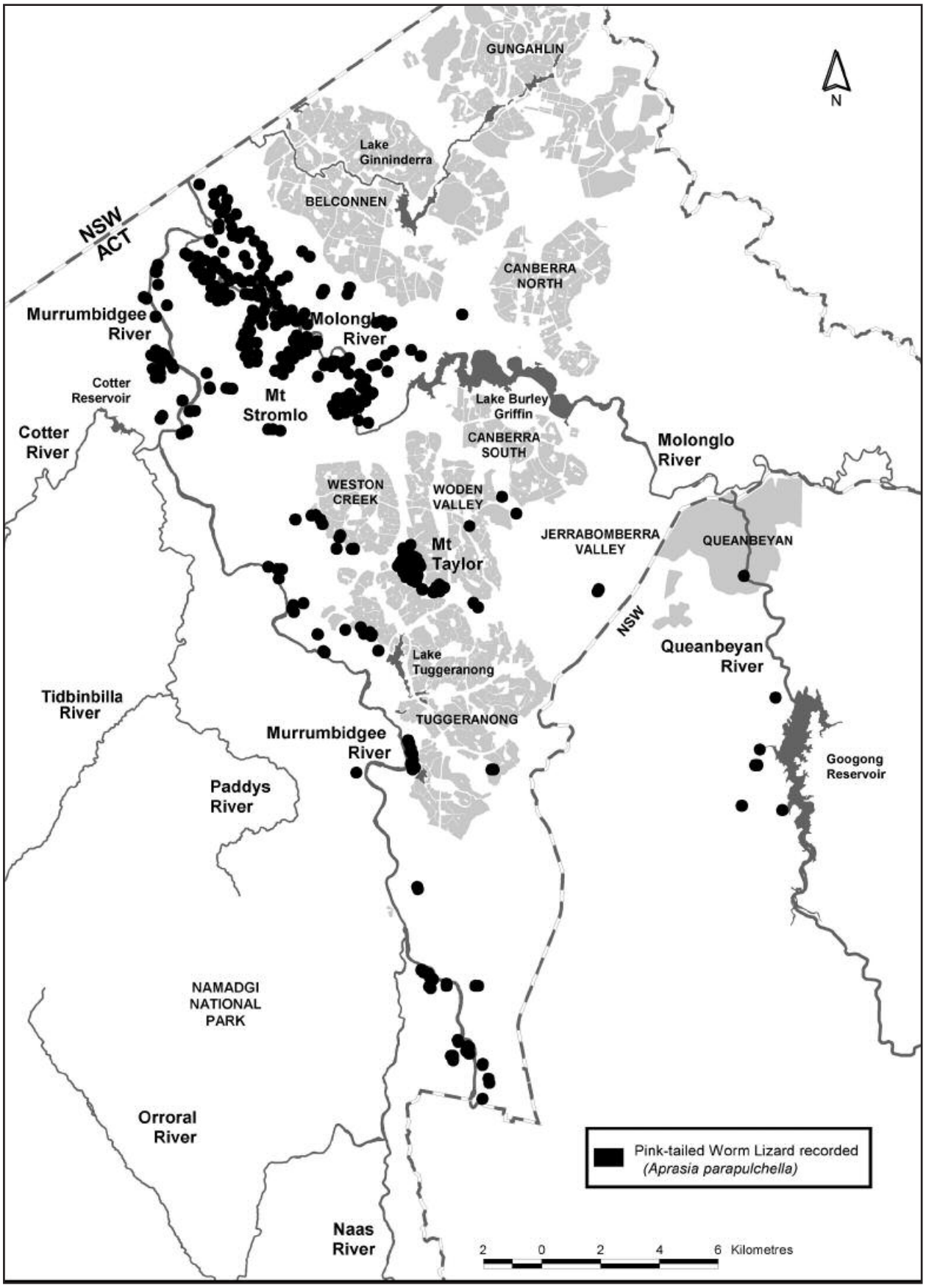
Because of its restricted distribution, low abundance, and threats to its habitat, the Pink-tailed Worm Lizard has been given formal conservation status at the national level and in each state or territory in which it occurs. It is declared threatened (endangered) in Victoria, and vulnerable in NSW and under Commonwealth legislation (Table 3.1). In the ACT, the species is reasonably common, mostly occurs in nature reserves, and is not considered to be in danger of extinction (Osborne and Coghlan 2004). For this reason it is not declared a threatened species in the ACT, but has been assigned Special Protection Status (SPS) under the *Nature Conservation Act 1980* (ACT), recognising the importance of the ACT populations in a national and regional context.

#### THREATS

The Pink-tailed Worm Lizard is a grassland species closely associated with rocky ground surfaces. The main threats to the species are:

- The loss or degradation of this habitat (by livestock grazing, cultivation and other forms of soil disturbance, rock removal, tree and/or shrub growth, weed invasion).

**Figure 3.1: Records of the Pink-tailed Worm Lizard (Aprasia parapulchella) in the ACT and at Googong Foreshores**



- The small size and fragmentation of the sites that now support the species across its known range.

The concentration of remaining populations of the species in the ACT appears to be related to less soil (and rock) disturbance than elsewhere, evidenced by the presence of a native grass cover, particularly Kangaroo Grass *Themeda triandra*, Red-leg Grass *Bothriochloa macra*, and Wattle Mat-rush *Lomandra filiformis*. The likelihood of occurrence of the lizard increases with increasing cover of Kangaroo Grass. By contrast, increase in cover of speargrasses (*Ausrostipa scabra* ssp. *falcata, A. bigeniculata*), weeds (indicators of disturbance) and River Tussock (*Poa labillardieri*) decreases the likelihood of finding the species (Jones 1992, 1999). In NSW sites, dominance by Kangaroo Grass is not a common feature, but the sites would still be described as native grassland (NSW NPWS 1999). Livestock grazing and agricultural activities (e.g. pasture improvement, cropping) have probably had the most impact on populations of the species through ground disturbance and changes to groundcover vegetation, and remain a threat to the lizard in the ACT outside reserves.

Rocks are an important micro-habitat feature for the species and rock removal is a threat. Rock removal may increase predation risk and potentially have a significant impact on small separated populations (NSW NPWS 1999). Bushrock removal is listed as a key threatening process in NSW for a number of species including the Pink-tailed Worm Lizard.

Establishment of shrub or tree cover on grassland sites is another threat. In the ACT, plantation pine trees have been planted over rocky clearings that supported small populations (Osborne and Coghlan 2004). There is also a potentially serious threat from the spread of Burgan (*Kunzea ericoides*) and St John's Wort (*Hypericum perforatum*), which have colonised pastoral land and invaded native grassland along the Murrumbidgee and Molonglo rivers (Kirschbaum and Williams 1991; Osborne and Jones 1995, Osborne pers. comm.).

While ACT populations of the species are in areas with habitat connectivity (Murrumbidgee and Molonglo river valleys and Mt Taylor), the main threat to NSW populations is pasture improvement and the small and fragmented nature of sites that support the species. At Tarcutta and Bathurst, the species survives in single populations and extensive searches of apparently suitable sites have failed to locate more. This has serious consequences for the long-term survival of the lizard at these sites (NSW NPWS 1999). In the ACT, maintaining habitat connectivity is an important consideration in planning for urban development in the Molonglo Valley (ACT Government 2004b, p. 72). Habitat areas are likely to experience urban edge effects once urban development proceeds (see s. 2.3.1).

### CONSERVATION OBJECTIVE

The conservation objective is to protect in perpetuity viable populations of the Pink-tailed Worm Lizard in secure native grassland habitat across the range of the species in the ACT and maintain its potential for evolutionary development in the wild.

### CONSERVATION ACTIONS

A national recovery plan for the Pink-tailed Worm Lizard was prepared in 1995 and a significant proportion of the biological research recommended for the species has since been carried out (Osborne and Jones 1995; Jones 1999). Surveys were carried out in the ACT and region in the early 1990s (Osborne *et al.* 1991;Osborne and McKergow 1993; Barrer 1992b) and later, in the Tarcutta, Adelong and Bathurst districts, with no new records of the species (Jones 1999). Significant advance was made in the 1990s on knowledge of the biology and ecology of the species including diet, abundance and habitat relationships (Jones 1992); the relationship between the lizard and ant species (Robinson 1996); and diet and ant relationship, reproduction and population dynamics, habitat and microhabitat and conservation management (Jones 1999). There is still limited knowledge of the ability of the species to recover after habitat disturbance. Anecdotal evidence suggests limited ability to survive habitat changes following intensive grazing pressure and subsequent population extinctions. The specialised habitat and dietary requirements of the species suggest that more intensive, focussed management may be needed to maintain the species in the long term (NSW NPWS 1999).

The following conservation actions (mostly to be undertaken by Environment and Recreation) are framed within the objectives and actions for the Strategy as a whole in Table 6.1.

**Information (Survey, Monitoring, Research)**

- Maintain alertness to the possible presence of the Pink-tailed Worm Lizard when undertaking surveys in appropriate habitat.
- Continue to monitor habitat (vegetation composition and presence of rocks) and Pink-tailed Worm Lizard populations at known sites, including impacts of management practices (particularly grazing).
- Encourage, support, coordinate, and where practicable, undertake research into the biology

and ecology of the Pink-tailed Worm Lizard as a basis for managing the species and its habitat. More specifically, research is required to better understand:

- —movement, seasonal activity, home-range and habitat use, dispersal capability, ability to move between fragmented habitat;
- —population demographics, including sex ratios and age structure, survivorship, sources of mortality;
- —reproductive rates and behaviour, breeding requirements, oviposition sites;
- —susceptibility to fires and seasonal effects, optimum fire regimes, value and use of firebreaks;
- —ecological relationship to ants (food and shelter), ecological relationship of ants to habitat (vegetation, rocks);
- —impact of invasive species, particularly weeds such as Burgan (*Kunzea ericoides*) and St John's Wort (*Hypericum perforatum*); and
- —sensitivity of habitat to trampling or other potential damage from multiple use.

**Protection and Management**

- Seek to ensure known populations of the Pink-tailed Worm Lizard are protected from inadvertent damaging actions such as the application of fertilisers (e.g. by advising land owners and managers of their presence).
- Seek to ensure that urban development and associated recreational pressures do not adversely impact on the viability of the species in the ACT.
- Encourage management to be undertaken in an adaptive framework, and facilitate the incorporation of research results into management of the Pink-tailed Worm Lizard and its habitat.
- Manage sites, and provide advice to other landowners and managers, to maintain optimum habitat for the species (in particular, prevention of intensive grazing, maintenance of native grass cover, retention of partially embedded surface rocks).
- To assist landowners and managers, prepare specific management guidelines for the species, where required.

**Regional and National Cooperation**

Maintain links with, and participate in, regional and national recovery efforts for the Pink-tailed Worm Lizard to ensure that ACT conservation actions are coordinated with regional and national programs.

### 3.3.3 Conservation Actions: Uncommon Riparian Zone Fauna Species in the ACT

Species not declared under ACT or Commonwealth legislation as vulnerable, endangered or Special Protection Status may be also of conservation concern and it is important that their status be monitored over time and threats minimised.

Some species occurring in riparian zones are uncommon because they are either at the margin of their distribution, occur naturally at low density or have declined in abundance. Some are vagrants or annual seasonal migrants to the ACT (e.g. migratory honeyeaters). Some of these species are of conservation concern because declines (in the ACT or elsewhere) may be continuing and because small populations tend to be more vulnerable to disturbance. The conservation status of uncommon species needs to be considered in a regional context.

Riparian zone habitat on the Murrumbidgee, Molonglo and Cotter rivers was burnt in the major bushfire of January 2003 with severe impacts recorded on River Oak (*Casuarina cunninghamiana*) (Carey *et al.* 2003). This loss of habitat is likely to have had impacts for riparian zone fauna.

Many declining, uncommon or rare species in the ACT typically associated with woodlands or grasslands are also likely to use the adjacent riparian zone to varying extents, and these species are discussed in s. 3.2. Species strongly associated with the riparian zone that are uncommon in the ACT region include White-bellied Sea-Eagle, Peregrine Falcon, Nobbi Dragon, Rosenberg's Monitor, Southern Leaf-green Tree Frog (Cotter River form) and Brown Toadlet.

**CONSERVATION OBJECTIVE**

Uncommon fauna species using riparian zones in the ACT are maintained in viable populations in perpetuity.

**CONSERVATION ACTIONS**

The following conservation actions for uncommon riparian zone fauna species (mostly to be 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 fauna species when undertaking surveys in riparian zones.
- Maintain a database of known occurrences and abundance of uncommon fauna species that use the riparian zone to enable analysis of changes in distribution and abundance.

- Maintain a watching brief on uncommon fauna species that use ACT riparian zones and evaluate their conservation status in a regional context.
- Facilitate and encourage research that will provide information on the status of uncommon fauna species that use ACT riparian zones and their management requirements.

**Protection and Management**

- Seek to ensure known populations of uncommon fauna species and species that use ACT riparian zones are protected from inadvertent damaging actions (e.g. by advising landowners and managers of their presence).
- Prepare management guidelines for uncommon fauna species where necessary.
- Manage sites, and provide advice to other landowners and managers, to maintain optimum habitat (where known) for uncommon fauna species.
- Consider nomination for ACT listing if uncommon fauna species show evidence of local decline in extent and abundance.

**Regional and National Cooperation**

- Liaise with interstate agencies involved in protection and management of uncommon fauna species that use ACT riparian zones with the aim of increasing knowledge of their biology, and habitat and conservation requirements.

# 4 Fish, Crayfish and Macroinvertebrates in ACT Rivers

## 4.1

### Aquatic Habitats

The physical characteristics of ACT rivers and their riparian zones have been outlined in s. 2.1.1 to s. 2.1.3. Before European settlement, the upper reaches of these rivers were characterised by bogs and seepage lines developing into creeks and narrow, often rocky, stream channels. Through the undulating elevated plains around Canberra, stream channels became broader with deep pools separated by rock bars, and deposits of sand, silt, logs and debris. Floods formed river terraces within the normally confined valleys, but there was no substantial floodplain development. Snow melt and winter rainfall in the mountains was the main factor in providing an annual flow cycle, with high flows of colder water in spring, and flows reducing and water becoming warmer through the summer. Late spring and summer storms could bring temporary rises in water level, but it is likely that flows dropped to a trickle or dried up altogether in some seasons. During these times, aquatic life would find refuge in the deep river pools.

The European pastoral economy (see s. 2.3.1) brought rapid changes to rivers and streams, following clearing in catchments, intensive stock grazing and cultivation of some areas. Clearing of riparian vegetation removed the major source of logs, woody debris and leaves to the streams. Increased runoff following clearing and grazing resulted in stream channel incision and gully erosion, loss of the 'chain-of-ponds' structure in tributary streams (permanent pools separated by shallow or ephemeral areas), and substantial sedimentation of the rivers (that began to fill the deep pools) (Eyles 1977a, 1977b; NSW DLWC 2000). The drainage system within the Upper Murrumbidgee Catchment altered from grassed depressions flowing into swampy meadows and through chains-of-ponds into creeks and rivers to a connected channelled system. This was characterised by the development of a connected gully system on hillsides and many hundreds of kilometres of incised channels along valley floors. The incision of hillsides, hillslope depressions, valley floors and beds of rivers and creeks has resulted in a system that is more energetic and efficient in transporting sediment (Starr *et al.* 1999).

Sediments released upstream of the ACT from the mid-1800s, especially in the Bredbo River and Numeralla River catchments formed a series of slugs or bedload waves that accumulated in the ACT in the Tharwa depositional zone (Gigerline to Point Hut). This is the last major channel sand storage area in the Upper Murrumbidgee River, below which the river maintains a relatively steep gradient all the way to Burrinjuck Dam. The Tharwa reach is likely, therefore, to remain a depositional zone for as long as the inflow is equal to or greater than sediment export downstream, or sediment is extracted by other means (AWT and Fluvial Systems 1999, pp. 60–66).

In the 20th century, harnessing the rivers for irrigation, hydro-electric power and urban water supply brought a period of major dam construction. The Murrumbidgee River was dammed downstream of the ACT (Burrinjuck Reservoir), and later, in its headwaters, as part of the Snowy Mountains Hydro-Electric Scheme (Tantangara Reservoir) with the water being diverted to Eucumbene Reservoir. The first of three Cotter River storages (Cotter Reservoir) was constructed between 1912 and 1915, followed by Bendora and Corin Dams in the 1960s. In the 1970s, taking up water rights contained in the *Seat of Government Acceptance Act 1909*, the Commonwealth constructed Googong Dam on the Queanbeyan River. Beginning with Scrivener Dam in the 1960s, a series of dams and other structures have been constructed on rivers and creeks as part of the urban development of Canberra and Queanbeyan. These included weirs on the Murrumbidgee and lower Cotter rivers.

These developments brought changes to the rivers and streams that are the focus of this *Strategy*.

These included flow regimes (loss of high and low flows, and changed seasons of flows); changes in water temperatures (cold water releases from the bottom of dams and in some instances removal of shading riparian vegetation); and dislocation of upstream–downstream linkages due to the barriers created by dams and weirs. There have also been declines in water quality (addition of sediments, nutrients, pollutants), and modification of streambanks by adjacent land uses (removal of riparian vegetation, growth of exotic vegetation, trampling and destruction of bank structure). These changes have had a wide range of mostly detrimental impacts on the fish fauna of the region's rivers.

# 4.2

## Aquatic Fauna: Fish, Crayfish and Macroinvertebrates

### 4.2.1 Fish

Historical accounts indicate that rivers in the ACT region sustained large numbers of native fish and these were important in the pre-European Aboriginal economy of the area (Flood 1980). There are twelve species of native fish from eight families recorded from the Upper Murrumbidgee catchment (Lintermans 2002). Two of these fish are not considered native to the region, but have been translocated from adjacent areas or are rare vagrants. There has been a substantial decline in naturally occurring native fish populations and alien fish species now constitute up to 96% numerically of the total catch recorded in fish monitoring programs in the Murrumbidgee, Molonglo and Queanbeyan rivers (Lintermans and Osborne 2002). The main groups of native fish in the ACT are:

(a) **Large native fish:** Murray Cod (*Maccullochella peelii peelii*), Trout Cod (*Maccullochella macquariensis*), Macquarie Perch (*Macquaria australasica*), Golden Perch (*Macquaria ambigua*), Silver Perch (*Bidyanus bidyanus*). Natural populations of these fish have all declined dramatically in the ACT and region. All five species are angling species, with Murray Cod and Golden Perch stocked in Canberra's urban lakes and Googong Reservoir, and Silver Perch in Googong Reservoir. (For further information on those species declared threatened in the ACT, see Appendix 2.2, 2.3, 2.5. Distribution of these species in ACT rivers is shown in Figure 4.1).

(b) **Fish of upland streams:** Mountain Galaxias (*Galaxias olidus*), Two-spined Blackfish (*Gadopsis bispinosus*) (see Appendix 2.1 for more information on Two–spined Blackfish. Distribution of this species in ACT rivers is shown in Figure 4.1).

(c) **Small fish of lower elevation streams and lakes:** Australian Smelt (*Retropinna semoni*), Western Carp Gudgeon (*Hypseleotris klunzingeri*).

### 4.2.2 Crayfish

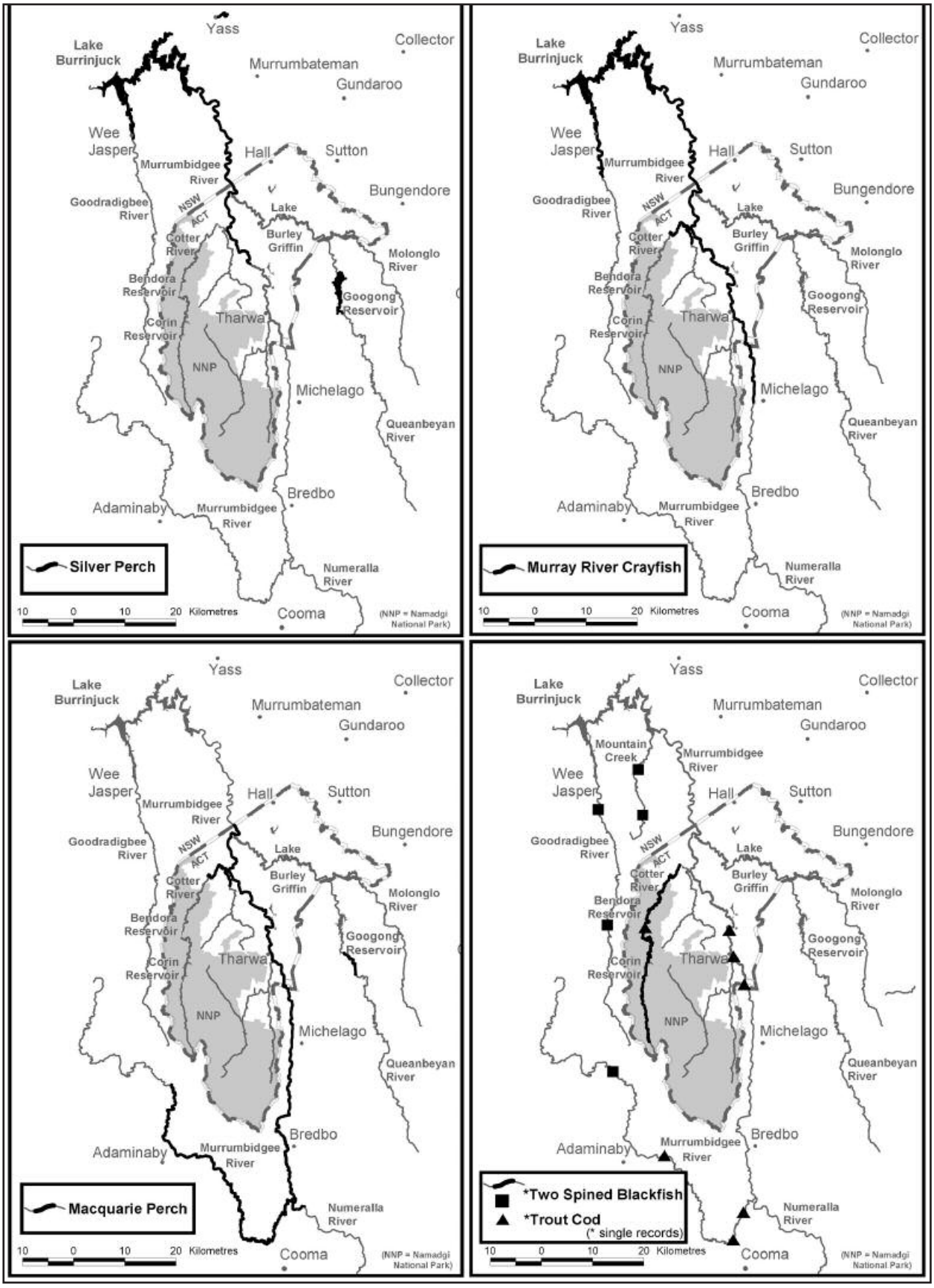
Riverine crayfish species found in the ACT are Murray River Crayfish (*Euastacus armatus*) (see Appendix 2.4, Figure 4.1), Yabby (*Cherax destructor*), and two species of small spiny crayfish. One of these lives predominantly in streams (*Euastacus crassus*); the other lives mainly in upland bogs (*E. rieki*). The Yabby is the most common freshwater crayfish and is abundant in most lowland freshwater habitats. Small spiny crayfish are found in upland areas including the upper Cotter River, but are not commonly seen and little is known of their ecology. It is known that *E. rieki* can suffer considerable predation by foxes (Carey *et al.* 2003) and that trout prey on young individuals of *E. crassus* (Lintermans and Osborne 2002). Also present in the ACT and the upper Murrumbidgee catchment is the burrowing crayfish *Engaeus cymus* (Lintermans 2002). This species occurs near creeks and seepages in forest areas of south-eastern Australia but little is known of its biology or ecology.

### 4.2.3 Aquatic Macroinvertebrates

Aquatic macroinvertebrates are diverse, representing a range of insect, crustacean and molluscan groups, including snails, water boatmen, dragonflies, stoneflies, mayflies, mites and aquatic worms. They are generally visible to the naked eye and occur in all freshwater habitats. They are an important food source for fish and platypus (Ball *et al.* 2001). Numerically dominant taxa in macroinvertebrate sampling of ACT rivers include Oligochaeta (aquatic worms), Chironomidae (aquatic larval and pupal stages of adult flies (midges, gnats)), Hemiptera (waterbugs), Ephemeroptera (nymphal stage of mayflies), Trichoptera (larval and pupal stages of caddis flies) (Environment ACT 2004e).

The diversity and abundance of aquatic macroinvertebrates are used as indicators of the health of aquatic ecosystems. They are widespread, easy to collect, relatively immobile and responsive to environmental changes in stream ecosystems. Their composition reflects the aggregate of environmental changes impacting on the stream ecosystem for up to several months prior to sampling (Ball *et al.* 2001). In the ACT, they have been used extensively in a well developed program as indicators of water quality, habitat degradation and ecological condition.

**Figure 4.1: Distribution of Threatened Fish and Crayfish Species in ACT and Region Rivers**



Macroinvertebrate sampling formed the basis of the First Australia-Wide Assessment of River Health, undertaken in the 1990s under the National River Health Program with approximately 6000 sites being assessed including about 200 in the ACT and upper Murrumbidgee river catchment (Environment Australia 2003). Under this program, the Cooperative Research Centre for Freshwater Ecology developed the Australian River Assessment Scheme (AUSRIVAS) predictive models for the biological assessment of river health. AUSRIVAS is a rapid, standardised method of assessing the ecological health of rivers, based on biological monitoring and habitat assessment. AUSRIVAS river health assessment scores are based on the ratio of the number of aquatic macroinvertebrate families found at 'test sites' to the number predicted to occur there under undisturbed conditions. The predictions are derived from a large set of 'reference' river sites with similar geographic, physical and chemical features.

Macroinvertebrate sampling based on AUSRIVAS now forms part of the annual ACT water quality monitoring program. Reference sites (three) are located on the Paddys, Tidbinbilla and Murrumbidgee rivers, and test sites (ten) on the Murrrumbidgee, Gudgenby, Molonglo and Queanbeyan rivers and major urban creeks. The same methods are used to regularly sample six sites in the Cotter River and tributaries and six sites in the Goodradigbee River and tributaries. A further sixteen sites have been sampled in the ACT pine forest estate as part of a study to establish the effectiveness of several riparian zone treatments. Six ad hoc sampling sites have been used to assess the effects of water transfers to Googong Reservoir and the Queanbeyan River. Standard AUSRIVAS methods are used for all sampling, ensuring data comparability. This biological assessment provides a basis for developing actions and priorities to improve water quality and aquatic and riparian habitat (Table 6.1.5).

Macroinvertebrate data is also collected by ACT Waterwatch Groups during the spring and autumn Water Bug snapshot. Waterwatch is a community water quality monitoring program that aims to equip local communities with the skills and knowledge to become actively involved in the protection and management of their local waterways and catchments (see www.act.waterwatch.org.au).

The National River Health Program assessments that concluded in 1999 indicated that most river systems in the ACT and New South Wales showed evidence of adverse human pressures on macroinvertebrate communities, with urban waterways most severely affected (Ball *et al.* 2001). The main habitat and water quality issues in the upper Murrumbidgee catchment are chemical pollutants (urban waterways), trace metal contamination (Molonglo River downstream of the abandoned Captains Flat mine), nutrient enrichment (treated sewage effluent and rural and urban runoff), habitat degradation and sedimentation, and river regulation (which affects most larger streams in the ACT). Low flows related to drought conditions also affect sampling results (Keen 2001). AUSRIVAS assessments, included in the ACT water quality monitoring program since 2000, show that urban streams have significant levels of impairment with an annual decline in spring and improvement in autumn. Non-urban Reference and Test sites generally have maintained a healthy condition though the Murrumbidgee River exhibits seasonal decline (ACT SOE 2003a). There was a noticeable decline in stream health in autumn 2003 following the major bushfires of January 2003 and dry conditions that extended from autumn 2002 to autumn 2003 (Dickson *et al.* 2003).

# 4.3

## Threatened Fish and Crayfish in the ACT

Four of the native fish species recorded from the ACT and the Murray River Crayfish are declared as threatened under ACT legislation, as well as in other jurisdictions. Murray Cod has recently been listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) but is not declared in the ACT (Table 4.1).

The following sections 4.4 to 4.7 discuss those factors considered to have contributed to the decline of native fish species in the Murray–Darling Basin, including the ACT, and which continue to be ongoing threats. As well as these general threats to fish populations, there are some specific threats applying to fish declared as threatened in the ACT (s. 4.8). These are the continuing impacts of the January 2003 bushfires and the potential impacts of native predators on localised populations. A summary ranking of the importance of particular threats to threatened fish and crayfish species is contained in section 4.9.

Table 4.2 provides a brief description of stream morphology, and the distribution of fish and crayfish species, including threatened species, for ACT rivers included in this *Strategy*. The river sections in Table 4.2 correspond to those in Table 2.2 and Table 5.1.

**Table 4.1: Conservation Status Nationally of Threatened Fish and Crayfish Species Occurring in ACT Rivers**

| | Statutory | | | Non-statutory |
|---|---|---|---|---|
| | ACT | NSW | Other | ASFB/IUCN/VDSE |
| **FISH**<br>Two-spined Blackfish<br>(*Gadopsis bispinosus*) | V | — | — | — |
| Trout Cod<br>(*Maccullochella macquariensis*) | E<br>(SPS) | E | P (SA)<br>T (Vic)<br>E (Cwlth) | (CE) ASFB<br>(E) IUCN<br>(CE) VDSE |
| Macquarie Perch<br>(*Macquaria australasica*) | E<br>(SPS) | V | T (Vic)<br>E (Cwlth) | (E) ASFB<br>(DD) IUCN<br>(E) VDSE |
| Silver Perch<br>(*Bidyanus bidyanus*) | E<br>(SPS) | V | T (Vic)<br>P (SA) | (V) ASFB<br>(V) IUCN<br>(CE) VDSE |
| Murray Cod<br>(*Maccullochella peelii peelii*) | — | — | T (Vic)<br>V (Cwlth) | (V) VDSE |
| **CRAYFISH**<br>Murray River Crayfish<br>(*Euastacus armatus*) | V<br>(PI) | — | T (Vic)<br>E (SA) | (V) IUCN |

**CE:** Critically Endangered; **E:** Endangered; **V:** Vulnerable; **T:** Threatened; **SPS:** Special Protection Species; **DD:** Data Deficient; **P:** Protected; **PI:** Protected Invertebrate

LEGISLATION:

**Commonwealth:** *Environment Protection and Biodiversity Conservation Act 1999*

**ACT:** *Nature Conservation Act 1980*

**NSW:** *Fisheries Management Act 1994*

**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 assessed in advisory lists prepared by the Victorian Department of Sustainability and Environment (VDSE 2006).)

NON-STATUTORY:

**ASFB:** Australian Society for Fish Biology (Conservation Status of Australian Fishes–2001 (ASFB 2001))

**IUCN:** IUCN (The World Conservation Union) Red List of Threatened Species (IUCN 2004)

**VDSE:** Victorian Department of Sustainability and Environment, *Flora and Fauna Guarantee ACT: Taxa and Communities of Flora and Fauna which are Threatened* (VDSE 2006).

**Table 4.2: River Sections—Brief Description of Stream Morphology, Fish and Crayfish Species**

| Current Planning and Management | Description of Stream and Banks | Key Features of Aquatic Fauna | Threatened/ Uncommon/ Aquatic Fauna | 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***<br>■ Gigerline Nature Reserve<br>■ Special Purpose Reserve (Tharwa)<br>■ Rural leasehold<br>***Management***<br>MRC Management Plan 1998 | **Angle Crossing to Gigerline Gorge**<br>For approximately five km immediately to the north of Angle Crossing (ACT/NSW border), the Murrumbidgee River is a series of relatively shallow pools with prominent rock bars, rapids and riffles. Some sandy beaches are present with previous small-scale sand extraction activities occurring in the reach. The river then narrows, turning north-west to flow through the steep, rugged Gigerline Gorge with extensive rocky terraces composed of boulders, bedrock and large stones. | **Angle Crossing to Gigerline Gorge**<br>■ The fish community is largely defined by the barrier presented by Gigerline Gorge and so represents a more 'upland' fish fauna. Lowland species such as Murray Cod, Golden Perch and the alien Redfin Perch are absent or extremely rare.<br>■ Common alien species include Carp, Goldfish, Brown Trout, Rainbow Trout, Eastern Gambusia, Oriental Weatherloach. | **Angle Crossing to Gigerline Gorge**<br>■ Trout Cod<br>■ Macquarie Perch<br>■ Murray River Crayfish<br>■ Silver Perch (anecdotal evidence only) | **Angle Crossing to Gigerline Gorge**<br>■ Illegal fishing (recreational fishing banned in this section)<br>■ Sedimentation<br>■ Reduction in flows (Tantangara and rural extraction upstream)<br>■ Alien species |
| | **Gigerline Gorge to Tharwa**<br>Upon exiting the Gigerline Gorge, the river abrubtly changes, widening to become a depositional stream with a sandy bed, long pools occasional beaches. Previous sand extraction activities at the old Tharwa Sandwash have resulted in a long, flat sandy terrace. The Gudgenby River enters at this point, although fish access to this river is restricted by the large quantities of sand in the Gudgenby channel. | **Gigerline Gorge to Tharwa**<br>■ The fish fauna of this reach contains more of the lowland elements including Murray Cod, Golden Perch and the alien Redfin Perch.<br>■ The full complement of alien species is present including Carp, Goldfish, Redfin Perch, Brown Trout, Rainbow Trout, Oriental Weatherloach and Eastern Gambusia. | **Gigerline Gorge to Tharwa**<br>■ Trout Cod<br>■ Murray Cod<br>■ Macquarie Perch<br>■ Murray River Crayfish | **Gigerline Gorge to Tharwa**<br>■ Sedimentation<br>■ Lack of riparian trees<br>■ Illegal fishing<br>■ Alien species |
| **MU 2: Tharwa to Point Hut Crossing** | | | | |
| ***Territory Plan***<br>■ Special Purpose Reserve (including Lanyon Landscape Conservation reserve)<br>■ Rural leasehold<br>***Management***<br>MRC Management Plan 1998 | North of Tharwa the river passes through broad river flats in an undulating, pastoral landscape. In this deposition zone, the channel is shallow and contains significant quantities of sand that has filled pools and smothered the previously stony substrate for several kilometres. The riverbanks have been largely cleared of the former stands of Ribbon Gum (*Eucalyptus viminalis*), leaving some isolated remnant individual trees as evidence of the earlier vegetation type. Stock access to the river has been limited in recent years by fencing off the river corridor. | ■ The fish fauna of this reach contains most of the lowland elements including Murray Cod, Golden Perch and the alien Redfin Perch<br>■ The full complement of alien species is present including Carp, Goldfish, Redfin Perch, Brown Trout, Rainbow Trout, Oriental Weatherloach and Eastern Gambusia. | ■ Trout Cod<br>■ Murray Cod<br>■ Macquarie Perch<br>■ Murray River Crayfish | ■ Sedimentation<br>■ Lack of riparian trees<br>■ Illegal fishing<br>■ Barrier to fish movement (Point Hut Crossing)<br>■ Alien species |

**Table 4.2:** *(Continued)*

| Current Planning and Management | Description of Stream and Banks | Key Features of Aquatic Fauna | Threatened/ Uncommon/ Aquatic Fauna | Threats to Species and/or Communities |
|---|---|---|---|---|
| **MU 3: Point Hut Crossing to Kambah Pool** | | | | |
| ***Territory Plan***<br>■ Special Purpose Reserve (Point Hut Crossing to Pine Island, Pine Island, Kambah Pool)<br>■ Bullen Range Nature Reserve (Pine Island to Kambah Pool)<br>■ Rural leasehold<br>***Management***<br>MRC Management Plan 1998 | Downstream from Point Hut Crossing the open valley environments give way to steeper slopes with elevated terraces of sandy or rocky banks, with shrub vegetation and scattered trees. The recreation area at Pine Island Reserve takes advantage of the river's broad channel and deep pools and occasional beaches and rocky substrate. Downstream of the Reserve is Red Rocks Gorge, a relatively less accessible area of high cliffs and rugged rock formations. Red Rocks Gorge meets the Bullen Range Nature Reserve near Kambah Pool recreation area. This part of the Murrumbidgee River has high ecological, scenic and conservation value, with some elements such as the Peregrine Falcon nesting sites requiring special attention in order to ensure they are protected from human disturbance. | ■ The fish fauna of this reach contains most of the lowland elements including Murray Cod, Golden Perch and the alien Redfin Perch<br>■ The full complement of alien species is present including Carp, Goldfish, Redfin Perch, Brown Trout, Rainbow Trout, Oriental Weatherloach and Eastern Gambusia. | ■ Trout Cod<br>■ Murray Cod<br>■ Macquarie Perch<br>■ Murray River Crayfish | ■ Sedimentation<br>■ Urban impacts<br>■ Lack of riparian trees<br>■ Illegal fishing<br>■ Alien species |
| **MU 4: Kambah Pool to Cotter River Confluence/Casuarina Sands** | | | | |
| ***Territory Plan***<br>■ Bullen Range Nature Reserve<br>■ Special Purpose Reserve (upslope areas on eastern side of Murrumbidgee R. above nature reserve)<br>■ Special Purpose Reserve (Cotter Reserve/ Casuarina Sands)<br>***Management***<br>MRC Management Plan 1998 | The Bullen Range is a controlling influence on the course of the river downstream of Kambah Pool. The Bulgar, New Station and McQuoids creeks drain the undulating pastoral land between the river and Weston Creek urban area. The river is deeply entrenched below surrounding terrain. The streambed is rocky with pools, rapids, rock bars, islands and sandy margins.<br>Riverine vegetation is well developed with River Oaks along almost the entire stretch.<br>This section was severely burnt in the bushfires of January 2003. | ■ Full complement of lowland fish present. Silver Perch historically common but now rare.<br>■ The full complement of alien species is present including Carp, Goldfish, Redfin Perch, Brown Trout, Rainbow Trout, Oriental Weatherloach and Eastern Gambusia. | ■ Trout Cod<br>■ Macquarie Perch<br>■ Silver Perch<br>■ Murray River Crayfish<br>■ Murray Cod | ■ Willows<br>■ Illegal fishing<br>■ Sedimentation<br>■ Alien species |
| **MU 5: Cotter River Confluence/Casuarina Sands to ACT/NSW Border** | | | | |
| ***Territory Plan***<br>■ Stony Creek Nature Reserve<br>■ Swamp Creek Nature Reserve<br>■ Woodstock Nature Reserve<br>■ Special Purpose Reserve (upslope areas above nature reserves)<br>■ Special Purpose Reserve (Uriarra Crossing)<br>***Management***<br>MRC Management Plan 1998 | Between the Cotter/Casuarina Sands area and the point at which the Murrumbidgee River leaves the ACT, the river passes through deeply dissected slopes cut through the surrounding undulating terrain. Stony Creek Nature Reserve protects much of the river's course as far as Uriarra Crossing where a small recreation area has been developed in association with a road crossing. North of Uriarra Crossing, and a few kilometres south of the ACT/NSW border, the Molonglo River joins the Murrumbidgee River. High up on the eastern edge of the confluence is the Lower Molonglo Water Quality Control Centre. | ■ Full complement of lowland fish. Silver Perch historically common but now rare.<br>■ The full complement of alien species is present including Carp, Goldfish, Redfin Perch, Brown Trout, Rainbow Trout, Oriental Weatherloach and Eastern Gambusia. | ■ Trout Cod<br>■ Macquarie Perch<br>■ Silver Perch<br>■ Murray River Crayfish<br>■ Murray Cod | ■ Willows<br>■ Illegal fishing<br>■ Sedimentation<br>■ Alien species |

**Table 4.2:** *(Continued)*

| Current Planning and Management | Description of Stream and Banks | Key Features of Aquatic Fauna | Threatened/ Uncommon/ Aquatic Fauna | Threats to Species and/or Communities |
|---|---|---|---|---|
| **Gudgenby River**<br>**(Tributaries: Naas and Orroral rivers)**<br>(*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***<br>■ Namadgi National Park<br>***Management***<br>Namadgi National Park Management Plan 2005 | Landscape characterised by deep open valleys, with small streams meandering through flood plains. Rivers and creeks are small in dimensions and flow and may partly dry up in extreme dry seasons. There are significant wetland areas in upper reaches, including a morass (Gudgenby) and fens (e.g. Nursery Creek, upper Naas River). | ■ Smaller streams dominated by Mountain Galaxias where trout are absent.<br>■ *Euastacus crassus* widely distributed.<br>■ Rainbow Trout and Brown Trout common in most streams. | ■ Two-spined Blackfish (anecdotal, historical reports) | ■ Willows<br>■ Alien species |
| GU 2: Namadgi NP to Murrumbidgee River | | | | |
| ***Territory Plan***<br>■ Special Purpose Reserve (possible Tennent Dam site)<br>■ Rural leasehold | The Naas–Gudgenby River confluence is in undulating to flat terrain north of the Billy Range. The Gudgenby River then follows a northward course through incised gorge-like areas including a rocky gorge near Mt Tennent. Under low flow conditions the river is shallow and the streambed comprises sand and gravel as well as granitic rocks. | ■ Mountain Galaxias present but only common in dry seasons.<br>■ Trout dominate fish fauna in wet or average years.<br>■ Alien Oriental Weatherloach, Carp, Eastern Gambusia and Redfin Perch present in lower reaches. | ■ Murray River Crayfish present in lower reaches. | ■ Willows<br>■ Sedimentation<br>■ Degradation of banks from uncontrolled stock grazing<br>■ Alien species |
| **Cotter River**<br>**(Tributary: Paddys River)**<br>(*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***<br>■ Tidbinbilla Nature Reserve<br>■ Rural leasehold<br>■ Plantation forestry<br>***Management***<br>Tidbinbilla Nature Reserve Management Plan 1999 | Paddys River is a small stream in a broad valley. Streambed carries sediments sourced from upper catchment. Bank erosion is common. Streambed contains pools, sand and gravel (often vegetated) and stretches of boulders. Condition of riparian areas is poor (ACT SOE 2003c). Paddys River catchment was severely burnt in the January 2003 bushfires. Significant areas of the lower catchment are dominated by pine plantations. | ■ Macquarie Perch still present in lower reaches, formerly more abundant and widely distributed.<br>■ Alien trout, Carp, Oriental Weatherloach, Eastern Gambusia and Redfin Perch present in lower reaches. | ■ Murray River Crayfish<br>■ Macquarie Perch<br>■ Two-spined Blackfish (historically) | ■ Sedimentation (fire, roads, forestry)<br>■ Riparian degradation<br>■ Weeds<br>■ Lack of connection with Murrumbidgee River<br>■ Alien species |

**Table 4.2:** *(Continued)*

| Current Planning and Management | Description of Stream and Banks | Key Features of Aquatic Fauna | Threatened/ Uncommon/ Aquatic Fauna | Threats to Species and/or Communities |
|---|---|---|---|---|
| **CO 2: Cotter River (Headwaters to Corin Dam)** | | | | |
| ***Territory Plan***<br>■ Namadgi National Park<br>***Management***<br>Namadgi National Park Management Plan 2005 | The Cotter River and tributary streams in the upper catchment are narrow, moderately incised, have dense overhanging vegetation (grasses, shrubs), and contain woody debris where larger shrubs and trees are present. Streambeds may be silty, stony, sandy or be comprised of rocks and cobbles. Wider open reaches have alluvial banks. Following the January 2003 bushfires and subsequent storms, there has been widening and deepening of some tributary creeks (ACT SOE 2003c).<br>This area was moderately and patchily burnt in the January 2003 bushfires.<br>Stream flows are natural (i.e. not affected by up stream structures). | ■ The fish fauna is that of an upland or montane stream with only two native species present (Mountain Galaxias and Two-spined Blackfish).<br>■ The crayfish fauna is represented by a single stream species (*Euastacus crassus*), with a bog-dwelling species (*Euastacus rieki*) also present in the montane areas of the catchment.<br>■ There is only a single alien species present (Rainbow Trout) due to the barriers to colonisation from downstream habitats presented by Corin and Bendora dams | ■ Two-spined Blackfish | ■ Sedimentation after 2003 fires<br>■ Pressure for recreational fishing access<br>■ Fire impacts on riparian zone<br>■ Introduction of Brown Trout<br>■ Inter-basin water transfers (from Tantangara) |
| **CO 3: Cotter River (Below Corin Dam to Bendora Dam)** | | | | |
| ***Territory Plan***<br>■ Namadgi National Park<br>***Management***<br>Namadgi National Park Management Plan 2005 | The river occupies a more deeply incised valley with vegetation communities characteristic of high altitude valley areas usually extending down to the river. Streambed is relatively narrow, commonly containing rocks and boulders.<br>This section was severely burnt in the bushfires of January 2003.<br>River flow is regulated by releases from Corin Dam. | ■ The fish fauna is that of an upland or montane stream with only two naturally occurring native fin fish species present (Mountain Galaxias and Two-spined Blackfish) plus two species introduced for conservation reasons (Trout Cod and Macquarie Perch).<br>■ The crayfish fauna is represented by two stream species (*Euastacus crassus* and Yabby), with a bog-dwelling species (*Euastacus rieki*) also present in the montane areas of the catchment. Yabbies are largely confined to the Bendora Reservoir in this river reach.<br>■ There is only a single alien species present (Rainbow Trout) due to the barriers to colonisation from downstream habitats presented by Bendora Dam. | ■ Two-spined Blackfish<br>■ Trout Cod<br>■ Macquarie Perch | ■ Thermal pollution<br>■ Altered flow patterns<br>■ Sedimentation after 2003 fires<br>■ Introduction of Brown Trout<br>■ Pressure for recreational fishing access<br>■ Inter-basin water transfers (from Tantangara) |

**Table 4.2:** *(Continued)*

| Current Planning and Management | Description of Stream and Banks | Key Features of Aquatic Fauna | Threatened/ Uncommon/ Aquatic Fauna | Threats to Species and/or Communities |
|---|---|---|---|---|
| **CO 4: Cotter River (Below Bendora Dam to Cotter Dam)** | | | | |
| ***Territory Plan***<br>■ Namadgi National Park<br>■ Special Purpose Reserve (upstream from Cotter Dam to boundary of Namadgi National Park)<br>***Management***<br>■ Namadgi National Park Management Plan 2005<br>■ Lower Cotter Catchment: Strategic Management Plan 2006 | Narrow, deeply incised river valley flanked by dry forest, variable shrub cover and extensive weed invasion (especially Blackberry). Streambed commonly narrow and rocky but gravelly-bottomed pools occur in areas with gentler gradients.<br>This section was severely burnt in the bushfires of January 2003.<br>River flow is regulated by releases and diversions from Bendora Dam. | ■ The fish fauna is that of an upland or montane stream with three naturally occurring native fish species present (Mountain Galaxias, Two-spined Blackfish and Macquarie Perch) plus one species introduced for conservation reasons (Trout Cod).<br>■ The crayfish fauna is represented by two stream species (*Euastacus crassus*, Yabby and Murray River Crayfish), with a bog-dwelling species (*Euastacus rieki*) also present in the montane areas of the catchment.<br>■ There are five alien species present (Rainbow Trout, Brown Trout, Oriental Weatherloach, Eastern Gambusia, Goldfish). The barrier to colonisation from downstream habitats presented by Cotter Dam prevents invasion by other alien species (Carp and Redfin Perch). | ■ Macquarie Perch<br>■ Trout Cod<br>■ Murray River Crayfish | ■ Thermal pollution<br>■ Altered flow patterns<br>■ Sedimentation (fire, roads, forestry)<br>■ Fire impacts on riparian zone<br>■ Barriers to fish passage (road crossings)<br>■ Introduction of Redfin Perch, Carp<br>■ Cormorant predation on Macquarie Perch and Trout Cod<br>■ Pressure for recreational fishing access to Cotter Reservoir<br>■ Pressure for other recreational use of Cotter Reservoir<br>■ Water extraction from Cotter Reservoir<br>■ Inter-basin water transfers |
| **CO 5: Cotter River (Below Cotter Dam to Murrumbidgee River)** | | | | |
| ***Territory Plan***<br>■ Special Purpose Reserve | The river and adjacent riparian areas have been extensively modified related to the construction of the nearby Cotter Dam and the Cotter recreation area. The streambed includes cobbles, low rocky areas, sand and gravel and there are low weirs. Near the Paddys River confluence there is a sandy bottomed pool used for swimming.<br>River flow is regulated by releases from Cotter Dam. | ■ The fish fauna in this section largely reflects that of the lower Murrumbidgee River. It lacks Two-spined Blackfish due to environmental degradation associated with decades of reduced flows and increased sedimentation.<br>■ The crayfish fauna is represented by two stream species (Murray River Crayfish and Yabby).<br>■ The full complement of alien species is present including Carp, Goldfish, Redfin Perch, Brown Trout, Rainbow Trout, Oriental Weatherloach and Eastern Gambusia. | ■ Macquarie Perch<br>■ Murray Cod<br>■ Silver Perch (rare)<br>■ Murray River Crayfish | ■ Altered flow patterns<br>■ Sedimentation<br>■ Fire impacts on riparian zone<br>■ Barriers to fish passage (weirs and fish passage to the Paddys River)<br>■ Alien species<br>■ Recreational fishing pressure (on Macquarie Perch) |

**Table 4.2:** *(Continued)*

| Current Planning and Management | Description of Stream and Banks | Key Features of Aquatic Fauna | Threatened/ Uncommon/ Aquatic Fauna | Threats to Species and/or Communities |
|---|---|---|---|---|
| **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***<br>■ Nature Reserve<br>■ Rural leasehold<br>■ Pine plantation | The Molonglo River is a relatively small stream in a moderately incised valley containing pools, small rapids and shallow areas. The river may be only a series of pools in extended dry periods. The stream channel is sandy or stony and fringing emergent vegetation is common e.g. *Typha* spp. (Anway *et al.* 1975). Approaching Molonglo Gorge, valley sides become steeper, more rugged and rocky and flow is confined. Blue Tiles is a large deep pool. | ■ Mountain Galaxias and trout are the only fish known, but anecdotal reports of carp.<br>■ Yabbies present. | None recorded | ■ Heavy metal pollution events<br>■ Invasion by alien species from downstream (Carp, Redfin Perch, Oriental Weatherloach)<br>■ Urban edge (potential impact if urban development occurs in Kowen) |
| **MO 2: Molonglo Gorge to Lake Burley Griffin** | | | | |
| ***Territory Plan***<br>■ Nature Reserve<br>■ Rural leasehold<br>■ Other leasehold | Molonglo Gorge has steep valley sides. The streambed is rocky (including large rock outcrops) with pools and rapids. Willows are common in the river channel. There are extensive areas of river-washed rocks where the river exits the gorge. Downstream of the gorge the Molonglo River is joined by the Queanbeyan River before entering the backed up waters of Lake Burley Griffin. The Pialligo area contains a former flood plain and old river channels (filled by the waters of Lake Burley Griffin). | ■ Stocked impoundment (Lake Burley Griffin) influences fish community.<br>■ Yabbies common.<br>■ The full complement of alien species is present including Carp, Goldfish, Redfin Perch, Brown Trout, Rainbow Trout, Oriental Weatherloach and Eastern Gambusia. | ■ Silver Perch (stocked, overflow from Googong Reservoir)<br>■ Murray Cod | ■ Willows<br>■ Urban/industrial runoff<br>■ Weeds |
| **MO 3: Scrivener Dam to Coppins Crossing** | | | | |
| ***Territory Plan***<br>■ Urban Open Space (Scrivener Dam to Tuggeranong Parkway)<br>■ Special Purpose Reserve (Tuggeranong Parkway to Coppins Crossing)<br>■ Rural leasehold | Streambed contains shallow areas, pool, rock bars, cobbles and is heavily overgrown by a wide variety of woody weeds. In some places these completely overshadow the stream channel. Poor water quality related to bottom releases from Scrivener Dam. Occasional overbank flows due to releases from Scrivener Dam after high rainfall events. Valley contains relatively flat areas along stream in places. | ■ Spill over from Lake Burley Griffin stockings.<br>■ The full complement of alien species is present including Carp, Goldfish, Redfin Perch, Brown Trout, Rainbow Trout, Oriental Weatherloach and Eastern Gambusia. | ■ Murray River Crayfish<br>■ Murray Cod | ■ Willows<br>■ Weeds<br>■ Potential barriers and urban edge effects (with proposed urban development)<br>■ Recreational use<br>■ Poor water quality discharge from Scrivener Dam |
| **MO 4: Coppins Crossing to Murrumbidgee River** | | | | |
| ***Territory Plan***<br>■ Lower Molonglo River Corridor Nature Reserve<br>***Management***<br>Lower Molonglo River Corridor. Management Plan 2001 | In this section, the river valley becomes more deeply incised and in the lower sections forms the Lower Molonglo Gorge (approximately 2 km in length) in volcanic rocks. Below the steep gorge sides, the riverbed contains rapids, deep and shallow pools, with rock bars across the river visible in low flow conditions. Features of the section are the terraces bordering the river from 2–5 m above normal (low) flow (NCDC 1988b). | ■ Spill over from Lake Burley Griffin stockings.<br>■ The full complement of alien species is present including Carp, Goldfish, Redfin Perch, Brown Trout, Rainbow Trout, Oriental Weatherloach and Eastern Gambusia. | ■ Murray River Crayfish<br>■ Murray Cod<br>■ Macquarie Perch (historical) | ■ Willows<br>■ Weeds<br>■ Recreational use<br>■ Discharge from Lower Molonglo Water Quality Control Centre<br>■ Poor water quality discharge from Scrivener Dam |

# 4.4

## Habitat Destruction or Modification

Alteration or destruction of habitat is widely regarded as one of the most important causes of native fish decline in Australia (Cadwallader 1978a; Koehn and O'Connor 1990a, b; Lintermans 1991; Hancock 1993) and overseas (Moberly 1993; Maitland 1987).

Habitat modifications occur in many forms but the major classes are:

- habitat degradation: damage to riparian zones, sedimentation, removal of in-stream habitat;
- barriers to fish passage;
- reduction in floodplain habitat;
- alteration to flow regimes by dams and weirs;
- thermal pollution; and
- reduction in water quality.
  (Lawrence 1991, MDBC 2004a)

### 4.4.1 Habitat Degradation

#### DAMAGE TO RIPARIAN ZONES

The quality of aquatic habitat is closely related to both the condition of the stream catchment and the riparian zone. The importance of native streamside vegetation to aquatic ecosystems cannot be over-emphasised. Riparian zone vegetation acts as a buffer from surrounding activities and interacts continuously with the stream (Koehn and O'Connor 1990a). Much of the in-stream habitat used by fish originates from the surrounding vegetation e.g. fallen trees, logs, woody debris, leaves and bark. Combined with aquatic and emergent vegetation, this organic matter forms the major primary source of nutrients for the aquatic food chain. Additional fish food in the form of terrestrial invertebrates also originates from bankside vegetation. Introduced plant species that provide a highly seasonal leaf input, such as willows and poplars, alter the timing, quality and consistency of this energy supply (Schulze and Walker 1997). Leaf fall and decomposition in streams has been studied in detail in the Lees Creek catchment (in the northern Cotter catchment), ACT, by Thomas *et al.* (1992). In this catchment, litter-fall is seasonal, occurring in late summer, and the material may decompose very quickly.

As well as providing significant carbon sources, large logs and branches in a stream provide a number of important structural functions for aquatic ecosystems. For fish, this includes the provision of spawning sites, shade, formation of scour pools, territorial markers or 'signposts', velocity refuges, ambush sites for predators, and refuges from both aerial and in-stream predators. Large woody debris is not so important in upland Australian streams where instream cover is largely provided by substrate (e.g. boulders, cobbles).

The root systems of bank vegetation help prevent erosion and sedimentation and submerged roots may also provide in-stream habitat. Streamside vegetation acts as a buffer strip by filtering sediment, pasture effluent and chemicals in runoff from surrounding areas and can be important in protecting bank areas from disturbances such as stock trampling. Shading is also important in helping to reduce summer stream temperatures and providing habitat areas for species avoiding predators (Koehn and O'Connor 1990a).

In the ACT, significant changes to the riparian zone have occurred since European settlement including loss of native vegetation (e.g. *Eucalyptus viminalis* Tableland Riparian Woodland along the Murrumbidgee River in the Lanyon area), loss of streamside vegetation complexity, and both planting and natural spread of introduced species, in particular willows (*Salix* spp.) and blackberries. Clearing of native riparian tree cover and the spread of willows mean that the opportunity for the natural replenishment of hardwood into streams is much reduced. Submerged roots of willows may also smother habitat in small streams.

#### SEDIMENTATION

Sediment in streams may derive from point sources (e.g. roads, stock access points, construction activities), from broad-scale catchment land use or as a result of extreme events such as fires and floods. High levels of suspended solids in streams may be lethal to fish and their eggs but the major damage is to aquatic habitat. Sediment fills pools and scour holes, decreases substrate variation and reduces usable habitat areas. Clogging of the substratum removes spaces between rocks used as rearing, refuge and habitat areas by juvenile fish, small species and stream invertebrates (Koehn and O'Connor 1990a).

Sedimentation and the associated increase in turbidity are likely to affect visual feeders like Trout Cod and Two-spined Blackfish more severely, as both the abundance and diversity of prey items are reduced and feeding success declines because of lowered water clarity. Addition of sediments to rivers is particularly detrimental to fish such as Two-spined Blackfish and Macquarie Perch that lay adhesive eggs on the substrate, as sediment may smother the eggs and prevent their attachment (Cadwallader 1978a). Increased sedimentation is also known to be damaging to benthic macroinvertebrate communities (Doeg and Koehn 1990a, b), which form the majority of the dietary items of the Two-spined Blackfish and Macquarie Perch.

In the Murrumbidgee River, there has been a decline in the quality and quantity of habitat through sediment filling spaces between rocks. This process has occurred over a 150-year period since the mid to late 1800s when poor land management practices and a series of large floods in the upper Murrumbidgee catchment resulted in extensive erosion and sediment addition to the river (Starr 1995; Olley 1997). Over-clearing, the effects of rabbit plagues in the 1920s, establishment of sand and gravel extraction and urban development contributed to the general siltation of the river. This sediment is still working its way through the river system and is slowly filling the deeper pools that are important as refuges for the larger native fish species such as cod and perch and the Murray River Crayfish. The establishment of several sand and gravel extraction facilities on rivers upstream of the ACT exacerbated the problem by destabilising river channels and resuspending fine sediments into the water column. A similar situation with land degradation existed in the catchment of the Molonglo River with reports in the 1960s documenting severe gully, sheet and stream bank erosion (Durham 1958; Eyles 1977b; NSW DLWC 2000).

Infill of sediment into spaces between rocks in the Murrumbidgee River reduces habitat for Murray River Crayfish and large bodied fish species, and results in a loss of sites for frogs to lay eggs. These spaces are used as refuges because the banks are generally not suitable for constructing burrows or there is little structural woody habitat (snags) available. Increased turbidity and sediment loads also have detrimental effects on submerged aquatic plant beds through reductions in light penetration, thus reducing an important food source for Murray River Crayfish. Sedimentation following the January 2003 bushfires in the ACT has smothered submerged macrophyte beds in the Cotter River catchment (M. Lintermans, pers. comm.).

The construction of Tantangara Dam in 1960, as part of the Snowy Mountains Hydro-electric Scheme probably contributed substantial amounts of sediment to the upper Murrumbidgee River. Tantangara Dam has reduced the frequency of winter flooding and increased the occurrence of low flows (<1000 megalitres/day) in winter (Jorgensen 1983). This has probably led to the continued accumulation of sediments in the river as there are now fewer and smaller high flow events that previously would have scoured the finer sediments out of the riverbed (Pendlebury 1997).

An important source of sediment addition to the Murrumbidgee River since the 1980s has been the urban development of Tuggeranong. A study of the effects of sediment addition in the Tuggeranong Creek catchment in 1987–88 found that platypus and aquatic invertebrate communities were noticeably depleted in the Murrumbidgee River, downstream of the confluence of Tuggeranong Creek (Hogg and Norris 1988). A follow up study of invertebrates in 1993 revealed that there had been little or no recovery in invertebrate numbers and that fine inorganic sediments were still a major component of the downstream sites (Grimes 1993). This was despite the incidence of several large flushing flows in the intervening years that would have removed the prior accumulations of fine inorganic material. Platypus are still uncommon in this sediment affected river reach, some 18 years after the initial impacts were first examined.

#### REMOVAL OF IN-STREAM HABITAT

In the ACT there has been little direct removal of in-stream habitat (such as the removal of logs from rivers and channelisation) as has occurred in lowland streams elsewhere in Australia (Koehn and O'Connor 1990a; MDBC 2004a).

### 4.4.2 Barriers to Fish Passage

It is estimated that there are now more than 4000 barriers to fish passage (weirs or dams) within the Murray–Darling Basin (MDBC 2004a). These 'river regulation' structures have had a significant deleterious impact on fish populations in the Basin. As well as major barriers, there is a plethora of minor barriers such as culverts and road crossings. Uniform channels (such as urban creeks) with no shelter from high water velocities may also pose passage problems for some fish species.

The unimpeded passage of fish throughout streams is crucial for spawning migrations, recolonisations, general movement and habitat selection (Koehn and O'Connor 1990a). For example, Golden Perch *Macquaria ambigua* are migratory, with adult and juvenile movements thousands of kilometres upstream being recorded, though migratory movements are usually much shorter. Murray Cod *Maccullochella peelii peelii* move up to 120 km upstream to spawn, on late winter/early spring high river levels, then return to the same area (Koehn 1997).

#### EFFECTS OF BARRIERS TO FISH PASSAGE IN THE UPPER MURRUMBIDGEE RIVER CATCHMENT

**Two-spined Blackfish:** This is not thought to be a migratory species and barriers to movement are unlikely to have played a substantial role in its decline (ACT Government 1999a; Lintermans 2002).

**Trout Cod:** The biology of Trout Cod is not well understood, but it appears to inhabit deep pools with in-stream cover (logs, boulders) and does not have a substantial spawning migration. However, it is known that this species can make significant exploratory movements of tens of kilometres. Barriers to movement are likely to have played a lesser role in the decline of this species, but have probably affected dispersal and recolonisation after substantial disturbance (ACT Government 1999b; Lintermans 2002).

**Macquarie Perch:** Construction of dams and other structures on ACT rivers and on the Queanbeyan River has fragmented the population of Macquarie Perch. Scrivener Dam effectively isolated the Molonglo and Queanbeyan rivers from the Murrumbidgee River and has prevented any recolonisation. The construction of Cotter Dam in 1915 also isolated the Cotter River population from the Murrumbidgee River stock. The Cotter River has three major impoundments. Macquarie Perch is now largely confined to the Cotter Reservoir and the 5.5 km stretch of river between the backed-up waters and Vanitys Crossing. The species was unable to traverse the concrete ford constructed at Vanitys Crossing in the late 1970s. The construction of a rock-ramp fishway at the Crossing in 2002 has allowed the species to commence colonisation of the river reach between the crossing and Bendora Dam, but the extent of this colonisation is currently unknown. The steeper gradient of the river downstream of the crossing, coupled with the reduction in flows caused by river regulation, is thought to have exacerbated fish passage problems posed by a number of natural barriers such as rock bars and cascades. These barriers are thought to severely restrict the capacity of fish in the reservoir to access the fishway at Vanitys Crossing (Lintermans 2004c).

On the Queanbeyan River, the construction of Googong Dam resulted in the flooding of all available Macquarie Perch spawning sites for a remnant population of this species. In addition, the species is unable to reach the river above the reservoir because of a waterfall, Curleys Falls, that forms a natural barrier to upstream movement (Lintermans 2003).

**Silver Perch:** This species matures at 3–5 years and spawns in spring and summer after an upstream migration when large schools often form. The construction of the Burrinjuck Dam in the 1920s effectively isolated the upper Murrumbidgee catchment from downstream populations, Scrivener Dam isolated the Molonglo and Queanbeyan rivers, and Cotter Dam isolated the Cotter River. The former 'run' of Silver Perch upstream from Lake Burrinjuck has not been recorded since the early 1980s (Lintermans 2002).

### 4.4.3 Reduction in Floodplain Habitat

The ACT is located in an upland area of the Murrumbidgee River catchment where floodplain development is not part of the morphology of the river. Reduction in this habitat is significant, however, for the overall decline in species found throughout the Murray–Darling Basin (MDBC 2004a). Two ACT threatened aquatic species (Macquarie Perch and Two-spined Blackfish) inhabit cooler upland waters not associated with floodplains while the remainder are more widely distributed into the lowland areas. Loss of floodplain habitat along with other impacts is likely to have been a contributing factor in the decline of the Trout Cod in lowland rivers such as the Murray, Macquarie and lower Murrumbidgee rivers where woody debris in backwaters and flood channels may have been a favoured spawning and larval development habitat.

### 4.4.4 Alterations to Flow Regimes above and below Dams and Weirs

The construction of dams and weirs has a severe effect on the quality of fish habitat through the modification of both the natural flow regimes and water quality of rivers below these structures. The effect of some dams (e.g. Corin Dam and Burrinjuck Dam) on downstream river flows is to partially reverse the seasonal nature of flows as water from autumn to spring rain and snow-melt is collected and stored for release in summer for irrigation or peak domestic water demand. Peak flows would have originally occurred in late winter to early summer with streams falling to a pool and riffle sequence in late summer. These former large flows and rising water temperatures are thought to have provided the natural environmental 'cues', as well as a sufficient water level, for upstream spawning migrations of species such as Murray Cod, Golden Perch, Silver Perch and Macquarie Perch, although some of these species are known to spawn under low-flow conditions (Humphries *et al.* 1999).

Other ACT and region impoundments such as Bendora, Cotter and Googong reservoirs (domestic water supply) and Lake Burley Griffin (ornamental) have a different impact in that insufficient water is released to maintain suitable environmental conditions in the rivers downstream. Long periods of low flow result in reduced water quality, altered channel morphology and significant changes to riparian vegetation, in particular, infestation of willows and other pest species. The quality of water released is also a problem in that it may be released from the lower levels of the reservoir and is much colder than

the surface waters. Temperature is now more tightly controlled in dam releases from ACT water storages and a new eWater project should provide more information on the impacts of ACT releases. Bottom-release water may also be deoxygenated, and contain high levels of iron, manganese and other minerals liberated from sediments (e.g. see s. 4.4.6 in relation to Scrivener Dam).

The large areas of still water created by dams may also have an impact on the egg and early larval stages of fish species and flood suitable spawning areas. Macquarie Perch is dependent on high quality habitat, with access to spawning gravels in flowing waters essential for successful reproduction. The construction of Googong Dam resulted in the flooding of the majority of suitable spawning areas in the Queanbeyan River. Regular monitoring of fish stocks within the impoundment showed that the species was not recruiting. Consequently in 1980, 57 individuals were captured and translocated past a natural barrier on the Queanbeyan River upstream of the impounded waters. This translocation is the basis of the remnant population now present in the Queanbeyan River above the reservoir (Lintermans 2003). Construction of the three dams on the Cotter River also probably resulted in the flooding of suitable spawning areas. In the case of Silver Perch, the drifting semi-buoyant eggs and newly hatched larvae may settle in unfavourable habitats such as the backed up waters of dams and weir-pools, making them susceptible to sedimentation and low oxygen levels.

A major effect of fewer and smaller high flow events below dams is a build up of sediments (particularly finer material) that previously would have been scoured out of the riverbed. The effects of such sedimentation have been discussed above.
Low-flows downstream of dams can also result in previously insignificant natural channel characteristics (e.g. rock bars, chutes) becoming significant fish passage barriers.

### 4.4.5 Thermal Pollution

Thermal pollution is increasingly being recognised as having significant impacts on aquatic ecosystems (Lugg 1999; Phillips 2001; Astles *et al.* 2003; Preece 2004; Ryan *et al.* 2003). Thermal (or cold-water) pollution occurs when cold-water from the bottom layers of large reservoirs is released to streams. The water stored in large reservoirs tends to stratify between spring and autumn, with a warm surface layer (the epilimnion) overlying cold bottom layers (the hypolimnion). The hypolimnion can be 12–15°C colder than surface water temperatures (Astles *et al.* 2003).

Many dams only have release valves or outlets that draw water from the hypolimnion, or for dams with multi-level off-takes, current operating practices mean that water has been preferentially drawn from the lower levels. Thermal pollution can have severe effects on growth, activity, survival and reproduction of aquatic organisms.

The release of a cold slug of water during the breeding season is thought to inhibit spawning behaviour of Silver Perch and other native fish species. Macquarie Perch respond to increasing water temperature associated with late spring to early summer flows as a cue to commence spawning (Llewellyn and MacDonald 1980; Cadwallader and Backhouse 1983). Koehn *et al.* (1995) found that two separate populations of the species in the Mitta Mitta River, Victoria, have disappeared since the construction of Dartmouth Dam from 1973–80. The demise of the Macquarie Perch and Murray Cod in this river is attributed to the effects of cold-water releases from the dam during the spawning season. Cold-water pollution can also delay the occurrence of critical thermal cues to initiate spawning, resulting in a reduced growing season for larval and juvenile fish before the onset of winter. Such delays can mean that juvenile fish are smaller when entering winter, potentially exposing them to increased risk of predation, particularly where cold-water species such as trout are present.

Astles *et al.* (2003) reported that Silver Perch grown in cold-water treatments for 31 days were approximately half the weight of those from warm-water treatments, and that three times as many fish survived in the warm-water treatment. Similarly, Murray Cod held for three months at 12.6°C did not increase in weight, whereas fish held at 21.2°C tripled in weight over the same period (Ryan *et al.* 2003).

Thermal pollution is a significant issue in the Cotter catchment, where there are two large dams (Corin and Bendora) and four threatened fish species. A recent study has demonstrated that the growth rate of Two-spined Blackfish was significantly less under cold-water conditions simulating thermal pollution (Hall 2005). Reduced growth rates mean that small fish will remain for a longer time-period in the size-class susceptible to predation, thus exacerbating the impacts of alien predators (see s. 4.6.2).

### 4.4.6 Reduction in Water Quality

Water provides dissolved oxygen for respiration, appropriate temperatures for metabolism and a flow of nutrients through the ecosystem. Reduction in water quality in the Murray–Darling Basin is due to increased nutrients, turbidity, sedimentation, salinity, artificial

changes in water temperature, pesticides and other contaminants (MDBC 2004a). While fish deaths due to short-term toxic spills are readily recognisable, sub-lethal water pollution and long-term changes to water quality parameters are less obvious in their effects.

River regulation, including dams and reservoirs in particular, has the capacity to seriously alter these parameters. The effects of seasonal flow reversal and low water temperatures from bottom releases from dams have been referred to above. These bottom releases are usually low in dissolved oxygen and may have excessive nutrient loads due to release of nutrients from bottom sediments under anaerobic conditions, as in the case of low to normal flow releases from Lake Burley Griffin through Scrivener Dam (NCPA 1995). In some instances impoundments may also act as nutrient traps by allowing organic particles that normally flow down the stream to settle out. Consequently, the water released downstream is not as rich in nutrients as the inflow to the storage and the productivity of the stream may be reduced (Koehn and O'Connor 1990a).

Evidence is now well established of another significant threat to water quality, the addition of endocrine disrupting chemicals to waterways. Endocrine disrupting chemicals cause adverse effects by interfering with hormones, either disrupting normal hormone function, or mimicking hormones to give an unnatural response. Research has shown the impacts of endocrine disruptors on aquatic fauna such as frogs, mussels and fish (Jobling *et al.* 1998; Matthiessen *et al.* 2002; Quinn *et al.* 2004; Rodgers-Gray *et al.* 2001, 2002; Solé *et al.* 2002; Sonnenschein and Soto 1998).

A wide variety of chemicals released into the aquatic environment are believed to disrupt normal endocrine function in fish, thereby causing reproductive disorders and abnormalities (Sumpter 2002). Potentially, they could have a severe impact on the ability of species to successfully reproduce. One group of endocrine disruptors is the environmental oestrogens that can mimic the female hormone, oestrogen. Major sources of environmental oestrogens are pesticides, detergents and prescription drugs such as antibiotics. These chemicals enter waterways either via runoff from agriculture, or discharge of treated sewage effluent. In the ACT, Kalish (1999) demonstrated, through cell assays, oestrogenic activity in discharge from the Lower Molonglo Water Quality Control Centre (the sewage treatment works for the ACT), but there has been no follow-up work on fish in the Molonglo or Murrumbidgee rivers. It is unlikely to be an issue for the Cotter River. Endocrine disruption represents a threat to Australian aquatic life and further investigation is urgently required (Lintermans 2002).

Reductions in water quality that are likely to have had major effects on fish in the ACT and region are addition of sediment (see s. 4.4.1) and the catastrophic pollution of the Molonglo River following the collapse of slimes dumps at the Captains Flat mine in 1939 and again in 1942. These collapses released large quantities of heavy metals including zinc, copper and lead, which virtually removed the entire fish population in the Molonglo River (Joint Government Technical Committee on Mine Waste Pollution of the Molonglo River 1974). The river is still unable to support fish life for at least 15 km downstream of Captains Flat, an area that would probably have supported populations of Macquarie Perch, Golden Perch, Murray Cod and Murray River Crayfish prior to the collapse of the mine dumps.

## 4.5

## Over-exploitation

Over-exploitation is an important contributor to the decline of native fish stocks across the Murray–Darling Basin. Historically, a commercial fishery operated, which responded opportunistically to seasonal changes in flow conditions. Murray Cod, Golden Perch, Silver Perch and Common Yabby (*Cherax destructor*) were the main species sought (Reid *et al.* 1997). There is no longer a riverine native fish based commercial industry in the Murray–Darling Basin (except for Common Yabby) with the last of the operators ceasing in 2003. Commercial fishing is not known to have operated in the ACT. Illegal take of threatened fish species and illegal 'trade' (barter or sale) in some recreationally desirable species (e.g. Murray Cod and Murray River Crayfish) still occurs in the Canberra region and is an ongoing threat.

Recreational angling is popular on inland rivers and lakes (including in the ACT) and can place significant pressure on fish stocks, especially threatened species. The National Recreational and Indigenous Fishing Survey (Henry and Lyle 2003) concluded that approximately 566 000 recreational fishers fished in the Murray–Darling Basin during the 12 month period prior to May 2000. In the ACT an estimated 53 500 fishers (19.2 per cent of the population) took an annual catch of 35 735 fin fish and 19 936 freshwater crayfish within the Territory. Golden Perch was the most commonly caught native species, comprising 16 per cent of the total catch. Overfishing has been shown to

be important in the decline of many native fish and crayfish species including the threatened Macquarie Perch (Cadwallader 1978a; Harris and Rowland 1996), Trout Cod (Douglas *et al.* 1994; Berra 1974), Murray Cod (Rowland 1989; Jackson *et al.* 1993) and the Murray River Crayfish. While the major impact on Silver Perch is thought to have been river regulation, intense fishing pressure was often applied during its upstream 'runs' (Lintermans 2002). Overfishing was cited as one of the contributing factors in the decline of blackfish in Victoria in the late 1800s (Lewis 1917; Roughley 1953), however, Two-spined Blackfish is unlikely to have been affected by overfishing as its small size means it is generally not sought by anglers. Most captures are probably accidental (ACT Government 1999a). Under the provisions of the ACT *Fisheries Act 2000*, fishing is prohibited in the Cotter River catchment above Bendora Dam, thus providing some protection for Two-spined Blackfish.

Berra (1974) in discussing the now locally extinct 'wild' ACT Trout Cod population noted that the ACT was subject to heavy angling pressure directed primarily at Murray Cod. As Trout Cod was only described as a separate species in 1972, it is highly likely that anglers would not have distinguished between the two cod species, and that anglers took many Trout Cod individuals.

Macquarie Perch has been sought after as an angling species, and previously, heavy pressure was placed on its spawning runs (Battaglene 1988; Cadwallader and Rogan 1977). Illegal fishing of small remnant populations probably remains a threat, including targeting of spawning runs. Surveys of the population in the Queanbeyan River (above Googong Reservoir) in the 1990s showed that the abundance of the species increased with increasing distance from easy public access, suggesting that the population was still being illegally fished (ACT Government 1999c).

Murray River Crayfish is a sought after species in NSW and Victoria that has been overfished (Geddes 1990). Even though the species has been protected by bag, size and gear limits in NSW for many years, the species is still illegally targeted, particularly in the reservoirs on the Tumut River (ACT Government 1999d). The crayfish are particularly abundant in Blowering Reservoir and Jounama Pondage where they are actively sought by anglers in the cooler months (Lintermans and Osborne 2002). Regulations introduced in NSW from 2000, including an increased minimum size limit, and smaller bag limits, along with a closed season from September to April inclusive will assist in protecting these populations

In the ACT, overfishing is considered a major factor in the decline of Murray River Crayfish. Surveys of the Murrumbidgee River in the late 1980s found the abundance and size of crays at individual sites to be inversely proportional to the ease of recreational access (and hence fishing pressure), with the majority of large crays removed from one site in a twelve month period (Lintermans and Rutzou 1991). Based on monitoring data (Environment ACT), there has been some recovery of ACT populations following their protection under the *Nature Conservation Act 1980*.

# 4.6

## Alien Species

In Australia, with regard to fish and crayfish species, the term 'alien' has largely replaced the term 'exotic'. Alien fish/crayfish species are those from both other countries and other parts of Australia, which have been intentionally or accidentally dispersed by human agency outside their historically known native range (Koehn and MacKenzie 2004). Currently, the known major detrimental impacts derive from the introduction and establishment (formation of self-sustaining populations) of species from other countries rather than native species. Little is known of the impacts of alien native species.

In the Murray–Darling Basin, eleven alien fish species from other countries are established and make up a quarter of the Basin's total fish species. Nine of these species have established populations or have been recorded in the upper Murrumbidgee catchment of the ACT and region (Lintermans 2002; MDBC 2004a). These are listed in Table 4.3 with information on their origin, distribution and abundance in the Upper Murrumbidgee Catchment, and impacts on native species. The two species not established or ever recorded in the ACT are Tench (*Tinca tinca*), found at lower elevations in the Murray–Darling Basin, and Roach (*Rutilus rutilus*), which occurs in Victoria.

There are also two native fish species present in the Murray–Darling Basin that are not native to the Basin's rivers. The Broad-finned Galaxias (*Galaxias brevipinnis*) has been transferred to the upper Murray drainage by the Snowy Mountains Scheme and has been recorded recently in a tributary of the Tumut River, the first record for the Murrumbidgee drainage (Lintermans and Osborne 2002). The other species is Spotted Galaxias (*Galaxias truttaceus*), found in a Victorian tributary of the Murray River, which was probably introduced via bait-bucket transfers (Lintermans 2004a).

**Table 4.3: Alien Fish Species (Excluding Natives) in the Murray–Darling Basin and the Upper Murrumbidgee Catchment**

| Fish Species | Origin, Distribution and Abundance in the Upper Murrumbidgee Catchment | Impacts on Native Species |
|---|---|---|
| **Family: Salmonidae (Salmons, Trouts, Chars)** | | |
| Rainbow Trout (*Oncorhynchus mykiss*) | Origin: North America. Established in the majority of rivers of ACT and region. Found throughout catchments including smallest headwater streams. Survival poor in urban lakes and no longer stocked. | Species has had a significant impact (predation) on the distribution and abundance of native Mountain Galaxias with galaxids unable to survive where trout are present. Carrier of parasitic copepod *Lernaea* sp. Likely significant predators on larval stages of riverine frog species (see s.4.6.2). |
| Brown Trout (*Salmo trutta*) | Origin: Europe and western Asia. Prefers cool upland streams and lakes and is found in most suitable streams in the region. Not suitable for ACT urban lakes. No longer stocked at Googong Reservoir or streams where threatened native species known to be present. Stocked in lakes throughout region. | Species has had a significant impact (predation) on the distribution and abundance of native Mountain Galaxias. Suspected of having deleterious impacts on threatened fish species such as Trout Cod and Macquarie Perch. May feed on juvenile Murray River Crayfish. Carrier of parasitic copepod *Lernaea* sp. Likely significant predators on larval stages of riverine frog species (see s.4.6.2). |
| Atlantic Salmon (*Salmo salar*) | Origin: Rivers draining to North Atlantic ocean. Stocked into Lake Jindabyne and Burrinjuck Dam, no natural recruitment. Occasional unconfirmed angler reports from Murrumbidgee River but mis-identification likely (with Brown Trout). | Not considered a threat in the ACT. |
| Brook Char (Brook Trout) (*Salvelinus fontinalis*) | Origin: East coast North America. Cool water species of clear streams and lakes that does not coexist well with other salmonids. Stocked in ACT urban lakes in 1970s. Has also been stocked into Lake Burrinjuck. | No known surviving population in the ACT. |
| **Family: Cyprinidae (Carps, Minnows, etc.)** | | |
| Goldfish (*Carassius auratus*) | Origin: Eastern Asia. Associated with warm, slow-flowing lowland rivers and lakes. Abundant after filling of Canberra's urban lakes but declined after stocking of predatory fish. Widespread throughout region. | Goldfish in the ACT region often heavily infected with the parasitic copepod *Lernaea* sp. A consignment of Goldfish from Japan to Victoria is believed to have brought in the disease 'Goldfish ulcer' that also affects salmonid species such as trout. Otherwise few or no adverse impacts have been documented for this species. |
| Carp (European Carp, Common Carp, Koi Carp) (*Cyprinus carpio*) | Origin: Central Asia. Usually associated with warm, slow-flowing lowland rivers or lakes. Tolerant of a wide variety of environmental conditions including low levels of dissolved oxygen. Widespread in ACT and region. Not yet established in Googong Reservoir. Form ~ 70% of fish biomass in ACT rivers and 70–90% of fish biomass in Canberra's urban lakes. | Now the dominant species in the Murray–Darling Basin and likely to compete with native species for food and space. Feeding behaviour 'mumbling' in sediments raises turbidity. Carp carry the parasitic copepod *Lernaea* sp. that affects other native and introduced species. |
| **Family: Cobitidae (Loaches)** | | |
| Oriental Weatherloach (*Misgurnus anguillicaudatus*) | Origin: Central and eastern Asia. Imported as an aquarium fish from the 1960s, detected in the wild in 1984 and importation banned in 1986. Found in slow-flowing or still water with sand or mud substrates. They occur in habitats ranging from degraded rural and urban streams to relatively pristine headwater streams. Found in streams and some lakes throughout ACT and region. Illegal use as live bait by anglers considered significant factor in their spread. | Impacts on native species have not been studied. Diet has significant overlap with that of native Mountain Galaxias. Their feeding habits indicate they may be an egg predator of some native fish species. Weatherloach are known to carry a range of parasites not previously recorded in Australia. |

**Table 4.3:** *(Continued)*

| Fish Species | Origin, Distribution and Abundance in the Upper Murrumbidgee Catchment | Impacts on Native Species |
|---|---|---|
| **Family: Poeciliidae (Livebearers)** | | |
| Eastern Gambusia (Mosquito Fish) (*Gambusia holbrooki*) | Origin: Rivers draining Gulf of Mexico. Widely distributed throughout Australia and widespread in warmer lowland waters in the ACT and region. Not generally recorded from higher cooler waters but can survive if introduced. Tolerant of wide range of environmental conditions, breed rapidly and assume plague proportions in many habitats. | An aggressive species that will chase and fin-nibble tadpoles and fish much larger than themselves. Prey on eggs of native fish and amphibians. Implicated in the decline of 30 species world-wide (nine in Australia). Listed as a key threatening process for amphibian populations in NSW and implicated in decline of more than 10 frog species in Australia. |
| Family: Percidae (Freshwater Perches) | | |
| Redfin Perch (*Perca fluviatilis*) | Origin: Cool temperate waters of Northern Hemisphere. Mainly occurs in slow flowing or still water where there is aquatic vegetation. Present in ACT urban lakes, Googong Reservoir and Murrumbidgee River (upstream to Tharwa). Not recorded from Naas, Gudgenby or Orroral rivers, or the Cotter River upstream of Cotter Dam. | Known to prey on native Western Carp Gudgeon (*Hypseleotris klunzingeri*) and possibly juvenile Murray River Crayfish. Redfin Perch is the main host for a virus, Epizootic Haematopoietic Necrosis Virus (EHNV) first isolated in 1985 and unique to Australia. It causes sudden high mortalities in fish. Experimental work has shown that Macquarie Perch, Silver Perch and Mountain Galaxias are extremely susceptible to the disease. The virus also affects trout species, which can act as vectors to spread the disease. |

(Sources: Koehn and O'Connor 1990a; Lintermans 2000a; Lintermans 2002; Lintermans and Osborne 2002)

Detrimental effects of alien fish species on native fish populations derive from:

- competition for food and habitat (spawning areas, territory);
- predation;
- introduction and spread of diseases and parasites; and
- habitat degradation.

The establishment of alien fish species is often cited as a cause of native fish declines in Australia, however there is little scientific documentation of this. This is because the majority of alien species (in particular, predatory trout and the Redfin Perch) became established in the mid to late 1800s when the distribution and abundance of native fish was poorly known or documented and 'acclimatisation' was seen as a way of enhancing Australia's fauna, which was assumed by some to be deficient. Salmonid (mainly Brown Trout and Rainbow Trout) stocking has a long history of community and government support without attention to assessing and managing the potential environmental impacts (Jackson *et al.* 2004). Past probable negative impacts, e.g. predation on fish, frogs and spiny crayfish by salmonids are inferred from current knowledge as well as the fact that these species have colonised almost the entire catchment in cooler upland areas of Australia. There is a small number of scientific studies that clearly support the inferred impacts of trout on native galaxid species (Fletcher 1979; Lintermans 2000b; Tilzey 1976).

In the case of Carp, now the dominant species in the Murray–Darling Basin, many native species were already well in decline by the time Carp began their rapid expansion in the late 1960s and 1970s. Increases in Carp populations were probably facilitated by the already reduced native fish populations, rather than the commonly held perception that Carp caused these declines (Koehn *et al.* 2000). In turn, the major causes of the decline in native fish species have been river regulation and habitat degradation, resulting in waterways suited to Carp but much less suited to native species. In this way Carp may be seen as a symptom of river degradation rather than a cause.

### 4.6.1 Competition for Food and Habitat

Competition between newly introduced species and native species is believed to be common but is difficult to demonstrate (Li and Moyle 1993 in Koehn *et al.* 2000). Competition occurs when the niches of two or more species overlap and food and/or habitat are limited in some way that requires the species to compete for particular survival requirements.

Dietary overlap is one consideration, but the important factor is whether the food sources are in such limiting amounts so as to cause competition (Koehn *et al.* 2000). The diets of trout and Redfin Perch are similar to those of many native species, particularly freshwater blackfish, Murray Cod and Golden Perch. In the ACT, dietary overlap has been recorded between Two-spined Blackfish and Rainbow Trout (Lintermans 1998a) and between Mountain Galaxias and Oriental Weatherloach (Lintermans and Osborne 2002). Competition may also occur between Macquarie Perch and Carp, Redfin Perch and trout (Battaglene 1988; Butcher 1945; Jackson 1981; Cadwallader 1978a; Lintermans 2006a). Overlap in the diet of Carp with small native fish such as Australian Smelt (*Retropinna semoni*) and Western Carp Gudgeon (*Hypseleotris klunzingeri*) has been reported. It is possible that Carp have an advantage over other species by early spawning, which gives larvae and juveniles access to food earlier than native species that spawn later (Roberts and Ebner 1997). However, such competition for limited food resources has not been demonstrated (Koehn *et al.* 2000).

There is little information on competition for spawning sites and territory. Two-spined Blackfish appears to be able to coexist with trout in its preferred habitat, but its ability to do so in sub-optimal habitats is unclear (ACT Government 1999a). This coexistence is probably due to utilisation of different habitats, as trout prefer faster flowing waters and blackfish slower flowing waters (Koehn and O'Connor 1990a).

There has been speculation on the effects of habitat interactions between Carp and other species, but these have not been quantified. Koehn and Nicol (1998) found overlap in habitat use by Carp and native species, with both using snags and areas of slower flowing water. Harris (1997) suggested that Carp have been able to utilise under-used aquatic habitat, resulting from the decline of native species. However, the large numbers, large size and density of Carp may be placing behavioural pressures on smaller native species forcing them from preferred habitats. Concern has been expressed that Carp may interfere with the nesting sites of Freshwater Catfish (*Tandanus tandanus*), affecting spawning, guarding of nests and survival of deposited eggs (Koehn *et al.* 2000). Benthivorous feeding and destruction of aquatic vegetation by Carp may reduce the suitability of habitat for native fish species.

Murray River Crayfish are potentially threatened by non-local crayfish species such as Marron (*Cherax tenuimanus*) and Redclaw (*C. quadricarinatus*) should they become established in the ACT. There is now extensive movement of crayfish species throughout Australia associated with aquaculture.

### 4.6.2 Predation

Murray Cod were formerly the top predators in the larger, lowland streams of the Murray–Darling Basin with Trout Cod and Golden Perch also predatory on other fish. In the upland streams, Two-spined Blackfish and Macquarie Perch would have been the top predators until the arrival of the alien trout species. Amongst the alien species found in the Upper Murrumbidgee catchment, Koehn and O'Connor (1990a) describe Brown Trout, Rainbow Trout and Redfin Perch as 'voracious predators' and native species may form a large part of their diet.

In upstream waters like the ACT, Brown Trout and Rainbow Trout have been clearly identified as predators of Galaxiidae with the latter eliminated from many streams (Tilzey 1976; Frankenberg 1966, 1974; Fletcher 1979; Cadwallader 1979; Cadwallader and Backhouse 1983; Jackson 1981; Jackson and Williams 1980; Lintermans and Rutzou 1990a; Lintermans 2000b). In such situations galaxiids are generally only found above waterfalls or swamps that prevent trout access. An experiment to remove Rainbow Trout from a section of Lees Creek (Brindabella Range) in the ACT has resulted in the recolonisation by galaxiids of the trout-free section of the stream (Lintermans 2000b). However, Rainbow Trout are still expanding their range in the ACT, recently becoming established above Gibraltar Falls and threatening the local population of Mountain Galaxias. This range expansion required human assistance, as the falls are too high to be bypassed naturally. It is unknown what impact trout have had on Murray River Crayfish, but predation on juvenile and immature crays is likely.

Brown Trout are suspected of having deleterious impacts on the threatened species, Trout Cod and Macquarie Perch (Wager and Jackson 1993). Consequently, Brown Trout are no longer stocked in Googong Reservoir (where there is an existing trout population from earlier stocking) or streams of the Upper Murrumbidgee catchment in which threatened species are known to be present (Lintermans 2002; NSW Fisheries 2003). Trout predation on tadpoles exerts significant population pressure on some riverine frog species and is probably a major factor in causing the low density of some species in upland streams (Gillespie and Hero 1999; Gillespie and Hines 1999).

The diet of Redfin Perch includes crustaceans, zooplankton and small fish. In the ACT region, the

species is known to prey on the native Western Carp Gudgeon (*Hypseleotris klunzingeri*), Murray Cod and the alien Eastern Gambusia, and is suspected to prey on Macquarie Perch. The Western Carp Gudgeon is abundant in ACT urban lakes and the population in Lake Burley Griffin appears to have increased following depletion of the Redfin Perch population by the Epizootic Haematopoietic Necrosis Virus (EHNV) (Lintermans and Osborne 2002). Redfin Perch are a potential threat to remnant populations of threatened species such as the small populations of Macquarie Perch located in the Queanbeyan River above Googong Reservoir, and in the Cotter Reservoir. Redfin Perch are currently not known from the either of these two locations. Redfin Perch may also prey on juvenile and immature Murray River Crayfish.

Carp are often accused of damaging populations of native fish by feeding on their eggs and larvae or eating whole fish. However, the evidence available and the feeding morphology (mouth shape and location, and type of teeth) of Carp suggest that fish are a negligible component of carp diets (Koehn *et al.* 2000). Eastern Gambusia is an aggressive species that has been implicated in the decline of many fish species and feeds on the eggs of native fish and amphibians (Table 4.3).

### 4.6.3 Introduction and Spread of Diseases and Parasites

A potentially serious impact of alien species is their capacity to introduce or spread (mostly foreign) diseases and parasites to native fish species. Carp or Redfin Perch are considered to be the source of the Australian populations of the parasitic copepod *Lernaea cyprinacea* (Langdon 1989a). This copepod has been recorded on trout and Goldfish (*Carassius auratus*) as well as a number of native fish species in the Murray–Darling Basin, including Murray Cod, Golden Perch, Silver Perch (Langdon 1989a), Macquarie Perch, and Mountain Galaxias (M. Lintermans. unpubl. data). *Lernaea* has been recorded on Peron's Tree Frog (*Litoria peroni*) in the Cotter River (Lintermans unpubl data), and may infect other stream-dwelling frog species in the ACT. Carp are susceptible to a range of parasites and disease organisms, some of which are known to occur in native fish (see Koehn *et al.* 2000).

Carp, Goldfish or Eastern Gambusia are probably implicated as the source of the Asian fish tapeworm *Bothriocephalus acheilognathi*, which has been recorded in native fish species in the ACT (Dove *et al*. 1997). This tapeworm causes widespread mortality in juvenile fish overseas and may have similar effects on local native species. The tapeworm has low host-specificity at both stages of its life cycle with the adult stage recorded from at least 50 species of fish in five taxonomic orders (Dove *et al.* 1997).

The most serious disease threat from alien fish species may lie in the impacts of Epizootic Haematopoietic Necrosis Virus (EHNV). This virus, unique to Australia, was first isolated in 1985 on Redfin Perch (Langdon *et al.* 1986). It is characterised by sudden high mortalities of fish, which display necrosis of the renal haematopoietic tissue, liver spleen and pancreas (Langdon and Humphrey 1987). The disease also affects trout species and these can act as vectors. Experimental work by Langdon (1989a, b) demonstrated that Silver Perch and Macquarie Perch were two of several species found to be extremely susceptible to the disease, but other native species such as Trout Cod and Two-spined Blackfish have not been examined for susceptibility.

EHNV was first recorded from the Canberra region in 1986 when an outbreak occurred in Blowering Reservoir near Tumut (Langdon and Humphrey 1987). Subsequent outbreaks have occurred in Lake Burrinjuck in late 1990, Lake Burley Griffin in 1991 and 1994, Lake Ginninderra in 1994 and Googong Reservoir, also in 1994 (Lintermans 2000a; Whittington *et al.* 1996). Its robust characteristics and the ease with which it can be transmitted from one geographical location to another on nets, fishing lines, boats and other equipment have aided the spread of EHNV. Langdon (1989b) found that the virus retained its infectivity after being stored dry for 113 days. Once EHNV has been recorded from a water body it is considered impossible to eradicate.

The Murrumbidgee River and Googong Reservoir populations of Silver Perch and Macquarie Perch have been exposed to the virus. It is highly likely the Queanbeyan River population of Macquarie Perch (upstream of Googong Reservoir) has been exposed through the movement of infected adult trout between the reservoir and the river. It is now speculated that the sudden and severe depletion of the Lake Eildon (Victoria) Macquarie Perch population may have in part been due to EHNV (Langdon 1989b).

The Cotter River and reservoirs above Cotter Dam are not affected by EHNV, and restrictions or prohibitions on recreational fishing in these river sections are aimed at maintaining that status by preventing the establishment of Redfin Perch.

# 4.7

## Translocation and Stocking (Native Fish)

As natural populations of native fish have declined, there has been growing interest in aquaculture of native species and stocking of waterways with hatchery-bred native fish. Stocking has enabled the maintenance of recreational fisheries, especially in artificial lakes, where natural breeding is rarely possible because of unsuitable habitat and barriers to upstream movement to potential spawning areas. The presence of these stocked fish may assist in reducing angling pressure on remnant natural populations. Artificially propagated native fish have been used to rehabilitate depleted populations of a number of threatened fish species in south-eastern Australia (see Lintermans *et al.* 2005). In the ACT, hatchery bred Trout Cod have been released into Bendora Reservoir and the Murrumbidgee River at Angle Crossing as part of a National Recovery Plan. However, the composition and evolution of naturally occurring native fish populations can be threatened by the liberation of fish outside their natural range or stocking from hatcheries (MDBC 2004a; Phillips 2003).

Natural populations of native fish are threatened by the potential release of genetically restricted material from native fish aquaculture or stocking with hatchery-bred fish using limited brood stock. The release of such material has potential to reduce the genetic fitness and hence viability of fish populations especially where the existing wild population is small in number (Harris 1997; MDBC 2004a). Large numbers of hatchery fish added to a small residual wild population can out-compete the wild fish for food and habitat (Harris 1997). Stocking and translocation also have the potential to introduce diseases and unwanted species, inadvertently included in hatchery supplied fish consignments. The apparent success of hatchery breeding of native fish and their growth in stocked waterways potentially draws attention away from the need to conserve natural populations.

Human assisted dispersal of fish (both deliberate and inadvertent) is widespread (Lintermans 2004a). All Australian States and Territories have adopted the *National Policy for the Translocation of Live Aquatic Organisms* (MCFFA 1999). The ACT has a *Fish Stocking Plan* (Environment ACT 2000a) that sets out principles for fish stocking in the ACT, and a five-year rolling stocking program for urban lakes.

# 4.8

## Localised Threats

### 4.8.1 Impacts of the 2003 Bushfires in the ACT

In 2003 bushfires burnt 70% (164 914 hectares) of the ACT including 90% of Namadgi National Park (Cotter, Gudgenby, Naas rivers) and Tidbinbilla Nature Reserve (Tidbinbilla River). The fires also affected the Murrumbidgee River Corridor, and the Lower Molonglo Nature Reserve. The geographic extent and severity of the fires was unprecedented in the ACT and is likely to have significant short and long-term consequences for the natural ecosystems of the Territory (Carey *et al.* 2003). Impacts of bushfire on aquatic communities can include:

- Sedimentation from denuded catchments following rain events.
- A decrease in dissolved oxygen concentrations as organic material (leaves, ash) washed into streams following rain events begins to decompose.
- Chemical changes in water quality as ash is deposited in streams.
- Impacts from the loss of the riparian (streamside) vegetation including:
  - —loss of food resources because there is no insect fall from overhanging vegetation;
  - —increase in water temperature due to lack of shade; and
  - —increase in algal abundance due to increased sunlight reaching the stream.
- Increased algal growth due to increased nutrient load.
- Changes to streamflow patterns as upland swamps and bogs (sponges/filters) are damaged and runoff increases after rainfall because there is no vegetative cover remaining.

Studies on the Cotter River have shown that river regulation has exacerbated the effects of the fires and sediment addition. A North American study documented increases in summer water temperatures of 8–10 °C following fire, due to the increased light reaching streams as a result of the removal of riparian vegetation (Minshall *et al.* 1989). Such a rise could have significant effects on cool water species such as the Two-spined Blackfish, which only occurs in the Cotter River Catchment in the ACT (Lintermans 2002; Lintermans and Osborne 2002) and has a restricted distribution in the Canberra region.

A total of almost 840 km of streamside vegetation was burnt in 2003 with a relatively even split between three categories of burn severity (Table 4.4). Only 30.8% of stream length would have retained its riparian canopy cover as the vegetation in the 'Very High' and 'High Severity' categories lost its canopy during or post-fire.

**Table 4.4: Length (km) of Stream Within the Burnt Area in Three Fire Severity Categories Following the 2003 Bushfires in the ACT**

| Fire Severity Category | Length of Stream (km) | Percent of Stream Length |
|---|---|---|
| Very High | 291.95 | 34.8 |
| High | 288.3 | 34.4 |
| Moderate to Low | 258.41 | 30.8 |

(Source: Carey *et al*. 2003, p. 50)

Inputs of sediment and ash can cause fish kills, and significantly change habitat leading to reduction in available food supplies (aquatic and riparian macro-invertebrates), reduction in breeding opportunities for fish (smothering of spawning sites), and increased vulnerability to predators (trout and cormorants). Although no fish kills were recorded for the Cotter catchment upstream of Cotter Reservoir, fish kills were recorded in the Murrumbidgee River and the Cotter River below Cotter dam following local rainfall events (Carey *et al.* 2003). It is likely that other localised fish kills caused by the fires occurred in the Canberra region. However, the largely uninhabited terrain of the national parks, nature reserves and forestry plantations where the fires occurred, probably reduced the chances of such kills being detected or reported.

Significant erosion and sediment input to the Cotter River and tributaries has been evident following the fires (Starr 2003; Wasson *et al.* 2003; CRCFE 2004) and it is expected that this sediment supply to the river and reworking of in-channel sediment will continue for many years.

### 4.8.2 Impacts of Native Predators

Recent research on Macquarie Perch and Trout Cod in the Cotter and Murrumbidgee rivers has suggested that bird predators such as cormorants or mammalian predators such as the Eastern Water Rat may be significantly limiting population size or hampering reintroduction efforts for these two species (Environment and Recreation unpubl. data). The population of Macquarie Perch in Cotter Reservoir must leave the reservoir to spawn in the upstream section of the Cotter River. Radiotelemetry investigations indicate that a small population of cormorants may prey on a significant proportion of adult fish as they leave the deep-water habitats of the reservoir and move up the shallow river channel. Encouragement of research into the effects of cormorant predation and, if desirable, means to limit the impact is an action identified in Table 5.1. In the Murrumbidgee River, a trial reintroduction of adult and sub-adult Trout Cod is thought also to have been affected by high predation rates, as there appears to be little refuge habitat available to accommodate these larger fish.

## 4.9

## Summary: Threats to Threatened Fish and Crayfish Species

Table 4.5 contains a summary of the importance of particular threats to threatened fish and crayfish species, discussed in sections 4.4 to 4.7.

## 4.10

## Threatened Fish and Crayfish: Conservation Goals, Objectives and Actions

Consistent with the requirements for threatened species in the *Nature Conservation Act 1980*, the Protection Goal adopted for threatened fish and crayfish in this *Strategy* is to:

> **Conserve in perpetuity, viable, wild populations of all aquatic and riparian native flora and fauna species in the ACT.**

The Management Goal incorporates the possible reinstatement of fish species to ACT and/or regional streams where they no longer occur naturally:

> **Aquatic and riparian communities and habitats in the ACT are maintained and where degraded, rehabilitated to support the range of flora and fauna typical of the ACT. Rehabilitation may include the re-introduction of threatened or locally extinct fish species to ACT and/or regional streams where they no longer occur naturally.**

To achieve the conservation goal the following strategic actions are necessary:

(a) **Information (Survey, Monitoring, Research):** Improve understanding of the biology and ecology of threatened fish and crayfish species as the basis for managing the species and their habitat. Give specific attention to establishing causes of population decline. Investigate translocation as a

**Table 4.5: Summary—Ranking of Importance of Particular Threats to Threatened Fish and Crayfish Species in the Murray–Darling Basin and the Upper Murrumbidgee Catchment**

| Threats | ACT Threatened Species | | | | | Other |
|---|---|---|---|---|---|---|
| | Two-spined Blackfish | Trout Cod | Macquarie Perch | Silver Perch | Murray River Crayfish | Murray Cod |
| **Habitat destruction and modification (s. 4.4)** | | | | | | |
| Habitat degradation | | | | | | |
| ■ damage riparian veg. | H | H | H | M | M | M |
| ■ sedimentation | H | H | H | L | M | H |
| ■ removal of in-stream habitat | L (N/A) | M (L) | M (L) | M (L) | M (L) | M (L) |
| Barriers to fish passage | L | M | H | M | L | M |
| Flow regime alteration | M | H (M) | H | M (L) | M (L) | M |
| Reduced water quality | M | M | H (M) | M | L | M |
| Thermal pollution | M | H (L) | H (M) | M (L) | N/A | M (L) |
| **Over-exploitation (s. 4.5)** | | | | | | |
| Illegal harvesting | L | M | M | L | M | M |
| Recreational angling | L | H | H | M | H | L |
| **Alien species (s. 4.6)** | | | | | | |
| Competition for food/habitat | M | M | M | M | M | M |
| Predation | H | H | H | L | L | L |
| Diseases/parasites | L | M | H | H | L | M |
| **Translocation and stocking (s. 4.7)** | | | | | | |
| Disease/genetic effects/competition | L | M | M | M | M | |
| **Localised threats in the ACT (s. 4.8)** | | | | | | |
| Impacts 2003 bushfires | H | M | H | L | L | M |
| Native predators | L | M | M | N/A | N/A | N/A |

**Notes: Threat ranking (high, medium, low, not applicable):**

1. The table provides a generalised ranking of the importance of particular threats to threatened fish/crayfish species:
   **H (High):** Highly significant threat to existing populations or re-introductions. Likely to result in local extinctions.
   **M (Medium):** Moderately significant threat to existing populations or re-introductions. Likely to result in significantly reduced populations and could result in local extinctions over the long term.
   **L (Low):** Less significant threat. Unlikely by itself to result in significantly reduced population or extinction.
2. **Importance in parentheses** indicates importance in the upper Murrumbidgee Catchment, where this is different to the Basin as a whole.
3. Threat ranking only applies to current or potential threats and should not be used as an indication of the relative importance of these issues in past declines. Many threats are inter-related (e.g. potential for stocking to introduce diseases) and are not well documented scientifically.

management option for establishing new sub-populations (see s. 4.11).

(b) **Protection and Management:** Protect sites and habitats that are critical to the survival of threatened fish and crayfish species. Manage activities in the Murrumbidgee, Cotter and Paddys River catchments in the ACT to minimise or eliminate threats to fish and crayfish populations. Evaluate means and undertake actions to maintain and expand existing populations. Re-introduce Trout Cod to their former habitat in the ACT (see s. 4.12).

(c) **Education:** Increase community awareness of the need to protect aquatic species and their habitats (see s. 4.13).

(d) **Regional and National Cooperation:** Maintain links with, and participate in, regional and national recovery efforts for threatened aquatic species (see s. 4.14). Closely liaise with NSW DPI (Fisheries) in the management of the Queanbeyan River population of Macquarie Perch.

The following sections identify specific actions for the conservation of declared threatened fish and crayfish species in the ACT, and are framed within the objectives and actions of the *Strategy* in Table 6.1. The actions outlined here are based on an evaluation of progress with the actions contained in the previously published Action Plans for the four threatened fish species and the Murray River Crayfish (ACT Government 1999a–d, 2003), as well as new actions identified as being necessary for the next few years.

# 4.11

## Conservation Actions: Information

### 4.11.1 Survey

There has been an ongoing survey program for fish in the ACT since the mid 1980s, with most major catchments having some survey information (Lintermans 2002) (Table 4.6). Additional surveys and monitoring in the upper Murrumbidgee Catchment have been carried out by NSW DPI (Fisheries).

The previous Action Plans for threatened fish and crayfish species noted the deficiencies in knowledge of the distribution, abundance and dispersal of species in ACT and regional streams and included relevant survey actions. There was a better knowledge of Silver Perch due to the more recent date of the Action Plan (2003) and the parlous state of this species within the ACT. Progress with previous *Survey* actions and new and continuing actions required are contained in Table 4.7.

**Table 4.6: Fish Surveys Conducted in the Upper Murrumbidgee Catchment 1986 to 1999**

| Catchment | No. of Sites Sampled | Year Sampled | Reference |
|---|---|---|---|
| Naas/Gudgenby/Orroral rivers | 22 | 1986–87 | Jones *et al.* 1990 |
| Ginninderra Creek | 21 | 1988 | Lintermans *et al.* 1990a |
| Upper Cotter River (above Corin Dam) | 28 | 1988–89 | Lintermans & Rutzou 1990a |
| Middle Cotter River (between Corin and Bendora dams) | 14 | 1989–90 | Lintermans unpubl. data |
| Lower Cotter River (below Bendora Dam) | 31 | 1990 | Lintermans unpubl. data |
| Molonglo River | 23 | 1992–93 | Lintermans unpubl. data |
| Tidbinbilla River | 16 | 1992 | Rutzou *et al.* 1994 |
| Lower Cotter/Lower Paddys rivers | 16 | 1992 | Lintermans 1993 |
| Middle Paddys River | 3 | 2000 | Lintermans unpubl. data |
| Middle Queanbeyan River | 3 | 1996–97 | Lintermans 2006a |
| Lower Queanbeyan River | 3 | 1998, 2001, 2004 | Lintermans 1998c, Lintermans *et al.* 2001 Jekabsons & Lintermans 2005 |
| Upper Murrumbidgee Catchment | 5 | 1994–96 | Harris & Gehrke 1997 |
| Upper Murrumbidgee Catchment | 20 | 1998–99 | Lintermans unpubl. data |

**Table 4.7: Survey—Progress with actions in previous Action Plans and new and continuing actions for this *Strategy***

| Species (Issue) | Knowledge Requirement or Deficiency Identified in Original Action Plan* | Actions Proposed 1999–2003* | Progress with Actions (to April 2005) | Actions for ths *Strategy* |
|---|---|---|---|---|
| **Two-spined Blackfish (Distribution)** | (a) Incomplete knowledge of distribution in upper Murrumbidgee River catchment.<br>(b) Species identity unknown of unconfirmed reports of blackfish from upper Lachlan River catchment, north of the ACT. | (a) Survey of the upper Murrumbidgee River catchment (E&R).<br>(b) Investigation of specific identity of blackfish from Gunning/Dalton area. | (a) Survey of major streams completed (1998–9) and a single small population located in Murrumbidgee River above Yaouk. Population previously reported from below Yaouk not located.<br>(b) Specific identity of blackfish in the Gunning/Dalton area confirmed as River Blackfish (*Gadopsis marmoratus*) not Two-spined Blackfish. | (a) Undertake more detailed survey for the presence of Two-spined Blackfish in the upper Murrumbidgee River catchment.<br>(b) Undertake detailed survey of Condor Creek to ascertain extent of population.<br>(c) Undertake specific surveys to confirm identity when blackfish reported from other locations in the region (e.g. unconfirmed report from the Tinderry Range, NSW). |
| **Trout Cod (Dispersal)** | Incomplete knowledge of the extent of dispersal of stocked Trout Cod in the upper Murrumbidgee River catchment. | Survey of the upper Murrumbidgee River catchment to examine whether the sub-adults and adults of the species are dispersing downstream from stocking sites (E&R). | Survey completed (1998–9) and species not detected away from stocking sites. | Continue to encourage reporting by anglers of incidental captures. |
| **Macquarie Perch (Distribution and Abundance)** | Incomplete knowledge of distribution and abundance of Macquarie Perch in upper Murrumbidgee River catchment. | To assess distribution and status:<br>(a) Survey upper Murrumbidgee River catchment (outside ACT).<br>(b) Survey Paddys River.<br>(c) Survey Queanbeyan River outside Googong Foreshores area. | (a) Upper Murrumbidgee River survey completed (1998–9). Good populations above Cooma, small population at Michelago. Population in Goodradigbee River now considered not viable.<br>(b) Paddys River surveyed 2000. Species recorded in extremely low numbers from one site near Cotter River confluence.<br>(c) Lower Queanbeyan River surveys 1998–2004 did not record the species. Above Googong Reservoir, species occupies 15 km of river. Waterfall at Silver Hills blocks upstream movement. | Maintain original action for Queanbeyan River:<br>(a) Survey the Queanbeyan River upstream of the Googong Foreshores area to assess the distribution and status of Macquarie Perch (E&R, 2006–7).<br>(b) Assess status of population in Cotter River downstream of Cotter Dam.<br>(c) Monitor spread of species upstream of Vanitys Crossing on Cotter River.<br>(d) Investigate reports of Macquarie Perch upstream of Tantangara Reservoir. |
| **Silver Perch (Distribution and Abundance)** | Knowledge of distribution of Silver Perch in upper Murrumbidgee River catchment is largely complete. Status of Lake Burrinjuck population not assessed since mid-1980s when concern expressed about the impact of Redfin Perch. ACT population thought to be largely dependent upon Lake Burrinjuck population. | Liaise with NSW Fisheries regarding an assessment of the status of the Lake Burrinjuck Silver Perch population (E&R). | Issue raised informally with NSW DPI (Fisheries) scientists, but NSW has not had the resources to undertake a targeted survey to date. Monitoring at two sites in Lake Burrinjuck in 2004 failed to locate any specimens (Gilligan 2005). | Maintain original action:<br>(a) Liaise with NSW DPI (Fisheries) regarding an assessment of the status of the Lake Burrinjuck Silver Perch population (E&R).<br>(Status of Lake Burrinjuck population will be raised when NSW prepares State Recovery Plan for the species.) |
| **Murray River Crayfish (Distribution and Abundance)** | Knowledge of distribution and abundance in Paddys River catchment incomplete. | Survey the Paddys River catchment for the species (E&R). | Not undertaken to date. | Maintain original action:<br>(a) Survey the Paddys River catchment for the species (EAR).<br>(b) Assess status of newly located population upstream of Cotter Dam. |

Notes: * Summary form only. For detail see previous Action Plans (ACT Government 1999a–d, 2003) **E&R:** Environment and Recreation (TAMS)

### 4.11.2 Monitoring

The previous Action Plans noted the need for a long-term monitoring program to detect changes in the distribution and abundance of threatened fish and crayfish species. Monitoring of catchments in the region outside of the ACT was also needed to place the ACT program in regional context. Regular monitoring of the Murrumbidgee River was established well before preparation of the first Action Plans for aquatic species in 1999 and continues in the form of a biennial monitoring at six sites (Lintermans 2002). Other specific monitoring programs were undertaken e.g. for environmental flow monitoring in the Cotter and Queanbeyan rivers. Progress with previous monitoring actions and new and continuing actions required are contained in Table 4.8.

Monitoring of the impacts of the January 2003 bushfires on fish communities, and of their subsequent recovery, has been undertaken from 2003 to 2005. The need for continued monitoring of the recovery following the bushfires encompasses a number of the threatened fish species and fish communities in general, and so is not specifically identified in Table 4.8 (see Table 6.1).

Currently, there is no centralised database to hold the results of aquatic survey and monitoring programs. This will potentially hamper data management and retrieval as the amount of information increases. The development of a database to house survey and monitoring information on aquatic species is an overarching action for all threatened fish and crayfish species, and so is not specifically identified in Table 4.8 (see Table 6.1).

**Table 4.8: Monitoring—Progress with actions in Previous Action Plans and New and Continuing Actions for this *Strategy***

| Species (Issue) | Knowledge Requirement or Deficiency Identified in Original Action Plan* | Actions Proposed 1999–2003* | Progress with Actions (to April 2005) | Actions for ths *Strategy* |
|---|---|---|---|---|
| **Two-spined Blackfish (Distribution and Abundance)** | The disappearance of Two-spined Blackfish from the Cotter River below Cotter Dam and the Murrumbidgee River in the ACT raises concerns as to whether other sub-populations of the species are declining. A long-term monitoring program is required to evaluate these concerns. To place the results from the ACT monitoring program in a regional context, it is proposed to monitor a small number of sites in adjacent NSW waters. | (a) Establish a monitoring program for Two-spined Blackfish at representative sites in the Cotter River catchment (E&R).<br>(b) Monitor the fish population in the Murrumbidgee River in the ACT. Include monitoring techniques suited to detecting the presence of Two-spined Blackfish (E&R).<br>(c) Liaise with NSW DPI (Fisheries) in the ACT region to exchange information on the species (E&R).<br>(d) Encourage monitoring of populations of Two-spined Blackfish in areas of NSW adjacent to the ACT. Potential streams include Goodradigbee River, Micalong Creek, Mountain Creek, Murrumbidgee River near Yaouk (E&R). | (a) Monitoring program implemented on the Cotter River (2001, 2003, 2004, 2005), now covers nine sites.<br>(b) Biennial fish monitoring of Murrumbidgee River undertaken (2000, 2002, 2004) with no individuals detected.<br>(c) There is on-going liaison with NSW DPI (Fisheries). Species was included in review of threatened species of Murray–Darling Basin being prepared by NSW Fisheries.<br>(d) Monitoring undertaken by EACT at three NSW sites: Mountain Creek, Micalong Creek (Goodradigbee River catchment), Goobarragandra River in 2001, 2003, 2004, 2005.<br>**Note:**<br>Monitoring recorded significant decline in the species following bushfires of January 2003 and substantial recovery at most sites in 2004.<br>**Other monitoring (not specified in original Action Plan):**<br>Monitoring of impacts of environmental flows on blackfish recruitment 2001, 2003, 2005. Continue actions from original Action Plan adapted to recognise new information (all E&R): | (a) Continue Two-spined Blackfish monitoring program in the Cotter River.<br>(b) Continue to include techniques suited to Two-spined Blackfish in the biennial Murrumbidgee River monitoring.<br>(c) Continue liaison with NSW DPI (Fisheries) to exchange information on the species.<br>(d) Continue monitoring of Two-spined Blackfish populations in streams adjacent to the ACT.<br>(e) Continue monitoring of impacts of environmental flows on blackfish recruitment.<br>(f) Monitor success of 2004 reintroduction to the lower Paddys River.<br>(g) Liaise with NSW DPI (Fisheries) about cooperative approaches to regional monitoring for threatened fish populations. |

**Table 4.8:** *(Continued)*

| Species (Issue) | Knowledge Requirement or Deficiency Identified in Original Action Plan* | Actions Proposed 1999–2003* | Progress with Actions (to April 2005) | Actions for ths *Strategy* |
|---|---|---|---|---|
| **Trout Cod (Distribution, Abundance, Dispersal)** | There are currently two stocked populations of Trout Cod in the ACT: Bendora Reservoir on the Cotter River (monitored since 1992) and Angle Crossing on the Murrumbidgee River (monitored since 1997). The site-specific monitoring aims to determine growth rate and survival of stocked fish and detect natural recruitment. Regular monitoring of fish populations in the Murrumbidgee River in the ACT should be capable of detecting dispersal of Trout Cod from the Angle Crossing stocking site. | (a) Continue monitoring program for the two ACT stocking sites for Trout Cod (E&R).<br>(b) Monitor the fish population in the Murrumbidgee River in the ACT. Include monitoring techniques suited to detecting the presence of Trout Cod (E&R).<br>(c) Liaise with Victorian and NSW fisheries agencies to ensure there is an exchange of information on the species (E&R). | (a) Annual monitoring undertaken at both sites. **Angle Crossing:** (i) Good survival of stocked fish but unable to catch individuals more than 3 years old; (ii) dispersal downstream detected in 2000. **Bendora Reservoir:** Catch rate low as it is more than 15 years since stocking, and fish are thought to be largely beyond reach of sampling equipment. Juvenile fish (estimated 1–2 years old) collected in 2004, indicating a successful breeding event.<br>(b) Biennial monitoring of Murrumbidgee River undertaken. Downstream dispersal from Angle Crossing detected in 2000 but not in 2002 or 2004.<br>(c) Regular contact with researchers and managers in NSW and Vic. maintained. ACT is member of National Trout Cod Recovery Team and actively participates. | Continue actions from original Action Plan adapted to recognise new information (all E&R):<br>(a) Continue annual monitoring program for the two ACT stocking sites for Trout Cod (E&R).<br>(b) Liaise with NSW DPI about cooperative approaches to regional monitoring for threatened fish populations<br>(c) Continue to include Trout Cod in the biennial Murrumbidgee River monitoring.<br>(d) Continue membership of the National Trout Cod Recovery Team and other liaison forums. |
| **Macquarie Perch (Distribution and Abundance)** | Decline of Macquarie Perch in the Murrumbidgee River and small distribution and population sizes in the Queanbeyan and Cotter rivers raises concerns about the long-term viability of these sub-populations. A long-term monitoring program is required. To place the results from the ACT monitoring program in a regional context, it is proposed to monitor a small number of sites in adjacent NSW waters. | (a) Establish a monitoring program for the Cotter, Murrumbidgee and Queanbeyan river sub-populations of Macquarie Perch (E&R).<br>(b) Based on results of upper Murrumbidgee River survey (see Table 4.7), monitor a small number of sites in NSW waters adjacent to the ACT (E&R).<br>(c) Liaise with Victorian and NSW fisheries agencies to ensure there is an exchange of information on the species (E&R). | (a, b) Macquarie Perch monitoring program implemented from 2001 including Queanbeyan, Cotter, Goodradigbee and upper Murrumbidgee rivers. Individuals also detected in Murrumbidgee River biennial fish monitoring in 2000. Monitoring in 2001 produced numbers considerably lower than previously. Monitoring in 2003, 2004 and 2005 failed to record species at Goodradigbee River site and no recruitment in the Queanbeyan River. Spawning and recruitment were successful in the Cotter River under drought modified environmental flows in 2004 and 2005. (Increased monitoring undertaken, related to drought affected environmental flow regime.)<br>(c) Regular contact with researchers and managers in NSW and Vic. maintained. ACT is involved in preparation of National Recovery Plan for the species. | Continue actions from original Action Plan adapted to recognise new information (all E&R):<br>(a) Continue monitoring program for Macquarie Perch in ACT and adjacent NSW streams.<br>(b) Commence monitoring of population in Cotter River downstream of Cotter Dam and in lower Paddys River.<br>(c) Continue to participate in liaison forums and in preparation of National Recovery Plan for Macquarie Perch.<br>(d) Liaise with NSW DPI (Fisheries) about cooperative approaches to regional monitoring for threatened fish populations. |

**Table 4.8:** *(Continued)*

| Species (Issue) | Knowledge Requirement or Deficiency Identified in Original Action Plan* | Actions Proposed 1999–2003* | Progress with Actions (to April 2005) | Actions for ths *Strategy* |
|---|---|---|---|---|
| **Silver Perch (Distribution and Abundance)** | The decline of Silver Perch in the Murrumbidgee River raises concerns about the long-term viability of this population. A long-term monitoring program capable of detecting changes in distribution and abundance of the species, which are outside the normal variation in these parameters is required. | (a) Monitor the fish population in the Murrumbidgee River in the ACT. Include monitoring techniques suited to detecting the presence of Silver Perch (E&R).<br>(b) Liaise with Victorian and NSW fisheries agencies to ensure there is an exchange of information on the species (E&R). | (a) Suitable techniques for detecting the species have been included in Murrumbidgee River biennial fish monitoring since its inception in 1994. No individuals detected.<br>(b) Liaison with NSW and Vic. fisheries agencies through forums such as the Murray–Darling Basin Commission Fish Management and Science Committee. | (a) Continue to include suitable techniques for Silver Perch in the biennial Murrumbidgee River monitoring (E&R).<br>(b) Continue liaison with NSW and Vic. fisheries agencies (E&R). |
| **Murray River Crayfish (Distribution and Abundance)** | The recreational fishery for Murray River Crayfish in the ACT was closed in 1991 to allow populations to recover. Monitoring in the Murrumbidgee River in 1994 and 1996 indicated some recovery. In order to detect trends in population abundance and size structure of ACT populations of the species, a long-term monitoring program needs to be established. | (a) Establish a monitoring program for Murray River Crayfish at representative sites in the ACT (E&R).<br>(b) Liaise with Victorian and NSW fisheries agencies and research institutions to ensure there is an exchange of information on the species (E&R). | (a) Murray River Crayfish has been collected in the biennial Murrumbidgee River fish monitoring with individuals detected at several sites in 2000, and 2002#. Monitoring program for the species designed, covering 10 sites in the Murrumbidgee River Monitoring conducted during 1998 (under draft Action Plan). Sampling scheduled for 2003 not yet done due to change of priorities following bushfires.<br>(b) Regular contact with researchers and managers in NSW and Vic. maintained, including through Murray–Darling Basin Commission Fish Management and Science Committee. In 2005, ACT and NSW secured funds from MDBC to review ecological knowledge and identify knowledge gaps for the species. | (a) Undertake monitoring for Murray River Crayfish by 2006 and thereafter 5 yearly (E&R).<br>(b) Continue liaison with NSW and Vic. fisheries agencies and involvement in Murray–Darling Basin Commission Fish Management and Science Committee (E&R).<br>(c) Liaise with NSW DPI (Fisheries) about cooperative approaches to regional monitoring for threatened fish populations. |

**Notes:**

* Summary form only. For detail see previous Action Plans (ACT Government 1999a–d, 2003)

# The major sampling technique for the biennial Murrumbidgee River fish monitoring program has changed from gill nets to boat electrofishing. The majority of Murray River Crayfish were previously sampled in gill nets, and boat electrofishing is not effective for their capture.

**E&R:** Environment and Recreation, Department of Territory and Municipal Services

**NSW DPI:** NSW Department of Primary Industries

### 4.11.3 Research

This section focuses on research needs for ACT threatened aquatic species, however, there is also a need for research on other species closely associated with streams and riparian areas such as the spiny crayfish and land burrowing crayfish (s. 4.2.2). The nature of their habitat and difficulty in locating the species hinder such research work.

Previous Action Plans for threatened aquatic species in the ACT outlined knowledge gaps needing to be researched, as well as the presence of existing information on the biology and ecology of most species, much of this unpublished. Recognition of the significant decline in native fish stocks in the Murray–Darling Basin since the 1950s and the need to rehabilitate native fish communities (MDBC 2004a) has resulted in more research being undertaken, as well as compilations of existing knowledge combining both research and the results from monitoring programs (Lintermans 2002). Koehn (2004) has noted a progression in freshwater fish science based on field-based research with greater scientific rigour, replacing previous natural history and hatchery-based research, largely centred around major angling species. However, there is still often little systematic integration of the results of scientific research into river and fish habitat rehabilitation projects. Progress with previous *Research* actions and new and continuing actions required are contained in Table 4.9.

Some research needs are common to all or most ACT threatened aquatic species. These are habitat management, effects of alien species, effects of EHN Virus in the wild, movement ecology and requirements, effective mechanisms for establishing new populations and aspects of breeding:

(a) **Habitat management:** While there is knowledge of broad habitat requirements, research is needed on:

- —seasonal use of microhabitat by different age classes of fish;
- —the effects of land use and management that cause disturbance in catchments;
- —the benefits and techniques of habitat rehabilitation; and
- —the extent and impacts of sedimentation (stemming from bushfire damage) on aquatic habitats.

(Two-spined Blackfish, Trout Cod, Macquarie Perch, Murray River Crayfish)

(b) **Effects of alien species:** The effects of alien fish species on native species are discussed in s. 4.6 and summarised in Table 4.3. Lack of information on the historical distribution of native species means that the specific impacts of alien species are largely unknown. It is not known whether some species (e.g. Two-spined Blackfish, Trout Cod) have changed habitat preferences or utilisation patterns (as galaxids have done) in response to the presence of trout. Useful lines of research would include:

- —dietary niche and habitat preferences for Two-spined Blackfish at sites where trout are present (currently the majority of known blackfish sites) and not present (if sufficient sites can be located);
- —types (egg, larval, juvenile) and level of predation by trout and Redfin Perch; and
- —the effects of ecosystem alterations attributed to, or exacerbated by, the presence of Carp and Redfin Perch.

(All native fish and crayfish species especially threatened species)

(c) **Effects of EHN Virus in the wild:** The threat posed to native fish species by introduced diseases and parasites is discussed in s. 4.6.3. EHN Virus was first isolated on Redfin Perch in 1985. Susceptibility of Trout Cod and Two-spined Blackfish to the virus is not known. Macquarie Perch and Silver Perch have been shown to be susceptible in laboratory studies. Important research needs are to:

- —investigate the effects of EHN Virus on wild populations of native fish species;
- —design a testing procedure to determine if fish species have been exposed to EHN Virus;
- —design a water-testing procedure to determine if EHN Virus is present in water body; and
- —investigate susceptibility of other native fish species.

(All native fish species especially threatened species)

(d) **Movement ecology and requirements:** The timing (diel and seasonal), life-stage involved (adult, sub-adult, juvenile, larval) and extent of spawning, foraging and other movements are largely unknown for most of the ACT's threatened fish species. The swimming capabilities of all ACT threatened fish species are unknown. This knowledge is essential for effective fish passage to be maintained or restored. Information on movement requirements and potential barriers is essential for effective management. Some aspects of adult and sub-adult movement and the home-range of Macquarie Perch and Trout Cod have been recently investigated, but nothing is known of juvenile or larval movements of these species (Macquarie

Perch, Trout Cod, Two-spined Blackfish, Murray River Crafish).

(e) **Effective mechanisms for establishing new populations:** The establishment of additional sub-populations of threatened fish is required to minimise risks associated with local catastrophic events. There is little information on the effectiveness and cost-benefits of using different life stages (juveniles, sub-adults, adults) in such re-establishment attempts, and whether hatchery stock is preferable to wild stock. Techniques to increase the survival of released fish (that might be predator naïve) need to be investigated or developed (Trout Cod, Macquarie Perch, Two-spined Blackfish).

(f) **Aspects of breeding and recruitment:** Details about breeding are unknown for some threatened aquatic species. While the basic reproductive ecology of Two-spined Blackfish and Macquarie Perch is known, the spawning cues have not been identified. Two-spined Blackfish has low fecundity and protection of spawning cues under flow management activities such as environmental flow releases is an important management action. Macquarie Perch are reduced to a single population in the Cotter, and protection of spawning cues under environmental flow releases is critical. While Trout Cod have been bred in captivity, little is known of the flow regime and temperature cues for the species to spawn in the wild. It has been established that there is geographic variation in the size at which female Murray River Crayfish mature, resulting in the minimum legal length for Victorian individuals being larger than in NSW. Age at first breeding is not known for populations in the ACT (Trout Cod, Macquarie Perch, Two-spined Blackfish, Murray River Crayfish).

**Table 4.9: Research—Progress with Actions in Previous Action Plans and New and Continuing Actions for this *Strategy***

| Species | Knowledge Requirement or Deficiency Identified in Original Action Plan* | Actions Proposed 1999–2003* | Progress with Actions (to April 2005) | Actions for ths *Strategy* |
|---|---|---|---|---|
| **Two-spined Blackfish** | There is considerable existing information on biology and ecology of Two-spined Blackfish, much unpublished. Information available on distribution, diet, reproduction, home range but critical knowledge gaps remain:<br>—longevity;<br>—spawning requirements;<br>—effects of alien species;<br>—population genetics;<br>—habitat management. | (a) Encourage research into a number of priority areas with key information gaps. These include longevity, spawning requirements, effects of alien species, population genetics, habitat management (E&R).<br>(b) Cooperate with other agencies in a coordinated study of the population genetics of the sub-populations of Two-spined Blackfish in the Canberra region, including those in the Cotter, Goodradigbee, Goobarragandra and upper Murrumbidgee rivers and Mountain Creek (E&R). | (a) Research completed:<br>—Investigation of effects of environmental flows on the species (Lintermans 2001b, 2005).<br>—Honours project completed at Univ. of Canberra examining genetic relationships between Two-spined Blackfish populations in eastern Australia. Thesis showed that there is little variation between populations in the Canberra region (Beitzel 2002).<br>—Effects of habitat changes under environmental flow scenarios investigated (Maddock *et al.* 2004).<br>—Honours project completed at Univ. of Canberra on potential impacts of thermal pollution from impoundments on growth rates. Thesis showed that there may be significant growth rate depression associated with cold-water releases (Hall 2005).<br>(b) Research commenced:<br>—Impacts of fires and sediment on parental care behaviour (PhD, ANU). | (a) Continue to encourage research into the species related to the evolving knowledge of its biology and ecology and to management issues (EACT).<br>Important knowledge gaps are:<br>—longevity;<br>—spawning requirements;<br>—effects of alien species;<br>—susceptibility to EHN Virus;<br>—habitat management;<br>—movement ecology;<br>—establishment techniques for new populations. |

**Table 4.9:** *(Continued)*

| Species | Knowledge Requirement or Deficiency Identified in Original Action Plan* | Actions Proposed 1999–2003* | Progress with Actions (to April 2005) | Actions for ths *Strategy* |
|---|---|---|---|---|
| **Trout Cod** | Lack of knowledge of ecological requirements and tolerances of Trout Cod makes management in the wild difficult. Critical knowledge gaps are:<br>—breeding requirements;<br>—effects of alien species;<br>—habitat management;<br>—dispersal;<br>—stocking strategy. | Encourage research into a number of priority areas with key information gaps. These include breeding requirements, effects of alien species, habitat management, dispersal and stocking strategies (E&R). | (a) An experimental habitat rehabilitation undertaken at Tharwa, ACT is discussed in s. 4.12.3.<br>(b) Research completed:<br>—Pilot project (NHT funded) to examine movements of Trout Cod in Cotter River using radio-transmitters (Ebner *et al.* 2005).<br>(c) Research commenced:<br>—Project (FRDC funded) using radiotelemetry to examine movement of wild fish and hatchery-reared fish in Murrumbidgee River at Narrandera (2003). Project continued in Cotter and Murrumbidgee rivers in ACT (2004–2005).<br>—Project (NHT funded) to examine fine scale spatial and temporal movements and habitat use by Trout Cod in Cotter River. Uses same radio-collared fish as in FRDC project (2004–2005). | (a) Continue to encourage research into the species related to the evolving knowledge of its biology and ecology and to management issues (E&R).<br>Important knowledge gaps are:<br>—breeding requirements;<br>—effects of alien species;<br>—habitat management;<br>—susceptibility to EHN Virus;<br>—movement ecology;<br>—establishment techniques for new populations. |
| **Macquarie Perch** | There is some existing information on the biology and ecology of Macquarie Perch, much unpublished. Distribution, diet and reproduction have been studied to some degree. Critical knowledge gaps are:<br>—resolution of the taxonomic status (inland and coastal populations);<br>—effects of alien trout and Redfin;<br>—effects of EHN Virus in the wild. | Encourage research into a number of priority areas with key information gaps. These include resolution of the taxonomic status (inland and coastal populations), effects of alien trout and Redfin, and effects of EHN Virus in the wild (E&R). | (a) An experimental habitat rehabilitation project undertaken at Tharwa, ACT is discussed in s. 4.12.3.<br>(b) Research completed:<br>—Honours project (Univ. of Canberra) on predicting suitable habitat (Broadhurst 2002).<br>—Project on impacts of environmental flows on species (Lintermans 2001b, 2005).<br>—Project (NHT funded) investigating movement requirements of species in Cotter Reservoir and lower Cotter River. Fish had relatively restricted daytime home-sites, with more extensive night-time movements. Important river reach for breeding identified immediately upstream of Cotter Reservoir.<br>*(Continues next page)* | (a) Develop an ARC Linkage grant application to investigate issues around EHN Virus and threatened fish species (E&R).<br>(b) Continue to encourage research into the species related to the evolving knowledge of its biology and ecology and to management issues (E&R).<br>Important knowledge gaps are:<br>—effects of alien trout and Redfin Perch;<br>—movement ecology of riverine populations;<br>—swimming capabilities of different life stages;<br>—spawning cues and timing of spawning;<br>—techniques to enhance adult habitat (cover) during reservoir drawdown;<br>—impacts of bird or mammalian predation on remnant populations;<br>*(Continues next page)* |

**Table 4.9:** *(Continued)*

| Species | Knowledge Requirement or Deficiency Identified in Original Action Plan* | Actions Proposed 1999–2003* | Progress with Actions (to April 2005) | Actions for ths *Strategy* |
|---|---|---|---|---|
| **Macquarie Perch** *(continued)* | | | (c) Researched commenced:<br>—Genetic study to resolve taxonomic issues (NSW DPI).<br>(d) Workshop on EHN Virus held mid-2004. | —techniques to maintain pool habitats after bushfire related sedimentation;<br>—genetic structure of existing populations in the upper Murrumbidgee River;<br>—effective adult population size of the Cotter Reservoir population;<br>—strategies for establishing new sub-populations (translocation). |
| **Silver Perch** | There is some existing information on the biology and ecology of Silver Perch, much unpublished. Diet, movement and reproduction have been studied to some degree, but many studies are from aquaculture ponds or laboratories with few studies from the wild. Critical knowledge gaps are:<br>—effects of Carp and Redfin Perch;<br>—effects of EHN Virus in the wild. | (a) Encourage research into a number of priority areas with key information gaps. These include effects of Carp and Redfin Perch and effects of EHN Virus on wild fish populations (E&R).<br>(b) Encourage investigations into the identification of the genetic composition of Lake Burrinjuck populations of Silver Perch (E&R). | (a) Priority research areas raised at forums such as Murray–Darling Basin Commission Fish Management and Science Committee.<br>(b) Investigations into genetic composition of Lake Burrinjuck populations not yet undertaken. | (a) Develop an ARC Linkage grant application to investigate issues around EHN Virus and threatened fish species (E&R).<br>(b) Continue to encourage research into the species related to the evolving knowledge of its biology and ecology and to management issues (E&R).<br>An important knowledge gap is:<br>—effects of alien species such as Carp and Redfin Perch.<br>(c) Continue to encourage investigations into the identification of the genetic composition of Lake Burrinjuck populations of Silver Perch (E&R). |
| **Murray River Crayfish** | There is little published information on the biology and ecology of Murray River Crayfish. Some information is available on broad distribution and response to recreational catch. Most research has been on lowland river systems. Critical knowledge gaps are:<br>—habitat management;<br>—effects of alien species;<br>—age at first breeding. | Encourage research into a number of priority areas with key information gaps. These include habitat management, effects of alien species and age at first breeding (E&R). | (a) Honours thesis on Murray River Crayfish completed 1999 (Charles Sturt University).<br>(b) Terms of reference of MDBC Fish Management & Science Committee expanded in 2004 to include Murray River Crayfish.<br>(c) Review of Murray River Crayfish ecology and knowledge gaps commissioned by MDBC (2005).<br>(d) Honours thesis on movement ecology of Murray River Crayfish completed (Ryan 2005). | (a) Continue to encourage research into the species related to the evolving knowledge of its biology and ecology and to management issues. Incorporate results of MDBC review to establish research priorities (E&R).<br>Important knowledge gaps are:<br>—movement ecology;<br>—effects of alien species;<br>—age at first breeding;<br>—habitat requirements and usage; and<br>—juvenile ecology. |

**Notes:**

* Summary form only. For detail see previous Action Plans (ACT Government 1999a–d, 2003)

**E&R:** Environment and Recreation, Department of Territory and Municipal Services

**FRDC:** Fisheries Research and Development Corporation (Cwlth)

**NHT:** Natural Heritage Trust (Cwlth)

**EHN Virus:** The exotic fish disease Epizootic Haematopoietic Necrosis Virus

**MDBC:** Murray–Darling Basin Commission

# 4.12

## Conservation Actions: Protection and Management

### 4.12.1 Legislative Protection

**SPECIES**

The legislative status of ACT threatened fish species and the Murray River Crayfish in jurisdictions other than the ACT is shown in Table 4.1. Two species warrant further consideration in relation to these listings:

(a) **Silver Perch:** This species is in decline across the Murray–Darling Basin (MDBC 2004a; Clunie and Koehn 2001a; Morris *et al.* 2001). A non-statutory recovery plan for the species in the Basin was prepared in 2001 (Clunie and Koehn 2001b), but has not been implemented, and a recovery plan has been prepared for NSW (NSW DPI 2006). Though it is declared endangered in the ACT, vulnerable in NSW, threatened (critically endangered) in Victoria, and protected in South Australia, the species is not declared under Commonwealth legislation. It is listed as vulnerable by the Australian Society for Fish Biology (ASFB 2004), however, this listing has no statutory effect. Its status warrants a national statutory nomination.

(b) **Murray Cod:** Previously widespread and abundant, Murray Cod now have a fragmented distribution and are found in low abundance (Kearney and Kildea 2001; Lintermans and Phillips 2005; MDBC 2004a; MDBC 2004b). The species is declared threatened (vulnerable) in Victoria and vulnerable under Commonwealth legislation. Formerly abundant in major ACT streams (Lintermans 2002), the species is now only maintained in ACT urban lakes through stocking. There is anecdotal evidence of further decline of the species in streams since the 2003 bushfires. A review is appropriate to consider if Murray Cod warrant the preparation of a nomination as a threatened species in the ACT.

**HABITAT**

Aquatic habitats of threatened species have little legislative protection under the *Nature Conservation Act 1980.* It is currently an offence to disturb 'nests' of native animals, and it is assumed that this provides some protection to spawning sites, but other potentially critical habitats are not identified or protected.

**ACTIONS**

1. Support the preparation of a nomination for Silver Perch as a threatened species under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).
2. Review ACT information on Murray Cod to see if it warrants the preparation of a nomination as a threatened species in the ACT.
3. Review mechanisms in the ACT for declaring critical or important habitat for aquatic species and enhance legislative protection for aquatic habitats.

### 4.12.2 Environmental Flows

The adverse impacts on native fish species of alterations to flow regimes above and below dams and weirs have been discussed in s. 4.4.4. All of the larger streams in the ACT and region have structures that affect stream flow (Googong Dam and Queanbeyan Weir on the Queanbeyan River, Scrivener Dam on the Molonglo River, Tantangara Dam and Burrinjuck Dam on the Murrumbidgee River, Corin, Bendora and Cotter dams on the Cotter River). The smaller Paddys–Tidbinbilla River and Gudgenby–Naas River (tributaries of the Murrumbidgee River) in the southwest of the ACT are not currently affected by dams or weirs.

Dams and weirs on ACT rivers and most of those in the Murray–Darling Basin were constructed when there was limited understanding of the ecology of native fish species and of the effects of such abstraction and diversion on aquatic communities. Managing riverine structures is one of the most significant issues for native fish recovery in the Murray–Darling Basin (MDBC 2004a). Removal of obsolete weir structures and redesigning other barriers, construction of fish-ways, and instigating environmental flows are measures aimed at improving opportunities for native fish species.

The natural flow regime in ACT streams is highly variable. Rivers and streams have periods of low flow and floods of different sizes. Flows in ACT streams also vary seasonally with the higher flows usually occurring in the spring months. Environmental flows are specific releases of water from storages aimed at ensuring that flows in rivers and streams best mimic the flows that would occur naturally, therefore allowing the healthy functioning of in-stream and riparian ecosystems. For the ACT, environmental flows are defined as:

> the streamflow (including aquifer discharge) necessary to sustain habitats (including channel morphology and substrate), provide for spawning

and the usual migration of fauna species to previously unpopulated habitats, enable the processes upon which succession and biodiversity depend, and maintain the desired nutrient structure within lakes, streams, wetlands and riparian areas. Environmental flows may comprise elements from the full range of flow conditions, which describe long-term average flows, variability of flows including low flows and irregular flooding events (ACT Government 2006a).

Determining appropriate environmental flows is an inexact science involving the integration of ecological information and requirements with social and economic considerations. A range of approaches has been used in Australia.

Environmental flows are part of the ACT Government's long-term strategy for managing the water resources of the Territory set out in *Think water, act water* (ACT Government 2004d). Preparation of environmental flow guidelines is a requirement of the *Water Resources Act 1998* (ACT). The first guidelines established in 1999 have been reviewed after a five-year period, and revised guidelines prepared (ACT Government 2005b). These will again be reviewed in five years (or earlier, if evidence indicates this is warranted). The guidelines cover all water-bodies in the ACT as well as Googong Reservoir, managed by the ACT Government. Given the uncertainties in determining appropriate environmental flows, an adaptive management approach has been taken.

Major changes in the revised (2006) guidelines include (ACT Government 2006a):

1. Identification of specific ecological objectives for environmental flows in the different ecosystems. For the Cotter River (Water Supply Catchment Ecosystem) specific objectives are to maintain populations of the threatened Two-spined Blackfish, Macquarie Perch and the Cotter River Frog.
2. Refinement of the flow components based on recent research and monitoring, particularly in the Cotter Catchment. This work has led to identification of more precise base flows, and riffle, pool, and channel maintenance flows.
3. Specification of Drought Flow Rules recognising that during dry periods when the urban population experiences water restrictions, it is appropriate that environmental flows also be reduced.

Environmental flows are a crucial consideration for this *Strategy*, however, two major rivers (Molonglo and Murrumbidgee) have their headwaters in New South Wales for which environmental flow guidelines have not yet been established. For the Murrumbidgee River, it is anticipated that future environmental flows from NSW would pass through the ACT unaffected by activity in the ACT (ACT Government 2006a).
For the Molonglo River, to ensure protection of the Commonwealth's paramount rights to water, it is expected that only the current limited uses would be permitted and this should ensure adequate environmental flows (ACT Government 2006a).
The operation of Scrivener Dam in relation to environmental flows for the Molonglo River is being reviewed by the National Capital Authority. No specific environmental flows are currently released from the dam (see s. 4.4.6 and s. 5.6.13) (ACT Government 2006a). As part of the decision to return some water to the Snowy River, the NSW Government has committed to a program to return environmental flows to the Murrumbidgee River. This will increase flows in the river both upstream of and within the ACT; however, Burrinjuck Dam is still an impenetrable barrier to upstream fish movement.

The construction of new water treatment facilities at Mt Stromlo following the 2003 bushfires has allowed the reinstatement of Cotter Reservoir as part of Canberra's domestic water supply. Prior to 2003, Cotter Reservoir had been rarely used because of poor water quality, and the abundance of higher quality water supplies in Bendora, Corin and Googong reservoirs. It has been proposed to transfer water from the Cotter catchment (including Cotter Reservoir) to Googong Reservoir, to provide greater security for domestic water supply. Such transfers will result in drawdown of the water level in Cotter Reservoir, potentially isolating macrophyte beds (important Macquarie Perch habitat) in the reservoir. The drawdown could also affect access to riverine spawning sites for Macquarie Perch.

With regard to environmental flows in the Cotter River, there are some matters needing further investigation; including the flow conditions antecedent to the recent natural recruitment of Trout Cod in Bendora Reservoir; the adequacy of the drought flows in allowing blackfish recruitment in the lower 5 km of the Cotter River; the effects on Macquarie Perch of drawdown of Cotter Reservoir; and the effectiveness of flushing flows in moving sediment from the pools and riffles below Bracks Hole (upstream of the Cotter Reservoir). More specific information related to spawning flows for Macquarie Perch in the Cotter River between Corin and Bendora dams is contained in Lintermans (2005). Results of investigations into various environmental flow regimes including drought flows is discussed in CRCFE (2004) and Lintermans (2001b, 2004c).

**ACTIONS**

1. Keep environmental flow requirements under review and liaise with ACTEW AGL to ensure that the appropriate drawdown levels and flows under the ACT Environmental Flow Guidelines are maintained or released from storages operated by the company. Special attention needs to be given to the requirements for threatened fish such as Macquarie Perch and Two-spined Blackfish and for the Cotter River Frog.
2. Continue monitoring of the ecological effects of the environmental flow program in the Cotter River, with the impacts on pools and riffles in the lower river reaches to be incorporated into the monitoring program.
3. Investigate the age of naturally recruiting Trout Cod in Bendora Reservoir, and determine the antecedent flow conditions for this spawning event.

### 4.12.3 Habitat Rehabilitation

As discussed in s. 4.4, the majority of riverine ecosystems in eastern Australia have been adversely affected by human activities with a resultant modification of aquatic habitats. Rivers in the ACT region have been impacted by the effects of adjacent rural and urban land uses and dam construction. Poor land management and a series of major floods in the mid to late 1800s in the upper Murrumbidgee catchment resulted in extensive soil erosion and sediment addition to rivers. Clearing of the riparian zone in some areas removed nearly all the large eucalypts which were previously common, hence there remains no source of large woody debris (snags) to provide in-stream structural complexity and habitat diversity for both fish and invertebrate populations.

All previous Action Plans for threatened fish/crayfish species in the ACT, except for Two-spined Blackfish (ACT Government 1999b–d, 2003) included an action to 'investigate options for rehabilitating critical fish habitats'. It was noted that such rehabilitation is costly and that funding partnerships would be sought. Subsequently, a habitat rehabilitation experiment has been undertaken on a section of the Murrumbidgee River in the ACT, downstream of Tharwa. The Murray–Darling 2001 FISHREHAB component of the Natural Heritage Trust provided funds for the project. This 1.5 km section of the Murrumbidgee River, formerly a pool and riffle sequence, has been largely filled in with sandy sediment. The shallow, featureless riverbed forms a barrier to upstream and downstream dispersal of fish. The riparian zone is also degraded, particularly with the removal of large eucalypt species formerly common in the area. The two major elements of the rehabilitation works were (Lintermans 2004b):

- A series of regularly spaced flow deflectors (rock walls) to create scour holes to improve habitat for fish dispersal.
- A habitat pool with large woody debris (snags) added for structural complexity. Snags were also incorporated into seven of the deflectors.

Some early observations on the results of the experiment are (Lintermans 2004b):

- Scour holes can be created and maintained by deflectors even under low flow conditions, but to provide linked scour holes, deflector spacing needs to be closer than that suggested in the international literature.
- It is important to investigate whether the location of the thalweg (thread of deepest water) in the stream channel is constant, as even a minor change in thalweg position can isolate individual deflectors.
- The benefits of incorporating woody debris into deflectors appear minimal where sediment loads are high, as sediment displaced by scour holes tends to swamp the snags.
- In streams with high sediment loads, it may be necessary to extract sand from the riverbed upstream of rehabilitation works to prevent scour holes being swamped by sand (not undertaken in this experiment).
- Fish sampling in 2000 and 2001 recorded the endangered Trout Cod immediately adjacent to two of the small trial deflectors.
- The habitat pool has completely filled with sand, with the snags totally buried.

The success of the rehabilitation works for recovery of threatened fish can only be assessed through long-term monitoring, which is being undertaken on a biennial basis.

The 2003 bushfires have resulted also in the deposition of large quantities of sediment into streams such as the Cotter, Paddys, Tidbinbilla and Naas–Gudgenby rivers, with many of these streams demonstrating significant loss of deep pool habitats through the accumulation of fire-related sediment. Rehabilitation activities in these smaller streams are necessary, but smaller-scale approaches than those used in the Murrumbidgee River need to be investigated and developed.

**ACTIONS**

1. Monitor and assess the success of rehabilitation works undertaken on the Murrumbidgee River at Tharwa. Based on this assessment, investigate further options for rehabilitating critical fish habitats in a range of stream sizes. These options include selective removal of sand, construction of in-stream deflectors to restore critical pool/riffle habitats, and provision of additional cover such as snags or boulders.
2. Investigate mechanisms for rehabilitating and improving the protection of riparian vegetation along the Murrumbidgee River in the ACT.
3. Release environmental flows combined with natural flows to flush sediments.

### 4.12.4 Potential Impacts of Future Water Supply Options

One of the three potential future water supply sources for the ACT is the lower Cotter River, with the Gudgenby River (Tennent Reservoir) and the Murrumbidgee River (Tantangara Reservoir) the other two sources (ACTEW 2005). Of the four options fully investigated for the lower Cotter, the preferred option is the construction of a new, large (78 GL) Cotter Dam, which would have a crest height approximately 50 m above the existing dam. The new dam would have a multi-level off-take tower, and be located approximately 125 m downstream of the existing dam (ACTEW 2005).

As part of the review of water supply options, Lintermans (2004c) has reviewed the potential issues, benefits and knowledge gaps for threatened fish related to the construction of a new Cotter Dam. These are listed in Appendix 3. Considerations include habitat changes and their effects on threatened fish species, environmental flows, predation on threatened fish species, maintaining an enlarged reservoir free of Carp and Redfin Perch, and the effects of EHN Virus on Macquarie Perch.

**ACTIONS**

1. Continue to liaise with ACTEW regarding the potential impacts on native fish and crayfish species of future water supply options.
2. Should the construction of an enlarged water storage on the lower Cotter River proceed, provide advice to ACTEW on the means to maximise opportunities for threatened fish conservation and habitat enhancement in the reservoir design and the construction program.
3. Monitor or assess the effects of inter-basin water transfers.
4. Encourage research into knowledge gaps associated with Future Water Supply Options.

### 4.12.5 Protection of the Cotter River Catchment from Invasion by Alien Fish Species

The Cotter River is one of the few rivers in the Murray–Darling Basin in which Carp or Redfin Perch are not established, though both are now widespread in the Basin and the Canberra region. Cotter Dam provides a barrier to invasion from the Murrumbidgee River (Lintermans *et al.* 1990b; Lintermans 1991).

Prior to the drought of 2002–5, Cotter Reservoir was not regularly used for the supply of domestic water to Canberra, with the water usually drawn from Corin and Bendora reservoirs. However, new scientific knowledge on climate change, the likely reduction in runoff following vegetation regrowth in fire-affected catchments, the projected growth of the ACT population, and the forecast need to augment existing water storages to avoid prolonged or severe water restrictions mean that Cotter Reservoir could be substantially increased in volume through construction of a new dam (ACTEW 2004). It is important that the significance of this barrier continues to be recognised during further evaluation or construction (see Appendix 3). Similarly, Bendora Dam acts as a barrier to the colonisation of the upper and middle Cotter catchment by Brown Trout, which are present in the Cotter River and Cotter Reservoir below Bendora Dam.

Another mechanism for the unwanted introduction of exotic fish species is the use by anglers of live fish as bait. It is illegal to use live fish as bait under the *Fisheries Act 2000* (ACT), however discouraging bait fishing of any kind provides further safeguards against such introductions. The designation of the Cotter River between Bendora Dam and the junction of the Cotter River with Pierces Creek (approximately 1 km upstream of Cotter Reservoir) as a 'trout water' with only artificial fly or lures allowed as a fishing method assists in the prevention of establishment of unwanted fish. The stocking of fish species for recreational purposes in the Cotter catchment is not undertaken, as the introduction of additional species would encourage bait fishing and potentially impose further stress on threatened fish populations (ACT Government 2000).

In 1986 the waters (streams and reservoirs) of the Cotter catchment from the headwaters downstream to the Bendora Dam wall were closed to recreational fishing. This was to protect threatened fish and their habitats in the catchment (ACTP&CS 1986). The (then) ACT Environment Advisory Committee reviewed recreational usage of the Cotter Reservoir in 1997 and recommended that the reservoir should remain closed to recreational fishing because of the threat posed to native fish species by the establishment of introduced

fish. The Government adopted this recommendation, which remains current policy for the area (ACT Government 2000). Following the 2003 bushfires, the ACT Government reviewed opportunities for non-urban areas, resulting in the *Shaping Our Territory* reports (Non-Urban Study Steering Committee 2003; Shaping Our Territory Implementation Group 2004). These reports discussed recreational opportunities on Cotter Reservoir, including fishing. The introduction of recreational fishing is not desirable as it greatly enhances the risk of introduction of the alien fish species Carp and Redfin Perch (and enhances the risk of EHN Virus establishing (see section 4.6.3)). Consequently, the introduction of recreational fishing to Cotter Reservoir would be strongly opposed by Environment ACT.

**ACTIONS**

1. Highlight the importance of maintaining the integrity of the Cotter Dam barrier to upstream fish colonisation in the event of reconstruction or augmentation of Cotter Dam.
2. Highlight the importance of maintaining the integrity of the Bendora Dam barrier to upstream fish colonisation.
3. Continue the policy of maintaining the Cotter River below Bendora Dam as a declared 'trout water' for artificial fly or lure fishing only (under the Fishing Act 2000).
4. Continue the policy of prohibiting fishing in the waters (streams and reservoirs) of the Cotter catchment from the headwaters downstream to Bendora Dam wall.
5. Maintain the policy of not stocking fish for recreational purposes in water supply reservoirs in the Cotter River catchment as outlined in the ACT Fish Stocking Plan (ACT Government 2000).
6. Continue the policy of prohibiting fishing in Cotter Reservoir.

### 4.12.6 Monitoring and Control of alien fish species

Alien fish species continue to expand their distribution in the ACT and the upper Murrumbidgee catchment. Rainbow Trout have recently become established in Gibraltar Creek upstream of Gibraltar Falls, with likely devastating effects on the previously secure population of Mountain Galaxias in this stream. Similarly, the Oriental Weatherloach has established new populations in the Queanbeyan and Molonglo rivers (Lintermans *et al.* 2001). Both of these new incursions are likely to be the result of illegal human-assisted dispersal (see Lintermans 2004b).

Control options for alien fish are limited, particularly where threatened native species are present, because of the potential of control measures to affect non-target fauna. Any control program is likely to have a greater chance of success if control is attempted whilst the population of alien fish is small. Consequently, early detection and monitoring programs are critical in the successful control of alien fish. Additional research is also required into potential control techniques, along with the development of rapid response plans for new pest fish incursions. The new Invasive Animals Cooperative Research Centre (IACRC) (of which Environment and Recreation is a member) is establishing a research program for freshwaters that will deal with a number of these knowledge or management gaps.

**ACTIONS**

1. Keep a watching brief on new developments in alien fish control methods, through participation in the IACRC.
2. Seek to develop rapid response plans for new pest fish incursions through participation in the IACRC.
3. Investigate the feasibility of control options for Rainbow Trout upstream of Gibraltar Falls.
4. Establish a program to monitor the ACT distribution of the most important alien fish species, utilising existing monitoring sites where possible.

### 4.12.7 Policy of Not Stocking Fish in Natural Streams in the ACT for Recreational Purposes

A program of fish stocking is undertaken in ACT urban lakes and Googong Reservoir, but stocking of streams is no longer practised in the ACT except in special circumstances (e.g. a release or relocation of a threatened species for conservation purposes). The major reasons why stream stocking is not undertaken are outlined in the ACT *Fish Stocking Plan* (ACT Government 2000). They include concerns about habitat suitability, possible pressure on remnant natural populations, and potential loss of stocked fish out of the ACT. Limited funds for fish stocking mean that it is best to direct these funds to where there is the greatest opportunity to effectively augment the fishery.

The effects on genetic integrity are a further consideration. Hatchery-bred fish used in fish stocking programs are usually derived from a small number of brood fish, and so may lack the normal range of genetic variation present in wild populations. For example, an investigation into the genetic variability of

Silver Perch in rivers and dams within the Murray–Darling Basin has revealed that stocked populations have less genetic diversity than wild populations (Keenan *et al.* 1996; Bearlin and Tikel 2003). The introduction of hatchery-bred fish into remnant wild populations may lead to reduced genetic variability in the population as a whole, and reduction in its adaptive capacity. The remnant population of Silver Perch in Lake Burrinjuck has been augmented with hatchery-bred fish for many years, and it is not known whether 'wild' levels of genetic diversity remain in this population. The investigation of the genetic variability within stocked and wild populations of Silver Perch is identified as a recovery action in the NSW recovery plan for this species (NSW DPI 2006). The plan also identifies the need to implement the Freshwater Fish Stocking Management Strategy (see NSW Fisheries 2003) to prevent significant impacts from stocking of Silver Perch on wild (riverine) populations.

**ACTION**

1. Maintain the policy of not stocking fish for recreational purposes in ACT streams. Fish may be stocked for special purposes (e.g. a release or relocation of a threatened species for conservation purposes, or a release for research purposes).

### 4.12.8 Stocking and Translocation of Fish in Natural Streams in the ACT for Conservation Purposes

**STOCKING**

There are no captive breeding programs for Macquarie Perch or Murray River Crayfish currently operational within fisheries agencies in the Murray–Darling Basin. The previous breeding program for Macquarie Perch in Victoria has ceased.

There are large hatchery-breeding programs for Silver Perch in the Basin. These programs are directed towards recreational fishing or aquaculture, rather than conservation purposes (NSW DPI 2006; Clunie and Koehn 2001a). Until the genetic status of the Lake Burrinjuck population of Silver Perch is known, it is not considered desirable to stock this species for conservation purposes into the Murrumbidgee River in the ACT (see s. 4.12.7).

Trout Cod have been stocked for conservation purposes in Bendora Reservoir (1989–1990, 8740 fish) and in the Murrumbidgee River at Angle Crossing (1996–2005, 99 500 fish). These populations are included in fish monitoring programs (see Table 4.8). The majority of fish released in the stocking program have been supplied from the NSW Department of Primary Industries fish hatchery at Narrandera. In 2002, fish were purchased from the Snobs Creek hatchery in Victoria. The ACT does not have a facility for breeding native fish, and such a facility could not be justified on a cost-benefit analysis, given the relatively small demand for native fish breeding in the ACT. In the 2004 Trout Cod monitoring program for Bendora Reservoir, a number of small (90–250 mm) Trout Cod were captured, indicating that stocked fish had bred in the previous 2–3 years. This demonstrates the need for long-term monitoring of stocked populations (it is now more than 15 years since the species was stocked) and highlights the long time-frames often required before the success or otherwise of the stocking program can be ascertained.

The ACT stocking program for Trout Cod is part of a broader national recovery effort for the species across the Murray–Darling Basin. In the upper Murrumbidgee catchment, fish have been stocked in several locations, including sites near Cooma and Adaminaby that were stocked between 1988 and 1997. Modelling of alternative Trout Cod stocking programs revealed that programs that release large numbers of fish over a relatively short time-frame produced the highest probability of establishing a large population after 20 years, However the risk of total failure was also high with this approach. Lower risk strategies (fewer fish over a longer time period) produced a lower probability of establishing large populations, but a higher probability of establishing small populations over 20 years, with an almost zero chance of total failure (Bearlin *et al.* 2002). The ACT has pursued a low-risk stocking program for Trout Cod, primarily because of the lack of availability of fingerlings for large stockings.

Recent research into the movement ecology of adult and sub-adult Trout Cod has revealed that fish can make relatively extensive movements (10–60 km) along a river. Similarly, in the 1990s there were a number of reports of Trout Cod being caught by anglers in the ACT, with these fish thought to represent downstream dispersal from the stocking sites around Cooma. These results suggest that there may be benefits in increasing the number of stocking sites (without decreasing the number of fish stocked per site), allowing fish from adjacent sites to interact with each other. Additional stocking sites could be located within the ACT or in adjacent areas of NSW. In 2005 an additional site on the Murrumbidgee River (just downstream of the NSW/ACT border) was incorporated into the NSW Trout Cod stocking program.

**ACTION**

1. Continue to stock Trout Cod for conservation purposes in the ACT.

2. Investigate the potential for additional Trout Cod stocking sites in the ACT, and liaise with NSW DPI (Fisheries) about the potential for additional sites in adjacent areas of the Murrumbidgee River.
3. Liaise with NSW DPI (Fisheries) about the genetic status of Lake Burrinjuck Silver Perch populations, and consider stocking Silver Perch into the Murrumbidgee River if appropriate.

**TRANSLOCATION**

- **Macquarie Perch**

In 1985, forty-one Macquarie Perch were removed from Cotter Reservoir when it was drained for dam wall maintenance. These fish were released into Bendora Reservoir, however, there have been no records of the fish in subsequent monitoring. Occasional reports of fish in the stilling pool below the dam wall were made for several years after the translocation. This failure is probably due to the release of cold water from Corin Dam, disrupting natural reproductive cycles of this species.

Though a fishway has been constructed at Vanitys Crossing on the Cotter River between Cotter and Bendora reservoirs (s. 4.4.2), it may still be useful to accelerate the establishment of a viable population of Macquarie Perch upstream of the crossing by translocating individuals above the crossing. The expansion of the Macquarie Perch population in the Cotter catchment would reduce the extinction risk associated with local catastrophic events. Translocation of Macquarie Perch to the Cotter River upstream of Corin Dam may also be worthwhile, as it would establish a population in a river reach not subject to recreational angling, land use impacts such as forestry, and flow regulation. Such translocation and population establishment is a long-term process as it could take ten or more years to establish a viable population.

Historically. Macquarie Perch were probably present in the Molonglo River and lower reaches of the Queanbeyan River, with populations likely to have been affected by heavy metal pollution from the Captains Flat Mines (see s. 2.1.2). The remnant populations of this species in the Murrumbidgee River and the Queanbeyan River above Googong Reservoir are unable to recolonise these areas because of barriers to fish movement (Scrivener Dam, Queanbeyan Weir, Googong Dam, Molonglo Gorge) and the small size of the remnant populations. Potential exists to re-establish a population in the Molonglo River upstream of Molonglo Gorge, as Redfin Perch (and hence EHN Virus) is not present in this river reach, public access is relatively limited, and fishing pressure is low. Similarly there are anecdotal records of Macquarie Perch from the Paddys River near Murray Corner, but they are no longer thought to be present in the reach. Translocation of individuals from existing populations in the upper Murrumbidgee catchment is worth investigating as a mechanism for re-establishing these populations. Genetic characterisation of existing donor populations is a prerequisite to translocation between rivers to ensure that disruption of existing genetic structure does not occur (see Table 4.9).

In an attempt to prevent the local extinction of a population of Macquarie Perch in Googong Reservoir, 57 adult fish were removed from the Reservoir in November 1980 and released into the Queanbeyan River upstream. This translocation was successful, with a reproducing population established in the river that was recruiting regularly in the late 1990s (Lintermans 2003). There is also potential habitat for Macquarie Perch in the Queanbeyan River in the Silver Hills area (NSW) upstream of Googong Dam, where a large waterfall blocks upstream dispersal from the previous translocation. Fish in this area would have some protection from angling pressure due to its remoteness from access.

**ACTION**

1. Evaluate the conservation benefit of translocating Macquarie Perch to the river section above Vanitys Crossing on the Cotter River upstream of the Cotter Reservoir.
2. Evaluate the conservation benefit of translocating Macquarie Perch above Corin Dam.
3. Evaluate the feasibility and conservation benefit of translocating Macquarie Perch into the Molonglo River above Molonglo Gorge and into the Paddys River.
4. Liaise with NSW DPI (Fisheries) regarding the desirability of translocating Macquarie Perch in the Queanbeyan River past the natural barrier posed by the Silver Hills waterfall upstream of Googong Reservoir.

- **Two-spined Blackfish**

Two-spined Blackfish were previously present in the Cotter River downstream of Cotter Dam and in the lower Paddys River. There also is a museum record of this species from the Murrumbidgee River at Casuarina Sands, at the Cotter confluence (Lintermans 1998a). It is thought that sedimentation is responsible for the disappearance of this species from the Paddys and Cotter rivers below the dam. A trial translocation of 55 sub-adult and adult Two-spined Blackfish from the Cotter catchment to the lower Paddys River occurred in late 2004. These fish had been held in

aquaria for a number of months as part of research projects, and they were translocated rather than being returned to the Cotter River. Monitoring of the fate of these fish has not yet been conducted, but is planned for 2005/06. If this translocation has proved successful, there is potential for additional translocations aimed at reinstating a population of this species in the Cotter River below Cotter Dam.

**ACTIONS**

1. Monitor the fate of the Two-spined Blackfish translocated in 2004 into the lower Paddys River.
2. Investigate the feasibility of additional translocations of Two-spined Blackfish into the Cotter River downstream of Cotter Dam.

- **Murray River Crayfish**

The previous Action Plan for Murray River Crayfish (ACT Government 1999d) included an action to 'investigate the possibility of re-establishing a population of Murray River Crayfish in Cotter Reservoir'. There are previous records and unconfirmed reports of the crayfish in the Cotter River above and below the present reservoir. It was proposed to relocate individuals from below the dam to the reservoir, where Carp and Redfin Perch are not present and fishing is prohibited. Subsequently, a number of individuals were discovered in the Cotter River above the reservoir. On this basis translocation is not considered necessary, however further survey to determine the extent and abundance of the population is required.

Monitoring between 1994 and 2003 of the potential impacts of discharge of treated effluent from the Lower Molonglo Water Quality Control Centre on fish and crayfish populations of the Molonglo and Murrumbidgee Rivers suggests that Murray River Crayfish are absent from the discharge zone in the Molonglo River (Lintermans 1998b, 2004d). It has been hypothesised that crayfish may be avoiding the discharge zone, and this prevents colonisation from the Murrumbidgee River. A translocation of crayfish past the discharge zone may be effective in re-establishing the species in the lower Molonglo River.

**ACTIONS**

1. Survey the Cotter River between the Cotter Reservoir and Bendora Dam to determine the extent of the Murray River Crayfish population.
2. Investigate the feasibility of translocating Murray River Crayfish into the Lower Molonglo River.

### 4.12.9 Remediation of Barriers to Fish Passage

The ACT has relatively few major barriers that require remediation, and fish passage is incorporated into structures during scheduled maintenance work or upgrades. Examples are the vertical slot fishways constructed on the Cotter River lower weir and Casuarina Sands low weir during scheduled maintenance in 2001, and the Vanitys Crossing rock-ramp fishway constructed in 2002 (s. 4.4.2). There are still some low weirs on the Cotter River, between its junction with the Murrumbidgee River and its confluence with the Paddys River, that do not have fishways. These weirs need to be assessed for their suitability for fish passage, and fishways incorporated during future upgrades or maintenance. It is intended that eventually, the provision of fishways will reconnect the fish populations in the Murrumbidgee, lower Cotter and Paddys rivers. It is not proposed to provide fish passage past Cotter Dam, as the dam provides a barrier to invasion by alien fish species (see s. 4.12.5).

There are a number of road crossings of the Cotter River between Vanitys Crossing and Bendora Reservoir that are likely to pose barriers to Macquarie Perch as the population expands up the river. These barriers need to be assessed and fish passage options examined. Similarly, in other ACT catchments there are a number of road or management trail crossings that may pose fish passage problems, with opportunities to improve fish passage often available during maintenance, upgrading or realignment.

Similarly, the impacts of Point Hut Crossing on fish passage in the Murrumbidgee River have not been formally assessed, but it is thought likely that fish passage is impeded under some flow conditions, and this needs verification. There are now engineering guidelines available to facilitate fish passage past road crossings (Fairfull and Witheridge 2003), and these guidelines should be incorporated into existing and future road construction and maintenance programs.

**ACTIONS**

1. Monitor the performance of the fishway for Macquarie Perch at Vanitys Crossing on the Cotter River.
2. Investigate the requirements and design options for fish passage at existing road crossings on the Cotter River between Vanitys Crossing and Bendora Reservoir.
3. Incorporate stream-crossing guidelines into existing and future road works programs in the ACT.

4. Assess the need for fish passage at low weirs on the Cotter River between the Paddys and Murrumbidgee river confluences, and Point Hut Crossing. Incorporate construction of fishways (where necessary) into future upgrades or maintenance works on these weirs and crossing.

### 4.12.10 Control of Trade in Freshwater Crayfish

Horwitz (1990) considered that the uncontrolled translocation of Australian freshwater crayfish posed a considerable threat to native crayfish through the potential spread of parasites and diseases, and the potential for disruption of natural crayfish communities.

Merrick (1995) expressed concerns about the demands of the burgeoning aquaculture industry for freshwater crayfish, and noted that the biological attributes of desirable aquaculture species (frequent breeding and rapid growth), also make them a potential threat to local endemic species should they escape or be deliberately stocked. The spread of the popularly cultured Hairy Marron (*Cherax tenuimanus*) in southern Victoria, the establishment of Redclaw Crayfish (*Cherax quadricarinatus*) in Lake Argyle, the decline of endemic Hairy Marron in the Margaret River after the introduction of the Smooth Marron (*Cherax cainii*) in Western Australia (D. Morgan pers. comm.), and the spread of the Yabby (*C. destructor*) in Western Australia are cases in point.

The regulations governing the intra- and interstate movement of freshwater crayfish in Australia are not consistent between jurisdictions, with few controls applicable in the ACT.

**ACTION**

1. Liaise with other Australian States and Territories in order to inform the development of an ACT policy on trade in freshwater crayfish.

# 4.13

## Conservation Actions: Education

The previous Action Plans for threatened aquatic species in the ACT (ACT Government 1999a–d, 2003) identified the need to improve both public knowledge about the reasons for decline of native fish and crayfish and angler ability to properly identify fish species.

Large sections of the general community are unaware of the reasons for the decline of native fish, and the actions that can help to halt this. In addition, some anglers either cannot, or choose not to discriminate between threatened and non-threatened fish species. Consequently some individuals of threatened species are not returned unharmed to the water after accidental capture. Since 2000, a range of information materials has been developed aimed at enhancing community understanding of threatened species and engendering community support for research and management actions. These include:

(a) Information on angling and threatened fish and crayfish species on the Environment and Recreation website.

(b) A poster on *Australian Capital Territory Freshwater Fishes* (funded by the Natural Heritage Trust).

(c) Publication of *Wet and Wild: A Field Guide to the Freshwater Animals of the Southern Tablelands and High Country of the ACT and NSW* (Lintermans and Osborne 2002) and *Fish in the Upper Murrumbidgee Catchment: A Review of Current Knowledge* (Lintermans 2002) (funded by the Natural Heritage Trust).

(d) Employment of a Fisheries Action Program coordinator from 1997–2003 and publication of ACT Fisheries Action Program Newsletter (funded by the Natural Heritage Trust).

(e) Employment of an Aquatic Education Officer in 2003–04 (funded by the Natural Heritage Trust).

This is additional to a wide range of website information now available e.g. from NSW DPI, Australian Society for Fish Biology (ASFB), Australian and New Guinea Fisheries Association (ANGFA), and the Murray–Darling Basin Commission.

**ACTIONS**

1. In cooperation with State and Commonwealth government agencies and community organisations, review existing education and community awareness materials and programs with a view to providing new or updated information. The aim of this is to increase

awareness of threatened aquatic species and threatening processes, and how the community can contribute to the conservation and recovery of aquatic species.

2. Pursue funding opportunities to expand the extent of public information and education activities in aquatic conservation and management.

## 4.14 Conservation Actions: Regional and National Cooperation

Actions taken in the ACT to conserve and rehabilitate aquatic ecosystems are carried out in the context of integrated catchment management for the Murray–Darling Basin as a whole. The degraded state of riverine and riparian ecosystems is well documented as is the generally parlous state of native fish populations. It is important, therefore, for the initiatives in this *Strategy* to be linked, as appropriate, to regional and national policies and programs.

The ACT Government participates in a number of regional and national forums that deal with the conservation or management of aquatic resources.

Examples include:

- the MDBC Fish Management and Science Committee (which guides implementation of the Native Fish Strategy for the Murray–Darling Basin 2003–2013);
- the Murray Cod Reference Group;
- the National Recovery programs for Trout Cod, Murray Cod, and Macquarie Perch;
- the Invasive Animals Cooperative Research Centre; and
- the eWater Cooperative Research Centre.

**ACTIONS**

1. Maintain links with, and participate in national recovery efforts for threatened aquatic species to ensure that ACT conservation actions are coordinated with national programs.
2. Liaise with relevant NSW Government agencies with the aim of achieving a coordinated, regional approach to the conservation of threatened aquatic species.

# 5 ACT Rivers and Riparian Zones: Planning and Management for Conservation

The importance of ACT rivers in the development of the national capital has been long recognised. Their place in the rural economy before and after the establishment of the Territory and attractiveness for recreation is discussed in s. 2.3.1. The ornamental Lake Burley Griffin on the Molonglo River floodplain is the centrepiece of Walter Burley Griffin's plan for the capital. Subsequent town centre development has included ornamental lakes, also serving a water quality control purpose (urban stormwater and protection of the rivers). The potential for water supply from the forested mountain catchment of the Cotter River was recognised in choosing the site for the capital. Protection of this catchment was initiated in 1914 with a 'restricted use' policy under the *Cotter River Ordinance 1914–1959*, providing the legal means to restrict camping and picnicking in the catchment area (NCDC 1986). In summary, rural production, recreation, urban ornamental and symbolic national capital purposes, retention of run-off and pollution control, and water supply have dominated the use, planning and management of ACT rivers and streams. Only more recently have nature conservation and healthy ecosystem function become explicit goals for planning and management of aquatic and riparian areas.

## 5.1

## Planning, Protection and Management of Rivers and Riparian Zones in the ACT

This *Strategy* builds upon a substantial existing reservation, planning and management framework for catchments and river corridors in the ACT. For the ACT as a whole, the key issue for the rivers and riparian areas is not the need for reservation or recognition in statutory planning, but the need to strengthen and coordinate management (e.g. Molonglo below Scrivener Dam), prepare management plans for some areas (e.g. Molonglo Gorge), and undertake work on particular management issues (e.g. weeds including willows) based on effective implementation plans. The development of a strategic management plan for the Lower Cotter Catchment is a good example of a strategic approach to land management where multiple agencies are managing for diverse outcomes (water supply, water quality, biodiversity and recreation) (ACT Government 2006b).

### 5.1.1 Planning

In a national capital context, ACT rivers and riparian zones are a key element in the concept of the National Capital Open Space System (NCOSS) in the *National Capital Plan* (NCA 2005). A *Principle* and *Policies*, that include environmental protection, are prescribed for NCOSS. Under the provisions of the *Australian Capital Territory (Planning and Land Management) Act 1988* (Cwlth), the *National Capital Plan* also sets out 'special requirements' for the Lanyon Bowl area, the Murrumbidgee and Molonglo River Corridors, and the Namadgi National Park Area (being the Park and adjacent areas in the Gudgenby and Cotter catchments). In effect, all the areas covered by this *Strategy*, except for Paddy's River, are included in the 'special requirements' provisions. The *National Capital Plan* includes Policy Plans for the 'Murrumbidgee River Corridor' and 'Namadgi National Park and Adjacent Areas', which together with *Territory Plan* policies provide the context for the preparation of management plans.

In a Territory planning context, *The Canberra Spatial Plan* (ACT Government 2004b) contains policies for the protection of the river corridors (biodiversity conservation) and policies for the management of water quality to improve the quality of stormwater runoff to streams. Detailed land use policies in the *Territory Plan* (ACTPLA 2005) that are of particular relevance to this *Strategy* are those for river corridors and water use and catchments (see also s. 1.5.1). In addition, all proposals for buildings within areas covered by the River Corridors Land Use Policies are subject to mandatory environmental impact assessment (Preliminary Assessment) under Appendix II of the *Plan*.

River Corridors Land Use Policies (*Territory Plan* Part B13) give primacy to the protection of natural and cultural values and recognise recreation as the key use. A number of land uses consistent with the *National Capital Plan* (NCA 2005) may be permitted and these may be subject to mandatory preliminary assessment under Part IV of the *Land (Planning and Environment) Act 1991*. Objectives of the River Corridors Land Use Policies are:

(a) to conserve the ecological and cultural values of the ACT's major river corridors;

(b) to protect streamflow, water quality and floodplains from adverse impacts;

(c) to ensure that the type and intensity of development is sustainable;

(d) to provide opportunities for a range of water and land based recreational activities;

(e) to ensure compatibility between land uses, water uses and the general character of the rivers; and

(f) to provide opportunities for appropriate environmental education and scientific research activities.

A range of controls applies, including restrictions on livestock grazing, protection from urban development, and protection of streamflow and water quality. Special conditions may apply including controls on use of fertilisers, pesticides and weedkillers. Sand and gravel removal, and channel stabilisation works, may be undertaken as required to rehabilitate and stabilise aquatic habitats and flood channels.

Water Use and Catchment Policies (*Territory Plan* Appendix 1) allocate waters of the ACT in terms of their permitted water uses and environmental values to be protected. Three Water Use Catchments have been defined:

(a) Conservation (includes Molonglo River Corridor, Murrumbidgee River Corridor and some of the Murrumbidgee River catchment in the ACT; catchment of the Gudgenby and Naas rivers);

(b) Water Supply (Cotter River catchment); and

(c) Drainage and Open Space (includes Paddys and Tidbinbilla rivers, streams in non-urban ACT).

The Conservation Catchments incorporate those lakes, streams and wetlands for which the primary value is conservation of aquatic habitats (natural and modified), migratory routes or landscape qualities. The Water Supply Catchments incorporate those reservoirs and streams for which the primary value is domestic water supply. The Drainage and Open Space Catchments incorporate those lakes and streams for which the primary value is drainage of the catchment and associated provision of open space. Policies for each of these allow for a range of secondary uses that are compatible with the primary value. The intent of these policies is expressed in a number of ways, an important means being a management plan prepared for a particular area (see s. 5.1.3).

### 5.1.2 Statutory Protection

The rivers and riparian zones considered in this *Strategy*, except for Paddys River and most of the lower sections of the Naas and Gudgenby rivers, are categorised as Public Land under the *Land (Planning and Environment) Act 1991* (ACT). This land is identified in *The Territory Plan* (Other Policies C1—Overlay Provisions). Public Land designation requires the preparation of Plans of Management. There are several categories of Public Land, for each of which the Act defines management objectives. Public Land categories assigned to ACT rivers and riparian zones or to areas containing rivers are described in Section 5.4.

The area of Public Land adjacent to the rivers varies widely. In the upper Cotter River, it encompasses the whole of the catchment. Along parts of the Murrumbidgee River, Special Purpose Reserve forms a buffer between riverine Nature Reserve and rural land (e.g. in the Bulgar Creek area and near the northern ACT border). Between Tharwa and Pine Island, land on both sides of the Murrumbidgee River is Special Purpose Reserve, including the Lanyon Landscape Conservation Reserve, which is managed as an historic rural landscape. In the lower Molonglo River valley the Nature Reserve (generally less than a kilometre wide) directly abuts adjacent rural land. The latter highlights a feature of river corridor reserves and a major management consideration—their linearity and high perimeter to area ratios. This exposes them to an extended interface with often contrasting and potentially poorly compatible land uses.

### 5.1.3 Management

The *Land (Planning and Environment) Act 1991* requires the preparation of a (draft) Plan of Management for an area of Public Land identified in the *Territory Plan*. This process is not complete for the rivers and riparian zones. The following plans are currently in place:

- *Namadgi National Park Draft Management Plan* (ACT Government 2005c). An approved Namadgi National Park Management Plan will supersede the 1986 *Namadgi National Park Management Plan* that was prepared under Commonwealth legislation (ACTP&CS 1986). The upper and middle sections of the Cotter, Gudgenby and Naas rivers and most of the Orroral River are in the Park.

**Figure 5.1: Territory Plan Land Use Policies and Areas of Public Land in the Murrumbidgee River Corridor**

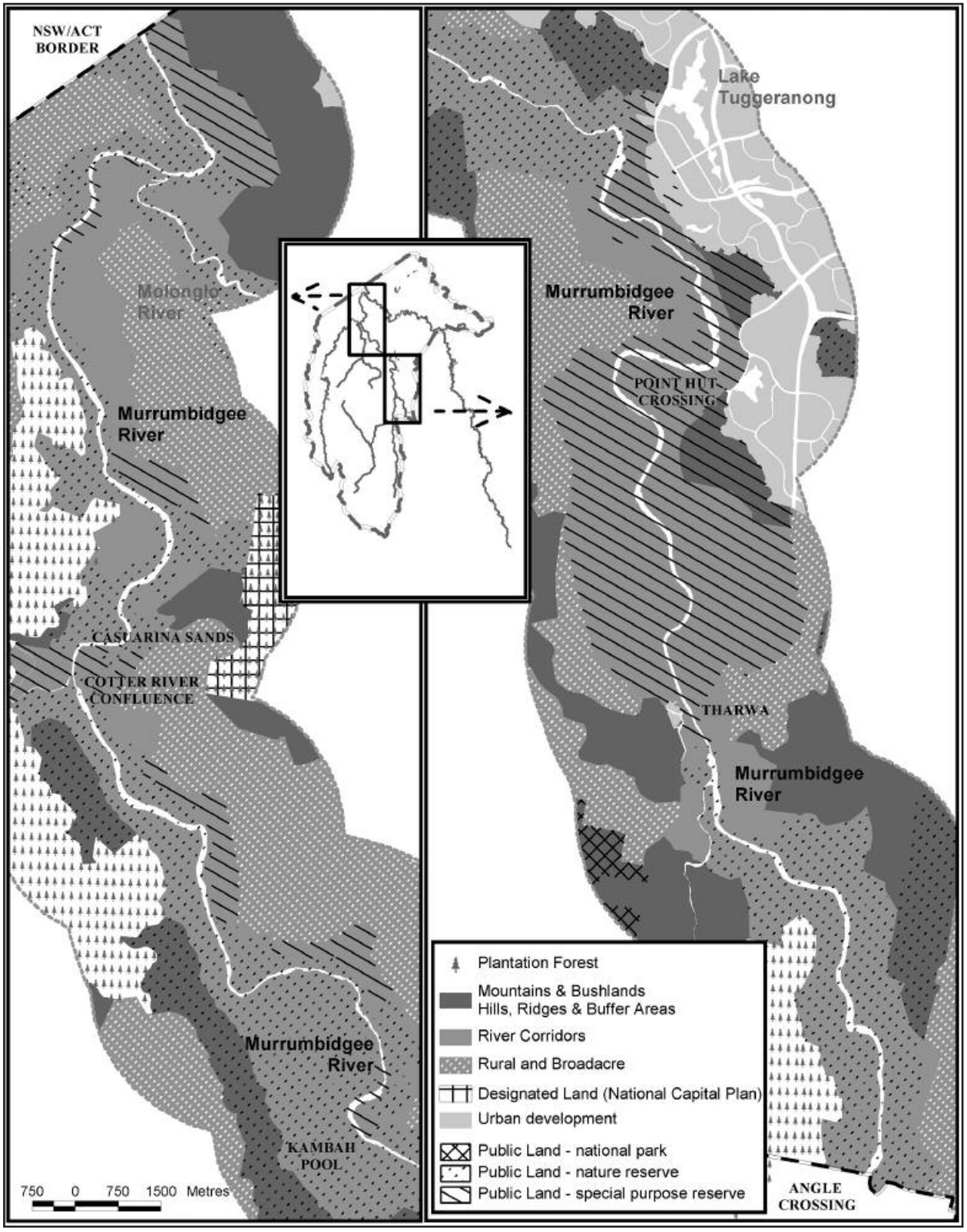


**Figure 5.2: Territory Plan Land Use Policies and Areas of Public Land in the Gudgenby, Naas and Orroral River Catchments**

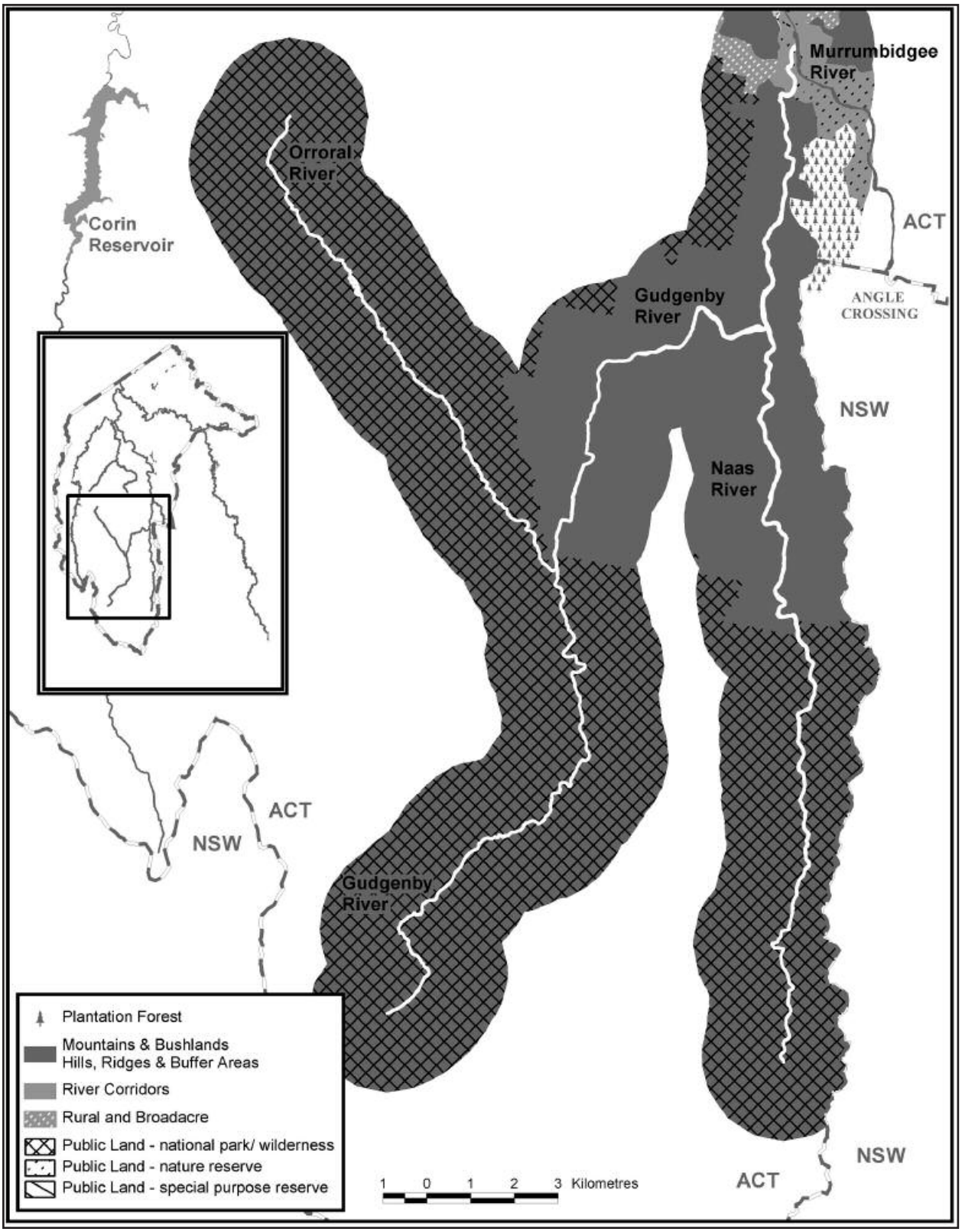


**Figure 5.3: Territory Plan Land Use Policies and Areas of Public Land in the Cotter, Paddys and Tidbinbilla River Catchments**

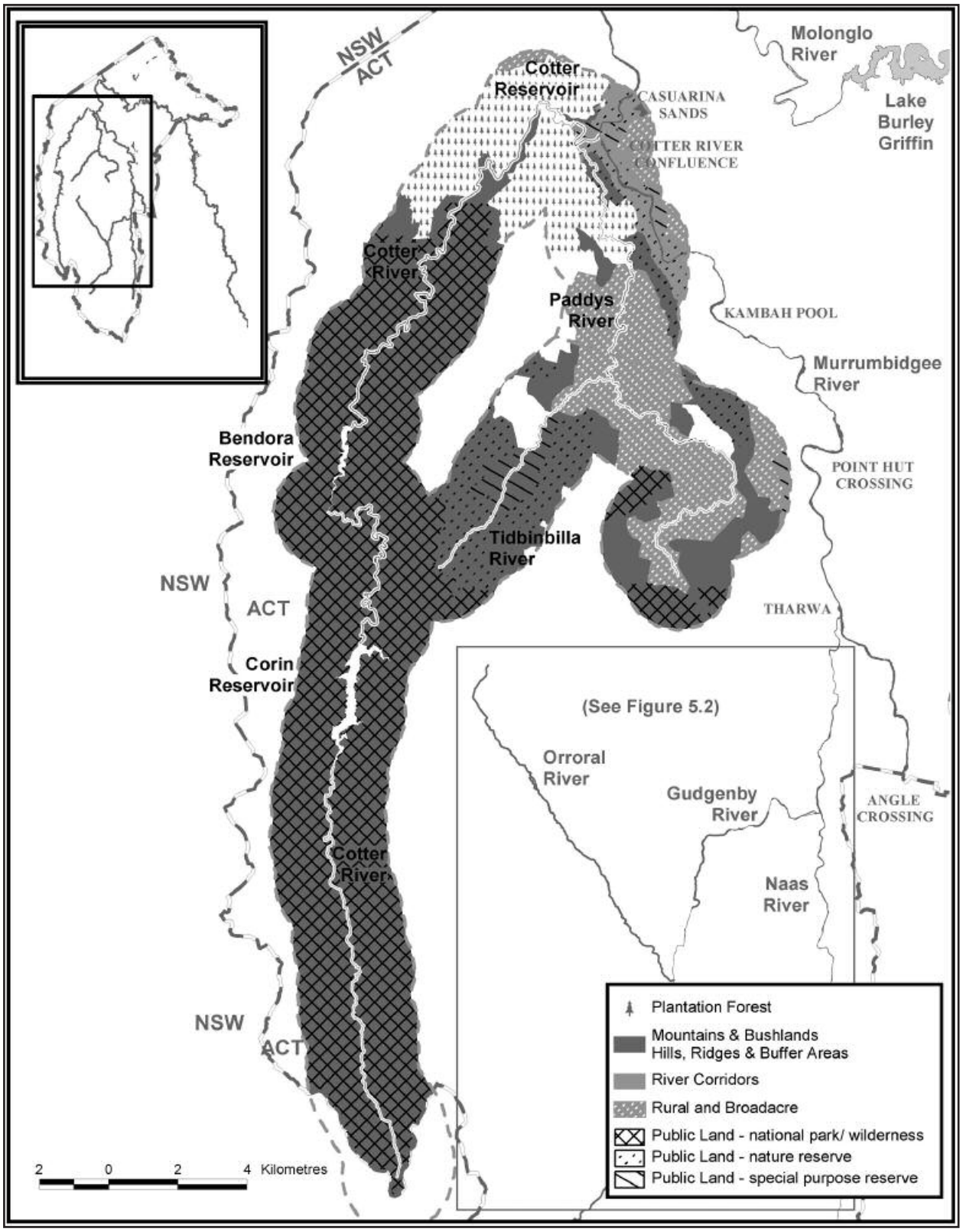
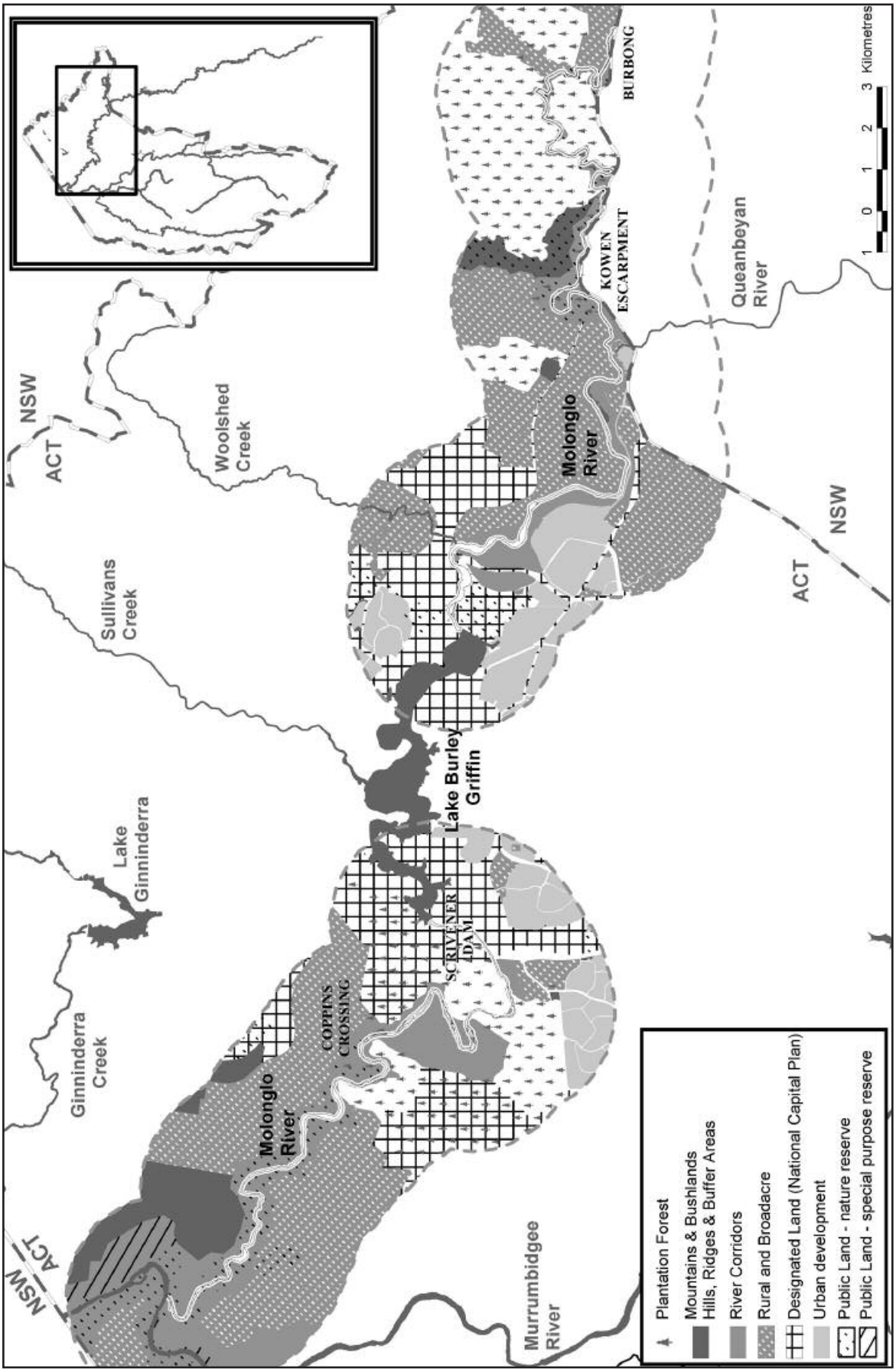


**Figure 5.4: Territory Plan Land Use Policies and Areas of Public Land in the Molonglo River Corridor**



- *Lower Cotter Catchment: Strategic Management Plan* (ACT Government 2006b).
- *Murrumbidgee River Corridor Management Plan* (Environment ACT 1998).
- *Lower Molonglo River Corridor Management Plan* (Environment ACT 2001b).
- *Tidbinbilla Nature Reserve Management Plan* (Environment ACT 1999). This reserve includes most of the Tidbinbilla River, a tributary of Paddys River.

Management of the National Park, Nature Reserve and River Corridor Special Purpose Reserve areas is the responsibility of Environment and Recreation (Department of Territory and Municipal Services). The activities of other government agencies as well as other organisations also influence the management of these areas (e.g ACTEW Corporation; Emergency Services Authority).

In relation to the rivers and riparian zones in the ACT, there are three aspects of management that need consideration:

- **Management Responsibility:** This is clearly established for Namadgi National Park and the parts of the Murrumbidgee and Molonglo river valleys that are Nature Reserve and Special Purpose Reserve, which are managed by Environment and Recreation (Department of Territory and Municipal Services). Some other riparian areas have not been actively managed and are very degraded, in particular, along the Molonglo River near Fyshwick, and below Scrivener Dam. More active conservation management is proposed for the Cotter River between Cotter Reservoir and Namadgi National Park with a change in the focus of land use to water supply (ACT Government 2006a).
- **Management Plans:** Management Plans have not been prepared for some Public Land areas, in particular, Molonglo Gorge (Kowen) where there is established recreational use and a nearby land use (pine plantation) with potential to impact on the area.
- **On-ground Management:** Parts of the riparian zone require increased management input e.g. willow control, other weed control, vegetation restoration, and improved management of the sand and gravel stockpile site in the Public Land river corridor near Fyshwick. The former extraction site in this area needs rehabilitation.

# 5.2

## River and Riparian Zone Conservation Areas

As noted in s. 5.1.2 above, most rivers and riparian areas are included in Public Land under the *Land (Planning and Environment) Act 1991*. Outside of Namadgi National Park, Nature Reserve classification has been applied to the more environmentally significant river sections and Special Purpose Reserve to other sections and upslope areas (Table 5.1, Figures 5.1–5.4). In the *Land (Planning and Environment) Act 1991*, management objectives for Special Purpose Reserve are 'to provide for public and community use of the area for recreation and education'. In practice, in the Murrumbidgee River Corridor, the two reserve types are managed as one, or as complementary. Special Purpose Reserves may provide land suitable for siting of recreational facilities away from areas of greater environmental significance or sensitivity. The Special Purpose Reserve Classification is also used for areas where recreational activities were focused historically (e.g. the river crossings and major pools on the Murrumbidgee River).

As noted previously (s. 5.1, s. 5.1.1 to s. 5.1.3), there is comprehensive reservation of ACT riparian zones as well as planning controls that apply to the river corridors (Figures 5.1 to 5.4). For these reasons, the *Strategy* does not propose new reservations. A priority action for the *Strategy* is to undertake a program of systematic survey of vegetation and habitat in ACT riparian zones (s. 6.5.1, Table 6.1). This will complement the knowledge built up over time of aquatic habitat and ecology (through fish survey and monitoring, macroinvertebrate monitoring and water quality monitoring). Together these will provide an information base to consider the adequacy of reservation and planning controls, however, their greatest value is likely to be in refining the management of already reserved areas.

The following planning and management considerations arise in relation to the differing reserve classifications along the rivers and riparian land uses:

- **Fragmentation and linear connectivity:** River and riparian nature reserves, like their terrestrial counterparts, may be fragmented (i.e. separated by river sections with other land uses). Unlike their terrestrial counterparts, however, there is linear, mainly downstream connectivity provided by flows of water, sediments, organic materials and living organisms. This means that high conservation value areas cannot be isolated from the effects of

activities in the stream lengths that separate them, or from upstream.

This is especially relevant for the Molonglo River, where Molonglo Gorge (Kowen) and the lower gorge (near the Murrumbidgee River confluence), which have significant nature conservation values, are separated by Lake Burley Griffin, sections with major urban stormwater inflows, and lengths of degraded river. In particular, there are substantial willow invasions and other woody and herbaceous weeds, and macroinvertebrate sampling sites on the Molonglo River (Site 242) and nearby Queanbeyan River (Site 235) indicate that these river sections are severely impaired to impoverished in their macroinvertebrate assemblages (ACT Government 2004e). In the Murrumbidgee River, habitat has been seriously affected by upstream erosion and sedimentation with major deposition of sand and gravel in the Tharwa area (see s. 4.1).

Comprehensive conservation management along rivers has proven difficult to achieve, even in a small geographic area such as the ACT. Habitat fragmentation in riparian zones and damage to riverbanks has been caused by grazing (though this is substantially reduced in the ACT), tree clearing and ongoing tree decline, extractive industries, establishment of recreation areas and other facilities.

- **Stream crossings:** Related to the above are the impacts of the number, design and placement of stream crossings. These provide entry points to river and riparian areas for human activity, weeds, dumping of rubbish, illegal fishing and are a source of sediment. The design of crossings can have a severe impact on fish passage. Guidelines are now available for the construction of various types of new crossings and rehabilitation of existing ones that facilitate fish passage e.g. Fairfull and Witheridge (2003). Construction of the rock-ramp fishway at Vanitys Crossing on the Cotter River is an example of such rehabilitation (see s. 4.4.2).
- **Impacts of upslope land uses:** A major management problem for rivers and riparian zones is their linearity and high perimeter to area ratios. They are a very difficult reserve shape for the protection of natural integrity. In the ACT it is evident that the best remnants of low elevation riparian vegetation are in the more rugged gorge areas (Gigerline and Bullen Range adjacent to the Murrumbidgee River and gorges in the lower Molonglo River and at Kowen). These areas have been protected by virtue of their topography and have not experienced the impacts of grazing, fire and recreation to the same extent as more accessible riparian areas. By contrast, in the lower Paddys River and lower Cotter River areas, extensive pine plantations have reduced native vegetation in the riparian zone to a narrow strip.

# 5.3

## Conservation Planning for Rivers and Riparian Zones

Rivers and their riparian zones possess particular features that require special consideration in their conservation and management (adapted from Williams 1993):

- **Linearity and instability:** They are linear landscape features and inherently unstable because of riverflows. This makes them vulnerable to disturbance and invasion. Conversely, river regulation and reduced flow variability (in particular, reduced high flows) have created conditions suitable for invasion by pest plants and animals.
- **Tenures and land uses:** Their linearity means that rivers pass through differing tenures and land uses. Upstream and upslope uses and management, including the results of activities that occurred a long time ago, influence downstream river sections.
- **Remnant riparian vegetation:** Riparian vegetation is often the sole or major form of remnant vegetation in an area and therefore has increased value for local biodiversity conservation. Riparian areas often provide specialised habitats (e.g. moist areas, rocky gorges, areas protected from climatic extremes, unstable substrates) that support locally uncommon plant and animal species and ecological communities. Riparian vegetation may include relict species (from previous different climatic environments) and species lost from surrounding terrestrial vegetation communities due to grazing pressure from stock.
- **Land uses:** Rivers and riparian areas are the focus of many land uses, activities and demands making them critical zones for land use planning. These include recreation, domestic or urban water supply, rural or agricultural water supply, irrigation, pastoralism, sand and gravel extraction, urban sewage treatment and disposal. Despite this, their small size relative to the total landscape may result in a low public profile. Presence of these uses and demands may result in some reluctance to accept the concept of and need for the maintenance of environmental flows especially in times of drought.

- **Water supply and ecological systems:** Historically, public policy in the ACT has been primarily focused on river systems as a water supply. Major changes to rivers and their catchments occurred before there was the ecological knowledge that could have predicted the effects of these changes. While the importance of maintaining water quality and biological diversity has been increasingly recognised, water supply demands are also growing. At the broader catchment level, this is the major conservation planning issue for rivers and the riparian zone, although quality and quantity of water supply will be linked to the quality and function of the riparian and aquatic ecosystems.

There are some particular conservation planning challenges for the ACT and region with regard to the rivers, aquatic species and the riparian zone. Foremost amongst these are:

- **Urban growth:** The growth of Canberra and Queanbeyan continues to exert significant development pressures on land in and around existing urban areas, including the rivers and riparian areas. Proposed future urban development in the Molonglo Valley and the Kowen Plateau (ACT Government 2004b) will substantially increase the urban population living in close proximity to the Molonglo River.

  Particular attention is being given to the relationship between proposed new urban developments in the Molonglo Valley and the adjacent river and riparian areas. This includes protection of habitat (e.g. for raptors and the Pink-tailed Worm Lizard) and the potential to rehabilitate the degraded river section between Scrivener Dam and Coppins Crossing.

  As a result of detailed planning processes undertaken by the ACT Planning and Land Authority, there may be a requirements to adjust the boundaries of the areas formally protected under the Territory Plan. This will include reductions and additions as required to River Corridor land use policy areas that reflect the most appropriate balance between planning and the environment, incorporating appropriate protection and mitigation measures as considered necessary.

- **Aquatic habitat:** The recovery of ACT threatened aquatic species is highly dependent upon the maintenance and improvement of aquatic habitat. Key aspects of this are improvements to water quality, maintenance of environmental flows, protection and improvement of riverbanks and riparian condition, removal of willows, sediment and nutrient management, and in-stream habitat improvement (e.g. through interventions to create scour holes and habitat holes, increase large woody debris, and remove large sand and gravel deposits).

- **Riparian zone management:** (see s. 5.1.3 above).

- **Cross-border issues:** A number of streams span jurisdictional boundaries (Molonglo, Queanbeyan and Murrumbidgee rivers) and so the planning and management of different river sections may not be well integrated.

- **Bushfire Recovery:** In January 2003, bushfires of high intensity burnt 70 per cent of the ACT including all of the Cotter catchment, the riparian zone of the Murrumbidgee River and the lower Molonglo River corridor. The effects of these fires on catchment stability and flora and fauna, and land use planning considerations resulting from the destruction of existing assets (including a substantial area of pine plantation) have long term implications for the rivers and riparian zones. Particular issues are:
  - —Long-term establishment of stable vegetation cover, which is not predominantly invasive weed species, in former pine plantation areas that are not to be re-planted with pines.
  - —Planned urban and other development in the lower Molonglo River valley.
  - —Potential new recreational facilities in river corridor areas (Non-Urban Study Steering Committee 2003).
  - —Potential intensification of rural use (Non-Urban Study Steering Committee 2003).
  - —Sediment addition to streams following the fires.
  - —Longer-term stabilisation of catchments and riparian areas.
  - —Re-establishment of riparian vegetation along the Cotter River between Cotter Reservoir and Bendora Dam (an area previously surrounded by pine plantation).
  - —Recovery of the *Casuarina cunninghamiana* Riparian Woodland, which is not a fire-dependent system, following the January 2003 bushfires (England *et al*. 2004). The dominant *Casuarina cunninghamiana* may resprout epicormically after fire, but after a high intensity fire appears not to be able to maintain this growth. Trees along the Murrumbidgee and Cotter rivers that produced epicormic shoots after the fire have subsequently died. Continuing drought may have been a factor in this.
  - —Recovery of the *Callitris endlicheri* Woodland/ Open Forest. The dominant *Callitris endlicheri*

regenerates by seedling regrowth and is eliminated by frequent intense fire (England *et al.* 2004). Fire severity for this species was high to very high in the Mt Tennent area (Carey *et al.* 2003). River corridor populations were not surveyed immediately following the fires.

### 5.3.1 Conservation Planning Principles

Some conservation planning principles for rivers and their riparian zones are similar to those applying to the conservation of ecological communities elsewhere and have been discussed in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a, Ch. 5) and the *ACT Lowland Native Grassland Conservation Strategy* (ACT Government 2005a, Ch. 3). Where relevant, these have been integrated into the principles below:

**Protection Upstream and Upslope**

1. Areas that have the highest conservation values should be protected.
   - This includes protection from the impact of upstream uses.
   - It may necessitate the rehabilitation of upstream river sections.
2. For conservation areas, consideration of size (viability), diversity, representativeness, distinctiveness (rarity) and naturalness is required.
3. Replication of conservation areas in fragmented habitats is necessary to hedge against catastrophic and/or unpredictable local extinction. Integration of smaller systems within broader conservation systems increases their conservation value. River sections should be considered in a catchment context, where appropriate.

(Adapted from ACT Government 2005a; Williams 1993)

**Management**

Management should be based on a statutory management plan that clearly sets out management objectives, and includes actions, practices and responsibilities to achieve those objectives.

**Threats**

Management of threats should be a key focus. A scale appropriate to the threat using a catchment framework, and recognising linkages between site values and catchment processes, is required (Kingsford *et al.* 2005).

**Riverflows**

Riverflows should be protected at a level and regime that sustains all in-stream biota and ecological processes (Kingsford *et al.* 2005).

- The best scientific information available should be used to design water strategies that will sustain the ecological values of water-dependent ecosystems (Arthington and Pusey 2003).
- An adaptive management approach is preferred for the calculation and refinement of environmental flows.
- Environmental flow calculations should include assessment of the needs of threatened species.

**Linear Connectivity**

Statutory protection, planning and management need to recognise the linear connectivity along streams and riparian zones and to tributary streams. Highly significant ecologically, it also means that the effects of activities are inextricably linked to downstream sections.

**Upslope Connectivity**

Statutory protection, planning and management need to recognise the connectivity between the stream, the riparian zone and terrestrial areas (not influenced by the stream), and the importance of this connectivity for ecosystem functioning.

**Streamflows and Aquifers**

Management should explicitly recognise the interdependence of surface riverflows and subterranean catchments (Kingsford *et al.* 2005). Connected aquifers are part of the river.

**Assessment**

All proposed activities that affect ecological processes and values of aquatic and riparian systems should be adequately assessed and managed, taking into account catchment scale considerations (Kingsford *et al.* 2005).

### 5.3.2 Information: Survey, Monitoring and Research

An adequate information base is a necessary precursor to sound conservation planning. Preparation of this *Strategy* has highlighted the unevenness and some deficiencies in the knowledge of species and ecological communities in the rivers and riparian zones of the ACT. In summary there is:

- Good knowledge of the ecological condition of ACT streams based on macroinvertebrate sampling at 200 sites.
- Good knowledge of water quality in ACT lakes and streams based on monitoring since the late 1960s.
- Sound knowledge of many aspects of the biology, distribution, abundance and threats to native fish (including threatened species) and the Murray River Crayfish, Platypus and Eastern Water Rat.
- Less knowledge of other aquatic animal species and aquatic ecological communities.

- Sufficient ecological and distributional information on the Pink-tailed Worm Lizard on which to base conservation action. Research needs for this species are identified in s. 3.3.2.
- A reasonable knowledge of other riparian zone fauna generally. Most species are also found in other ecosystems (see s. 3.2).
- Variable information on riparian vegetation communities, as riparian areas as a whole have not been the subject of a systematic vegetation survey. Existing surveys cover particular rivers or river sections and most are now outdated having been undertaken between 1975 and 1992 (see s. 2.2.1).

**SURVEY**

The need to undertake surveys of riparian vegetation, giving attention to threatened and uncommon species and ecological communities is identified in s. 2.2.1, s. 2.4.1 and s. 2.4.2. Similar actions for riparian fauna are outlined in s. 3.3. Survey objectives and actions for the *Strategy* as a whole are contained in Table 6.1.1. A follow up to comprehensive survey is the assessment of the conservation status of species and ecological communities to identify those that warrant consideration for nomination as threatened species or ecological communities under the *ACT Nature Conservation Act 1980*.

**MONITORING**

An objective of the *Strategy* is to keep information on aquatic and riparian communities current by means of an appropriate monitoring program. As noted above, comprehensive monitoring of water quality, fish populations and aquatic macroinvertebrates has been undertaken in the ACT and is ongoing. Monitoring by community organisations may also make an important contribution e.g. Canberra Ornithologists Group's ten year woodland bird monitoring and monitoring of the annual honeyeater migration along the Murrumbidgee, Frogwatch and Waterwatch monitoring. A monitoring program aimed at understanding the long-term ecological effects of the January 2003 bushfires and the recovery of ecological communities and component species is a priority action (Table 6.1.1). This has already commenced (see s. 2.3.1).

**RESEARCH**

Scientific research, including that undertaken by honours and higher degree students, has made a significant contribution to knowledge about aquatic and riparian species, ecological communities and habitats. The *Strategy* encourages the continuation of such research effort, which might include the effects of, and recovery from, the January 2003 bushfires (Table 6.1.1).

### 5.3.3 Protection

Statutory protection of areas of high conservation value is a key aspect of conservation planning. As noted previously (s. 5.1.2) a high level of statutory protection currently exists for ACT rivers and riparian areas.

### 5.3.4 Management

It has been noted in s. 5.1 and s. 5.1.3 that the strengthening of management is the key issue for ACT rivers and riparian areas. Management of rivers and riparian zones has five main objectives (Williams 1993):

- to protect water quality from any damaging effects of pollution;
- to protect the quality of downstream waters;
- to minimise erosion of water courses;
- to maintain the biological diversity of aquatic and riparian biotas; and
- to provide aesthetically and ecologically acceptable recreational facilities.

The effects of past and continuing land and water uses mean that rehabilitation activities are likely to play a central role in management of rivers and riparian areas (see s. 5.5.2). Two particularly intractable problems are (a) the spread and naturalisation of alien fish species and pest plants (Georges and Cottingham 2002), and (b) re-establishing native species and communities in regulated rivers, especially as water needs continue to grow. Table 6.1.5 contains management objectives and actions for the *Strategy* as a whole. More specific actions are in sections 2.4, 3.3, 4.11 to 4.14.

General and detailed management objectives for specified values and for particular reserve areas are outlined in management plans for river corridors, Tidbinbilla Nature Reserve and Namadgi National Park (listed in s. 5.1.3). As noted in s. 1.7, this *Strategy* is not a management plan.

## 5.4

## Planning and Conservation Issues for Rivers and Riparian Zones in the ACT

Table 5.1 contains a summary of planning and conservation issues and priority actions for defined river sections and riparian zones in the ACT. The river sections in Table 5.1 correspond to those in Table 2.2 and Table 4.2.

**Table 5.1: River Sections and Riparian Zones: Planning and Conservation1 Issues and Actions**
(Objectives and actions for the Strategy as a whole are outlined in Table 6.1 and provide the context for the identification of issues and actions for individual river sections and adjacent riparian zones in this table)

| Current Planning and Management | Description (for more details see Tables 2.2 and 4.2) | Planning and Conservation Issues for Identified River Section and Riparian Zone | Priority Actions |
|---|---|---|---|
| **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***<br>■ Gigerline Nature Reserve<br>■ Special Purpose Reserve (Tharwa)<br>■ Rural leasehold<br>***Management***<br>MRC Management Plan 1998 | Native vegetation cover has been cleared and altered through long history of pastoral use. Gigerline Gorge retains native vegetation. Streambed has been affected by deep sedimentation (sand and gravel).<br>Most of section burnt in January 2003 bushfires. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Illegal fishing for threatened species.<br>(b) Weed invasion including willows.<br>(c) Effects of uncontrolled riparian grazing including riverbank degradation.<br>(d) Loss and continuing decline of in-stream fish/crayfish habitat especially through sedimentation (sand and gravel).<br>**Protection**<br>(a) Habitat for Pink-tailed Worm Lizard (*Aprasia parapulchella*).<br>**Management (Rehabilitation)**<br>(a) Loss and continuing decline of native riparian vegetation (including *Eucalyptus viminalis* Riparian Woodland).<br>(b) Loss of native fish species. | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) Enforce the ACT fishing regulations.<br>(b) Continue to undertake coordinated weed control based on weed control priorities.<br>(c) Control grazing, including fencing out riparian areas where desirable.<br>(d) Investigate and where feasible undertake in-stream restoration of degraded habitat.<br>**Protection**<br>(a) As part of management, ensure protection of the habitat of the Pink-tailed Worm Lizard (see s. 3.3.2 for specific actions).<br>**Management (Rehabilitation Activities)**<br>(a) Undertake actions to regenerate and restore native riparian vegetation (including *Eucalyptus viminalis* Riparian Woodland).<br>(b) Monitor results of Trout Cod reinstatement in this section as a basis for future stocking. |
| **MU 2: Tharwa to Point Hut Crossing** | | | |
| ***Territory Plan***<br>■ Special Purpose Reserve (including Lanyon Landscape Conservation reserve)<br>■ Rural leasehold<br>***Management***<br>MRC Management Plan 1998 | The river passes through broad river flats cleared of their former woodland cover (area is now Lanyon Landscape Conservation Reserve). The river channel is shallow and infilled with sand. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Illegal fishing for threatened species.<br>(b) Weed invasion including willows.<br>(c) Effects of uncontrolled riparian grazing including riverbank degradation.<br>(d) Loss and continuing decline of in-stream fish/crayfish habitat especially through sedimentation (sand and gravel).<br>**Protection**<br>(a) Uncommon plants including *Discaria pubescens*.<br>**Management (rehabilitation)**<br>(a) Loss and continuing decline of native riparian vegetation (including *Eucalyptus viminalis* Riparian Woodland).<br>(b) Point Hut Crossing barrier to fish movement. | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) Enforce the ACT fishing regulations.<br>(b) Continue to undertake coordinated weed control based on weed control priorities.<br>(c) Control grazing, including fencing out riparian areas where desirable.<br>(d) Investigate and where feasible undertake in-stream restoration of degraded habitat. Investigate means to limit downstream sediment movement including potential for sand extraction<br>**Protection**<br>(a) As part of management, ensure protection of uncommon plants and habitat (see s. 2.4.2 for specific actions).<br>**Management (Rehabilitation Activities)**<br>(a) Undertake actions to regenerate and restore native riparian vegetation (including *Eucalyptus viminalis* Riparian Woodland).<br>(b) Investigate, design and construct fish passage past Point Hut Crossing. |

**Table 5.1:** *(Continued)*

| Current Planning and Management | Description (for more details see Tables 2.2 and 4.2) | Planning and Conservation Issues for Identified River Section and Riparian Zone | Priority Actions |
|---|---|---|---|
| **MU 3: Point Hut Crossing to Kambah Pool** | | | |
| ***Territory Plan***<br>■ Special Purpose Reserve (Point Hut Crossing to Pine Island, Pine Island, Kambah Pool)<br>■ Bullen Range Nature Reserve (Pine Island to Kambah Pool)<br>■ Rural leasehold<br>***Management***<br>MRC Management Plan 1998 | There is a diversity of vegetation related to topography and past land use. *Callitris endlicheri* is common on rocky slopes. Section contains southern limit of *Casuarina cunninghamiana* in ACT. The open river valley changes to steep slopes and terraces and includes Red Rocks Gorge. Most of section burnt in January 2003 bushfires.<br>Habitat of threatened *Muehlenbeckia tuggeranong*. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Illegal fishing for threatened species.<br>(b) Weed invasion including willows.<br>(c) Urban impacts and recreational use.<br>(d) Loss and continuing decline of in-stream fish/crayfish habitat especially through sedimentation (sand and gravel).<br>**Protection**<br>(a) Scenic values.<br>(b) Raptor habitat (including nesting sites).<br>(c) Threatened and uncommon plants (*Muehlenbeckia tuggeranong*, *Thesium australe, Discaria pubescens, Bossiaea bracteosa*). Snow Gum (*Eucalyptus pauciflora*) occurs near Red Rocks Gorge.<br>(d) Habitat for Pink-tailed Worm Lizard (*Aprasia parapulchella*).<br>**Management (Rehabilitation)**<br>(a) Loss and continuing decline of native riparian vegetation.<br>**Planning**<br>(a) Potential impacts of any future urban development or provision of recreational facilities. | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) Enforce the ACT fishing regulations.<br>(b) Continue to undertake coordinated weed control based on weed control priorities.<br>(c) Manage recreational impacts in accordance with the *Murrumbidgee River Corridor Management Plan*. Maintain recreation at nodes with appropriately sited, low key linear walking trails along the river corridors.<br>(d) Investigate and where feasible undertake in-stream restoration of degraded habitat. Investigate means to limit downstream sediment movement.<br>**Protection**<br>(a) Ensure protection of scenic values in accordance with the MRC Management Plan.<br>(b) Ensure protection of raptor habitat through management of recreational use and other potentially harmful activities.<br>(c) As part of management, ensure protection of threatened and uncommon plants and their habitat (see s. 2.4.1 and s.2.4.2 for specific actions).<br>(d) As part of management, ensure protection of the habitat of the Pink-tailed Worm Lizard (see s. 3.3.2 for specific actions).<br>**Management (Rehabilitation Activities)**<br>(a) Undertake actions to regenerate and restore native riparian vegetation.<br>**Planning**<br>(a) Assess development proposals under relevant legislation, planning and management frameworks. Ensure that planning of recreational infrastructure recognises and protects river corridor values. |

**Table 5.1:** *(Continued)*

| Current Planning and Management | Description (for more details see Tables 2.2 and 4.2) | Planning and Conservation Issues for Identified River Section and Riparian Zone | Priority Actions |
|---|---|---|---|
| **MU 4: Kambah Pool to Cotter River Confluence/Casuarina Sands** | | | |
| ***Territory Plan***<br>■ Bullen Range Nature Reserve<br>■ Special Purpose Reserve (upslope areas on eastern side of Murrumbidgee R. above nature reserve)<br>■ Special Purpose Reserve (Cotter Reserve/Casuarina Sands)<br>***Management***<br>MRC Management Plan 1998 | The Bullen Range and steep valley slopes in this section have retained their vegetation cover, mainly dry forests, Callitris Pine woodland and shrublands. River Oaks and shrub vegetation dominate the riverbanks.<br>This section was severely burnt in the January 2003 bushfires. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Illegal fishing for threatened species.<br>(b) Weed invasion including willows.<br>(c) Loss and continuing decline of in-stream fish/crayfish habitat especially through sedimentation (sand and gravel).<br>**Protection**<br>(a) Uncommon plants including *Discaria pubescens, Desmodium brachypodum, Pomaderris pallida*.<br>(b) Habitat for Pink-tailed Worm Lizard (*Aprasia parapulchella*).<br>**Management (Rehabilitation, Connectivity)**<br>(a) Post-fire recovery (January 2003 bushfires) of *Casuarina cunninghamiana* Riparian Woodland and *Callitris endlicheri* Woodland.<br>(b) Maintaining and improving ecological connectivity through Cotter/Casuarina Sands recreation area.<br>**Planning**<br>(a) Potential impacts of provision of recreational facilities associated with recovery following January 2003 bushfires (see s. 5.3). | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) Enforce the ACT fishing regulations.<br>(b) Continue to undertake coordinated weed control based on weed control priorities.<br>(c) Investigate means to limit downstream sediment movement.<br>**Protection**<br>(a) As part of management, ensure protection of uncommon plants and their habitat (see s. 2.4.2 for specific actions).<br>(b) As part of management, ensure protection of the habitat of the Pink-tailed Worm Lizard (see s. 3.3.2 for specific actions).<br>**Management (Rehabilitation Activities, Maintaining Connectivity)**<br>(a) Monitor post-fire recovery of *Casuarina cunninghamiana* Riparian Woodland and *Callitris endlicheri* Woodland. Evaluate means to assist recovery of the *Casuarina cunninghamiana* and *Callitris endlicheri* woodlands, if necessary.<br>(b) Maintain and improve ecological connectivity through Cotter/Casuarina Sands recreation area in management of the area (see also **Planning** below).<br>**Planning**<br>(a) Assess development proposals under relevant legislation, planning and management frameworks. Ensure that planning of recreational infrastructure recognises and protects river corridor values. Give attention to maintaining and improving ecological connectivity through Cotter/Casuarina Sands recreation area in provision of recreational facilities associated with recovery following January 2003 bushfires. |

**Table 5.1:** *(Continued)*

| Current Planning and Management | Description (for more details see Tables 2.2 and 4.2) | Planning and Conservation Issues for Identified River Section and Riparian Zone | Priority Actions |
|---|---|---|---|
| **MU 5: Cotter River Confluence/Casuarina Sands to ACT/NSW border** | | | |
| ***Territory Plan***<br>■ Stony Creek Nature Reserve<br>■ Swamp Creek Nature Reserve<br>■ Woodstock Nature Reserve<br>■ Special Purpose Reserve (upslope areas above nature reserves)<br>■ Special Purpose Reserve (Uriarra Crossing)<br>***Management***<br>MRC Management Plan 1998 | The river passes through deeply dissected slopes cut from undulating terrain. Riverbanks and valley slopes are in parts densely vegetated with Tableland Shrubland (dominated by *Kunzea ericoides*) and emergent *Callitris enlicheri*. Dry forest is also common in this section. Riverine vegetation consists of *Casuarina cunninghamiana* with shrubs in rocky areas. This section was severely burnt in the January 2003 bushfires. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Illegal fishing for threatened species.<br>(b) Weed invasion including willows.<br>(c) Loss and continuing decline of in-stream fish/crayfish habitat especially through sedimentation (sand and gravel).<br>**Protection**<br>(a) Uncommon plants including *Bossiaea bracteosa*.<br>(b) Habitat for Pink-tailed Worm Lizard (*Aprasia parapulchella*).<br>(c) Raptor habitat (including nesting sites).<br>**Management (Rehabilitation)**<br>(a) Post-fire recovery (January 2003 bushfires) of *Casuarina cunninghamiana* Riparian Woodland and *Callitris endlicheri* Woodland. | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) Enforce the ACT fishing regulations.<br>(b) Continue to undertake coordinated weed control based on weed control priorities.<br>(c) Investigate means to limit downstream sediment movement.<br>**Protection**<br>(a) As part of management, ensure protection of uncommon plants and their habitat (see s. 2.4.2 for specific actions).<br>(b) As part of management, ensure protection of the habitat of the Pink-tailed Worm Lizard (see s. 3.3.2 for specific actions).<br>(c) Ensure protection of raptor habitat through management of recreational use and other potentially harmful activities.<br>**Management**<br>(a) Monitor post-fire recovery of *Casuarina cunninghamiana* Riparian Woodland and *Callitris endlicheri* Woodland. Evaluate means to assist recovery of the *Casuarina cunninghamiana* Woodland, if necessary. |

## 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***<br>■ Namadgi National Park<br>***Management***<br>Namadgi National Park Draft Management Plan 2005, Namadgi National Park Management Plan 1986 | Open valley floors in the Naas–Gudgenby catchment contain grassy vegetation communities and limited areas of shrubland and wetland complexes. There is variable tree cover, from open forest to open woodland. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Reestablishment of willows following major willow removal program.<br>**Protection**<br>(a) Uncommon plants including *Violea caleyana, Discaria pubescens*.<br>**Management (Rehabilitation)**<br>(a) Post fire recovery (January 2003 bushfires) of riparian vegetation and habitat.<br>(b) Restoration of native riparian vegetation and rehabilitation of habitat following willow removal. | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) As follow-up to willow removal programs, monitor willow regeneration and undertake removal if necessary.<br>**Protection**<br>(a) As part of management, ensure protection of uncommon plants and their habitat (see s. 2.4.2 for specific actions).<br>**Management (Rehabilitation Activities)**<br>(a) Monitor post-fire recovery of riparian vegetation and habitat, and evaluate means to assist recovery if necessary.<br>(b) Undertake vegetation restoration and habitat rehabilitation following willow removal. |

**Table 5.1:** *(Continued)*

| Current Planning and Management | Description (for more details see Tables 2.2 and 4.2) | Planning and Conservation Issues for Identified River Section and Riparian Zone | Priority Actions |
|---|---|---|---|
| **GU 2: Namadgi NP to Murrumbidgee River** | | | |
| ***Territory Plan***<br>■ Special Purpose Reserve (possible Tennent Dam site)<br>■ Rural leasehold | Vegetation has been extensively modified by pastoral use. Native vegetation present in the steep, rocky valley of the Gudgenby River near Mt Tennent. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Re-establishment of willows following major willow removal program.<br>(b) Effects of uncontrolled riparian grazing including riverbank degradation.<br>(c) Loss and continuing decline of instream fish/crayfish habitat especially through sedimentation (sand and gravel).<br>**Management (Rehabilitation)**<br>(a) Restoration of native riparian vegetation and rehabilitation of habitat following willow removal. | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) As follow-up to willow removal programs, monitor willow regeneration and undertake removal if necessary.<br>(b) Control grazing, including fencing out riparian areas where desirable.<br>(c) Investigate means to limit downstream movement of sediment including removal of sediment from this section.<br>**Management (Rehabilitation Activities)**<br>(a) Undertake vegetation restoration and habitat rehabilitation following willow removal. |
| **Cotter River**<br>**(Tributary: Paddys River)**<br>(*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***<br>■ Tidbinbilla Nature Reserve<br>■ Rural leasehold<br>■ Plantation forestry<br>***Management***<br>Tidbinbilla Nature Reserve Management Plan 1999 | Vegetation has been substantially altered by pastoral use. Extensive pine plantation in lower reaches (destroyed in January 2003 bushfires). *Kunzea ericoides* has colonised valley slopes and there is a wide variety of weed species. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Illegal fishing for threatened species.<br>(b) Weed invasion (wide variety of weed species including willows).<br>(c) Effects of uncontrolled riparian grazing including riverbank degradation.<br>**Protection**<br>(a) Uncommon plants including *Drabastrum alpestre, Pomaderris pallida, Bossiaea bracteosa, Thesium australe*.<br>**Management (Rehabilitation)**<br>(a) Loss and continuing decline of in-stream fish/crayfish habitat especially through sedimentation (effects of January 2003 bushfires, roads, forestry activities).<br>(b) Degradation of riparian habitat (grazing, weeds, recreational use, forestry activities, erosion).<br>(c) Potential for re-establishing threatened fish populations.<br>**Planning**<br>(a) Potential impacts of provision of recreational facilities associated with recovery following the January 2003 bushfires (see s. 5.3). | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) Enforce the ACT fishing regulations.<br>(b) Continue to undertake coordinated weed control based on weed control priorities.<br>(c) Control grazing, including fencing out riparian areas where desirable.<br>**Protection**<br>(a) As part of management, ensure protection of uncommon plants and their habitat (see s. 2.4.2 for specific actions).<br>**Management (Rehabilitation Activities)**<br>(a) Ensure all management activities incorporate measures to ensure erosion control and manage sedimentation into drainage lines and the river.<br>(b) Investigate appropriate means to restore riparian habitat and incorporate into management activities.<br>(c) Investigate appropriate techniques for re-establishing a viable Macquarie Perch population.<br>**Planning**<br>(a) Assess development proposals (including those associated with recovery following the January 2003 bushfires) under relevant legislation, planning and management frameworks. Ensure that planning of recreational infrastructure recognises and protects riverine and riparian values. |

**Table 5.1:** *(Continued)*

| Current Planning and Management | Description (for more details see Tables 2.2 and 4.2) | Planning and Conservation Issues for Identified River Section and Riparian Zone | Priority Actions |
|---|---|---|---|
| **CO 2: Cotter River (Headwaters to Corin Dam)** | | | |
| ***Territory Plan***<br>■ Namadgi National Park<br>***Management***<br>Namadgi National Park Draft Management Plan 2005, Namadgi National Park Management Plan 1986 | Vegetation of the river flats comprises open woodland, tussock grassland, wetland and bog communities Grassland areas may contain many weeds species. The majority of the streambed is narrow and shallow with dense fringing shrub vegetation. This area was moderately and patchily burnt in the January 2003 bushfires. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Weeds (mainly weeds associated with previous pastoral use).<br>(b) Pressure for recreational fishing access.<br>(c) Threat to Two-spined Blackfish from potential introduction of Brown Trout.<br>**Protection**<br>(a) Uncommon plants including *Discaria pubescens, Blechnum fluviatile.*<br>(b) Threatened fish species (Two-spined Blackfish).<br>(c) Cotter River form of the Leaf-green Tree Frog (Litoria nudidigitus).<br>(d) Maintenance of status of Cotter Catchment as free of EHN virus.<br>**Management (Rehabilitation)**<br>(a) Post fire recovery (January 2003 bushfires) of riparian vegetation and habitat and aquatic fauna. Erosion and sedimentation following the fires.<br>(b) Need to establish additional populations of Macquarie Perch to spread risk. | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) Monitor weed presence and undertake weed control as required, based on weed control priorities.<br>(b) Maintain this section as Prohibited Waters for recreational fishing and continue current limits on access (no public vehicle access).<br>(c) As above.<br>**Protection**<br>(a) As part of management, ensure protection of uncommon plants and their habitat (see s. 2.4.2 for specific actions).<br>(b) As part of management, ensure protection of threatened fish species and their habitat, including protection from alien fish species.<br>(c) As part of management, ensure protection of the habitat of the Cotter River form of the Leaf-green Tree Frog (see s. 3.3.3 for specific actions for uncommon species).<br>(d) Maintain this section as Prohibited Waters for recreational fishing, which is the most effective means of avoiding accidental introduction.<br>**Management (Rehabilitation Activities)**<br>(a) Monitor post-fire recovery of aquatic fauna, riparian vegetation, riverine and riparian habitat. Evaluate means to assist recovery, if necessary. Take action to control ongoing erosion and sedimentation problems at particular sites, if necessary.<br>(b) Investigate techniques for establishing a Macquarie Perch population. |
| **CO 3: Cotter River (Below Corin Dam to Bendora Dam)** | | | |
| ***Territory Plan***<br>■ Namadgi National Park<br>***Management***<br>Namadgi National Park Management Plan 1986 | Dry sclerophyll and wet sclerophyll forest communities characteristic of higher altitude valley areas usually extend down to the river. Above Bendora Dam the streambed is narrow, shallow and rocky, fringed by shrubby vegetation, below steep valley sides. This area was severely burnt in the January 2003 bushfires. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) For aquatic species, altered streamflow patterns and thermal pollution.<br>(b) Pressure for recreational fishing access.<br>(c) Threat to Two-spined Blackfish, Trout Cod and Macquarie Perch from potential introduction of Brown Trout.<br>**Protection**<br>(a) Threatened fish species (Two-spined Blackfish, Trout Cod and Macquarie Perch).<br>*(Continues next page)* | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) Maintain environmental flows and keep under review.<br>(b) Maintain this section as Prohibited Waters for recreational fishing.<br>(c) As above.<br>**Protection**<br>(a) As part of management, ensure protection of threatened fish species and their habitat, including protection from alien fish species.<br>*(Continues next page)* |

**Table 5.1:** *(Continued)*

| Current Planning and Management | Description (for more details see Tables 2.2 and 4.2) | Planning and Conservation Issues for Identified River Section and Riparian Zone | Priority Actions |
|---|---|---|---|
| **CO 3: Cotter River (Below Corin Dam to Bendora Dam)** *(continued)* | | | |
| | | **Protection** *(continued)*<br>b) Maintenance of status of Cotter catchment as free of EHN Virus.<br>(c) Cotter River form of the Leaf-green Tree Frog (*Litoria nudidigitus*).<br><br>**Management (Rehabilitation)**<br>(a) Post fire recovery (January 2003 bushfires) of riparian vegetation and habitat and aquatic fauna. Erosion and sedimentation following the fires. | **Protection** *(continued)*<br>(b) Maintain this section as Prohibited Waters for recreational fishing, which is the most effective means of avoiding accidental introduction. Also highlight potential threat from inter-Basin water transfers.<br>(c) As part of management, ensure protection of the habitat of the Cotter river form of the Leaf-green Tree Frog (see s. 3.3.3 for specific actions for uncommon species).<br><br>**Management (Rehabilitation Activities)**<br>(a) Monitor post-fire recovery of aquatic species, riparian vegetation, riverine and riparian habitat. Evaluate means to assist recovery, if necessary. Take action to control ongoing erosion and sedimentation problems at particular sites, if necessary. |
| **CO 4: Cotter River (Below Bendora Dam to Cotter Dam)** | | | |
| ***Territory Plan***<br>■ Namadgi National Park<br>■ Special Purpose Reserve (upstream from Cotter Dam to boundary of Namadgi National Park)<br><br>***Management***<br>Namadgi National Park Draft Management Plan 2005<br>Lower Cotter Catchment: Draft Strategic Management Plan 2006 | Below Bendora Dam, dry forest and variable shrub cover occupies the river valley. Above Cotter Dam, the riparian vegetation is flanked by pine plantation. This was destroyed in the January 2003 bushfires when the area was severely burnt.<br><br>In 2006 the ACT Government determined that there would be a change in land use for the Lower Cotter Catchment from pine plantation to catchment protection for water supply, with native vegetation cover (natural regeneration and planting) (ACT Government 2006). | **Information**<br>(a) Lack of recent riparian vegetation survey.<br><br>**Threats**<br>(a) Weeds.<br>(b) For aquatic species, altered flow patterns, thermal pollution.<br>(c) Barriers to fish passage (road crossings).<br>(d) Pressure for recreational fishing and other recreational access to Cotter Reservoir.<br>(e) Cormorant predation (Macquarie Perch) in Cotter Reservoir.<br>(f) Potential introduction of alien fish species (Redfin Perch, Carp).<br>(g) Water extraction from Cotter Reservoir.<br>(h) Sedimentation resulting from the effects of the January 2003 bushfires.<br><br>**Protection**<br>(a) Threatened fish and crayfish species (Trout Cod, Macquarie Perch and Murray River Crayfish).<br>(b) Maintenance of status of Cotter catchment as free of EHN virus.<br><br>**Management (Rehabilitation)**<br><br>*(Continues next page)* | (a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br><br>**Threats**<br>(a) Continue to undertake coordinated weed control based on weed control priorities.<br>(b) Maintain environmental flows and keep under review.<br>(c) Identify barriers to fish passage and rectify. Ensure new crossings are designed to allow fish passage.<br>(d) Maintain closure of Cotter Reservoir to fishing and other water based recreational use. Do not stock fish for recreational purposes.<br>(e) Encourage research into effects of cormorant predation, and if desirable, means to limit impacts.<br>(f) Maintain closure of Cotter Reservoir to fishing and other water based recreational use.<br>(g) Liaise with ACTEW regarding the impacts on aquatic fauna of future water supply options (for more detail see s. 4.12.2 and s. 4.12.4).<br>(h) Encourage research into sediment delivery and movement.<br><br>**Protection**<br>(a) As part of management, ensure protection of threatened fish species and their habitat, including protection from alien fish species.<br>(b) Maintain Cotter Reservoir as Prohibited Waters for recreational fishing, which is the most effective means of avoiding accidental introduction. Discourage inter-Basin water transfers<br><br>**Management (Rehabilitation Activities)**<br><br>*(Continues next page)* |

**Table 5.1:** *(Continued)*

| Current Planning and Management | Description (for more details see Tables 2.2 and 4.2) | Planning and Conservation Issues for Identified River Section and Riparian Zone | Priority Actions |
|---|---|---|---|
| **CO 4: Cotter River (Below Bendora Dam to Cotter Dam)** *(continued)* | | | |
| | | (a) Post-fire recovery (January 2003 bushfires) of riparian vegetation and habitat. Erosion and sedimentation following the fires.<br>**Information** | (a) Monitor post-fire recovery of aquatic species, riparian vegetation, riverine and riparian habitat. Evaluate means to assist recovery, if necessary. Take action to control ongoing erosion and sedimentation problems at particular sites, if necessary.<br>(b) Ensure ecological integrity is maintained in undertaking native revegetation in former pine plantation areas in the riparian zone. This involves protection of natural regeneration, weed control and restoration with appropriate species sourced from seed of local provenance. |
| **CO 5: Cotter River (Below Cotter Dam to Murrumbidgee River)** | | | |
| ***Territory Plan***<br>■ 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 confluence with Murrumbidgee River confluence. Many of the *Casuarinas* were severely burnt in the January 2003 bushfires. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>(b) Lack of information on status of threatened fish and crayfish.<br>**Threats**<br>(a) Weeds.<br>(b) For aquatic species, altered flow patterns, thermal pollution.<br>(c) Barriers to fish passage (weirs and fish passage to Paddys River).<br>**Protection**<br>(a) Uncommon plants including *Pomaderris pallida*.<br>(b) Threatened fish and crayfish species (Macquarie Perch, Murray Cod, Silver Perch, Murray River Crayfish).<br>**Management (Recreational Use and Rehabilitation)**<br>(a) Recreational use of the area.<br>(b) Post-fire recovery (January 2003 bushfires) of riparian vegetation and habitat and aquatic fauna. Erosion and sedimentation following the fires.<br>**Planning**<br>(a) Potential impacts of provision of recreational facilities associated with recovery following January 2003 bushfires (see s. 5.3). | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>(b) Instigate monitoring of Macquarie Perch and Murray River Crayfish.<br>**Threats**<br>(a) Continue to undertake coordinated weed control based on weed control priorities.<br>(b) Maintain environmental flows and keep under review.<br>(c) Identify barriers to fish passage and rectify. Evaluate means to open fish passage to Paddys River.<br>**Protection**<br>(a) As part of management, ensure protection of uncommon plants and their habitat (see s. 2.4.2 for specific actions).<br>(b) As part of management, ensure protection of threatened fish species and their habitat.<br>**Management (Recreational Use and Rehabilitation Activities)**<br>(a) Manage recreational use to minimise impacts on the riverine environment.<br>(b) Monitor post-fire recovery of riparian vegetation and riverine and riparian habitat. Evaluate means to assist recovery, if necessary. Take action to control ongoing erosion and sedimentation problems at particular sites, if necessary.<br>**Planning**<br>(a) Assess development proposals (including those associated with recovery following the January 2003 bushfires) under relevant legislation, planning and management frameworks. Ensure that planning of recreational infrastructure recognises and protects riverine and riparian values. |

**Table 5.1:** *(Continued)*

| Current Planning and Management | Description (for more details see Tables 2.2 and 4.2) | Planning and Conservation Issues for Identified River Section and Riparian Zone | Priority Actions |
|---|---|---|---|
| **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***<br>■ Nature Reserve<br>■ Rural leasehold<br>■ Pine plantation | Native vegetation in this section has been affected by previous pastoral use and the establishment of adjacent pine plantations. There is some remnant woodland. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Willows and other weeds.<br>(b) Heavy metal pollution in the river from the former Captains Flat mine potentially limits opportunities to re-establish aquatic fauna.<br>(c) Potential invasion by alien fish (Redfin Perch, Carp) from downstream.<br>**Management**<br>(a) Ecological connectivity through pine plantation areas.<br>(b) Need to establish additional populations of Macquarie Perch to spread risk.<br>**Planning**<br>(a) Potential urban edge effects (if urban development occurs in Kowen). | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) Continue to undertake coordinated weed control based on weed control priorities.<br>(b) Investigate feasibility and techniques for re-establishing Macquarie Perch.<br>(c) Instigate monitoring for Carp and Redfin Perch.<br>**Management**<br>(a) Seek to ensure that ecological connectivity is maintained and improved along the riparian zone in pine plantation areas.<br>(b) Investigate techniques for establishing a Macquarie Perch population.<br>**Planning**<br>(a) Assess development proposals under relevant legislation, planning and management frameworks. Ensure that planning of recreational infrastructure recognises and protects river corridor values. |
| **MO 2: Molonglo Gorge to Lake Burley Griffin** | | | |
| ***Territory Plan***<br>■ Special Purpose Reserve<br>■ Rural leasehold<br>■ Other leasehold | The steep, rocky slopes of Molonglo Gorge support dry forest with *Callitris* and a scattered shrub understorey. Below Molonglo Gorge there are some isolated stands of *Casuarina luehmannii* and native shrubs. However, willows and other weed species dominate most of the riparian environment down to Lake Burley Griffin. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Willows and other weeds.<br>(b) Poor water quality in Molonglo River and macroinvertebrate sampling that indicates severely impaired stream condition.<br>(c) Illegal fishing for threatened species.<br>**Management**<br>(a) Riparian ecological connectivity.<br>**Planning**<br>(a) Potential urban edge effects on Molonglo Gorge area (if urban development occurs in Kowen) and urban/industrial edge effects at Fyshwick. | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) Continue to undertake coordinated weed control based on weed control priorities.<br>(b) Investigate reasons for poor water quality and impoverished macroinvertebrate assemblages in the Molonglo River.<br>(c) Enforce ACT fishing regulations.<br>**Management**<br>(a) Undertake riparian habitat rehabilitation including that following removal of willows.<br>**Planning**<br>(a) Assess development proposals under relevant legislation, planning and management frameworks to ensure river corridor values are recognised in planning and the river corridor is given appropriate protection in physical planning. Ensure that planning of recreational infrastructure recognises and protects river corridor values. |

**Table 5.1:** *(Continued)*

| Current Planning and Management | Description (for more details see Tables 2.2 and 4.2) | Planning and Conservation Issues for Identified River Section and Riparian Zone | Priority Actions |
|---|---|---|---|
| **MO 3: Scrivener Dam to Coppins Crossing** | | | |
| ***Territory Plan***<br>■ Urban Open Space (Scrivener Dam to Tuggeranong Parkway)<br>■ Special Purpose Reserve (Tuggeranong Parkway to Coppins Crossing)<br>■ Rural leasehold | Riparian vegetation in this section is highly modified with only fragments of native vegetation remaining. There is dense woody weed growth below Scrivener Dam. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>(b) Lack of information on fish species and platypus<br>**Threats**<br>(a) Willows and other weeds (including wide range of woody weeds).<br>(b) Poor water quality (bottom discharge from Scrivener Dam).<br>(c) Poor water quality from Yarralumla and Weston creeks (stormwater flows from highly urbanised catchment, gross pollutant traps at downstream end of concrete channels are the only treatment).<br>**Management**<br>(a) Management responsibility for the section is not defined and there is lack of active management based on a management plan.<br>(b) Riparian ecological connectivity.<br>**Planning**<br>(a) Potential urban edge effects related to new urban development of Molonglo. | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>(b) Undertake survey of fish and platypus.<br>**Threats**<br>(a) Undertake coordinated weed control based on weed control priorities.<br>(b) NCA is reviewing environmental flow requirements for Lake Burley Griffin.<br>(c) Water quality management plan is being prepared for Molonglo Valley, Woden valley and Weston Creek (ACTPLA).<br>**Management**<br>(a) Identify management responsibility, prepare a management plan and undertake management activities.<br>(b) Undertake riparian habitat rehabilitation including that following removal of willows.<br>**Planning**<br>(a) Assess development proposals under relevant legislation, planning and management frameworks to ensure river corridor values are recognised in planning and the river corridor is given appropriate protection in physical planning including any appropriate adjustments to statutory and/or management boundaries. Ensure that planning of recreational infrastructure recognises and protects river corridor values. |

**Table 5.1:** *(Continued)*

| Current Planning and Management | Description (for more details see Tables 2.2 and 4.2) | Planning and Conservation Issues for Identified River Section and Riparian Zone | Priority Actions |
|---|---|---|---|
| **MO 4: Coppins Crossing to Murrumbidgee River** | | | |
| ***Territory Plan***<br>■ Lower Molonglo River Corridor Nature Reserve<br>***Management***<br>Lower Molonglo River Corridor Management Plan 2001 | Protected in the gorge environment, vegetation in this section of the river displays high floristic diversity. Weeds typical of the ACT riparian zone are also found in this section. | **Information**<br>(a) Lack of recent riparian vegetation survey.<br>**Threats**<br>(a) Willows and other weeds.<br>(b) Barrier to Murray River Crayfish and Golden Perch movement from LMWQCC discharge.<br>**Protection**<br>(a) Threatened fish and crayfish species (Murray Cod, Macquarie Perch (historical presence in lower section), Murray River Crayfish).<br>(b) Uncommon plants including *Bossiaea bracteosa, Pomaderris pallida, Desmodium brachypodum, Adiantum hispidulum*.<br>(c) Habitat for Pink-tailed Worm Lizard (*Aprasia parapulchella*).<br>(d) Raptor habitat (including nesting sites). | **Information**<br>(a) Undertake a survey of this section as part of a systematic vegetation survey of ACT riparian areas.<br>**Threats**<br>(a) Undertake coordinated weed control based on weed control priorities.<br>(b) Investigate translocation of Murray River Crayfish past discharge zone<br>**Protection**<br>(a) As part of management, ensure protection of threatened fish/crayfish and their habitat.<br>(b) As part of management, ensure protection of uncommon plants and their habitat (see s. 2.4.2 for specific actions).<br>(c) As part of management, ensure protection of the habitat of the Pink-tailed Worm Lizard (see s. 3.3.2 for specific actions).<br>(d) Ensure protection of raptor habitat through management of recreational use and other potentially harmful activities.<br>**Planning**<br>(a) Assess development proposals under relevant legislation, planning and management frameworks to ensure river corridor values are recognised in planning and the river corridor is given appropriate protection in physical planning including any appropriate adjustments to statutory and/or management boundaries. Ensure that planning of recreational infrastructure recognises and protects river corridor values. |

**Notes:**

1. **Conservation** means all the processes and actions of looking after a place so as to retain its natural significance and always includes protection, maintenance and monitoring. Conservation may, according to circumstance, also include regeneration, restoration, enhancement, reinstatement, preservation or modification, or a combination of all these. Conservation includes conserving natural processes of change (as opposed to artificially accelerated change) (AHC 2002).
2. **Public Land Category and Management Objectives (adapted from Schedule 1 of the *Land (Planning and Environment) Act 1991*)**

| | |
|---|---|
| Wilderness Area | (Management Objectives: Conservation of the natural environment and restricted public use) |
| National Park | (Management Objectives: Conservation of the natural environment and public use for recreation, education, research) |
| Nature Reserve | (Management Objectives: Conservation of the natural environment and public use for recreation, education, research) |
| Special Purpose Reserve | (Management Objectives: Public and community use for recreation and education) |
| Urban Open Space | (Management Objectives: Public and community use) |

# 5.5

## Management of Rivers and Riparian Zones for Conservation

### 5.5.1 Best Practice Management and Adaptive Management

The goals of this *Strategy* involve both the conservation of aquatic and riparian flora and fauna species and ecological communities, and the management and rehabilitation of habitats (Table 6.1). Management that is regarded by experts in a particular field to be of the highest standards at the time is termed 'best practice management'. In the context of biodiversity conservation, best practice management is that which promotes biodiversity and healthy ecosystem function. It is underpinned by monitoring and research, that assist in providing up to date information about the biodiversity effects of different management practices. The concept is discussed in more detail in ACT Government (2004a; 2005a).

Adaptive management has been defined as 'the systematic process for continually improving management policies and practices by learning from the outcomes of operational programs' (ACT Government 2006b). Adaptive management is an approach that recognises that management actions should be undertaken, even though many uncertainties remain because of lack of knowledge. Adaptive management requires clearly defined objectives based on current knowledge, rigorous review of the outcomes of actions, and subsequent change or refinement of management actions. Adaptive management is to varying degrees, experimental. For more detail see ACT Government (2004a; 2005a).

### 5.5.2 Conservation of Aquatic and Riparian Habitat

Conservation of aquatic and riparian habitats and ecological communities is a major national environmental issue about which there is a substantial literature, as well as national and state policies, management plans, recovery plans and a wide range of programs and activities. These provide a context for this *Strategy*, but it is beyond the scope of this *Strategy* to review them in detail. For an introduction and overview at the national level, see:

(a) (Commonwealth) Department of Environment and Heritage <http://www.deh.gov.au.html>

(b) *Overview of the Australian Government's Natural Resource Management Initiatives: Protecting, Conserving, Repairing* (Australian Government 2004). This briefly outlines two major national initiatives: the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality. <http://www.nrm.gov.au/publications/nrm-overview/index.html>

(c) Murray–Darling Basin Commission (particularly the Native Fish Strategy 2003–2013 (MDBC 2004a)). <http://www.mdbc.gov.au>

The need to improve the management of rivers and riparian zones is made clear by two comprehensive nationwide assessments: the *Australian Catchment, River and Estuary Assessment 2002* (Commonwealth of Australia 2002a), and the *Australian Terrestrial Biodiversity Assessment 2002* (Commonwealth of Australia 2002b).

The primary task of the Assessment of River Condition (ARC) was to assess the aggregate impacts of resource use on rivers and identify the priority management challenges for their maintenance or improvement. The two main components of the ARC are features of the environment ($ARC_E$) and the aquatic biota ($ARC_B$). The $ARC_E$ is made up of four indices: the Catchment Disturbance Index, the Hydrological Disturbance Index, the Habitat Index and the Nutrient and Suspended Sediment Index (Norris *et al.* 2001).

Nation-wide, the river assessments collated and interpreted data for about 14 000 river reaches across the more intensively used catchments. The assessments showed impaired aquatic biota (one-third of river lengths); significant modification of environmental features (85% of river lengths); modified habitat, mainly changes to sediment loads (more than half of river lengths); and increased nutrient (mainly phosphorus) and suspended sediment loads (over 90% of reaches with 33% substantially modified). In summarising management priorities, the rivers assessment noted that rivers with the most urgent need for rehabilitation and strategic management included parts of the Murray–Darling Basin. These rivers generally have highly modified catchments, are subject to high nutrients and suspended sediment loads, have lost much of their riparian vegetation, and have dams and levees that disrupt the movement of biota and material into, along and from the river. River reaches with habitat severely modified by dams need protection and restoration of environmental flows and fish passage.

Summary assessment of river condition in the ACT according to the two ARC indices is shown in Table 5.2. Thirty-six per cent of the river length assessed in the ACT had damaged biological communities, with 29% of the river length assessed as being in significantly impaired condition, indicating that

**Table 5.2: Assessment of River Condition in the ACT Under the National Land and Water Resources Audit**

| Indices | Total Length of Reach in Each Category and Percentage of Total | | | |
|---|---|---|---|---|
| **$ARC_B$ (aquatic biota)** | **Reference** | **Significantly Impaired** | **Severely Impaired** | **Extremely Impaired** |
| | 169 km<br>64% | 76 km<br>29% | 17 km<br>7% | 0<br>0 |
| **$ARC_E$ (environmental features)** | **Largely Unmodified** | **Moderately Modified** | **Substantially Modified** | **Severely Modified** |
| | 43 km<br>16% | 191 km<br>71% | 36 km<br>13% | 0<br>0 |

(Source: Norris *et al.* 2001, p. 57)

**$ARC_B$** contains data for 97% (262 km) of ACT stream lengths used in the audit.

**$ARC_E$** contains data for 100% (270 km) of ACT stream lengths used in the audit.

20–50 per cent of the different kinds of animals expected to occur have been lost from these communities. The Audit concludes that the key issues affecting ACT rivers are changes to all aspects of the hydrological regime including substantial changes to the quantity, timing and duration of flow. High loads of total phosphorus and elevated levels of suspended solids are also problems for ACT rivers (Norris *et al.* 2001, p. 56).

The *Terrestrial Biodiversity Assessment* based on bioregions and subregions across the continent (IBRA 5.1 (Environment Australia 2000)) also reported on riparian zones. The assessment concluded that:

- The condition of riparian zones is degraded (meaning recovery is unlikely in the medium term) across much of southern and eastern Australia (31% of subregions assessed) and an additional number require significant management intervention to achieve recovery (38% of subregions assessed);
- The trend for riparian zones is declining significantly across much of Australia (73% of subregions assessed).

The ACT is located in a broad area of south-eastern Australia where the average condition of riparian zones is categorised as *degraded* and the trend is *declining*. The six major threats are: overgrazing, exotic weeds, changed hydrology, increased fragmentation, feral animals and changed fire regimes. All of these are threats in the South Eastern Highlands Region (IBRA) of which the ACT is part.

Aquatic and riparian habitat conservation may involve management actions to:

- improve water quality;
- maintain or restore flow regimes;
- improve connectivity;
- control threatening processes (e.g. wildfire, weeds, stock grazing);
- restore, regenerate or reinstate vegetation communities or component species of those communities; and
- repair land degradation (e.g. erosion gullies in tributary creeks).

Rehabilitation may be undertaken in a variety of ways and with varying degrees of human intervention. The cost, experimentation needed (and consequent potential for failures), lack of knowledge of appropriate techniques, and the scale and difficulty of reversing detrimental habitat changes illustrate the benefit of maintaining existing good quality habitat (for a case study of a fish habitat rehabilitation project, see s. 4.12.3 and Lintermans 2004b).

Riparian rehabilitation projects in the ACT have included removal of problem willow species (e.g. Ginninderra Creek, Yarralumla Creek, Gudgenby River, Molonglo River and many other areas), soil conservation work in the catchment of Lake Burley Griffin between 1965 and 1998 focused in the last decade on stabilisation of connected gullies (NSW DLWC 2000), and preparation of a Sullivan's Creek Catchment Management Plan included in which is the construction of small wetlands in O'Connor associated with urban redevelopment and water sensitive urban design. Rehabilitation of connecting creeks is an important component of aquatic and riparian habitat conservation. A major rehabilitation project is proposed for the former pine plantation areas of the Lower Cotter Catchment, given the change in land use focus to catchment protection for water supply (ACT Government 2006b).

Conservation actions for the recovery of native ecological communities may involve regeneration, restoration or reinstatement that represent

progressively greater degrees of human intervention. Definitions adopted for this *Strategy* are from the *Australian Natural Heritage Charter*, 2nd Edit. (AHC 2002).

- *Regeneration* means the natural recovery of natural integrity following disturbance or degradation.

Regeneration is essentially dependent on natural processes facilitating recovery from disturbance or degradation. It does not include physical intervention, but should be accompanied by monitoring and protection measures that do not create degradation (e.g. fencing of vegetation, prohibition on take of fish/crayfish species). Examples of regeneration in ACT rivers and riparian areas include some recovery of crayfish populations in the Murrumbidgee River following overfishing, and vegetation regrowth in riparian areas following the January 2003 bushfires, including in former pine plantation areas in the Lower Cotter Catchment. In many instances, environments have been so altered that regeneration cannot occur without some physical intervention e.g. weed control in riparian areas, removal of stock grazing, and *reinstatement* of fish species past barriers with the aim of establishing self-supporting populations.

- *Restoration* means returning existing habitats to a known past state or to an approximation of the natural condition by repairing degradation, by removing introduced species or by reinstatement.

A restoration process implies sufficient evidence of an earlier state to guide the conservation process. While historical and other records, the presence of remnant plant and/or animal species and ecological communities, modelling, and the existence of sites that appear relatively undisturbed provide some guidance, the actual species composition of pre-European ecological communities is unknown or uncertain. Restoration activities, consistent with the natural significance of the place, should therefore be focussed on maintaining and improving the native biological diversity of the site and improving its overall condition (Kirkpatrick *et al.* 1995, p. 87). Vegetation restoration may require weed control, direct seeding or planting with species currently growing or known to have grown in the area. Restoration of aquatic habitat includes removing barriers to fish passage (e.g. the construction of the rock-ramp fishway at Vanitys Crossing in the ACT) and returning important in-stream features (e.g. snags and deep pools (see Lintermans (2004b) for an experiment in the ACT near Tharwa)).

- *Reinstatement* means to introduce to a place one or more species or elements of habitat or geodiversity that are known to have existed there naturally at a previous time, but that can no longer be found at that place.

Reinstatement is unlikely to be part of native vegetation management except on a very small scale or for particular purposes. While there is clearly a role for restoration of existing remnants that might include some specific reinstatement, large-scale expansion or 're-creation' of native vegetation communities is not feasible with current knowledge, funding and technology. This is particularly the case for understorey and groundcover species. It is now well established that vegetation restoration activities should aim to consolidate least disturbed areas and work outwards from these (see ACT Government 2004a (s. 5.9.3); ACT Government 2005a (s. 3.7.3)).

With regard to native fish, reinstatement of species that have experienced dramatic population decline is undertaken in the ACT for recreational, ecosystem function and conservation purposes (ACT Government 2000). Experimental reinstatement of hatchery bred Trout Cod has been undertaken in Bendora Reservoir and the Murrumbidgee River. There is also scope to translocate individuals from existing fish populations past natural or artificial barriers (e.g. Macquarie Perch in the Queanbeyan River above Googong Reservoir past a waterfall to upstream sections of the river in the Silver Hills area) (see s. 4.4.2 and s. 4.12.8). Monitoring is required to evaluate the results of these management actions.

# 5.6

## Management Issues

This section identifies important management issues for aquatic and riparian species, the rivers and riparian areas that are the focus of this *Strategy*. This is not intended to be exhaustive and complements discussion of management issues for:

- watercourses and riparian areas in grassy woodlands generally (see, for example, MacLeod 2002a);
- the Murray–Darling Basin as a whole (e.g. the *Native Fish Strategy* (MDBC 2004a));
- the Murrumbidgee River catchment (Murrumbidgee Catchment Management Board 2003); and
- ACT rivers and riparian areas covered by management plans (s. 5.1.3), which effectively identify a wide range of management issues (though they are not categorised as such).

### 5.6.1 Management Plans

The lack of statutory management plans for some Public Land areas of the rivers and riparian zones has been referred to previously (s. 5.1.3).

- It is an objective of this *Strategy* that management plans are prepared for all Public Land areas of the rivers and riparian zones (Table 6.1.5).

### 5.6.2 Management Responsibility

The lack of active management of sections of the river corridors (in particular, the Molonglo River near Fyshwick and from below Scrivener Dam to Coppins Crossing) has been referred to previously (s. 5.1.3).

- It is an objective of this *Strategy* that management responsibility is established for the Molonglo River adjacent to Fyshwick and below Scrivener Dam to Coppins Crossing, and rehabilitation programs based on management plans are undertaken (Table 6.1.5).

### 5.6.3 Vegetation and Fauna Surveys

As noted in s. 5.3.2, there are deficiencies in the knowledge of species and ecological communities in the rivers and riparian zones. Surveys and regular monitoring have established a good understanding of the status of fish and the Murray River Crayfish, but information on other species and communities is more variable. Riparian areas have not been the subject of a systematic vegetation survey. Existing information sources are included with the descriptions of vegetation communities in s. 2.2.

Vegetation communities in the riparian zone are included in a current review of the classification of ecological communities in the ACT (Table 2.1). Future surveys in the riparian zone will assist in refining this classification, as well as providing more detailed information on component species, condition, ecology and habitat values.

- It is an objective of this *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).
  - —Within this overall objective, a survey program should be prepared and undertaken in a strategic manner, giving priority initially to (a) areas under most threat from current or proposed land uses or activities, (b) areas of high use, (c) areas where data is the most deficient.

### 5.6.4 Stock Grazing: Protecting Riparian Zones

The importance of the rivers and riparian zones in the rural economy before and after the establishment of the Australian Capital Territory has been discussed in s. 2.3.1. Rural leases currently border much of the Murrumbidgee River, the Gudgenby and Naas rivers (outside Namadgi National Park), Paddys River, and the lower Molonglo River. There are smaller areas adjoining the Molonglo River upstream of Lake Burley Griffin (Pialligo, Symonston, Burbong).

In general, uncontrolled livestock grazing of riparian zones and unrestricted access to streams has had major detrimental effects on riparian areas (including riverbanks), stream ecology and sediment loads. Particular effects include:

- lowered water quality (including increases in turbidity and nutrients);
- trampling and lack of regeneration of fringing aquatic vegetation that is important for bank stability and habitat e.g. *Phragmites* spp.;
- erosion and sedimentation due to the creation of tracks and bare areas, and soil compaction;
- deterioration in streambank stability, through trampling, track creation and loss of streambank vegetation;
- spread of weeds (into and out of riparian areas);
- disturbance to habitat, such as rocks and logs, and loss of ground surface detrital material (litter and woody debris);
- loss of habitat connectivity and impacts on the value of riparian areas as drought refuges for native species;
- lack of regeneration of native species, including dominant native tree cover; and
- loss of invertebrate and other species due to trampling and soil compaction, with associated effects on energy and nutrient cycling processes.

(Askey-Doran and Pettit 1999; Jansen and Robertson 2001; MacLeod 2002a; Price and Lovett 2002; Robertson and Rowling 2000)

Issues associated with managing livestock access to riparian zones are discussed in MacLeod (2002a) who states as a general principle that livestock should be excluded from watercourses to reduce soil erosion and maintain the quality of the water. Grazing should only be applied for conservation purposes, including weed control. The condition of riparian habitats generally responds rapidly to the exclusion of stock. The benefits and practicality of alternative approaches such as exclusion by fencing or strategic and controlled grazing management are the subject of ongoing debate. Management of grazing pressure on riparian lands should aim to maintain groundcover, with enough vegetation to protect the soil surface from heavy rain and provide a filter for nutrients and upslope sediments. The timing, intensity and duration

of grazing are important considerations for maintenance of biodiversity conservation and ecological functioning (Price and Lovett 2002). Weed control is likely to be an ongoing problem, especially in areas grazed for a long time (Jansen and Robertson 2001).

The most effective (and most expensive) approach is to fence out the riparian zone and provide alternative water sources (from formed access points at low erosion risk sites on the stream, pumped from the stream, from a streambed bore, or reticulated from upslope). A suggested alternative approach is to establish riparian paddocks, where stocking is managed in relation to the seasons, climatic conditions and ecological requirements e.g. seeding times for riparian plants. There is also a range of informal management actions that can be taken to reduce the local impacts of livestock and distribute grazing pressure (MacLeod 2002a, pp.163–164). MacLeod (pp. 158–161) could not find, however, a well-documented or even anecdotal example of targeted stock management that has successfully reduced stock impacts on riparian zones without fencing.

With regard to the management of grazing in the Murrumbidgee River Corridor, the stated intention in the Management Plan (Environment ACT 1998, p. 45) is to 'progressively remove grazing from the riverbank and selected creek tributaries'. In the Lower Molonglo River Corridor, grazing of riverbanks occurs under licence for weed and fire fuel control (Environment ACT 2001b). Grazing is included in the Controls under the River Corridors Land Use Policies, Part B13 of the *Territory Plan* (ACTPLA 2005):

- Livestock grazing, excluding horse agistment, shall only be permitted where retention of open grasslands or savanna woodlands is desired for landscape, ecology or management reasons. In environmentally sensitive areas grazing shall only be permitted for the purpose of environmental management such as vegetation management or fire hazard reduction.
- It is an objective of this *Strategy* that the impact of inappropriate stock grazing is controlled, reduced or eliminated by appropriate planning, research and/or management actions (Table 6.1.3).
  - —It is an action of this *Strategy* to complete the riparian fencing program to prevent uncontrolled stock grazing in riparian areas (Table 6.1.3).

### 5.6.5 Management of Public Access

Recreational use of riparian areas in the ACT is discussed in s. 2.3.1. Following the bushfires of January 2003, recreation and tourism use and opportunities in non-urban areas of the ACT have been investigated (Non-Urban Study Steering Committee 2003). The Cotter Reserve and adjacent areas is a particular focus in this study (see also, Shaping Our Territory Implementation Group (2004)). Increased recreational access and activity in the Molonglo River corridor is a likely outcome of planned residential development in Molonglo (adjoining the river section between the Tuggeranong Parkway and Coppins Crossing) and potentially on the Kowen Plateau (adjoining Molonglo Gorge) (ACT Government 2004b).

- It is an objective of this *Strategy* that Government and non-government organisations recognise the biodiversity conservation values of the rivers and riparian zones and incorporate their conservation requirements in planning, development and land management activities (Table 6.1.4). In particular:
  - —River corridor values are recognised in planning studies for new urban areas (Molonglo, Kowen) and river corridors are given appropriate protection in physical planning;
  - —Planning of recreational infrastructure recognises and protects river corridor values. Recreational infrastructure remains concentrated at nodes and linear impacts are minimised.

Low impact linear walking trails along the river corridors from the recreation nodes are an appropriate form of access provided they are sited to avoid damage to sensitive areas and habitat disturbance.

### 5.6.6 Weeds and Pest Animals

#### WEEDS

The susceptibility of riparian zones to weed invasion is discussed in s. 2.3.1 and the common weed species in the ACT are listed. Weeds are one of the most intractable management problems for riparian areas, benefiting from the moister and often higher nutrient conditions, especially if there is runoff from agricultural land. It is generally not practicable to completely eliminate weed species (though this is still a worthy long-term objective) but to aim for containment and control. Particularly important aspects are follow-up work to eliminate new outbreaks, and avoidance of reinvasion from upstream. For particular weed species or groups of species, their management requires a consideration of the potential range of control methods (e.g. chemicals, fire, grazing, physical removal, revegetation with desirable species that will suppress weed growth, biological control), preferably outlined in a management plan. Ten-year (2002–12) management plans have been prepared for many declared pest plants in the ACT and other weed species, including some of the main species found in riparian zones (ACT SOE 2003d). These plans are being reviewed and updated due to new classifications of weed species

under the *Pest Plants and Animals ACT 2005*. For species dispersed by water, weed control work is most effective if it is commenced in headwater areas and continued downstream.

In riparian areas where native vegetation has been wholly or partially replaced by weed species, the latter often provide a vegetation structure for birds and other animals. Weed control programs need to be strategic, with phased removal of weed species and replanting of substitute native species.

- It is an objective of this *Strategy* that the impact and/or occurrence of weeds has been reduced or eliminated by appropriate management actions (Table 6.1.3). A weed control program should be based on river sections and weed control priorities.

  Particular management actions related to this objective include:
  - —Continuing to undertake a comprehensive weed control program for riparian areas focused on high priority areas and weed species, and following up weed control work with revegetation of native species to reduce opportunities for reinvasion and provide habitat.
  - —Revegetating areas close to the rivers with species adapted to changing riverflows and able to withstand occasional high velocity flows.
  - —Advising lessees and other users of land adjacent to the riparian zone of the need to minimise fertiliser run-off, which is related also to erosion control.
  - —Controlling factors that facilitate weed invasion and reinvasion (e.g. erosion gullies, vehicle use, recreation).
  - —Evaluating the effectiveness of weed control programs and revising as necessary.
  - —Assessment of the biodiversity outcomes of weed control activities.

The wide range of weed species occurring in ACT riparian zones is discussed in s. 2.3.1. Two particularly problematic species/group of species are considered here: African Lovegrass (*Eragrostis curvula*) and willows (*Salix* spp.).

These are declared pest plants in the ACT in the *Pest Plants and Animals (Pest Plants) Declaration 2005* (No 1) made under the *Pest Plants and Animals Act 2005*.

**African Lovegrass**

This species is highly invasive of riparian areas and is widespread along rural roadsides and in the Murrumbidgee River Corridor. Native to southern Africa, African Lovegrass is a variable pasture species with many cultivated forms known as the '*Eragrostis curvula complex*' (Environment ACT 2002b). African Lovegrass is highly productive and is used in South Africa and in some countries where it has been introduced, for hay and forage (Parsons and Cuthbertson 1992). In Australia, it is only palatable to stock in its early growth stages before seed-set. It produces copious quantities of seed and rapidly dominates sparse, over-grazed pastures and roadsides, forming dense swards to the exclusion of other species. Its spread is enhanced by water courses and in the Murrumbidgge River Corridor it is a threat to the habitat of the Pink-tailed Worm Lizard. The *ACT African Lovegrass Management Plan* (Environment ACT 2002b) focuses on control of new and scattered infestations while undertaking management of existing heavy infestations.

The control program for African Lovegrass in the ACT includes:

- spot spraying of isolated plants and patches in the Murrumbidgee River Corridor;
- spraying of verges of rural roads; and
- a sustainable grazing program in riparian zones in rural areas.

Other important aspects of control are limiting vehicle movement in infested areas during seeding, vehicle cleaning, community and landholder advice, and revegetation aimed at reducing opportunities for reinvasion.

**Willows**

(All willow species except Weeping Willow (*Salix babylonica* var. *babylonica*) and the hybrids Pussy Willow (*S. x calodendron*) and *S. x reichardtii* are declared pest plants in the ACT).

Willows are the dominant woody weed species of streambanks and streambeds in the ACT (see s. 2.3.1). As well as vegetative reproduction, many willows are now reproducing from seed and by hybridisation. Some species are aggressive colonisers of any suitable substrate and have been favoured by river regulation and bank degradation. While they may have value in bank stabilisation, their growth in streambeds, and tendency to choke channels with growing and fallen trunks that results in channel diversion and bank erosion also has the opposite effect. Willows also have negative effects on aquatic habitat through leaf fall that can cause de-oxygenation, and growth of root mats that cover the banks and bottom of streams and destroy habitat. Generally, the disadvantages of willows are seen to outweigh their advantages (Rutherford *et al.* 1999). Their biology, environmental effects and potential for future spread are now well documented (see Cremer *et al*. 1995; Cremer 1996; Cremer 1999; Lang 1999; Schulze and Walker 1997).

Willows may be considered to have cultural heritage value but this mainly relates to the widely planted Weeping Willow (*Salix babylonica* var. *babylonica*), which is not on the ACT declared pest plant list, and where appropriate, may be retained for heritage or aesthetic purposes.

Willow removal is a costly and difficult task and should be followed by riparian revegetation programs to assist in avoiding new infestations. For best results, a long-term catchment based program is required, commencing in headwater areas and including follow-up treatments. In the ACT, extensive problem willow removal has been undertaken along the Naas and Gudgenby rivers, the Molonglo River including Molonglo Gorge, the Cotter River between Bendora Dam and the Cotter Reservoir, Paddy's River, and the parts of the Murrumbidgee River as well as Jerrabomberra and Woolshed creeks and Canberra urban creeks. Advice to landholders on the desirability of maintaining native riparian vegetation cover and stable bank conditions, and not planting willow species may be a valuable component of control programs.

**PEST ANIMALS**

Alien fish species and their impact on native species are discussed in s. 4.6, and monitoring and control of alien fish species is referred to in s. 4.12.6. Broad-scale eradication of established alien species is not currently possible, and control options are limited because of the potential impact of measures on native species. Control measures include:

(a) Prevention of establishment of new pest species through legislative controls such as adoption of the National Noxious Fish List recently developed by the National Ornamental Fish Policy Working Group;

(b) Eradication of localised populations (e.g. trout above Gibraltar Falls in the ACT);

(c) Prevention of spread of established pest fish (e.g. potentially using surveillance monitoring; consideration of issues in proposed inter-basin water transfers);

(d) Enforcement of the ban in the ACT on using live fish as bait.

While eradication of pest animals may be the long-term goal, this is rarely achievable, and an appropriate management objective is to undertake control programs that reduce undesirable impacts of pest animals to an acceptable level. The main terrestrial vertebrate pests in ACT riparian areas are noted in s. 3.1.3. The ACT approach to vertebrate pest management is set out in the *ACT Vertebrate Pest Management Strategy* (ACT Government 2002). Pest animal management objectives, programs and practices are also detailed in management plans for Public Land areas such as the reserves of the Murrumbidgee and Molonglo River Corridors (Environment ACT 1998, 2001b) and Namadgi National Park (ACT P&CS 1986, ACT Government 2005d). An important component of pest animal control is quick response to new occurrences of known or potential pest species, when eradication may be possible e.g. for Red-eared Slider Turtle (*Trachemys scripta elegans*) not known to be currently established in the ACT.

- It is an objective of this *Strategy* that the impact of pest animals is controlled, reduced or eliminated by appropriate planning and/or management actions (Table 6.1.3).
  - —It is an action of this Strategy to maintain pest animal control programs and report occurrences of known or potential new pest species e.g. Red-eared Slider Turtle (Table 6.1.3).
- It is an objective of this *Strategy* that (a) releases of aquarium and other pest species to streams, and (b) spread and impact of alien fish species is controlled, reduced or eliminated by appropriate planning and/or management actions (Table 6.1.3).
  - —Actions of this Strategy are to:
    - (a) Investigate means to reduce (a) the risk of releases of aquarium and other pest species to streams and (b) the impacts of already established species.
    - (b) Encourage investigation into control mechanisms to prevent the spread of established pest species (terrestrial vertebrates, alien fish) (Table 6.1.3).

### 5.6.7 Habitat Removal: Rocks, Firewood

Rocks, fallen timber and woody debris are important micro-habitat features. The importance of rocks in the habitat of the Pink-tailed Worm Lizard has been discussed in s. 3.3.2. Rocks may also provide sheltered habitat niches for plant species. Standing old and dead trees and fallen logs and branches are significant faunal habitat. Collection of hardwood for commercial purposes and from areas of Public Land is not permitted in the ACT. Under the *Nature Conservation Act 1980*, rural lessees may use timber on their properties for firewood but are not permitted to sell it. Access restrictions mean that firewood collection is no longer a significant threat to woodland and other tree cover in the ACT. However, there may be local habitat effects due to removal of fallen timber by residents in urban areas adjoining reserves, in campfires and for fire hazard fuel reduction.

Maintenance of rocks, fallen timber and woody debris is appropriately considered in management plans and other management arrangements and activities for riparian areas.

- It is an objective of this *Strategy* that specific recognition is given to habitat protection for the Pink-tailed Worm Lizard (*Aprasia parapulchella*) in planning studies for the Molonglo and Murrumbidgee river corridors (Table 6.1.4).
  - —It is an action of this *Strategy* to continue to develop and promote 'best practice' management of riparian zones and their component species giving particular attention to the protecting and managing the habitats of threatened, uncommon and declining species (Table 6.1.5).

The following management considerations are pertinent:

- **Access control:** in particular, limiting vehicle access and siting walking tracks away from important rocky habitat areas.
- **Alternative fuels:** in riverside recreation areas, providing wood for barbecues or gas barbecues.
- **Education:** providing educational materials and/or signs to advise of the importance of fallen timber and woody debris for habitat.

### 5.6.8 Fishing: Law Enforcement

Recreational fishing is Australia's largest outdoor participation sport, with about one-fifth of the population participating both nationally and in the ACT (Henry and Lyle 2003). Fishing in the ACT is governed by the *Fisheries Act 2000*. This legislation details the gear types and quantities that may be used for fishing, along with bag and size limits for fish species, and closed seasons or total prohibitions for particular species or water bodies. These fishing controls are designed to provide a satisfying and sustainable recreational experience. The provisions of the *Fisheries Act 2000* are largely consistent with the relevant fisheries legislation in NSW and Victoria, to minimise potential for confusion amongst anglers.

- It is an objective of this Strategy that recreational fishing in the ACT is managed so as to provide a satisfying and sustainable recreational experience, and to protect threatened, uncommon and declining species (Table 6.1.5).
  - —It is an action of this *Strategy* to continue to develop and promote 'best practice' management of recreational fishing, giving particular attention to protecting and managing threatened, uncommon and declining species, and promoting consistency in fisheries regulations with NSW (Table 6.1.5).

### 5.6.9 Fire

The January 2003 bushfires, which burnt 70 per cent of the ACT, have resulted in substantial planning and land use changes in areas drained by the Murrumbidgee, Molonglo and Cotter rivers. Subsequent to the fires, the Murrumbidgee River and land to the west of the river between Tharwa and Kambah Pool has been defined in the *Canberra Spatial Plan* (ACT Government 2004b) and the *Strategic Bushfire Management Plan* for the ACT (ACTESA 2005) as the western boundary of a Bushfire Abatement Zone to protect urban Canberra. This Zone provides a statutory planning basis to guide land management to reduce fuel loads, and land planning principles, including land use restrictions and performance measures for fire hazard reduction (*Spatial Plan*, p. 87). Protection of urban Canberra has therefore become a priority objective of fire management in the Murrumbidgee River Corridor, in addition to those objectives set out in the Management Plan for the corridor itself (Environment ACT 1998). Fire ecology is an important ongoing research need, including the integration of ecological and protection needs in fuel management. The origins, spread and means of control of landscape scale wildfires, and levels of fuel management in areas such as land west of the Murrumbidgee River in the ACT and adjacent land in New South Wales (including Kosciuszko National Park) are highly contested matters (see, for example, House of Representatives Select Committee into the recent Australian bushfires 2003; Leaver 2002).

Changes in fire regimes in the ACT since European settlement are discussed in s. 2.3.1. A range of conservation planning issues related to the January 2003 bushfires are outlined in s. 5.3 and potential impacts on aquatic communities are listed in s. 4.8.1.

- It is an objective of this *Strategy* that the impact and occurrence of inappropriate fire regimes is reduced or eliminated by appropriate planning, research and management actions (Table 6.1.3).

In the medium and longer term, an important management issue is the recovery of riparian vegetation communities, in particular, the Casuarina cunninghamiana Tableland Riparian Woodland and the Callitris endlicheri Tableland Dry Woodland/Open Forest. Table 6.1 contains specific actions related to these communities including monitoring of their recovery and review of fire management policies based on that recovery.

### 5.6.10 Environmental Flows

The purpose and importance of environmental flows for the maintenance of aquatic ecosystem structure and function, including the survival of threatened and

uncommon species, is discussed in s. 4.12.2, together with a brief outline of the environmental flow guidelines developed for the ACT. Given the uncertainties in determining environmental flows, an adaptive management approach is required. This involves preparing guidelines based upon the best available knowledge at a particular time and reviewing them on a regular basis. This approach has been followed in the ACT with the first guidelines (1999) being reviewed after a five-year period and revised guidelines prepared (ACT Government 2006a). Given their need to integrate environmental, social and economic considerations and in the context of population growth and increasing water needs, environmental flows are likely to remain an important management issue for ACT rivers.

- It is an objective of this *Strategy* that 'best practice' management is applied to rivers and riparian zones in the ACT with particular attention to the habitat of threatened, uncommon and declining species (Table 6.1.5).
  - —It is an action of this *Strategy* to prepare and keep under review environmental management policies and guidelines (e.g. fish stocking, environmental flows) that reflect commitment to active and effective conservation of rivers and riparian areas and conservation management of aquatic ecological resources (Table 6.1.5).
  - —For specific actions related to threatened fish species and other aquatic species, see s. 4.12.2.

### 5.6.11 Erosion and Sedimentation

Erosion in catchments and the subsequent sedimentation of aquatic habitats is one of the primary threats to aquatic fauna and processes. Sedimentation smothers feeding, breeding and resting habitats, and reduces in-stream habitat and substrate diversity (see s. 4.4.1). Intact riparian zones can provide significant filtering of overland transport of sediments and protection from streambank erosion (McKergow *et al.* 2002), as well as a number of other ecological functions. Canberra's urban lakes and the stormwater system provide significant protection against urban sediment impacting upon downstream ecological communities. However, large amounts of sediment are already present in river channels, either as a result of historical catchment management (e.g. Murrumbidgee, lower Naas, Paddys rivers) or through recent events such as the 2003 bushfires (e.g. Cotter, Orroral and upper Naas rivers). For most of these rivers, protection of the natural flow regime assists in preventing accumulation of sediment at any particular location. For the Cotter River, managed releases from impoundments assist in moving sediment along the stream channel (see Environmental Flows, s. 4.12.2).

- It is an objective of this *Strategy* that the ecological condition and habitat quality of rivers and riparian zones in the ACT is maintained or improved by appropriate rehabilitation activities (Table 6.1.5).
  - —It is an action of this *Strategy* to prepare and keep under review environmental management policies and guidelines (e.g. fish stocking, environmental flows) that reflect commitment to active and effective conservation of rivers and riparian areas and conservation management of aquatic ecological resources (Table 6.1.5). (Give particular attention to the channel maintenance flows to protect habitats for threatened, uncommon and declining species.)
  - —It is an action of this *Strategy* to investigate and undertake appropriate rehabilitation activities (see s. 4.12.3). This may involve streambed, riverbank and wider riparian activities including those of an experimental kind (Table 6.1.5).

### 5.6.12 Extractive Industries

Historic land management practices or large floods have resulted in substantial quantities of sediment being stored in river channels. For example, large quantities of sediment stored in the Tharwa–Point Hut Crossing reach of the Murrumbidgee River in the ACT are thought to have originated in the catchment upstream of the ACT as a result of a series of large floods in the mid-late 1800s (AWT and Fluvial Systems 1999). These sediments have been steadily moving down the river channel as each minor flood reworks in-stream deposits. The quantity of sediment involved may be too large for conventional land or river management activities to effectively deal with, and so important aquatic habitats such as pools have been lost through infilling with sediment. The Murrumbidgee River Corridor Management Plan (Environment ACT 1998) identifies controlled sand and gravel extraction as a potential option for rehabilitating the river channel to a pool and riffle structure. Such extractive activities could only be used for habitat rehabilitation purposes. A pilot project in the Murrumbidgee River at Tharwa identified that there were opportunities for sand and gravel extraction to play a role in habitat enhancement programs (Lintermans 2004b).

- It is an objective of this *Strategy* that the ecological condition and habitat quality of rivers and riparian zones in the ACT is maintained or improved by appropriate rehabilitation activities (Table 6.1.5).
  - —It is an action of this *Strategy* to investigate and undertake appropriate rehabilitation activities. This may involve streambed, riverbank and wider

riparian activities including those of an experimental kind (Table 6.1.5).

—It is an action of this *Strategy* to investigate options for the use of closely monitored commercial extractive industries to remove in-stream sand and gravel deposits, as part of a habitat enhancement program (Table 6.1.5).

### 5.6.13 Water Quality Management

The water quality in aquatic habitats is a primary consideration for ecosystem function and maintenance of aquatic life. As noted in s. 4.4.6, reduction in water quality in the Murray–Darling Basin is due to increased nutrients, turbidity, sedimentation, salinity, artificial changes in water temperature, pesticides and other contaminants (MDBC 2004a). Key factors affecting water quality in ACT lakes and rivers are rural land uses (agriculture and forestry, including the legacy of past rural land use), urban development (including storm water runoff), chemical pollution (e.g. hydrocarbons, pesticides), climatic conditions (especially events such as drought or heavy storm rains), water releases from the lower levels of urban lakes and ponds (cold, deoxygenated water with excessive nutrient loads), nutrient enrichment (discharge of treated sewage effluent, inputs from rural enterprises), endocrine disruptors (potentially present in sewage discharge (see s. 4.4.6)), and catchment wide extreme events such as the January 2003 bushfires.

The approach taken to protect water quality in the ACT draws upon the framework established by the *National Water Quality Management Strategy* (ANZECC/ARMCANZ 2000) with catchment specific management policies aimed at achieving defined environmental and social objectives. The ACT strategy for sustainable water use is set out in *Think water, act water* (ACT Government 2004d), which contains specific actions in relation to the issues raised (Volume 1). Regular water quality monitoring programs have been undertaken in the ACT since 1969 enabling an analysis of trends (Australian Department of Construction *et al.* 1978). The results of the annual water quality monitoring program, including the macroinvertebrate component, are contained in an annual *ACT Water Report* (ACT Government 2004f). Continued growth of the Canberra and regional population, and related urban, commercial and infrastructure development, will place ongoing pressures on the maintenance of water quality in lakes and streams, even with the mitigation of these impacts by well designed sediment and pollution control structures and legislation. In those areas burnt the January 2003 bushfires, water quality is likely to be adversely affected for many years (ACT SOE 2003b).

Scrivener Dam on the Molonglo River creates the largest lake in urban ACT and in common with other urban impoundments, does not have a multi-level off-take for water releases, which only occur through overtopping or release through a valve at the base of the dam. The issue of the poor quality of the water released from the dam has been recognised for some time (NCPA 1995) without resolution. The National Capital Authority is currently reviewing how it meets its environmental flow obligations both in Lake Burley Griffin and the Molonglo River downstream, which include temperature and flow variations to mimic natural conditions (ACT Government 2005b).

This *Strategy* does not include objectives or actions related to water quality, given the existing comprehensive policy framework for water management in the ACT including the strategy *Think water, act water* (ACT Government 2004d), legislation (*Environmental Protection Act 1997* and *Water Resources ACT 1998*), planning policies ('Water Use and Catchment Policies' of the *Territory Plan*), guidelines and plans (*Environmental Flow Guidelines, Water Resources Management Plan*), and ongoing monitoring and reporting (carried out by a range of government agencies and community groups and with the exception of Lake Burley Griffin (managed by the National Capital Authority) reported in the annual *ACT Water Report* e.g. ACT Government 2004e).

## 5.7

## Management Agreements and Networks

### 5.7.1 ACT Land Keepers Program

*Living Environment* is an ACT Government and community partnership with the Natural Heritage Trust (Australian Government) with respect to funding programs to address priority issues relating to biodiversity, water quality and flow, soil health, salinity and the capacity of the community to address these issues. Delivery of part of this program is through the ACT Land Keepers program, a partnership between Environment and Recreation and Greening Australia (ACT and SE NSW). This program has four components:

(a) **VegLink:** on-ground activities in native vegetation protection and enhancement.

(b) **Biodiversity Incentives:** on-ground conservation work on rural and non-urban land.

(c) **Greening Industry:** on-ground conservation work with agricultural and horticultural enterprises; and

(d) **ACT River Rescue:** implementing riparian habitat recovery along priority streams in the ACT to address biodiversity and water quality.

Projects targeting riparian habitat priorities include sites in the Ginninderra, Molonglo and Southern ACT Catchments. Activities include:

—fencing off creeks to allow (a) erosion control in major gullies and other soil conservation works, (b) protection of remnant vegetation, and (c) to facilitate control of grazing stock;

—revegetation projects that supplement remnant native vegetation and help restore ecological connectivity across the landscape; and

—weed control, particularly of willows and weeds of national significance.

Each of these categories of projects contributes to restoration of riparian function and potentially the quality of river environments and the water that flows through them. They form some of the essential on-ground works that will be needed over many years to implement the actions outlined in the *Strategy* (s. 6.2 and s. 6.5).

The ACT Minister for the Environment and the Australian Ministers for Environment and Heritage and Agriculture, Fisheries and Forestry approve projects funded through the Land Keepers program. Priorities and strategic targets are set out in the ACT Natural Resource Management Plan 2004–2014 (ACT NRM Board 2004) (see s. 6.3). This Strategy will be one of many sources that inform the Natural Resource Management Plan, through regular reviews of both the Plan and its investment program.

Many ACT community groups are involved in conservation activities related to riparian areas. This *Strategy* supports the work of such groups (Table 6.1.5, s.6.5.1).

### 5.7.2 Land Management Agreements

Land Management Agreements provide a basis for co-operative land management between lessees of rural land in the Australian Capital Territory and ACT Government agencies responsible for managing rural and non-urban land in the Territory. A Land Management Agreement (LMA) is required under the *Land (Planning and Environment) Act 1991* (section 186c) for all non-urban leases in the ACT and is linked to the granting of a long-term lease (20 and 99 years). LMAs are in place for the majority of leases in riparian zones. Some land in the Gudgenby–Naas catchment is held under agistment for which LMAs do not apply.

The principal objective of LMAs is to establish management practices on leases that support the land management aims of both the lessee and the ACT Government. This involves agreement on general management goals and responsibilities; documentation of the current state of the property (including nature conservation, cultural heritage or other significant values); and identification of land management issues and the means for their resolution. Environment and Recreation provides environmental information to lessees, drawing attention to conservation issues, in particular, presence of, or habitat for, threatened species and ecological communities. LMAs also address uncontrolled grazing and the fencing of riparian areas.

Lessees are required to address the following objectives in the LMA within a framework of sustainable agricultural and pastoral land use practices:

- Retain or improve the ecological functioning and integrity of the natural and modified resources of the leased area.
- Preserve the extent and character of any threatened ecological community or population of a threatened species.
- Pursue all development and management of the land in a way that is consistent with any Action Plan for a threatened species or ecological community.
- Manage vegetation identified in the LMA as being of significant conservation value, with the aim of maintaining its structure, floristics and habitat value.
- Ensure that any activities do not adversely impact on riparian or other wetland areas.

Land Management Agreements also provide for Land Action Plans to be prepared for a range of issues, including drought risk management, pest plants and animals, sites of significant natural or cultural heritage value, maintenance of water quality, and protection of riparian zones and other native vegetation. Lessees are required to ensure that a flexible grazing strategy is in place designed to achieve conservation objectives.

A review of each Land Management Agreement is required every five years or on the re-issuing, variation or transfer of the lease or on the written request of the Lessee or the Territory, whichever occurs first. If existing management practices are retained and there is no adverse impact on the environment over this period, no changes to the Agreement will be required.

# 6 The Aquatic Species and Riparian Zone Conservation Strategy

## 6.1

### Roles of the *Strategy*

The *Aquatic Species and Riparian Zone Conservation Strategy* is intended to fulfill a number of roles. These are:

- Action Plans for species listed as threatened under the *Nature Conservation Act 1980*.
- A multi-species strategy for the conservation of aquatic and riparian flora and fauna species, ecological communities and habitats.
- A source document on the rivers and riparian zones for ACT and Commonwealth Government agencies with responsibilities for nature conservation, planning and land management.
- A source document for community and other stakeholders with an interest in the conservation of aquatic and riparian flora and fauna species, ecological communities and habitats.

As an Action Plan prepared under the *Nature Conservation Act 1980*, the *Strategy* addresses the requirement in section 23 of the Act, that it 'shall include proposals to ensure, as far as is practicable, the identification, protection and survival of the species, or the ecological community; or proposals to minimise the effect of any process which threatens any species or ecological community'.

The *Strategy* provides information, strategic direction and performance criteria in relation to wider land use planning, and land and water management in the ACT, including the following documents:

- ***The Canberra Plan*** (ACT Government 2004f) (Theme 'Living with the Environment—Our Bush Capital' (p. 14)), which states that areas of high conservation value will be enhanced and protected.
- ***The Canberra Spatial Plan*** (ACT Government 2004b). *The Spatial Plan* contains the following objectives:
  (a) Under the GOAL to 'Maintain a Unique Sense of Place' (pp. 17, 64):
  —*Retain and strengthen the open space network, including the hills, ridges, natural watercourses and gullies.*
  (b) Under the GOAL to 'Respect the Natural Environment' (pp. 17, 72, 74):
  —*Protect and enhance biodiversity through nature reserves and maintaining connectivity between them.*
  —*Maintain water quality and availability.*

The *Plan* sets out policy responses related to the above objectives. The following, in particular, are relevant to this Strategy:

- The hills, ridges, major water features and gullies will be retained as the landscape setting (p. 64)
- The major river corridors, the urban hills and ridges, and the hills and reserves east and north of Gungahlin that create the main links for wildlife movement and connect into natural areas south and west of the Murrumbidgee River will be protected as wildlife corridors (p. 72).
- In the Molonglo Valley, environmentally sensitive areas of the Molonglo River corridor will be protected from the adverse impacts of development (p. 72).
- Urban areas are designed and managed to protect water quality in the receiving waters of the Molonglo and Murrumbidgee Rivers and ultimately the Murray–Darling River system (p. 74).
- ***The Social Plan*** (ACT Government 2004g): (**Priority 7 Respect and protect the environment**) '7.4 *Ecological protection and urban development:* The Government will help protect our threatened species and ecological communities as part of best practice planning for urban development'; and '7.5 *Conservation strategies:* The Government will continue to ensure that key biodiversity assets are identified, protected and managed through preparation of conservation strategies for lowland woodlands (2003), native grasslands (2004) and aquatic and riverine communities (2005)'.

As part of these planning processes, decisions will be made by the ACT Government with regard to the

level of protection and conservation management applied to the rivers and riparian zones. As noted in s. 5.1, most of the rivers and riparian zones included in the *Strategy* are Public Land under the *Land (Planning and Environment) Act 1991*. The key issues for these areas are not reservation or recognition in statutory planning, but the need to strengthen and coordinate management, improve their ecological condition and restore degraded areas (especially through weed control).

The central focus of this *Strategy* is on biodiversity and habitat conservation for the rivers and riparian zones, with some consideration of water resource management and recreation (especially recreational fishing) because of their importance in relation to habitat and threatened species conservation. Other natural and cultural values of river sections and adjacent riparian zones include Aboriginal and European cultural heritage, other forms of recreation, aesthetic amenity, educational and special scientific features (e.g. geological sites). These are normally considered in the planning phase before specific proposals are developed by government agencies, in environmental impact assessment, and in public consultation on proposals to amend the Territory Plan. Presenting information on these values is beyond the scope of this *Strategy*, which is not a management plan.

Description, assessment of significance, and management directions for the potentially broad range of values applicable to a place (such as a river section and its riparian zone) are set out in management plans for particular areas or groups of areas in the ACT (see Figure 1.2). Management plans pertinent to this *Strategy* are:

- *Namadgi National Park Management Plan* (ACTP&CS 1986) and *Namadgi National Park Draft Management Plan* (ACT Government 2005d).
- *Lower Cotter Catchment: Draft Strategic Management Plan* (ACT Government 2006b).
- *Murrumbidgee River Corridor Management Plan* (Environment ACT 1998).
- *Molonglo River Corridor Management Plan 2001* (Environment ACT 2001b).
- *Tidbinbilla Nature Reserve Management Plan* (Environment ACT 1999).

As noted in s. 5.1.3, management plans have not been prepared for some river sections and riparian zones that are Public Land.

These management plans set out overall management objectives and management objectives related to particular values (e.g. river and water values) and activities (e.g. interpretation and education). Overall management objectives, common to all the plans listed above, encompass the following:

- to conserve aquatic and riparian ecosystems and habitats, and diversity of native flora and fauna;
- to conserve cultural heritage landscapes, areas and sites;
- to conserve and enhance habitat links through the regional landscape;
- to conserve natural landforms, scenery and sites of geological, geomorphological and ecological significance;
- to maintain water quality;
- to provide appropriate recreational opportunities consistent with other objectives; and
- to provide environmental education and scientific research opportunities.

The plans subsequently outline management activities that support these objectives.

# 6.2

## Vision, Goals, Objectives and Actions for the *Aquatic Species and Riparian Zone Conservation Strategy*

Based on the approach adopted in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a) and the *ACT Lowland Native Grassland Conservation Strategy* (ACT Government 2005a), a vision statement, conservation goals and objectives, actions necessary to achieve those objectives, and performance criteria have been prepared for the *Strategy* as a whole. These have been derived from the more detailed discussion, objectives and actions set out in Chapters 2 to 5. The statements in Table 6.1 are grouped into: Information, Protection, Threats, Planning, Management, Community/Landholder Involvement and National and Regional Cooperation and are set out in a format similar to that adopted by some Australian jurisdictions for recovery plans for threatened species. Actions related to specified threatened or uncommon plant and animal species are included at the end of Table 6.1.

Performance Criteria have been developed as an aid to future reviews of progress in implementing the *Strategy*. Achievement of targets depends on a number of factors including budget funding by the ACT Government, commitment by landholders, the involvement of community groups and other factors beyond the control of Environment and Recreation, which will take a leading role in coordinating the implementation of the *Strategy*.

**Table 6.1: Vision, Goals, Objectives, Actions and Performance Criteria for the *Aquatic Species and Riparian Zone Conservation Strategy***

**VISION**

The Murrumbidgee and Molonglo rivers in the ACT and their major tributaries make an outstanding contribution to the conservation of aquatic and riparian ecosystems of the upper Murrumbidgee River catchment.

**PROTECTION GOALS**

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

**MANAGEMENT GOALS**

- Aquatic and riparian communities and habitats in the ACT are maintained and where degraded, rehabilitated to support the range of flora and fauna typical of the ACT. Rehabilitation may include the re-introduction of threatened or locally extinct fish species to ACT and/or regional streams where they no longer occur naturally.
- Maintain in perpetuity a well-connected system of aquatic and riparian environments that support movement of aquatic and riparian fauna in the ACT and region.

**NOTE:** (i) See end of table for abbreviations
(ii) Bracketed items at end of each Action indicate primary responsibility for, or significant participation in the Action

## 1. Information

| Objectives | Actions | Performance Criteria |
|---|---|---|
| (a) 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.<br>(b) A comprehensive database of aquatic and riparian ecological communities and component species in the ACT is maintained.<br>(c) With regard to the bushfires of January 2003, knowledge is gained and documented about:<br>(i) the long-term ecosystem effects of this event (in particular, the effects of sedimentation on aquatic fauna); and<br>(ii) the recovery of aquatic and riparian ecological communities and their component species (in particular, fire sensitive species such as *Casuarina cunninghamiana* and *Callitris endlicherii* and threatened fish species).<br>(d) ACT data is included in national, state and community databases, including the National Vegetation Inventory System (NVIS).<br>(e) Ecological information is used to underpin adaptive management.<br>(f) The ecological and habitat requirements of fish and crayfish are known and applied to their conservation management. | (a) Undertake a survey of vegetation and habitat in ACT riparian zones to update existing information and provide a baseline for subsequent monitoring (E&R). Give priority initially to (a) areas under most threat from current or proposed land uses or activities, (b) areas of high use, (c) areas where data is the most deficient.<br>(b) Prepare and undertake a monitoring program for riparian ecological communities and component flora and fauna species (E&R).<br>(c) Maintain a monitoring program for fish, Murray River Crayfish and aquatic macroinvertebrates in the ACT and appropriate external reference sites (E&R).<br>(d) Develop a database to house survey and monitoring information on aquatic species.<br>(e) Maintain a monitoring program aimed at understanding:<br>(i) the long-term effects of the January 2003 bushfires on riverine and riparian ecological communities and threatened species; and<br>(ii) recovery of ecological communities and their component species (in particular, fire sensitive species such as *Casuarina cunninghamiana* and *Callitris endlicheri*) (E&R).<br>(f) Encourage research on ACT aquatic and riparian ecological communities and component species, including research on the effects of, and recovery from the January 2003 bushfires (E&R).<br>(g) Assess the implications of research results for management (E&R).<br>(h) Maintain ACT flora and fauna databases to support planning, management and research (E&R).<br>(i) Link data collection to national (NVIS), state (especially NSW) and community databases (E&R, NSW, Cwlth, community). | **2008–2010**<br>■ Comprehensive survey undertaken of riparian vegetation and habitat for high priority areas.<br>■ Vegetation monitoring program designed and commenced for priority species/ecological communities.<br>■ Survey and other relevant data entered into ACT vegetation database within 6 months of collection.<br>■ Monitoring program for fish, crayfish and aquatic macroinvertebrates is maintained.<br>■ Database for survey and monitoring data on aquatic species is developed.<br>■ Extent of recovery of fire affected riverine and riparian ecosystems and ecological communities reported.<br>■ Number of research projects undertaken and extent to which management recommendations arising from research are adopted.<br>■ *Integrated Nature Conservation Plan* (INCP) includes up-to-date ecological data on rivers and riparian zones. |

**Table 6.1:** *(Continued)*

## 2. Protection

| Objectives | Actions | Performance Criteria |
|---|---|---|
| (a) The conservation status of aquatic and riparian species and ecological communities in the ACT has been assessed. Where appropriate, nominations have been prepared for consideration as threatened species or communities under the *Nature Conservation Act 1980*.<br>(b) Riverine and riparian habitats in the ACT are protected by reservation or other measures where reservation is not practicable or desirable.<br>(c) Key habitats for aquatic and riparian species or communities are protected. These include:<br>(i) spawning sites for native fish (e.g. Cotter River above Cotter Reservoir for Macquarie Perch);<br>(ii) raptor nesting sites in river gorges; and<br>(iii) riparian areas containing a high diversity of native plant species (e.g. lower Molonglo Gorge).<br>(d) An appropriate level of protection is in place for aquatic and riparian species in the ACT that are declared as threatened under legislation in surrounding jurisdictions or nationally (e.g. Murray Cod, Pink-tailed Worm Lizard, uncommon plant species).<br>(e) Development proposals affecting aquatic and riparian areas are assessed for their ecological impact and if proceeded with, adverse impacts are minimised to an acceptable level.<br>(f) The ACT Heritage Places Register contains aquatic and riparian areas, including key habitats for threatened species or ecological communities. | (a) Assess the conservation status of ACT aquatic and riparian species and ecological communities, which survey and monitoring results show may be at risk. Where appropriate, prepare nominations for consideration as threatened species under *Nature Conservation Act 1980* (E&R).<br>(b) Evaluate the adequacy of protection for ACT aquatic and riparian areas (E&R).<br>(c) Identify key habitats for aquatic and riparian species or communities. Develop and support appropriate legislative and other protection measures for these habitats (E&R).<br>(d) Identify the riparian zone in the lower Cotter Catchment (above Cotter Reservoir) as an area needing special attention in the rehabilitation of the surrounding former pine plantation, destroyed in the January 2003 bushfires (E&R).<br>(e) Keep protection measures for aquatic and riparian species in the ACT, declared as threatened under legislation in surrounding jurisdictions or nationally, under review (e.g. Murray Cod, Pink-tailed Worm Lizard, uncommon plant species) (E&R).<br>(f) Ensure land development proposals are assessed under relevant environmental impact and nature conservation legislation (E&R, ACTPLA).<br>(g) Work with the ACT Heritage Council to identify riverine and riparian areas, including key habitats for threatened species or ecological communities, suitable for nomination to the ACT Heritage Places Register. Prepare nominations (E&R, ACTPLA, ACT Heritage Council). | **2008–2010**<br>■ Conservation status of aquatic and riparian species and ecological communities assessed. Where appropriate, threatened species nominations prepared.<br>■ Key riverine and riparian habitats are protected by legislation, reservation, planning and management actions.<br>■ Plant and animal species declared threatened in the States or by the Commonwealth are protected in the ACT. ACT conservation status reviewed.<br>■ Extent to which development proposals are assessed under applicable legislation.<br>**2010–2012**<br>■ Rivers and riparian zones have been assessed for suitable entries to the ACT Heritage Places Register and nominations prepared. |

## 3. Threats

| Objectives | Actions | Performance Criteria |
|---|---|---|
| (a) Threats to:<br>■ riverine and riparian habitats;<br>■ native riparian flora, fauna and ecological communities;<br>■ native aquatic fauna;<br>have been assessed and priorities for action developed. Threats have been reduced.<br>(b) The impact and/or occurrence of the following threats is controlled, reduced or eliminated by appropriate planning, research and/or management actions:<br>(i) weeds;<br>(ii) pest animals;<br>(iii) inappropriate stock grazing;<br>(iv) inappropriate fire regimes;<br>(v) recreational activity and recreational infrastructure;<br>*(Continued next page)* | (a) Identify and monitor threats to:<br>■ riverine and riparian habitats;<br>■ native riparian flora, fauna and ecological communities;<br>■ native aquatic fauna.<br>(E&R, ACTPLA, land managers, community)<br>(b) Develop priorities for action, prepare and implement threat abatement responses, in particular:<br>(i) Continue to undertake a comprehensive weed control program for riparian areas focused on high priority areas and weed species, and follow up weed control work with revegetation of native species to reduce opportunities for reinvasion.<br>(ii) Maintain pest animal control programs. Report and where possible eradicate new occurrences of known or potential pest species e.g. Red-eared Slider Turtle.<br>*(Continued next page)* | **2008–2010**<br>■ Actions to address threats have been prepared and are being implemented.<br>■ Area of riparian zone occupied by weeds has been reduced. Incidence of high priority weeds has been reduced and their spread controlled.<br>**2010–2012**<br>■ Threats to rivers and riparian areas are substantially reduced or decreasing. |

**Table 6.1:** *(Continued)*

## 3. Threats *(Continued)*

| Objectives *(Continued)* | Actions *(Continued)* | Performance Criteria *(Continued)* |
|---|---|---|
| (vi) urban edge effects (potential, related to proposed urban development near the Molonglo River); and<br>(vii) releases of aquarium and other pest species to streams, and spread and impact of alien fish species. | (iii) Complete the riparian fencing program to prevent uncontrolled stock grazing in riparian areas.<br>(iv) Review fire management policies in relation to knowledge of the fire sensitivity of riparian species/ecological communities and recovery from the January 2003 bushfires.<br>(v) Encourage research into the fire ecology and post-fire recovery of *Callitris endlicheri* and *Casuarina cunninghamiana* communities.<br>(vi) Recognise and protect river corridor values in planning/management of recreational infrastructure/activities.<br>(vii) Evaluate potential impacts of urban development and seek to reduce these impacts in the planning process.<br>(viii) Investigate means to reduce (a) the risk of releases of aquarium and other pest species to streams and (b) the impacts of already established species;<br>(ix) Encourage investigation into control mechanisms to prevent the spread of established pest species (terrestrial vertebrates, alien fish).<br>(E&R, ACTPLA, land managers, landholders, community)<br>(c) Monitor the results of threat abatement measures (E&R, ACTPLA, land managers, landholders, community). | |

## 4. Planning

| Objectives | Actions | Performance Criteria |
|---|---|---|
| (a) The *Aquatic Species and Riparian Zone Conservation Strategy* and up-to-date ecological information is an important basis for assessing planning decisions impacting on the conservation of aquatic and riparian ecological communities and component species.<br>(b) Government and non-government organisations recognise the biodiversity conservation values of the rivers and riparian zones and incorporate their conservation requirements in planning, development and land management activities. In particular:<br>(i) River corridor values are recognised in planning studies for new urban areas (Molonglo, Kowen) and river corridors are given appropriate protection in physical planning.<br>(ii) Planning of recreational infrastructure recognises and protects corridor values. Recreational infrastructure remains concentrated at nodes and linear impacts are minimised.<br>*(Continued next page)* | (a) Consult with all government and non-government parties involved in planning processes for rivers and riparian zones to ensure that information on their conservation significance is incorporated: (i) into strategic planning for the ACT and region; (ii) at an early stage into planning for urban and other development in the ACT; and (iii) into development control and management plans. In particular, seek to ensure that:<br>(i) River corridor values are recognised in planning studies for new urban areas (Molonglo, Kowen) and river corridors are given appropriate protection in physical planning.<br>(ii) Planning of recreational infrastructure recognises and protects river corridor values, remains nodal and avoids linear impacts.<br>*(Continued next page)* | **2006**<br>■ Planning and development decisions (urban, recreation and infrastructure) are based on this Strategy and up-to-date ecological information.<br>**2008–2010**<br>■ Extent to which vegetation communities and linear habitat connectivity have been maintained and improved.<br>■ Extent to which habitat for Pink-tailed Worm Lizard and other rare and threatened species is protected. |

**Table 6.1:** *(Continued)*

## 4. Planning *(Continued)*

| Objectives *(Continued)* | Actions *(Continued)* | Performance Criteria *(Continued)* |
|---|---|---|
| (iii) Specific recognition is given to habitat protection for the Pink-tailed Worm Lizard (*Aprasia parapulchella*) in planning studies for the Molonglo and Murrumbidgee river corridors.<br>(c) Ecological connectivity along rivers and riparian zones is improved and further fragmentation is avoided or minimised. | (iii) Specific recognition is given to habitat protection for the Pink-tailed Worm Lizard (*Aprasia parapulchella*) in planning studies for the Molonglo and Murrumbidgee river corridors.<br>(E&R, ACTPLA, NSW, Cwlth, community).<br>(b) Work with other agencies and landholders (especially rural lessees) to improve existing connectivity and prevent or minimise further fragmentation in riparian zones. Give priority to areas where connectivity needs to be improved (EACT, landholders, community). | |

## 5. Management

| Objectives | Actions | Performance Criteria |
|---|---|---|
| (a) 'Best practice' management is applied to rivers and riparian zones in the ACT with particular attention to the habitat of threatened, uncommon and declining species and conservation of ecological communities.<br>(b) Recreational fishing in the ACT is managed so as to provide a satisfying and sustainable recreational experience, and to protect threatened, uncommon and declining species.<br>(c) Management plans are in place for all Public Land areas of the rivers and riparian zones.<br>(d) The ecological condition and habitat quality of rivers and riparian zones in the ACT is maintained or improved by appropriate rehabilitation activities (regeneration*, restoration* or reinstatement*).<br>(e) Management responsibility is established for the Molonglo River adjacent to Fyshwick and below Scrivener Dam to Coppins Crossing, and rehabilitation programs are underway based on management plans.<br>(f) Linear and upslope connectivity along rivers and riparian zones is improved and further fragmentation is avoided or minimised.<br>(g) Threats to riverine and riparian habitats, flora and fauna and ecological communities have been addressed by appropriate management actions.<br>(h) Land Management Agreements are completed for all rural leases in riparian zones. | (a) Prepare and keep under review:<br>■ management plans (Public Land);<br>■ other plans and agreements (for other tenures e.g. LMAs for rural leases);<br>■ environmental management policies and guidelines (e.g. fish stocking, environmental flows);<br>that reflect commitment to active and effective conservation of rivers and riparian areas, and conservation management of aquatic ecological resources (EAR, ACTEW, land managers, land holders, community).<br>(b) Continue to develop and promote 'best practice' management of rivers and riparian zones and their component species in the ACT. Give particular attention to the following:<br>(i) Protect and manage the habitats of threatened, uncommon and declining species.<br>(ii) Investigate and undertake appropriate rehabilitation activities (regeneration*, restoration*, reinstatement*). This may involve streambed, riverbank, habitat and wider riparian activities including those of an experimental kind. An important aim of such activities is to maintain and re-establish natural movement patterns for aquatic and riparian flora and fauna (e.g. honeyeater migration along the Murrumbidgee River Corridor).<br>(iii) Investigate options for the use of closely monitored commercial extractive industries to remove in-stream sand and gravel deposits, as part of a habitat enhancement program.<br>(iv) Continue with reinstatement of threatened fish species for conservation purposes and monitor the result.<br>(v) Manage recreational activity and the provision of recreational infrastructure so as to minimise environmental effects, especially in areas containing the habitat of threatened or uncommon flora and/or fauna species. *(Continued next page)* | **2008–2010**<br>■ Extent to which aspects of best practice management have been applied.<br>■ Management Plans prepared for all Public Land areas.<br>■ Extent to which ecological condition and habitat quality of rivers and riparian zones have been maintained or improved.<br>■ Management responsibility established for the Molonglo River adjacent to Fyshwick and below Scrivener Dam to Coppins Crossing. Rehabilitation programs commenced. |

* *Regeneration* means the natural recovery of natural integrity following disturbance or degradation.

* *Restoration* means returning existing habitats to a known past state or to an approximation of the natural condition by repairing degradation, by removing introduced species or by reinstatement.

* *Reinstatement* means to introduce to a place one or more species or elements of habitat or geodiversity that are known to have existed there naturally at a previous time, but that can no longer be found at that place (*Australian Heritage Commission* 2002).

**Table 6.1:** *(Continued)*

| **5. Management** *(Continued)* | | |
|---|---|---|
| **Objectives** *(Continued)* | **Actions** *(Continued)* | **Performance Criteria** *(Continued)* |
| | (vi) Ensure that information on flora and fauna and ecosystem function is included in considerations about water use and the establishment and maintenance of environmental flows.<br>(vii) Enforce the fishing regulations established under the *Fisheries Act 2000* (ACT) (e.g. prohibitions on take, bag limits, gear limits, closed seasons).<br>(viii) Monitor and review fishing legislation in jurisdictions surrounding the ACT to ensure fishing legislation is consistent across borders.<br>(ix) Continue to develop and promote 'best practice' management of recreational fishing, giving particular attention to protecting and managing threatened, uncommon and declining species, and promoting consistency in fisheries regulations with NSW.<br>(x) Include provisions for the protection and conservation management of rivers and riparian areas, ecological communities, and component flora and fauna in Land Management Agreements for rural leases adjacent to, or containing riparian areas.<br>(xi) Seek to ensure that adequate financial and other resources are applied to the rehabilitation of the Cotter River, tributary streams and riparian zones in the lower Cotter catchment.<br>(xii) Maintain linear and upslope connectivity and avoid management actions which increase fragmentation.<br>(xiii) Use the results of macroinvertebrate monitoring to develop management actions and priorities to improve water quality and aquatic and riparian habitat.<br>(E&R, ACTEW, ACTPLA, NSW, Vic., land managers, land holders, community)<br>(c) For the Molonglo River adjacent to Fyshwick and below Scrivener Dam to Coppins Crossing:<br>(i) Establish management responsibility for both areas.<br>(ii) Prepare management plans.<br>(iii) Undertake rehabilitation programs giving particular attention to major weed species, bank stability and riverflows.<br>(ACTPLA, TAMS, NCA, community) | |

**Table 6.1:** *(Continued)*

## 6. Community/Landholder Involvement

| Objectives | Actions | Performance Criteria |
|---|---|---|
| (a) Landholders, community groups (e.g. Waterwatch, Frogwatch) and others are actively involved in the monitoring and conservation management of rivers and riparian areas in the ACT.<br>(b) For rivers and riparian areas, land managers, landholders, and the community are linked together, exchanging information and skills and undertaking collaborative projects.<br>(c) The ACT community is better informed about the values of the rivers and riparian zones and the need for conservation management. | (a) Encourage the involvement of landholders, community groups and others in the conservation management of rivers and riparian areas in the ACT (E&R).<br>(b) For rivers and riparian areas, facilitate information and skills exchange and the undertaking of collaborative projects by land managers, landholders, and the community. Encourage catchment groupings and build upon the existing Land Keepers program (E&R, landholders, community).<br>(c) Undertake community information activities to promote the values of the rivers and riparian zones and the need for conservation management (E&R).<br>(d) Make information available to support and develop community awareness about the role and value of environmental flows (E&R). | **2008–2010**<br>■ Number and type of opportunities for managers of rivers and riparian zones to exchange information about 'best practice' management.<br>■ Number and type of opportunities for community groups to participate in conservation activities in the rivers and riparian zones.<br>■ Materials available to community groups to educate and raise awareness about aquatic and riparian issues. |

## 7. Regional and National Cooperation

| Objectives | Actions | Performance Criteria |
|---|---|---|
| The ACT takes an active role in national and regional programs and activities involved with the planning and management of rivers and riparian zones, and associated threatened species and ecological communities. | (a) Liaise with interstate and Commonwealth government agencies and other organisations involved in the planning and management of the Murray–Darling Basin, the Upper Murrumbidgee River catchment, and the particular rivers, riparian zones, threatened species and ecological communities to share knowledge and expertise (ACT, NSW, Vic., Cwlth, MDBC, other organizations).<br>(b) Maintain links with, and participate in, regional and national recovery efforts for threatened species and ecological communities to ensure that ACT conservation actions are coordinated with regional and national programs (E&R, Cwlth, NSW, Vic., MDBC).<br>(c) Work with regional bodies to encourage and develop coordinated control of threats e.g. weeds. | **2008–2010**<br>■ Extent and effectiveness of ACT involvement in relevant national and regional programs and activities. |

**Table 6.1:** *(Continued)*

## 8. Threatened and Uncommon Plants and Ecological Communities

(see s. 2.4 for more detail)

**(*Muehlenbeckia tuggeranong* and any other threatened or uncommon plant species/ecological community occurring in riparian zones)**

| Actions | Performance Criteria |
|---|---|
| **INFORMATION (Survey, Monitoring, Research)**<br>■ Maintain alertness to the possible presence of threatened or uncommon plant species when undertaking surveys in appropriate habitat (E&R).<br>■ Maintain a database of known occurrences and abundance of threatened and uncommon plant species to enable analysis of changes in distribution and abundance (E&R).<br>■ Maintain a watching brief on ACT populations of uncommon plant species and evaluate their conservation status in a regional context (E&R).<br>■ Facilitate and encourage research that will provide information on the status of threatened and uncommon plant species and management requirements (E&R).<br>(more detailed actions apply to *Muehlenbeckia tuggeranong*, see s. 2.4.1)<br>**PROTECTION**<br>■ Assess the conservation status of uncommon plant species, identified in survey and monitoring (E&R).<br>■ Ensure known populations of threatened and uncommon plant species are protected from inadvertent damaging actions (e.g. by advising landholders and managers of their presence) (E&R).<br>■ 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) (E&R).<br>**MANAGEMENT**<br>■ Prepare management guidelines for uncommon plant species for use by landowners and managers where necessary (E&R).<br>■ Manage sites, and provide advice to other landowners and managers, to maintain optimum habitat (where known) for threatened and uncommon plant species (EAR, landholders, land managers).<br>■ Consider nomination for ACT listing if uncommon plant species show evidence of local decline in extent and abundance (E&R).<br>**REGIONAL AND NATIONAL CO-OPERATION**<br>■ 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 (E&R). | **2008–2010**<br>■ Actions with regard to the reproduction of *Muehlenbeckia tuggeranong* have been undertaken (s. 2.4.1).<br>■ Threatened or uncommon plant species or ecological communities identified from surveys.<br>■ Conservation status of uncommon plant species or ecological communities assessed.<br>■ Land managers and landowners advised of presence of threatened or uncommon plant species or ecological communities and management guidelines provided.<br>■ Liaison with interstate agencies undertaken (as required). |

## 9. Threatened and Uncommon Animals of the Rivers and Riparian Zones

(see s. 3.3 and s. 4.10 to s. 4.14 for more detail)

**(Rivers: Two-spined Blackfish, Trout Cod, Macquarie Perch, Silver Perch, Murray Cod, Murray River Crayfish and any other threatened or uncommon animal)**

**(Riparian Zones: Painted Honeyeater and Pink-tailed Worm Lizard and any other threatened or uncommon animal)**

| Actions | Performance Criteria |
|---|---|
| **INFORMATION (Survey, Monitoring, Research)**<br>**Rivers**<br>■ Improve understanding of the biology and ecology of threatened and uncommon fish and crayfish species as the basis for managing the species and their habitat. Give specific attention to establishing causes of population decline. Investigate translocation as a management option for establishing new sub-populations.<br>(a) Survey: Undertake surveys for threatened fish/crayfish species to determine distribution and abundance (see s. 4.11.1 and Table 4.6);<br>(b) Monitoring: Continue monitoring program for threatened fish/crayfish species and liaise with NSW and Victorian fisheries agencies and the MDBC regarding threatened fish/crayfish species (see s. 4.11.2 and Table 4.7);<br>(c) Research: Continue to encourage research on ACT threatened fish/crayfish species, focused on priority areas with key information gaps (see s. 4.11.3 and Table 4.8). Encourage research on spiny crayfish and the burrowing crayfish *Engaeus cymus*.<br>Include uncommon species (e.g. Murray Cod) in above actions where appropriate.<br>**Riparian Zones**<br>■ Maintain alertness to the possible presence of threatened or uncommon fauna species when undertaking surveys in riparian zones (E&R).<br>*(Continued next page)* | **2008–2010**<br>■ Up-to-date database of threatened and uncommon animal species maintained.<br>■ Conservation status of uncommon animal species assessed.<br>■ Land managers and landowners advised of presence of threatened or uncommon animal species and management guidelines provided.<br>■ Habitat for threatened and uncommon species has been maintained or restored.<br>■ Liaison with interstate agencies undertaken (as required). |

**Table 6.1:** *(Continued)*

| **9. Threatened and Uncommon Animals of the Rivers and Riparian Zones** *(Continued)* | |
|---|---|
| **Actions** *(Continued)* | **Performance Criteria** *(Continued)* |
| ■ Maintain a database of known occurrences and abundance of threatened or uncommon fauna species that utilise the riparian zone to enable analysis of changes in distribution and abundance (E&R).<br>■ Maintain a watching brief on threatened or uncommon fauna species that utilise ACT riparian zones and evaluate their conservation status in a regional context (E&R).<br>■ Facilitate and encourage research that will provide information on threatened or uncommon fauna species that utilise ACT riparian zones and their management requirements (E&R).<br>**PROTECTION AND MANAGEMENT**<br>**Rivers**<br>■ Protect sites and habitats that are critical to the survival of threatened fish and crayfish species. Manage activities in the Murrumbidgee, Cotter and Paddys River catchments in the ACT to minimise or eliminate threats to fish and crayfish populations. Evaluate means and undertake actions to maintain and expand existing populations. Re-introduce Trout Cod to their former habitat in the ACT.<br>(a) Undertake protection and management actions for threatened and uncommon fish/crayfish species (related to legislative protection, environmental flows, habitat rehabilitation, future water supply options, alien fish species, fish stocking, barriers to fish passage and trade in freshwater crayfish) (see s. 4.12.1 to s. 4.12.10).<br>**Riparian Zones**<br>■ Seek to ensure known populations of threatened and uncommon fauna species and species that utilise ACT riparian zones are protected from inadvertent damaging actions (e.g. by advising landowners and managers of their presence).<br>■ Prepare management guidelines for uncommon fauna species where necessary.<br>■ Manage sites, and provide advice to other landowners and managers, to maintain optimum habitat (where known) for uncommon fauna species (*Casuarina cunninghamiana* riparian woodland for painted Honeyeater; native grassland with rocks for Pink-tailed Worm Lizard).<br>■ Consider nomination for ACT listing if uncommon fauna species show evidence of local decline in extent and abundance.<br>**EDUCATION**<br>**Rivers and Riparian Zones**<br>■ Provide information about and increase community awareness of the need to protect aquatic and riparian species and their habitats (see s. 4.13 for fish and crayfish).<br>**REGIONAL AND NATIONAL COOPERATION**<br>**Rivers**<br>■ Maintain links with, and participate in, regional and national recovery efforts for threatened aquatic species (see s. 4.14).<br>**Riparian Zones**<br>■ Liaise with interstate agencies involved in protection and management of threatened and uncommon fauna species that utilise ACT riparian zones with the aim of increasing knowledge of their biology, and habitat and conservation requirements. | |

**Abbreviations**

**ACTEW:** ACTEW Corporation Limited

**ACTPLA:** ACT Planning and Land Authority

**Cwlth:** Commonwealth Government (primarily Department of Environment and Heritage)

**TAMS:** Department of Territory and Municipal Services

**E&R:** Environment and Recreation (part of TAMS)

**GPT:** Gross Pollutant Trap

**INCP:** The *Integrated Nature Conservation Plan* is the central repository for information related to nature conservation in the ACT. Based on a Geographical Information System it shows, for example, all ACT reserves, distribution of threatened species and ecological communities, important fauna habitat and locations where major works are planned or being undertaken.

**MDBC:** Murray–Darling Basin Commission

**NSW:** NSW Government (primarily Department of Environment and Conservation and Department of Primary Industries)

**NCA:** National Capital Authority

**Vic.:** Victorian Government (primarily Department of Sustainability and Environment and Department of Primary Industries)

# 6.3

## Policy Guidelines for River and Riparian Zone Conservation in the ACT

ACT Government policies for conservation of riverine and riparian habitats, ecological communities, and flora and fauna are set out in documents such as *The Territory Plan*, *The Canberra Spatial Plan* and *The ACT Nature Conservation Strategy* (ACT Government 1998). Other relevant documents include *Think water, act water* (the ACT water resources strategy) (ACT Government 2004d), the *ACT Natural Resource Management Plan 2004–2014* (ACT NRM Board 2004), *An Integrated Catchment Management Framework for the ACT* (Environment ACT 2000b), the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a) and the *ACT Lowland Native Grassland Conservation Strategy* (ACT Government 2005a). Statements in these documents point towards a system of protection for the ACT that places its natural environments within a regional context and reflects national priorities. The latter are contained in the *Australian Guidelines for Establishing the National Reserve System* (Commonwealth of Australia, 1999), the *National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth of Australia 1996), and the *National Action Plan for Salinity and Water Quality* (COAG 2000).

A significant context for this *Strategy* is the *Murray–Darling Basin Initiative*, a cooperative arrangement between the Commonwealth Government, governments of New South Wales, Victoria, South Australia, Queensland, the Australian Capital Territory, and a Community Advisory Committee. This is aimed at promoting the equitable, efficient and sustainable use of the Basin's water, land and other environmental resources. The ACT is a participant in a number of programs, such as the sustainable rivers audit. A long-term native fish strategy has been prepared for the Basin (MDBC 2004a) with the goal 'to rehabilitate native fish communities in the Murray–Darling Basin back to 60 per cent of their estimated pre-European settlement levels after 50 years of implementation'.

A *Draft ACT Fisheries Management Plan* (Environment ACT (in prep.)) aims to provide directions and guidance for the conservation and management of ACT fisheries. Prepared pursuant to section 6 of the *Fisheries Act 2000* (ACT), the Plan identifies ACT fisheries and activities necessary for their management.

At the sub-regional level, the *Murrumbidgee Catchment Blueprint* (Murrumbidgee Catchment Management Board 2003) has been prepared to satisfy legislative requirements in the NSW *Catchment Management Act 1989* and in response to arrangements under the *National Action Plan for Salinity and Water Quality* (COAG 2000). Although the *Murrumbidgee Catchment Blueprint* is inclusive of the ACT at the broader catchment level, the ACT has a separately identified component that reflects the ACT's different governmental arrangements, land tenure system, and urban focus.

ACT aspects are dealt with in the *ACT Natural Resource Management Plan 2004–2014* (ACT NRM Board 2004). Originally developed (in its draft form) as a component of the *Murrumbidgee Catchment Blueprint*, this *Plan* has been refined to meet the requirements of a Territory Bilateral Agreement for the delivery of the Natural Heritage Trust. Funding under the Trust is mainly through a 'regional investment' program, with regions defined under the *National Action Plan for Salinity and Water Quality*, and made on the basis of a regional natural resource management plan incorporating major environmental issues in the area. The ACT *Plan* provides a strategic framework for natural resource management at the Territory and local scale and in the context of the Murrumbidgee River Catchment. Targets and actions in the *Plan* have been prepared through a process of community and government consultation. They are complementary to, and in some instances provide context for the objectives and actions in this Strategy. Examples are:

**Biodiversity BMT 3 (Wetland and riverine)**
(ACT NRM Board 2004, p. 42):

- Conduct a comprehensive survey of the condition and conservation status of riparian and wetland areas that is consistent with regional and NVIS (National Vegetation Information System) standards.
- Conserve and rehabilitate native riparian vegetation adjacent to plantations, public and rural lands with a priority focus on threatened species habitat and fire-affected land.
- Control livestock access to permanent streams and wetlands.
- Implement Murray–Darling Basin Fish strategy in cooperation with other States.
- Identify and manage invasive aquatic and riparian species to protect biodiversity.

**Water Resources (WMT 4)** (ACT NRM Board 2004, p. 51):

- Undertake research and monitoring to gain a greater understanding of environmental flows and aquatic ecosystem needs.
- Review environmental flows guidelines and ensure there is a clear mechanism for implementing these guidelines.
- Undertake a community education and awareness campaign about the role and value of environmental flows.

# 6.4

## The State of Protection and Conservation Management of Rivers and Riparian Zone in the ACT

The reservation, planning and management framework for catchments and river corridors in the ACT is outlined in s. 5.1, which shows that the river corridors are:

- covered by land use policies in both the *National Capital Plan* and the *Territory Plan*,
- mostly categorised as Public Land under the *Land (Planning and Environment) Act 1991* and declared as reserves (except for Paddys River and most of the lower sections of the Naas and Gudgenby rivers).

However, while significant sections of the river corridors are included in management plans, Public Land areas for which these have not been prepared are (Figure 1.1):

- Molonglo River
  - —MO 1. Burbong to Blue Tiles;
  - —MO 2. Molonglo Gorge to Lake Burley Griffin;
  - —MO 3. Scrivener Dam to Coppins Crossing.

The remaining river sections are mainly rural leasehold or plantation forestry areas (Figure 1.1):

- Paddys River (Rural leasehold, plantation forestry)
  - —CO 1. Paddys River (Tidbinbilla River within the Tidbinbilla Nature Reserve is included in the management plan for the reserve).
- Gudgenby River (Rural leasehold, Public Land (possible Tennent Dam site))
  - —GU 2. Namadgi National Park to Murrumbidgee River.

A priority action to improve protection and conservation management of rivers and riparian zones in the ACT is to include all Public Land areas of the rivers and riparian zones in management plans as required under the *Land (Planning and Environment) Act 1991* (s. 197 (1)). Related to this is the need to strengthen and coordinate management, including for those areas (above) that are not Public Land.

# 6.5

## Priority Actions to Improve Conservation Management of Rivers and Riparian Zones in the ACT

The status of planning, protection and management for ACT rivers and riparian zones is discussed in Chapter 5. Planning and conservation issues are outlined in s. 5.4 to s. 5.6, including Table 5.1, which contains planning and conservation issues and priority actions for the river sections and adjacent riparian zones identified in the *Strategy*. Actions for the Strategy as a whole are contained in Table 6.1. Actions taken to improve the state of the rivers and riparian zones in the ACT bring both local benefits and make a contribution to environmental improvement in the wider Murray–Darling Basin. The latter is identified in the *Australian Catchment, River and Estuary Assessment 2002* (Commonwealth of Australia 2002a) as having an urgent need for rehabilitation and strategic management, and in the *Australian Terrestrial Biodiversity Assessment 2002* (Commonwealth of Australia 2002b) as having degraded riparian zones that are continuing to decline.

MacLeod (2002a, p. 148) suggests that three broad 'strategies' should be given priority in managing riparian lands to maintain and/or improve their ecological condition:

- retaining and managing riparian vegetation;
- managing stock access to riparian areas; and
- controlling weeds and exotic species within riparian areas.

These 'strategies' can assist in protecting valuable riparian and aquatic ecosystems and, importantly, they include actions over which land owners and managers can exert some direct control. They are incorporated into the priority actions for this *Strategy* in s. 6.5.1 below.

### 6.5.1 Priority Actions

Priority actions to improve conservation management of rivers and riparian zones in the ACT are:

**INFORMATION**

- Undertake a program of systematic survey of vegetation and habitat in ACT riparian zones.
- Assess the conservation status of riparian species and ecological communities.
- Encourage research into the ecology and conservation requirements of ACT threatened and uncommon fish and crayfish species and aquatic habitats.
- Develop a database for storage of survey and monitoring information on threatened, declining or rare aquatic species.

**PROTECTION**

- Maintain the protection arrangements for threatened fish species and habitats in the Cotter River (fishing prohibition, access limitations).
- Review the adequacy of the *Nature Conservation Act 1980* to declare and/or protect habitats of threatened aquatic and riparian species.

**THREATS**

- Maintain, and keep under review, the weed control programs based on high priority areas and weed species.
- Investigate means to (a) reduce the risk of releases of aquarium and other pest species to streams; (b) reduce the impacts of already established species; and (c) control the spread of already established species.

**PLANNING**

- Protect river corridors in planning for new urban, recreational and infrastructure development noting that adjustments to the statutory and management boundaries of existing conservation areas may be made as part of detailed planning processes. Avoid fragmentation (loss of linear connectivity).

**MANAGEMENT**

- Prepare management plans and implementation plans, and where required, strengthen and coordinate management (see s. 6.4 above).
- Maintain and restore riverine and riparian habitat and connectivity:
  - —Rivers:
    - (a) Maintain environmental flows.
    - (b) Investigate options for rehabilitating critical fish habitat including sediment removal.
  - —Riparian zones:
    - (a) Maintain and rehabilitate native vegetation.
    - (b) Manage the impacts of riparian and upslope activities including grazing.
    - (c) Maintain and, where practicable, improve connectivity with upslope ecological communities, including lowland grassy woodland.
- Continue the range of threatened fish/crayfish research and conservation programs in the ACT and region (particularly the reinstatement of threatened fish species for conservation purposes and the monitoring the results) and keep these programs under review.
- Enforce the fishing regulations established under the *Fisheries Act 2000* (ACT) (e.g. prohibitions on take, bag limits, gear limits, closed seasons).
- Maintain a monitoring program for fish, crayfish and aquatic macroinvertebrates in the ACT and appropriate external reference sites.

**COMMUNITY/LANDHOLDER INVOLVEMENT**

- Maintain and develop community involvement and information activities in relation to the conservation management of rivers and riparian zones in the ACT.

**REGIONAL AND NATIONAL COOPERATION**

- Maintain liaison and participation with other Governments and organisations involved with the Murray–Darling Basin and recovery efforts for threatened species and ecological communities.

### 6.5.2 Priority River Sections

Planning and conservation issues and priority actions for all the river sections and riparian zones included in the *Strategy* are contained in Table 5.1. From the foregoing, conservation actions related to the following river sections and their riparian zones warrant high priority.

#### CO 1: Paddys River

**Key issues:**

- Weed infestation.
- Degraded in-stream and riparian habitat.
- Sedimentation.
- Loss of ecological connectivity.
- Potential impacts of provision of recreational facilities associated with recovery from January 2003 bushfires.
- Potential for reinstatement of threatened fish populations.

#### CO 4: Cotter River (below Bendora Dam to Cotter Dam)

**Key issues:**

- Post-fire recovery following January 2003 bushfires.
- Future land use, riparian protection and management.

- Weeds (including pine wildings).
- Issues related to threatened fish species (see Table 5.1).
- Altered flow patterns and thermal pollution.

**MO 2: Molonglo River—Molonglo Gorge to Lake Burley Griffin**

**Key issues:**

- Management responsibility.
- Weed infestation (especially willows).
- Poor water quality (impoverished macroinvertebrate assemblages).
- Riparian ecological connectivity.

**MO 3: Molonglo River—Scrivener Dam to Coppins Crossing**

**Key issues:**

- Management responsibility.
- Weed infestation (especially willows and other woody weeds).
- Poor water quality (bottom discharge from Scrivener Dam).
- Potential urban edge effects.
- Riparian ecological connectivity.
- Poor knowledge of aquatic biodiversity

### 6.5.3 Implementation

Implementation of priority actions across all river sections and their riparian zones (s. 6.5.1) and for high priority sections (s. 6.5.2) depends upon a variety of government administrative processes including implementing existing planning and management policies adopted under the *Territory Plan* and the *Land (Planning and Environment) Act 1991*. Briefly these are:

- Applying the *Strategy* and the information it contains to future planning proposals in the ACT.
- Applying the Policies of the *Territory Plan* relevant to the rivers and riparian zones, in particular: Part B13: River Corridors Land Use Policies; Appendix I: Water Use and Catchment Policies; Appendix II: Mandatory Preliminary Assessment.
- Completing and keeping under review, Land Management Agreements between Environment ACT and landholders of rural leases.
- Carrying out the management activities and programs detailed in existing management plans;
- Preparing management plans for Public Land areas consistent with the requirements of the *Land (Planning and Environment) Act 1991* (s. 197 (1)).
- Reviewing and revising management plans taking into account legislative requirements, changing circumstances and new information.
- Coordinating the activities of Government agencies and other organisations involved in water resource management in the ACT.
- Based on the results of survey and monitoring, nomination of species and/or ecological communities for consideration by the ACT Flora and Fauna Committee as threatened species under the *Nature Conservation Act 1980*.
- Implementing best practice management of the rivers and riparian zones managed by Environment ACT as well as areas managed by other agencies, organisations and individuals.

Promoting cross border cooperation amongst ACT and NSW government agencies and other stakeholders aimed at coordinated conservation planning and management activities. This will maximise the opportunities to achieve regional targets for biodiversity conservation.

APPENDIX

# 1 Threatened Riparian Species in the ACT (Listed Under the *Nature Conservation Act 1980* (ACT) and/or the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth))

## Appendix 1.1

### Tuggeranong Lignum *Muehlenbeckia tuggeranong*

In accordance with section 21 of the *Nature Conservation Act 1980*, the **Tuggeranong Lignum (*Muehlenbeckia tuggeranong*)** was declared an **endangered** species on 7 August 1998 (Instrument No. 192 of 1998). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Aquatic Species and Riparian Zone Conservation Strategy*. This supersedes the original Action Plan (ACT Government 1999e).

***Muehlenbeckia tuggeranong*** is a declared endangered species under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

**Conservation Status (ACT) Endangered**

**Criteria satisfied (ACT Flora and Fauna Committee 1995)**

The species is observed, estimated, inferred or suspected to be at risk of premature extinction in the ACT region in the medium-term future, as demonstrated by:

- Extremely small population.

#### SPECIES DESCRIPTION

The Tuggeranong Lignum *Muehlenbeckia tuggeranong* Mallinson (Figure 1) is a sprawling or procumbent shrub, eventually becoming a mounded loosely tangled mass to approximately 1 m high and 1–2 m across. Stems are wiry, brownish, and weakly and irregularly longitudinally striate. Leaves are alternate, persistent, green, not glaucous, simple, petiolate, solitary and well-spaced along the stems. Petioles are 0.5 to 3 mm long and leaf blades 5–13 mm long by 2–4 mm wide, showing considerable variation in form. Inflorescences are terminal (sometimes on short lateral branches) or very rarely axillary, simple or 2-branched; range from 12–20 mm from the subtending leaf to the apex; and bear 3–9 flowers in a lax spike. Flowers are unisexual or rarely hermaphrodite, and cream-green in colour. Plants are also mostly unisexual.

The species was formally described by Makinson and Mallinson (1997).

#### DISTRIBUTION AND ABUNDANCE

*M. tuggeranong* was described from a single female plant and six male plants discovered in the Murrumbidgee River Corridor (MRC) near Tuggeranong in 1997. In May 1999, an additional male plant was discovered in the MRC a short distance from the other seven plants. Although extensive searches have been undertaken, (R. Makinson pers. comm.), this population appears to be the only one in existence.

*M. tuggeranong* is similar in many respects to *M. axillaris* which occurs at higher altitudes (680–1200 m asl) in the ACT, NSW Southern Highlands, Victoria, Tasmania and New Zealand (Makinson and Mallinson 1997). The nearest known occurrences of *M. axillaris* to the *M. tuggeranong* site are about 25 km east-south-east in the Googong Reservoir area (altitude c. 680 m), and 35 km to the west-north-west on the upper Cotter River system (altitude c. 1010 m) (Makinson and Mallinson 1997).

#### HABITAT

The known habitat of the species is restricted to flood terraces, altitude c. 550 m, on the eastern bank of the Murrumbidgee River near Tuggeranong in the ACT, in areas of rocky outcrops with pockets of silty sandy soil (Makinson and Mallinson 1997).

*M. tuggeranong* is found in a highly disturbed riparian shrubby woodland association, heavily invaded by exotic weeds. The tree layer is largely remnant. The species is found on nearly bare rock, or tangled amongst other vegetation (D. Mallinson pers. comm.).

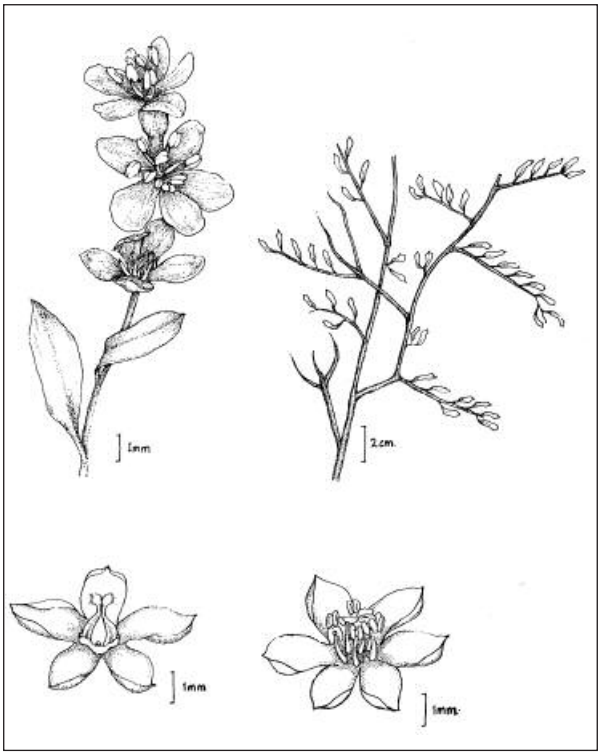



**Figure 1: Muehlenbeckia tuggeranong**
*Top:* Left—flowers and leaves;
Right—stems and leaves.
*Bottom:* Left—detail of female flower;
Right—detail of male flower.

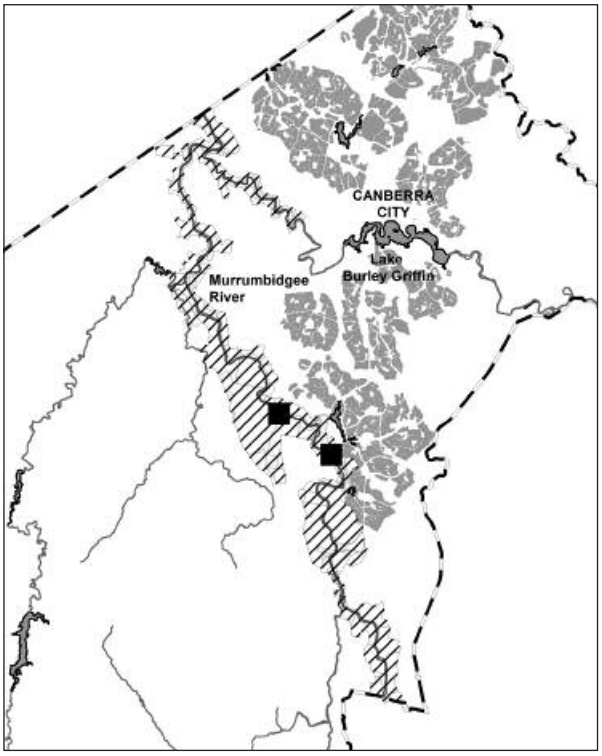



**Figure 2: Map showing location (■) of M. tuggeranong**
(Hatched area represents the Murrumbidgee and Molonglo River corridors)

Associated native species include River Oak *Casuarina cunninghamiana*; *Burgan Kunzea ericoides*; Silver Wattle *Acacia dealbata*; *Grevillea juniperina*; Purple Loosestrife *Lythrum salicaria*; Narrow-leaved Cumbungi *Typha domingensis*; a sedge *Isolepis* sp.; Common Tussock Grass *Poa labillardieri* and Common Reed *Phragmites australis*. There are also a range of introduced species including White Willow *Salix alba*; Briar Rose *Rosa rubiginosa*; Great Mullein *Verbascum thapsus*; *Oenothera* sp.; Viper's Bugloss *Echium vulgare*; Fennel *Foeniculum vulgare*; Lamb's Tongue *Plantago lanceolata*; Curled Dock *Rumex crispus*; St John's Wort *Hypericum perforatum*; Umbrella Sedge *Cyperus eragrostis*; Phalaris *Phalaris aquatica*; African Lovegrass *Eragrostis curvula* and Yorkshire Fog *Holcus lanatus* (D. Mallinson pers. comm.).

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 severity burnt the area in January 2003. A subsequent survey showed the recovery of all plants from basal shoots (Carey *et al.* 2003).

# Appendix 1.2

## Pink-tailed Worm Lizard *Aprasia parapulchella*

The Pink-tailed Worm Lizard has Special Protection Status in the ACT under s. 16 of the *Nature Conservation Act 1980*. The species is listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).


**Figure 1: Pink-tailed Worm Lizard (*Aprasia parapulchella*)**

### SPECIES DESCRIPTION

The Pink-tailed Worm Lizard *Aprasia parapulchella* is a member of the family Pygopodidae (legless lizards). The family contains 36 species in eight genera (NSW NPWS 1999). The Pink-tailed Worm Lizard was described by Kluge (1974) from 20 specimens collected from the type locality at Coppins Crossing in the ACT and one specimen from Tarcutta, New South Wales.

All pygopodids are small, slender lizards with a worm like appearance (Figure 1). They have an elongate body form and reduced limbs. The Pink-tailed Worm Lizard has a maximum snout–vent length of about 14 cm, and a total length of about 24 cm (Jones 1992). The ear opening is absent and the hind limb flaps are reduced to a single scale. The species has a dark brown to black head region and a grey to grey-brown body colour, becoming pink or reddish-brown beneath the tail. The body appears to have faint longitudinal lines on the upper surface because of the presence of a dark dot or longitudinal bar at the centre of each scale (Osborne and Jones 1995).

### DISTRIBUTION AND ABUNDANCE

It is likely that the Pink-tailed Worm Lizard was formerly widespread in south-eastern Australia. However, it now occurs in disjunct populations in an altitudinal range 300–800 m. In the 1990s, the species was thought to be largely restricted to the ACT, where numerous populations have been recorded; however, surveys in recent years have revealed that it has a wider distribution (Osborne and Coghlan 2004).

In the ACT, the species has a widespread but patchy distribution in the hilly slopes of the Molonglo and Murrumbidgee river valleys and on hills such as Mt Taylor and Googong Hill (Osborne and Coghlan 2004). There are records from a number of locations in NSW adjacent to the ACT including Dog Trap Road (16 km north of the ACT), Queanbeyan, Burra and Googong Reservoir (NSW NPWS 1999). Other outlying NSW populations occur at Tarcutta, Cootamundra, West Wyalong, Yass, Cooma and Bathurst. The species (or a closely related species) has been recently reported from Goulburn River National Park (near Merriwa and Mudgee). There is also a report from near Bendigo in Victoria (Osborne and Coghlan 2004).

The Pink-tailed Worm Lizard generally occurs in low abundance at individual sites, however, there is some uncertainty with regard to abundance due to the difficulty in obtaining population estimates. Low population counts reflect the difficulty in locating individuals and the small size of populations also relates to the small size of remaining habitat patches (NSW NPWS 1999). Populations tend to be higher than indicated by single surveys, with one ACT site having at least four times more animals than was initially recorded (Jones 1999).

Accurate estimates of the sizes of Pink-tailed Worm Lizard populations are difficult to obtain because of low recapture rates for the species. Density estimates based on the number of rocks turned to find the species tend to be low, with the highest density recorded by Jones (1999) as 9.1 lizards per 1000 rocks turned at Mt Taylor, ACT. Density estimates at a Bathurst site were 5.7 lizards per 1000 rocks turned (NSW NPWS 1999).

### HABITAT

Key habitat features for the presence of the Pink-tailed Worm Lizard are a cover of native grasses, particularly Kangaroo Grass (*Themeda triandra*), sparse or no tree cover, little or no leaf litter, and scattered small rocks with shallow embedment in the soil surface (Osborne *et al.* 1991).

The distribution of the species is centred on the ACT and this appears to be related to less soil (and rock) disturbance evidenced by the presence of a native grass cover, particularly Kangaroo Grass *Themeda triandra*, Red-leg Grass *Bothriochloa macra*, and

Wattle Mat-rush *Lomandra filiformis*. The likelihood of occurrence of the lizard increases with increasing cover of Kangaroo Grass. By contrast, increase in cover of speargrasses (*Stipa falcata, S. bigeniculata*) (which may indicate disturbance) and Common Tussock Grass *Poa labillardieri* decreases the likelihood of finding the species (Osborne and Coghlan 2004). In NSW sites, dominance by Kangaroo Grass is not a common feature, but the sites would still be described as native grassland (NSW NPWS 1999).

Livestock grazing and agricultural activities (e.g. pasture improvement, cropping) have probably had the most impact on populations of the species through ground disturbance and changes to groundcover vegetation, and remain a threat to the lizard outside reserves. Rocks are an important micro-habitat feature for the species and rock removal is a threat.

At most sites the Pink-tailed Worm Lizard is found sheltering beneath partially embedded rocks. Rocks most commonly used are 100–150 mm wide, 120–220 mm long and 50–150 mm thick (Jones 1999). Rocks are used for thermo-regulation, with lizards preferring rocks in direct sunlight (Barrer 1992b). Individuals may remain with the same rock for long periods. The lizards utilise ant burrows beneath the rocks and it is likely they retreat deeper into burrows during hot, dry weather (Osborne and Jones 1995).

**BEHAVIOUR AND BIOLOGY**

The Pink-tailed Worm Lizard lives a largely subterranean existence apparently spending a considerable time in burrows constructed by and often still inhabited by ants. Little is known of their movements within or between habitat patches. There is some evidence of movement (e.g. capture in pitfall traps) and research on other *Aprasia* spp. indicates considerable movement. Movement between habitat sites is likely to be hindered by the fragmentation and isolation of these sites (NSW NPWS 1999).

The species is oviparous (egg-laying) with a clutch size of two. Data on the few lizards found when gravid, suggest that only larger females produce eggs, and therefore, they may need to be three or four years old to reproduce (Jones 1999). The oviposition site may be within ant nests, but there is no evidence to support this. Gravid specimens have been found in December and hatching may occur in March, the time when the smallest juveniles have been collected (NSW NPWS 1999).

The Pink-tailed Worm Lizard is known to live with at least fifteen species of ants and one species of termite. Jones (1999) found that 75% of all lizards captured were beneath rocks in the nests of ants. Over 50% of all co-habitations were with the ant species group *Iridomyrmex 'rufoniger'* (Jones 1999). This is the dominant ant species in the diet of the Pink-tailed Worm Lizard, with eggs and larvae being the main food, and adults ingested infrequently and probably accidentally (NSW NPWS 1999).

APPENDIX

# 2 Threatened Aquatic Species in the ACT (Listed Under the *Nature Conservation Act 1980* (ACT)

## Appendix 2.1

### Two-spined Blackfish (*Gadopsis bispinosus*)

In accordance with section 21 of the *Nature Conservation Act 1980*, the **Two-spined Blackfish (*Gadopsis bispinosus*)** was declared a **vulnerable** species on 27 December 1996 (formerly Instrument No. 1 of 1997 and currently Instrument No. 192 of 1998). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Aquatic Species and Riparian Zone Conservation Strategy*. This supersedes the original Action Plan (ACT Government 1999a).

**Conservation Status (ACT) Vulnerable**

**Criteria satisfied (ACT Flora and Fauna Committee 1995)**

The species is observed, estimated, inferred or suspected to be at risk of premature extinction in the ACT region in the medium-term future, as demonstrated by:

- Current serious decline in population or distribution from evidence based on:
  —direct observation, including comparison of historical and current records.
- Imminent risk of serious decline in population or distribution from evidence based on serious threat from predators, parasites or competitors.
- Seriously fragmented distribution for a species currently occurring over a moderately small range or having a moderately small area of occupancy within its range.

#### SPECIES DESCRIPTION AND ECOLOGY

The Two-spined Blackfish *Gadopsis bispinosus* is a member of the family Gadopsidae, commonly known as blackfish, which is endemic to south-eastern Australian freshwater habitats. The Gadopsidae contains a single genus, *Gadopsis*, which has two species currently described; the Two-spined Blackfish *G. bispinosus* and the River Blackfish *G. marmoratus*. *G. bispinosus* can be distinguished from *G. marmoratus* by the presence of only two (range 1–3) instead of 11 (range 6–13) dorsal fin spines (Sanger 1984). *G. bispinosus* also has a distinct white edge on the dorsal, anal and caudal fins which *G. marmoratus* lacks.

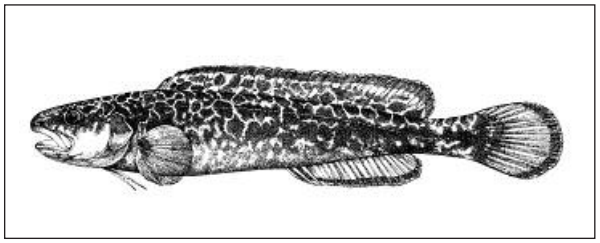


**Figure 1: Two-spined Blackfish (*Gadopsis bispinosus*)**

#### Description

*G. bispinosus* is a small to medium sized species with a relatively large head with rounded snout (Figure 1). The maximum total length for *G. bispinosus* is 300–350 mm. Most specimens in the Canberra region are less than 250 mm total length (Lintermans 1998a). *G. bispinosus* has a large mouth with fleshy lips, with the upper jaw overhanging the lower. The body is narrow and slightly compressed with long, low dorsal and anal fins. The pelvic fins are reduced to single bifid rays and are jugular in position. The scales are very small and the body heavily coated in slime. The colouration is variable, usually a yellowish-brown at the base, with two to three rows of dark brown blotches running the entire body length and extending onto the dorsal, anal and caudal fins. The ventral surface is uniformly pale to the origin of the anal fin. The outer edges of the dorsal, anal and caudal fins are pale or white, and are often bordered by an intense dark stripe (Jackson *et al.* 1996). Sexes are generally indistinguishable except during the breeding season when gravid females have eggs visible through the body wall.

**Habitat**

*G. bispinosus* only occurs in inland drainages of south-eastern Australia, where it is restricted to cool, clear upland or montane streams with abundant instream cover, usually in the form of boulders and cobble (Sanger 1984; Koehn 1987, 1990; Lintermans 1998a). In contrast, *G. marmoratus* occurs in slower-flowing lowland streams and has a requirement for log debris for spawning. *G. bispinosus* is more often found in the medium to larger streams where there is greater water depth and lower stream velocity. It is not found in the smallest headwater streams (Lintermans and Rutzou 1990a, 1990b; Lintermans unpubl. data). *G. bispinosus* is generally found in forested catchments, where there is little sediment input to the stream from erosion or land management practices.

**Behaviour and Biology**

There has been little published on the behaviour or biology of *G. bispinosus* with most information residing in an unpublished thesis (Curmi 1996) and ongoing research projects (J. Kalish, Division of Botany and Zoology, ANU, pers.comm.). Most of the information for the Canberra region is based on Lintermans (1998a). Life history information is difficult to gather for fish species as they are not easily observed in their aquatic habitats. The dark colouration and patterning of *G. bispinosus* makes it difficult to observe, even in shallow clear streams.

The diet is characterised by a predominance of aquatic insect larvae, particularly mayflies, caddisflies and midges. Terrestrial insects also make up a significant part of the diet, indicating the importance of intact riparian vegetation communities as a food source, for their associated insect fauna that falls onto the water. Young-of-year and juvenile blackfish eat proportionally more mayfly and midge larvae than adult fish, which consume larger items such as caddisfly larvae and terrestrial invertebrates.

Movement of *G. bispinosus* is extremely limited with the home-range of adult fish estimated at approximately 15 metres. Home-ranges are maintained from year to year, with fish thought to avoid the high velocity winter flows by sheltering amongst the rocks and boulders on the stream bed. Home-range in *G. marmoratus* is also limited and is estimated at approximately 20 metres (Koehn 1986).

Breeding is seasonal with egg laying commencing in November, probably induced by a relatively rapid rise in water temperature.

Fecundity is low and is positively correlated with fish length. Females are thought to commence breeding in their second or third year. Between 80 and 420 eggs are laid (Sanger 1986, 1990; Lintermans 1998a) in a single egg mass but the natural spawning sites are unknown. *G. bispinosus* will lay eggs inside PVC pipes placed into streams, and it is thought that all eggs are released at once, and that each egg mass is from a single female. It is suspected that the natural spawning site is on the underside of boulders or cobble (Lintermans 1998a).

The eggs are large (~3.5 mm diameter), yolky and adhesive, and are guarded by the male fish until the larvae have almost fully exhausted the yolk reserves and are free-swimming. Hatching occurs after approximately 16 days at a water temperature of 15˚C, with the large yolk sac remaining inside the ruptured egg membrane, effectively tethering the young to the spawning substrate until the yolk has been consumed (Lintermans 1998a). The larvae have almost fully consumed the yolk after approximately three weeks and then leave the spawning site, with the male guard fish also leaving.

In the upper Cotter River, *G. bispinosus* is known to be host to a small (~5mm) Glossiphonid leech of unknown species. Numerous small red bite marks are often observed on mature fish, although the leeches are rarely seen (Lintermans unpubl. data). Leeches are extremely rare on Australian freshwater fish species with only one other instance of leech attack documented (Cadwallader 1978b). *G. bispinosus* in the upper Cotter River are also known to carry the native parasitic fluke *Phyllodistomum magnificum* (Cribb 1987) which has been recorded in the bladder of infected animals (Lintermans unpubl. data).

**DISTRIBUTION**

There is little information on the historical distribution of *G. bispinosus* owing to the relatively recent description of the species. All descriptions made prior to 1984 referred to 'blackfish', with no distinction being made between *G. bispinosus* and *G. marmoratus*. Museum collections have revealed only four specimens of *G. bispinosus* collected prior to the late 1970s, all being from the Canberra region. Two were collected from the Goodradigbee River catchment in 1931, one from the Geehi River in Kosciuszko National Park in 1975, and the other from the Murrumbidgee River (ACT) in 1962 (Lintermans 1998a).

**Historical Distribution**

There is little historical information to assess whether the distribution of the species has changed over time. However, the distinct and different habitat preferences of the two inland blackfish species (*G. bispinosus* and

northern *G. marmoratus*) facilitate interpretation of some of the old literature records of 'blackfish'.

The records of blackfish from the Snowy River system (Llewellyn 1983; Tuma c1963; Tilzey 1969) can be assumed to be southern *G. marmoratus* as this is the only blackfish species found in coastal drainages. Both Stead 1908 (in Ogilby 1913) and Whitley (1964) note that blackfish were reportedly introduced into the Snowy River system but the origin of these introductions (and hence the species involved) were not mentioned.

Macleay (1885) commented on a specimen of *Gadopsis* sp. collected from the 'Little River near Yass'. The Little River is a local name for the Goobarragandra River where *G. bispinosus* was collected recently (Lintermans 1998a). Stead (1908) records the distribution of blackfish in NSW as 'the upland streams of the southern highland' but does not provide precise localities. However, some years later (in Ogilby 1913) Stead lists the 'Yarrangobilly River, Jounama Creek, Goobarragandra River, Adjungbilly Creek and other feeders of the Tumut River, the Tumut itself, the Upper Murrumbidgee, the Upper Snowy and its feeders...'. All of these streams with the exception of the upper Snowy and its tributaries would probably refer to *G. bispinosus*.

There are anglers' records of blackfish captures, probably of *G. bispinosus*, from the Yarrangobilly River prior to the early 1960s (Lintermans 1998a). Recent surveys in the Yarrangobilly River failed to locate any blackfish.

Similarly, there were a number of anglers' records of blackfish from the Goodradigbee drainage, with two specimens of *G. bispinosus* (collected in 1931) lodged in the Australian Museum. Four sites on the Goodradigbee River itself were sampled (Lintermans 1998a) but no blackfish were caught. A further five sites on tributary streams were sampled with *G. bispinosus* recorded in low numbers at one site on Micalong Creek, the collection locality of the 1931 specimen. As with the Yarrangobilly River, the Goodradigbee River contains excellent habitat for *G. bispinosus* but the species now appears to be largely absent or present in low numbers only.

Blackfish were known to be present in the Murrumbidgee River in the ACT until the 1960s (Jorgensen 1983; Greenham 1981) although their specific identity was unknown (Lintermans 1991a). The last reported capture of a blackfish in the Murrumbidgee in the ACT was in the mid-1970s (Lintermans 1998a). The only blackfish specimen known from the Murrumbidgee River in the ACT is of *G. bispinosus* and this is the only blackfish species known from the ACT and immediate surrounds. It is reasonable to assume that this was the only blackfish species present in the Murrumbidgee River. No blackfish have been recorded in the Murrumbidgee River in the ACT since the mid 1970s, although the species still occurs in the headwaters of the river (NSW Fisheries unpubl. data).

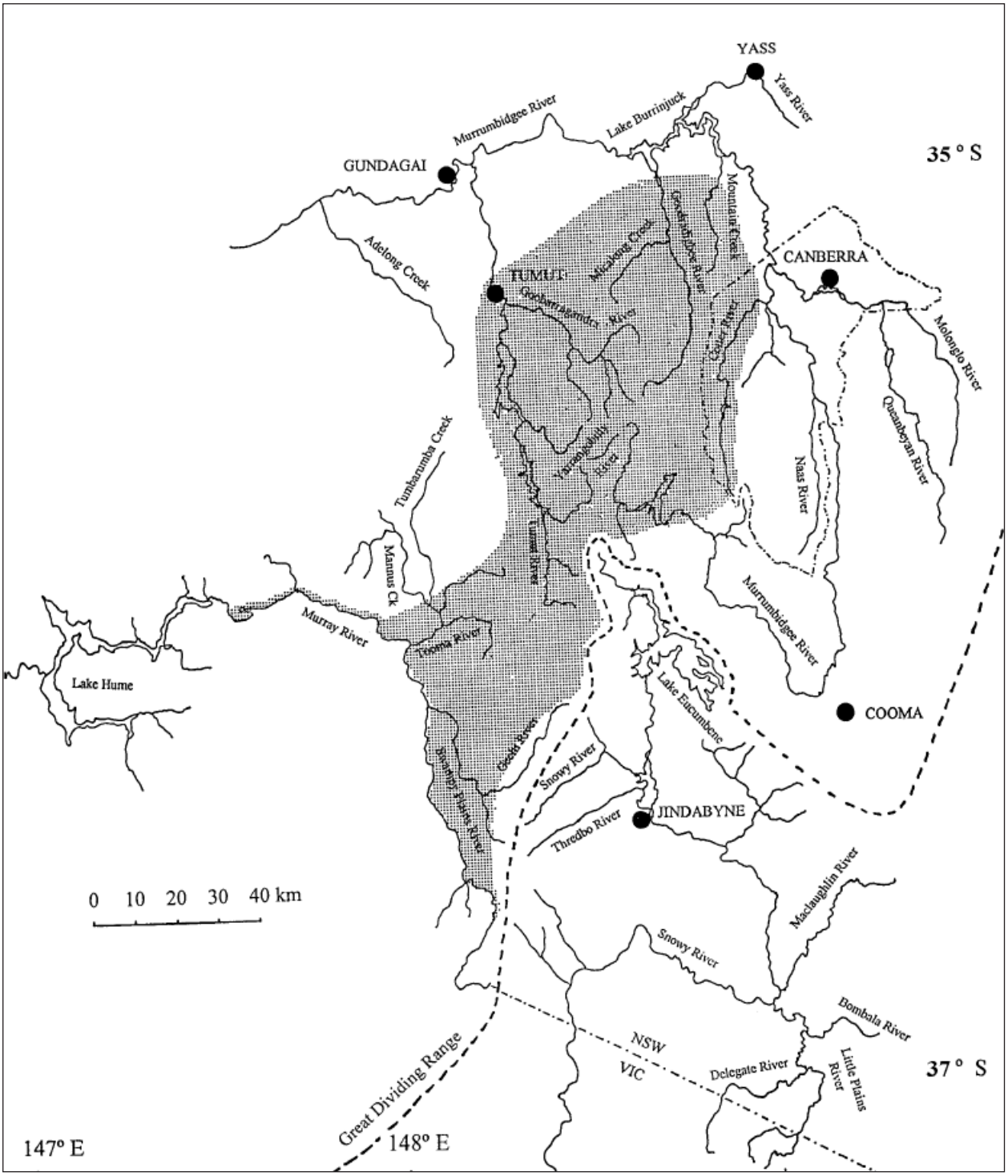
**Present Distribution**

The present distribution of the species covers a narrow band from north-eastern Victoria, extending through south-eastern NSW to the ACT, which is at the northern extremity of its range (Koehn 1990; Lintermans and Rutzou 1990a; Lintermans 1998a) (Figure 2).

An extensive survey of the NSW southern highlands (Lintermans 1998a) located *G. bispinosus* in the following stream systems:

- the upper Murray, including the lower reaches of the Swampy Plains, Tooma and Geehi Rivers;
- the upper Tumut system, including the lower reaches of the Goobarragandra River;
- the Goodradigbee River;
- Mountain Creek; and
- the upper Murrumbidgee River between Yaouk and Cooma.

In the ACT, the species is now found only in the Cotter River catchment upstream of the Cotter Dam.




Distribution of Two-spined Blackfish

**Figure 2: Distribution (1998) of Two-spined Blackfish in the ACT Region**

(Source: Redrawn from Lintermans 1998a)

# Appendix 2.2

## Trout Cod (*Maccullochella macquariensis*)

In accordance with section 21 of the *Nature Conservation Act 1980*, the **Trout Cod (*Maccullochella macquariensis*)** was declared an **endangered** species on 27 December 1996 (formerly Instrument No. 1 of 1997 and currently Instrument No. 192 of 1998). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Aquatic Species and Riparian Zone Conservation Strategy*. This supersedes the original Action Plan (ACT Government 1999b).

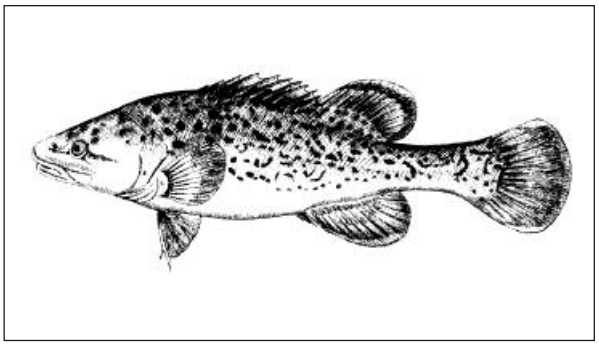


**Figure 1: Trout Cod (*Maccullochella macquariensis*)**

**Conservation Status (ACT) Endangered**

**Criteria satisfied (ACT Flora and Fauna Committee 1995)**

The species is known or suspected to occur in the ACT region and is already recognised as endangered or presumed extinct in an authoritative international or national listing.

The species is observed, estimated, inferred or suspected to be at risk of premature extinction in the ACT region in the near future, as demonstrated by:

- Current severe decline in population or distribution from evidence based on:
  - —direct observation, including comparison of historical and current records;
  - —severe decline in rate of reproduction or recruitment; severe increase in mortality; severe disruption of demographic or social structure; and
  - —very high actual or potential levels of exploitation or persecution.

### SPECIES DESCRIPTION AND ECOLOGY

The Trout Cod *Maccullochella macquariensis* is a member of the Percicthyidae, which contains the Australian freshwater basses and cods. The family contains two genera in eastern Australia: *Maccullochella* and *Macquaria*. Other species in the genus *Maccullochella* include the well known Murray Cod (*M. peelii peelii*), the nationally threatened Mary River Cod (*M. peelii mariensis*) and Eastern Freshwater Cod (*M. ikei*). *M. macquariensis* is similar in appearance to *M. peelii peelii* and was only formally recognised as a distinct species in the 1970s (Berra and Weatherley 1972).

#### Description

M. macquariensis is a large elongate deep-bodied fish (Figure 1), slightly laterally compressed and very similar to *M. peelii peelii*. The dorsal profile of the head is straight whereas in *M. peelii peelii*, it is concave. The mouth is terminal and large with the gape extending to behind the posterior of the eye. The upper jaw overhangs the lower jaw whereas in *M. peelii peelii*, the lower jaw is equal or protruding. The dorsal colouration is generally blue-grey with small dark grey to black spots or dashes, extending to the lower sides. The ventral surface is light grey to white. Adult and juvenile *M. macquariensis* have a dark stripe through the eye.

In contrast, the dorsal colouration of *M. peelii peelii* is typically olive-green to yellow-green with dark mottling (rather than spotting) extending to the lower sides. *M. peelii peelii* juveniles may have a dark eye stripe but it rarely persists in fish greater than 150 mm total length.

Maximum size of *M. macquariensis* is 16 kilograms and approximately 700 mm but fish over 3 kilograms are rare.

#### Habitat

The historical habitat preferences of *M. macquariensis* were never documented and the rivers where the species formerly occurred have probably changed dramatically since the species inhabited them. The two localities where the species currently survives and breeds are quite different in character. The Murray River from Yarrawonga to Cobram is a large (60–100 m wide), slow flowing and deep (>3 m) river with a sand, silt and clay substrate, and contains abundant snags and woody debris. Seven Creeks (Victoria) is a relatively narrow (5–7 m wide) stream having a rock, gravel and sand substrate. The pools are generally less than 2 m deep and are interspersed by rapids and cascades (Douglas *et al.* 1994).

The physical characteristics of the Murrumbidgee River in the ACT are intermediate between Seven Creeks and the Murray River. In general, it appears that *M. macquariensis* adults are essentially a pool-dwelling, cover-seeking fish.

**Behaviour and Biology**

There has been little published on the behaviour or biology of *M. macquariensis* with much information residing in ongoing research projects. The most comprehensive summary of information is by Douglas *et al.* (1994) from which much of the following information is taken.

The species is a carnivorous, top-order predator with the diet including freshwater crustaceans such as yabbies, crayfish and shrimp, as well as fish and aquatic insects. In Bendora Reservoir they have been recorded as eating yabbies, mudeyes, blackfish and the occasional frog.

Like *M. peelii peelii, M. macquariensis* is believed to form pairs and spawn annually, usually in spring and probably in response to increasing day-length and water temperature. The fertilised eggs are adhesive, demersal, opaque and 2.5–3.6 mm in diameter. It is thought that the eggs are laid on a hard substrate such as submerged logs, clay banks or rocks. The eggs hatch 5–10 days after fertilisation at 20˚C with newly hatched larvae being approximately 6–9 mm total length. Larvae begin feeding about 10 days after hatching.

The species reaches sexual maturity when younger and smaller (3–5 years, 0.75–1.5 kg) than *M. peelii peelii* (4–6 years, 2–2.5 kg).

It has been suggested that *M. macquariensis* was more common in the cooler, upper reaches of rivers (Cadwallader and Backhouse 1983) but there is little evidence to support this suggestion. Certainly the one remaining natural population in the Murray River below Yarrawonga does not fit this model. In the Murray River, *M. macquariensis* is usually found associated with snags and wood debris in areas of relatively fast flowing current. Unpublished research suggests that the species prefers deeper, faster water than *M. peelii peelii* in this location (J. Koehn pers. comm.). In Seven Creeks, larger *M. macquariensis* individuals are often found in the deeper pools but smaller fish have also been captured amongst boulders, logs and other cover in shallower waters.

**DISTRIBUTION**

*M. macquariensis* was once widespread in the southeastern region of the Murray–Darling Basin with records from the Murray, Murrumbidgee and Macquarie rivers in New South Wales/Australian Capital Territory and the Goulburn, Broken, Campaspe, Ovens, King, Buffalo and Mitta Mitta rivers in Victoria (Berra and Weatherley 1972; Cadwallader and Gooley 1984; Cadwallader 1977; Greenham 1981).

In the Canberra region, the last recorded capture of the species was from the Gigerline Gorge on the Murrumbidgee River in the late 1970s (Lintermans *et al.* 1988). The report of *M. macquariensis* from the Molonglo River (Merrick and Schmida 1984) appears to be an error as no reliable record from this locality is known. Recent fish surveys of the Murrumbidgee River in the ACT have failed to locate *M. macquariensis* (Lintermans 1995a, 1997, 1998b, unpubl. data).

There are now only two self-supporting populations remaining, one in the Murray River below Yarrawonga and the other in Seven Creeks above Euroa in Victoria. The Seven Creeks population is the result of translocations of ‘cod’ from the Goulburn River in 1921 and 1922 (Douglas *et al.* 1994).

As part of a national recovery plan, *M. macquariensis* is being artificially bred by both the New South Wales and Victorian fisheries agencies (Ingram and Rimmer 1992). The cod are then being stocked into streams (and some reservoirs) within the former range of the species. Two sites in the ACT have been stocked: 8750 fish were released into Bendora Reservoir in 1989–90 (Lintermans 1995b) and 34 500 were released into the Murrumbidgee River at Angle Crossing in 1996–1998.

The species has also been released in the Murrumbidgee River at a number of sites. These include:

- two sites near Cooma;
- one site below Adaminaby;
- one site near Gundagai; and
- one site near Wagga Wagga.

The locations of sites stocked with *M. macquariensis* in the ACT region are shown in Figure 2.

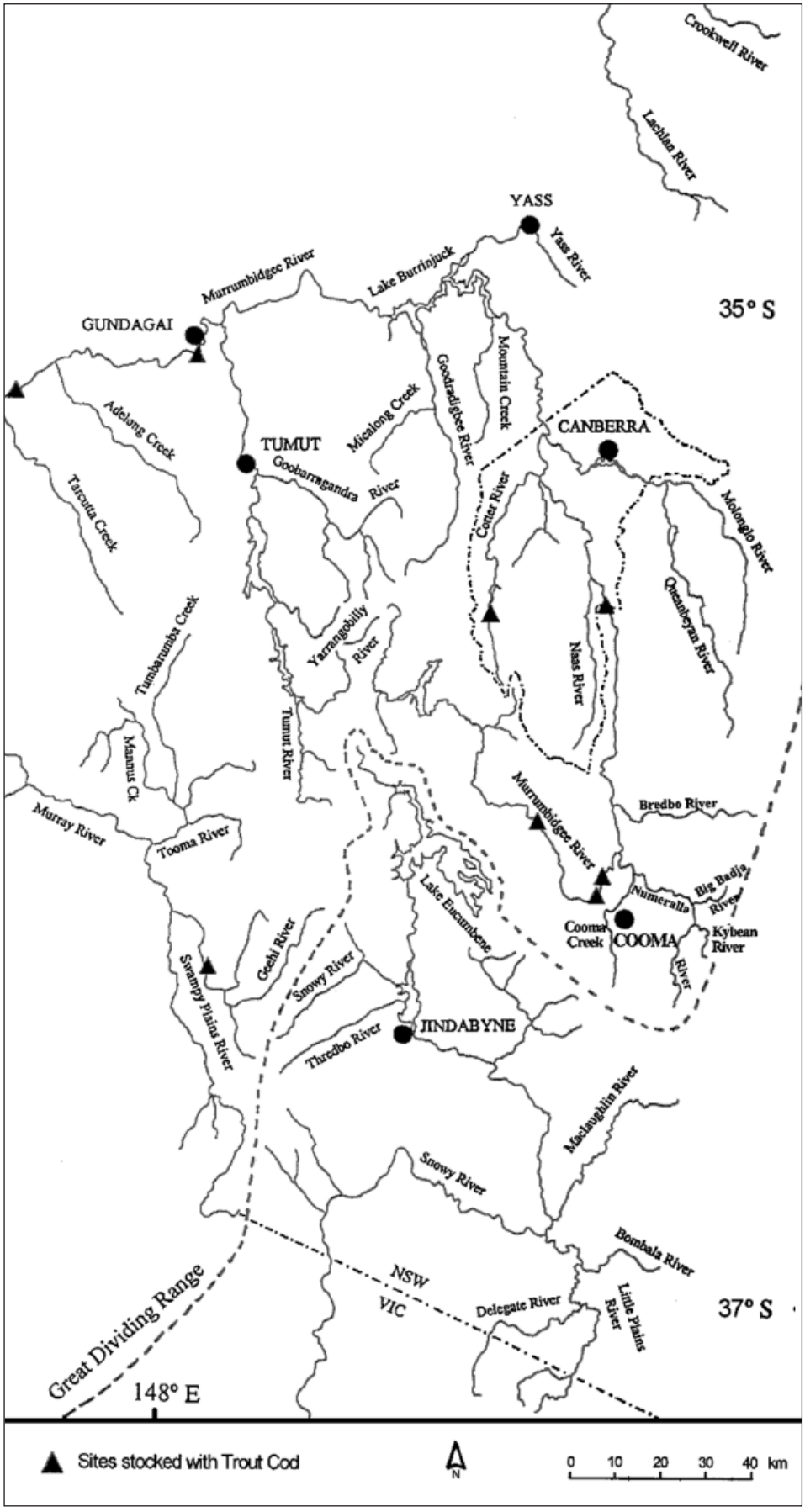



**Figure 2: Locations of Sites Stocked with Trout Cod in the ACT and Region**

# Appendix 2.3

## Macquarie Perch (*Macquaria australasica*)

In accordance with section 21 of the *Nature Conservation Act 1980*, the **Macquarie Perch (*Macquaria australasica*)** was declared an **endangered** species on 27 December 1996 (formerly Instrument No. 1 of 1997 and currently Instrument No. 192 of 1998). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Aquatic Species and Riparian Zone Conservation Strategy*. This supersedes the original Action Plan (ACT Government 1999c).

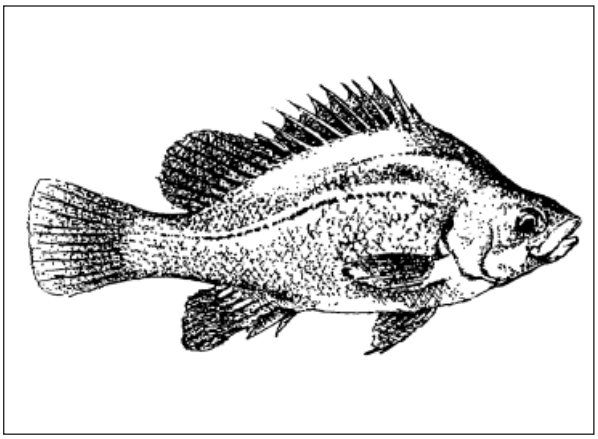


**Figure 1: Macquarie Perch (*Macquaria australasica*)**

**Conservation Status (ACT) Endangered**

**Criteria Satisfied (ACT Flora and Fauna Committee 1995)**

The species is observed, estimated, inferred or suspected to be at risk of premature extinction in the ACT region in the near future, as demonstrated by:

- Current severe decline in population or distribution from evidence based on:
  - —direct observation, including comparison of historical and current records.
  - —severe decline in rate of reproduction or recruitment; severe increase in mortality; severe disruption of demographic or social structure.
  - —severe decline in quality or quantity of habitat.
  - —very high actual or potential levels of exploitation or persecution.
  - —severe threats from herbivores, predators, parasites, pathogens or competitors.

### SPECIES DESCRIPTION AND ECOLOGY

Macquarie Perch *Macquaria australasica* is a member of the Percicthyidae which contains the Australian freshwater basses and cods. Other species in the family include the well-known Murray Cod (*Maccullochella peelii peelii*) and the nationally endangered Trout Cod (*Maccullochella macquariensis*). The genus Macquaria contains the popular angling species Golden Perch (*M. ambigua*), Australian Bass (*M. novemaculeata*) and Estuary Perch (*M. colonorum*).

#### Description

*M. australasica* is a moderately-sized, deep-bodied, laterally-compressed fish with large white eyes (Figure 1). The predominant body colour is grey to black on the dorsal and lateral surfaces with a whitish ventral surface. Colouration is variable between populations with some coastal populations being quite mottled (McDowall 1980; Merrick and Schmida 1984). The lateral line is obvious and there are conspicuous open pores on the lower jaw. Adult specimens possess a distinct 'humped back' and the tail is rounded.

The maximum size is 3.5 kg but fish over 1 kg are uncommon.

#### Habitat

The preferred habitat is cool, shaded, upland streams with deep rocky pools and substantial cover. The species will also survive well in impoundments with suitable feeder streams in which to breed. The species now seems to be confined to the upper reaches of catchments (Cadwallader 1981) that are more natural and less affected by agriculture and sedimentation.

#### Behaviour and Biology

*Macquaria australasica* are reported to live for up to 10 years (Battaglene 1988). Males reach sexual maturity at two years of age and 210 mm total length, and females at three years and 300 mm total length (Harris and Rowland 1996). Fish in reservoirs undertake a spawning migration into inflowing rivers. Fish gather in schools before spawning which can last several weeks (Battaglene 1988). Spawning occurs in late spring/summer when water temperatures reach approximately 16.5°C with fish depositing eggs above riffles or fast-flowing sections of river. The eggs are then washed downstream where they lodge in gravel or rocky areas until hatching.

Fecundity is approximately 31 000 eggs per kilogram of fish weight (Cadwallader and Rogan 1977), with females carrying up to 110 000 eggs (Battaglene 1988). Mature eggs are 1 to 2 mm in diameter and cream coloured. After fertilisation the eggs swell to approximately 4 mm diameter and are amber coloured

(Battaglene 1988). Larvae hatch in 10–11 days at water temperatures of 15–17°C (Gooley 1986) with the larvae being about 7 mm long upon hatching (Battaglene 1988).

The diet of *M. australasica* consists predominantly of small benthic aquatic insect larvae, particularly mayflies, caddisflies and midges. Shrimps, yabbies, dragonfly larvae and molluscs are also eaten (McKeown 1934; Cadwallader and Eden 1979; Butcher 1945; Battaglene 1988; Lintermans unpubl. data).

**DISTRIBUTION**

*M. australasica* is typically found in the cooler, upper reaches of the Murray-Darling river system in Victoria, New South Wales and the Australian Capital Territory. The species was introduced into some coastal drainages in the late 1800s and early 1900s. There are also some natural coastal populations in New South Wales, notably the Nepean, Hawkesbury and Shoalhaven rivers. A morphometric and genetic study in the mid 1980s suggested there were three distinct stocks of *M. australasica*, with the Murray-Darling populations being distinct from a Shoalhaven stock and a Hawkesbury stock (Dufty 1986). It was considered that these three stocks were distinct species (Dufty 1986). This study has never been published and so the conservation status of *M. australasica* has been unclear for some years. This Action Plan only relates to the Murray–Darling stock of *M. australasica*, and does not deal with the two coastal forms.

In the ACT, *M. australasica* is restricted to four rivers, the Murrumbidgee, Molonglo, Paddys and Cotter rivers. In the Cotter River, the species is restricted to the lower section of the river from its junction with the Murrumbidgee up to Vanitys Crossing (including Cotter Reservoir). Anecdotal reports indicate that the species did occur further upstream on the Cotter but has now disappeared from this area and appears unable to pass the high concrete causeway built at Vanitys Crossing in the late 1970s (Lintermans 1991). In 1985 a total of 41 individuals was removed from Cotter Reservoir as it was drained for maintenance of the dam wall. These fish were released into Bendora Reservoir but this translocation attempt appears to have failed (Lintermans unpubl. data).

Records from the Molonglo River are scarce and in recent times have only been from the lower end of the river below Lake Burley Griffin. The discharge of treated effluent from the Lower Molonglo Water Quality Control Centre since 1978 is likely to provide a chemical barrier that discourages dispersal of some native fish species from the Murrumbidgee to the Molonglo River. Scrivener Dam now prevents upstream movement of fish species from the lower Molonglo and effectively restricts access to the majority of the Molonglo River. It is likely that *M. australasica* historically occurred in the middle to upper reaches of the river but was almost certainly eliminated along with almost all other fish species due to heavy metal pollution from the Captains Flat mines. A fish survey in 1992–93 of the Molonglo River catchment from above Captains Flat to Lake Burley Griffin failed to locate the species (Lintermans unpubl. data).

The species has been recorded from along the entire length of the Murrumbidgee River in the ACT (Greenham 1981; Environment and Recreation unpubl. data) although more recent fish surveys byEnvironment ACT recorded no individuals in 1994, one in 1996 and one in 1998 (Lintermans 1995a, 1997, 1998b, unpubl. data).

The status of *M. australasica* in Paddys River is unknown as the only records from this stream are based on the results of angler interviews summarised in Greenham (1981). Environment and Recreation has not yet surveyed this catchment, however it is considered unlikely that a significant population occurs in this drainage given the lack of any angler records since the early 1980s.

In the Canberra region, *M. australasica* is also known from five other locations. These are:

- a small remnant population in the Queanbeyan River immediately upstream of Googong Reservoir;
- a population of unknown size in Burrinjuck Dam and the lower Goodradigbee River;
- a small population in the Lachlan River near Wyangla Dam;
- a population of unknown size in the Abercrombie River below Crookwell; and
- a population of unknown size in the Murrumbidgee River near Cooma.

The locations of current and unconfirmed records of *M. australasica* in the ACT region are shown in Figure 2.

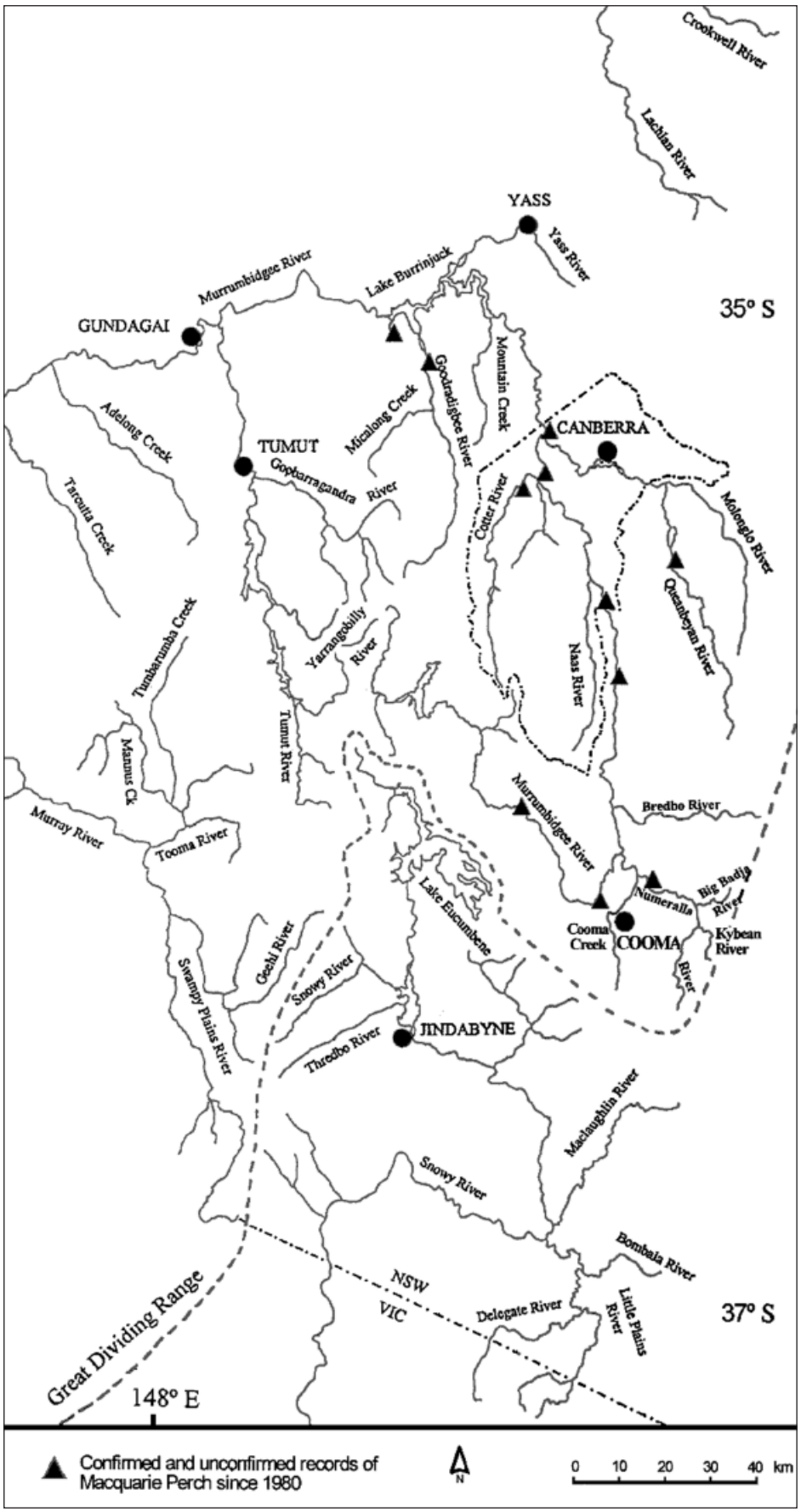



**Figure 2: Locations of Current and Unconfirmed Records of Macquarie Perch in the ACT Region**

# Appendix 2.4

## Murray River Crayfish (*Euastacus armatus*)

In accordance with section 21 of the *Nature Conservation Act 1980*, the **Murray River Crayfish (*Euastacus armatus*)** was declared a **vulnerable** species on 27 December 1996 (formerly Instrument No. 1 of 1997 and currently Instrument No. 192 of 1998). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Aquatic Species and Riparian Zone Conservation Strategy*. This supersedes the original Action Plan (ACT Government 1999d).

**Conservation Status (ACT) Vulnerable**

**Criteria satisfied (ACT Flora and Fauna Committee 1995)**

The species is observed, estimated, inferred or suspected to be at risk of premature extinction in the ACT region in the medium-term future, as demonstrated by:

- Current serious decline in population or distribution from evidence based on:
  - —direct observation, including comparison of historical and current records.
  - —a serious decline in quality and quantity of habitat.
  - —high actual or potential levels of exploitation or persecution.

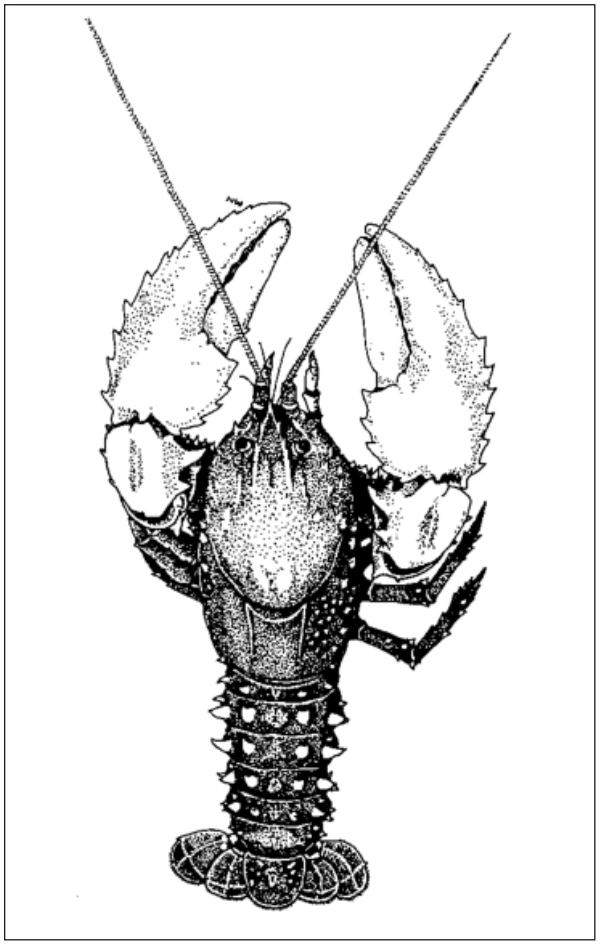


**Figure 1: Murray River Crayfish (*Euastacus armatus*)**

### SPECIES DESCRIPTION AND ECOLOGY

The Murray River Crayfish *Euastacus armatus* belongs to the family Parastacidae, which includes all the freshwater crayfish within the southern hemisphere. The family contains nine genera and approximately 100 species. The two largest genera are *Cherax* which contains the Common Yabby (*Cherax destructor*), Marron (*C. tenuimanus*) and Redclaw (*C. quadricarinatus*), and *Euastacus* which contains the spiny crays. The genus *Euastacus* includes several large crayfish species of which *E. armatus* is the largest. It is reportedly the second largest freshwater crayfish in the world, growing to 3 kg (Geddes 1990). There are 21 species of *Euastacus* known from New South Wales (Merrick 1995) but this number will increase as several new species are in the process of being described. In the Australian Capital Territory, there are three described species: *E. armatus*; *E. crassus* that lives predominantly in streams; and *E. rieki* that lives mainly in upland bogs.

#### Description

Adults average 20 to 30 cm in total length and are identified by their large white claws and ornately spined abdomen (Figure 1). The dorsal carapace colour is dark or medium green or brown, sometimes slightly tinged blue. The abdominal segments are laterally slightly tinged blue/green with the abdominal spines pale orange, cream or white. In small individuals, the claws are not white but are mottled green and yellow.

#### Habitat

*E. armatus* inhabits large and small streams in a variety of habitats including cleared pasture and dry and wet sclerophyll forests at altitudes from close to sea level to over 700 m ASL (Morgan 1986).

The species prefers faster flowing cool water habitats of the main channels of rivers, in contrast to the Yabby, which prefers slow warm water and billabongs.

**Behaviour and Biology**

*E. armatus* individuals do not reach sexual maturity until they are quite large (15 to 20 cm total length) and between six and nine years old. The larger individuals previously caught in the Murray River may have been from 20-50 years of age, but fishing pressure makes it unlikely that individuals will survive to that age now (Geddes 1990).

Between 500 and 1000 eggs are produced in late autumn and are carried on setae attached to the swimmerets under the female's abdomen throughout the winter months. Hatching occurs in spring or summer with the young remaining attached to the female for a short time (Department of Agriculture NSW 1984; Geddes 1990). The species is omnivorous, eating mainly vegetation, and scavenged fish and other animals.

*E. armatus* is active throughout the coldest months, from May until October when water temperatures are below 20ºC (Geddes 1990).

In lowland rivers such as the Murray and lower Murrumbidgee, the species constructs burrows in the clay river banks for shelter. In the upland rivers with stony beds such as the Tumut, Goobarragandra and upper Murrumbidgee, the species tends to use the interstitial spaces between boulders and cobbles on the river bed for shelter.

**DISTRIBUTION**

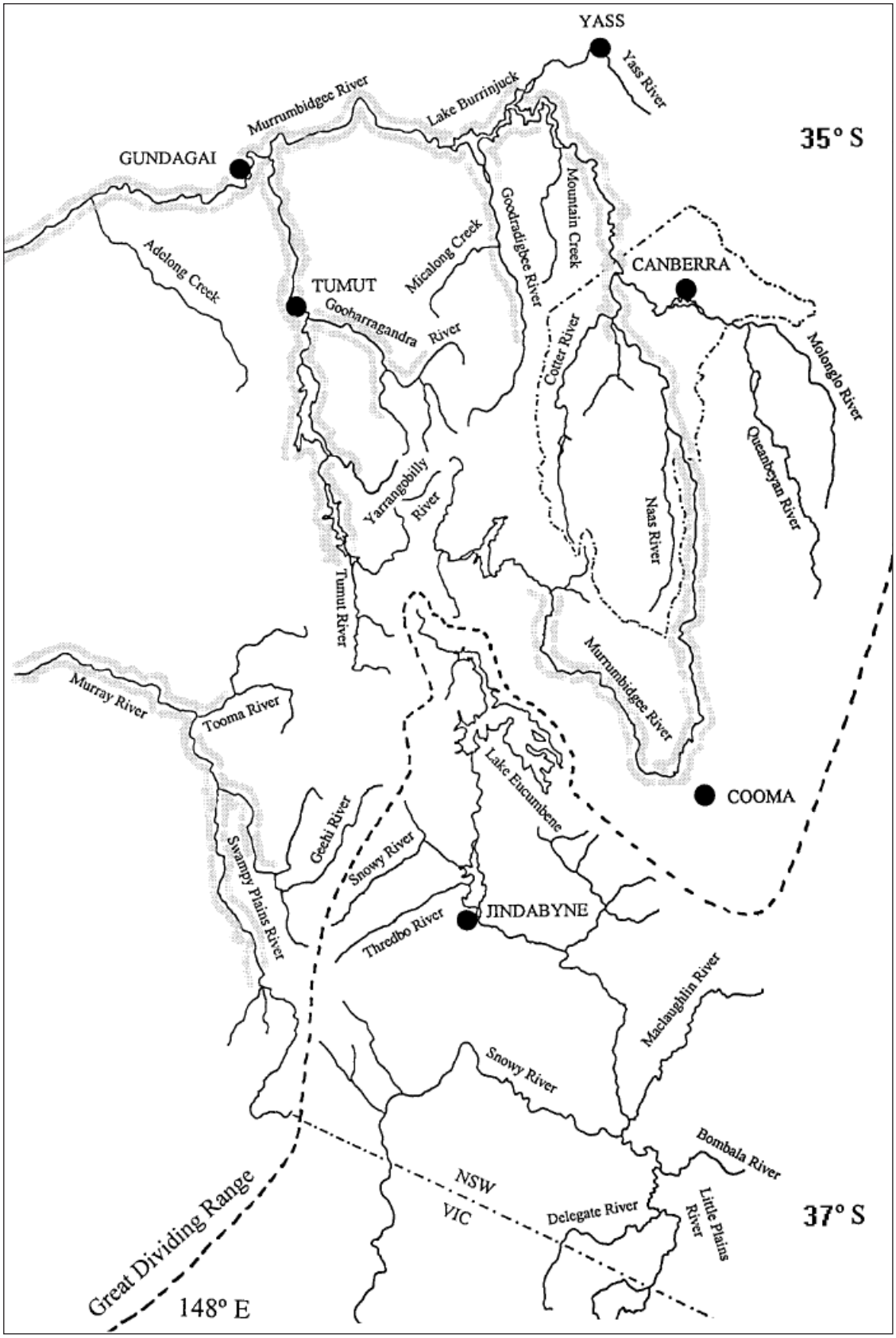
*E. armatus* has the largest geographic range of any of the spiny crayfish in Australia. While most spiny crayfish are restricted to the cooler, montane streams, the range of *E. armatus* extends into the warmer, lower reaches of the Murray-Darling Basin. Prior to the 1950s, the species was found in the Murray River for most of its length in South Australia and New South Wales, as well as occurring in its major tributaries in Victoria and New South Wales (with the exception of the Darling River). Its range extended over 800 km east-west and approximately 450 km north-south, with the most northerly record of the species near Kandos, 160 km west of Newcastle (Morgan 1986).

Within the ACT, *E. armatus* is mainly found in the Murrumbidgee River (Figure 2). The only other streams in the ACT in which the species has been reported are the Cotter River (Morgan 1986; Hogg 1990) and Paddys River (D. Roso pers. comm.). The report of this species from small montane streams in the ACT (NCDC 1984) is most likely to be an error and probably refers to the closely related *E. crassus*.

*E. armatus* is still known to occur in the section of the Cotter River below Cotter Dam. A report of the species being caught at Bracks Hole, upstream of Cotter Dam in the mid 1970s (W. Meredith pers. comm.) is unconfirmed and no recent reports are known from this area. Another spiny freshwater crayfish *E. crassus* is known to occur in the Cotter system (Lintermans unpubl. data) and misidentification of the two species by anglers is possible. Morgan (1986) records *E. armatus* from the Cotter River but does not give precise collection locality data.

In recent years in the ACT, it is suspected that *E. armatus* has been illegally translocated by anglers into a number of lakes and ponds. Water bodies in which it is suspected that the species has been introduced include Lake Ginninderra, Lake Burley Griffin, dams at the Canberra racecourse and ponds at Technology Park in Bruce. It is also likely that Murray River Crayfish have been translocated into the Yass River near Sutton in NSW. The origin of stock for most of these translocations appears to be impoundments on the Tumut River, particularly Blowering Reservoir and Jounama Pondage.

In the Canberra region, *E. armatus* is known to inhabit the Tumut and Goobarragandra River systems, with occasional reports from the Goodradigbee River (Morgan 1986; Lintermans unpubl. data). A single newspaper report from 1991 (*Queanbeyan Age* 6 May 1991) records them from the Queanbeyan River. The species was historically present in the Yass River (Bennett 1834), although its current status in this waterway is unknown. The species is also known from Lake Burrinjuck on the Murrumbidgee River downstream from Canberra.




Distribution of Murray River Crayfish

**Figure 2: Distribution (1998) of Murray River Crayfish in the ACT Region**

# Appendix 2.5

## Silver Perch (*Bidyanus bidyanus*)

In accordance with section 21 of the *Nature Conservation Act 1980*, the **Silver Perch (*Bidyanus bidyanus*)** was declared an **endangered** species on 4 September 2001 (Instrument No. 192 of 2001). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Aquatic Species and Riparian Zone Conservation Strategy*. This supersedes the original Action Plan (ACT Government 2003).

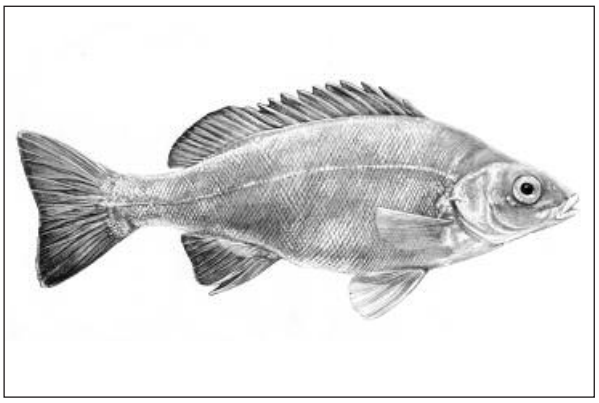


**Figure 1: Silver Perch (*Bidyanus bidyanus*)**

**Conservation Status (ACT) Endangered**

**Criteria Satisfied (ACT Flora and Fauna Committee 1995)**

The species is observed, estimated, inferred or suspected to be at risk of premature extinction in the ACT region in the near future, as demonstrated by:

- Current severe decline in population or distribution from evidence based on:
  - —direct observation, including comparison of historical and current records.
  - —severe decline in rate of reproduction or recruitment; severe increase in mortality; severe disruption of demographic or social structure.
  - —severe decline in quality or quantity of habitat.
  - —very high actual or potential levels of exploitation or persecution.
  - —severe threats from herbivores, predators, parasites, pathogens or competitors.

### SPECIES DESCRIPTION AND ECOLOGY

The Silver Perch *Bidyanus bidyanus* is a member of the family Terapontidae, which contains the freshwater grunters or perches. The family contains a total of about 22 species in eight genera in Australian freshwaters, of which one species, the Silver Perch, is found in the ACT and surrounding area. The majority of terapontids occur in northern Australian streams.

#### Description

*B. bidyanus* is a moderate to large fish (maximum length of about 500 mm and a maximum weight of around 8 kg) which commonly reaches 300–400 mm and 0.5–1.5 kg in rivers (Figure 1). The body is elongate and slender in juvenile and immature fish, becoming deeper and compressed in adults. The head is relatively small, jaws are equal in length, and eyes and mouth are small. The scales are thin and small (compared to Macquarie Perch or Golden Perch) and the tail is weakly forked. The lateral line follows the profile of the back. Colour is generally silvery grey to black on the body, with the dorsal, anal, caudal fins also grey. The pelvic fins are whitish (Merrick 1996, Merrick & Schmida 1984).

#### Habitat

*B. bidyanus* is found over a broad area of the Murray–Darling Basin and is often found in similar habitats to Murray Cod (*Maccullochella peelii*) and Golden Perch (*Macquaria ambigua*), that is, lowland turbid rivers. There are some reports that suggest that *B. bidyanus* prefers faster, open water, but the general scarcity of information on the habitat preferences of the species makes generalisation difficult. The species is not found in the cool, fast-flowing, upland rivers of the Murray–Darling Basin.

#### Behaviour and Biology

*B. bidyanus* is slow-growing and long-lived in rivers, with a greatest age of 17 years recorded from the Murray River and 27 years recorded from Cataract Dam. A 1.4 kg fish could be 17 years old (Mallen-Cooper *et al.* 1995, 1997). Growth rates in dams are much faster with a 2.3 kg fish from Googong Reservoir being approximately 6 years old (M. Lintermans unpublished data).

*B. bidyanus* matures at 3–5 years and spawn in spring and summer after an upstream migration. They school in large numbers during the upstream migration and research conducted at Torrumbarry Weir demonstrated that large numbers of immature fish were part of this migration (Mallen-Cooper *et al.* 1997).

This species is bred artificially in a number of government and commercial hatcheries and is widely stocked in farm dams and reservoirs, however, it rarely

breeds in impoundments. The species is of considerable interest for its potential as an aquaculture species (Kibria *et al.* 1998).

*B. bidyanus* is omnivorous, consuming aquatic plants, snails, shrimps and aquatic insect larvae. Reports that the species becomes mainly herbivorous once they reach lengths of 250 mm are incorrect, at least for lake populations, as their diet in Googong Reservoir shows little change with fish size (M. Lintermans unpublished data).

**DISTRIBUTION**

Formerly widespread over much of the Murray Darling Basin (excluding the cooler upper reaches), the species has declined over most of its range. Numbers of *B. bidyanus* moving through a fishway at Euston Weir on the Murray River have declined by 93% between 1940 and 1990 (Mallen-Cooper 1993). The ACT probably represented the upstream limit of the species distribution in the Murrumbidgee catchment, but it could not be considered as a vagrant because it was a regular component of the recreational fishery.

In the Canberra region the species has been recorded from the Murrumbidgee River where numbers recorded in a fish trap at Casuarina Sands between 1980 and 1991 declined noticeably from the mid-1980s (Lintermans 2000a). Monitoring of the Murrumbidgee fishery in the ACT since 1994 has failed to capture any *B. bidyanus* (Lintermans 1995a, 1997, 1998b). In the last decade there have been a small number of angler reports of *B. bidyanus* from the Murrumbidgee River in the ACT.

Formerly a 'run' of *B. bidyanus* from Lake Burrinjuck migrated upstream to the lower reaches of the Murrumbidgee River in the ACT in spring/summer, but this migration has not been recorded since the late 1970s/early 1980s (Lintermans 2000a). In the ACT, *B. bidyanus* has not been recorded further upstream than Kambah Pool (Lintermans 2000a). There have been occasional angler reports of *B. bidyanus* from the Murrumbidgee River at Bredbo, but these are thought to have originated from releases into local farm dams.

Greenham (1981) reported anecdotal angler records of *B. bidyanus* from the Molonglo River in the 1940s and 1950s but no contemporary records are known from this river (other than stocked fish). There are no records of the species from the Paddys, Naas, or Gudgenby Rivers. There are occasional angler records of *B. bidyanus* from the Queanbeyan River below Googong Reservoir but these fish are assumed to be stocked fish displaced downstream from the reservoir.

In the Canberra region *B. bidyanus* is also known from four other locations. These are:

- a stocked population in Googong Reservoir on the Queanbeyan River;
- a stocked population in the Yass weir pool on the Yass River;
- a stocked population in Lake George; and
- a population of unknown size in Burrinjuck Dam (which is supplemented/maintained by stocking by NSW Fisheries).

*B. bidyanus* is also regularly stocked into farm dams by landholders in the Canberra region.

## APPENDIX

# 3 Potential Issues for Threatened Fish Related to the Construction of a New, Enlarged Cotter Dam

As part of the review of water supply options, Lintermans (2004c) has reviewed the potential issues, benefits and knowledge gaps for threatened fish related to the construction of a new Cotter Dam.

Potential *issues* for threatened fish include:

1. Threatened fish issues may place some constraints on dam operation (timing and rate of change of water levels). (**Moderate**)
2. Increase in reservoir size will facilitate expansion of existing alien fish species in the Cotter Reservoir (Oriental Weatherloach, Eastern Gambusia, Goldfish) that prefer slow or still water habitats. (**Minor**)
3. Increase in open water area may facilitate increase in the trout population, known predators of Macquarie Perch. (**Moderate**)
4. Increase in reservoir size may facilitate increase in piscivorous bird population (cormorants), known to prey on Macquarie Perch during spawning runs out of Cotter Reservoir. (**Moderate**)
5. Increase in reservoir size will destroy by inundation, critical Macquarie Perch spawning habitat immediately upstream of the current Cotter Reservoir. (**Minor**: providing replacement habitat available and accessible above new reservoir.)
6. Projected maximum storage level of the enlarged reservoir may end in area containing minor barriers to fish movement that will prevent Macquarie Perch spawning. (**Minor**: manipulation of drown-out flows may be able to alleviate this problem.)
7. During the filling phase, existing macrophyte beds in Cotter Reservoir (important habitat for adult Macquarie Perch) will be flooded and it is likely that new macrophyte beds will not establish for several years. Fluctuating or prolonged lowering of water levels once the reservoir is established will adversely impact on fringing macrophyte beds in the expanded Cotter Reservoir. (**Moderate**)
8. Fluctuating or prolonged lowering of water levels once the expanded reservoir is established, may adversely impact on edge boulder habitat in Cotter Reservoir (important habitat for juvenile Macquarie Perch). (**Moderate**)
9. Depending on sediment loads, an expanded reservoir may destroy existing habitat of Two-spined Blackfish in the section of Cotter River to be impounded. There are no blackfish in Cotter Reservoir, which contains a high level of sedimentation, but abundant blackfish in Bendora Reservoir in which sedimentation is low. (**Minor**)
10. Reduction in flows below Cotter Dam may compromise program of re-establishing connectivity between Murrumbidgee River and Paddys River fish communities. (**Moderate**)
11. Reduction in flows may impact on the small population of Macquarie Perch in the lower Cotter and lower Paddys rivers. (**Moderate**)
12. Reduction in flows will compromise attempts to re-introduce Two-spined Blackfish populations below Cotter Dam. (**Minor**)

There are some potential *benefits* to fish populations from the construction of a large Cotter Dam, namely:

1. An enlarged Cotter reservoir will provide a substantially larger water body for the population of nationally threatened Macquarie Perch. A larger reservoir may provide additional food resources, as well as an increased abundance of edge habitats. A deeper reservoir may provide additional refuge from aerial predation, as well as enhanced thermal refuge from high summer water temperatures.
2. Construction of an enlarged reservoir will provide opportunities to enhance habitat quality for

Macquarie Perch (through the addition of boulder piles or other edge-structure prior to filling). This capacity to enhance or provide additional habitat may significantly offset some of the issues associated with this option.

3. An enlarged reservoir would drown-out some existing movement barriers for Macquarie Perch that are currently limiting upstream movement from Cotter Reservoir. Currently there is a significant barrier approximately 2.5 km upstream of the impounded waters of Cotter Reservoir. The barrier is approximately 2 metres high, and would be submerged by the proposed reservoir.

4. There would be no requirement for provision of fish passage facilities at the dam wall, as the dam serves as an important barrier to the upstream invasion of alien fish species such as Carp and Redfin Perch. It is important that the integrity of the barrier posed by the existing dam wall is maintained during construction of the new dam wall.

5. There may be an opportunity during the construction program to rehabilitate degraded stream reach below Cotter Dam (mechanically reduce armouring) and reintroduce blackfish to this stretch of river.

6. The ability to harvest water from Cotter Reservoir may facilitate the release of additional flushes from Bendora Reservoir under drought conditions, as additional flushes can be captured in Cotter Reservoir and still used for potable supply. Such flushes would provide additional environmental benefits for the aquatic communities between Bendora and Cotter reservoirs by moving sediment accumulations and drowning out small natural barriers to fish movement.

7. Construction of a larger reservoir may potentially facilitate access to an alternative spawning stream for Macquarie Perch (Condor Creek), but a preliminary field inspection indicates that some remedial work would be required to facilitate fish passage past barriers on the creek immediately upstream of the junction with the Cotter River.

The review of fish impacts from future ACT water supply options highlighted a number of *knowledge gaps* that need to be addressed. These are:

1. There is little known of the movement requirements of freshwater crayfish (both Murray River Crayfish and *Euastacus crassus*).

2. There is no knowledge of the ecological requirements and little knowledge of the distribution of *Euastacus crassus* or *E. rieki*.

3. There is a need to determine spawning cues for Macquarie Perch (an investigation of the role of water temperature, flow and day-length).

4. There is a need to clarify the spawning season of Macquarie perch and extent of the river being utilised for breeding (larval survey).

5. There is a need to identify location and characteristics of Macquarie perch spawning sites.

6. Impacts of fluctuating reservoir water levels and river flows on spawning movements of Macquarie Perch need investigation.

7. Swimming capacity of different life-stages of Macquarie Perch (to enable assessment of potential instream barriers) need investigation.

8. There is a need to make an inventory of, and map potential instream barriers to Macquarie Perch movement, and the behaviour and water velocities over these barriers under different flow volumes

9. Movement patterns of sub-adult and juvenile Macquarie Perch in both reservoir and riverine habitats need investigation.

10. There is a need to investigate and quantify cormorant predation on spawning migrations of Macquarie Perch.

11. There is a need to investigate and carry out trials with habitat enhancement in reservoirs (snags and boulder habitat) to enable adequate supply of habitat across fluctuating reservoir levels.

12. Options for augmentation of fish passage past 'natural' barriers in the river channel caused by low flow need investigation.

13. Methods for restoring habitat below Cotter Dam as part of dam augmentation (if Cotter Reservoir enlargement is selected as the preferred option) need investigation.

14. With expanded reservoir size, changes in population levels of alien species such as Oriental Weatherloach, Goldfish, and Eastern Gambusia need investigation.

15. With expanded reservoir size, changes in population levels of predatory trout species need investigation. This includes quantification of predation levels on Macquarie Perch and the life-stages involved.

16. Techniques for facilitating rapid development of fringing macrophyte beds in new or expanded reservoirs need investigation.
17. There is a need to monitor deposition of sediment in new or expanded reservoirs and monitor changes in abundance and distribution of Two-spined Blackfish in inundated areas.
18. There is a need to investigate and carry out trials of translocation strategies for establishing new sub-populations of Macquarie Perch. Such investigations should consider the numbers, timing and life-stages of fish to be used in the establishment trials.
19. Laboratory trials are required to test susceptibility of Two-spined Blackfish to EHN virus.
20. Field investigations are required on the exposure to and impacts of EHN virus on Macquarie Perch, in particular, to determine if there is serological evidence that ACT populations of Macquarie Perch have been exposed to the virus.

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# GLOSSARY

### Abbreviations

asl = above sea level
mm = millimetre
cm = centimetre
m = metre
km = kilometre
GL = gigalitre (1 000 000 000 litres or 1000 megalitres)
ML = megalitre (1 000 000 litres)
ha = hectare
yr = year

### Adaptive Management

Adaptive management is the systematic process for continually improving management policies and practices by learning from the outcomes of operational programs (ACT Government 2006a).

### Alien Species

An alien species (non-native, non-indigenous, foreign, exotic) means a species, subspecies, or lower taxon occurring outside its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans). An alien invasive species means an alien species that has established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity (IUCN 2000). 'Alien' has largely replaced the use of the terms 'introduced' and 'exotic' in discussions of aquatic ecosystems.

### Batholith

A large body of igneous rock, bounded by irregular cross-cutting surfaces or fault planes, and believed to have crystallised at a considerable depth below the earth's surface (Delbridge *et al.* 1996).

### Benthic

Associated with the bottom of rivers or lakes (Lintermans and Osborne 2002).

### Biodiversity

The variability among living organisms from all sources (including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part) and includes diversity within and between species and the diversity of ecosystems (AHC 2002).

### Buffer

A buffer is a form of vegetation or land use (e.g. road or other infrastructure) that acts as a barrier or absorbs the effects of an activity or another land use. It is undesirable to have high intensity land uses located next to areas of high conservation value, and low or medium intensity land uses may be used as buffers (MacLeod 2002b).

### Chute

Faster flowing water issuing from the constricted space between obstructions in a stream (usually rocks) where there is a steepening of the gradient of the stream.

### Connectivity

Habitat connectivity is the degree to which an organism can move around the landscape due to the presence of suitable habitat. For fauna, connectivity has been defined as the 'degree to which the landscape facilitates or impedes movement among patches' (Bennett 1999).

### Conservation value

With regard to the natural environment, conservation value is an expression of the importance of a place in terms of its *natural significance*. *Natural significance* means the importance of ecosystems, biodiversity and geodiversity for their existence value or for present or future generations, in terms of their scientific, social, aesthetic and life-support value (AHC 2002).

### CRA Data

Vegetation data from the Southern Region Comprehensive Regional Assessment (CRA).

### Declining species

Species that have a reduced extent of occurrence and/or decline in abundance, significant enough to raise conservation concern.

### Diel

A diel period is 24 hours.

### Disturbance

An event that removes organisms and opens up space that can be colonised by individuals of the same or different species (Begon *et al.* 1990). Examples include soil cultivation, herbicide use, tree removal, fire and grazing.

**Dominant Species**

Species that make up a large proportion of biomass, or numbers of organisms in a community (Begon *et al.* 1990).

**Ecological Community**

An assemblage of plant and animal species that occur together in space and time.

**Ecological Processes**

All the processes that occur between organisms, and within and between communities, including interactions with the non-living environment, that result in existing ecosystems and bring about changes in ecosystems over time (AHC 2002).

**Ecosystem**

A dynamic complex of organisms and their environment, interacting as a functional unit (AHC 2002).

**Ecosystem Function**

In a functioning (or healthy) ecosystem, processes such as nutrient, energy and water flows, and the organisms and their populations, are maintained at levels appropriate to that system. A degraded or dysfunctional ecosystem has one or more of these processes disrupted (McIntyre *et al.* 2002).

**Ecotone**

Transition zone between two vegetation communities (e.g. between woodland and grassland).

**Endangered**

Means:

(a) In relation to a community—an ecological community that is in immediate danger of extinction unless the circumstances and factors threatening its distribution, composition and viability as an ecological unit cease.

(b) In relation to a species:

(i) its likely extinction unless the circumstances and factors threatening its abundance, survival or evolution cease; or

(ii) the reduction of its numbers or habitats to such a level that the species is in immediate danger of extinction.

(*Nature Conservation Act 1980*).

**EHN Virus**

Epizootic Haematopoietic Necrosis Virus is unique to Australia and was first isolated in 1985. It is characterised by sudden high mortalities of fish, which display necrosis of the renal haematopoietic tissue, liver, spleen and pancreas (Langdon and Humphrey 1987).

**Evolutionary Processes**

Genetically-based processes by which life forms change and develop over generations (AHC 2002).

**Exotic Species**

A species of foreign origin; not native; introduced from abroad (Delbridge *et al.* 1996). (see **Alien Species** above)

**Fin fish**

As defined in the *Fisheries Act 2000* (ACT), 'fin fish means a marine, estuarine or freshwater fish of the class pisces'. Used in this *Strategy* to distinguish from crustaceans, which are included in the definition of 'fish' under the Act (see below).

**Fish**

As defined in the *Fisheries Act 2000* (ACT), 'fish means marine, estuarine or freshwater fish or other aquatic animal life, or any of their parts, at any stage of their history (whether alive or dead), and includes:

(a) abalone, oysters and other aquatic molluscs;

(b) crustaceans;

(c) echinoderms; and

(d) beachworms and other aquatic polychaetes;

but does not include—

(e) reptiles;

(f) birds; and

(g) amphibians.

**Fault**

An approximately plane surface of fracture in a rock body, caused by brittle failure, and along which observable relative displacement has occurred between adjacent rocks (Allaby and Allaby 1990).

**Fragmentation**

The separation into parts, of an assumed previously continuous vegetation community.

**Geodiversity**

The natural range (diversity) of geological (bedrock), geomorphological (landform) and soil features, assemblages, systems and processes (AHC 2002).

**Graben**

A downthrown, linear, crustal block bordered lengthways by normal faults (Allaby and Allaby 1990).

**Habitat**

The structural environments where an organism lives for all or part of its life, including environments once occupied (continuously, periodically or occasionally) by an organism or group of organisms, and into which organisms of that kind have the potential to be reinstated (AHC 2002).

**Horst**

Upthrown block lying between two steep angled fault blocks (Allaby and Allaby 1990).

**Hypolimnion**

The bottom stratum of water in a lake, which shows a temperature gradient of less than one degree C per metre of depth (Gilpin 1976).

**Land Management Agreement**

An agreement between a lessee and the Territory establishing a co-operative management regime for non-urban land in the ACT.

**Lentic**

Standing waterbodies where there is no continuous flow of water, as in freshwater ponds and lakes.

**Natural Integrity**

The degree to which a place or ecosystem retains its natural biodiversity and geodiversity and other natural processes and characteristics (AHC 2002).

**Organism**

Any living being.

**Protection**

Taking care of a place by managing impacts to ensure that natural significance is retained (AHC 2002).

**Regeneration**

The natural recovery of natural integrity following disturbance or degradation (AHC 2002).

**Restoration**

Returning existing habitats to a known past state or to an approximation of the natural condition by repairing degradation, by removing introduced species or by reinstatement (AHC 2002).

**Species Diversity**

The variety of species in a place (AHC 2002).

**Tectonic**

From tectonism: deformation within the earth's crust and its consequent structural effects (Allaby and Allaby 1990).

**Threatened**

An umbrella term for various categories of risk of premature extinction.

**Vulnerable**

In relation to a species, means a species that within the next 25 years is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolution cease (*Nature Conservation Act 1980*).

**Weed**

A plant that threatens human welfare by competing with other plants that have food, timber or amenity value (Begon *et al.* 1990). Environmental weeds are plants that threaten diversity and functioning in native ecosystems.