SURVEY OF VEGETATION AND HABITAT IN KEY RIPARIAN ZONES OF TRIBUTARIES OF THE MURRUMBIDGEE RIVER IN THE ACT:

Naas, Gudgenby, Paddys, Cotter and Molonglo Rivers

Lesley Peden, Stephen Skinner, Luke Johnston, Kevin Frawley, Felicity Grant and Lisa Evans

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Environment and Sustainable Development

Front cover: The Murrumbidgee River and environs near Tharwa Sandwash recreation area, Tharwa, ACT.
Photographs: Luke Johnston, Lesley Peden and Mark Jekabsons.

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ESDD staff that directly contributed to the planning, implementation, outputs and review of the project include: Lesley Peden, Stephen Skinner, Luke Johnston, Matt Beitzel, Felicity Grant, Mark Jekabsons, Diwani Velasquez, Lisa Evans and Sharon Lane. Kevin Frawley revised and edited a draft of the document.

Table of Contents

List of Figure and Plates

List of Appendices

Executive Summary

Following the survey of the distribution and condition of the riparian vegetation communities of the Murrumbidgee River within the ACT by Johnston et al. (2009), it was decided to acquire similar information for the major tributaries of the Murrumbidgee in the ACT. The objectives of this project were to map the distribution and assess the condition of the riparian vegetation along the five main tributaries of the Murrumbidgee River in the ACT (the Naas, Gudgenby, Paddys, Cotter and Molonglo rivers). It was beyond the scope of the project to undertake on-ground surveys, similar to the project for the Murrumbidgee River, across such a wide and diverse area. Therefore, the distribution of riparian vegetation communities was defined using a combination of satellite imagery; high resolution, low altitude oblique aerial photographs; and point based on-ground survey.

The project used the same vegetation community classification as in Johnston et al. (2009) with the addition of those communities that do not occur along the Murrumbidgee River, in particular, montane and subalpine ones. Twenty vegetation communities were defined for the rivers surveyed, including adjacent hillslope communities. These communities ranged from subalpine bogs to low elevation river flats containing stands of *Casuarina cunninghamiana*. Many of these communities were impacted to varying degrees of severity by the 2003 bushfire and the report comments on the level of recovery that was apparent. The survey results for each river are reported by river section with accompanying maps of vegetation communities and photographs. Following the community descriptions, there is an evaluation of the condition of the riparian vegetation and brief management recommendations.

The condition of the riparian and associated hillslope vegetation along the surveyed rivers was found to vary widely across the region and within each river. Along the Cotter River the condition was extremely good in Namadgi National Park, but in poorer condition in the former softwood plantation area of the lower Cotter. The Naas, Gudgenby and Paddys rivers demonstrate the long term effects of rural land use. However, in the sections of these rivers in Namadgi National Park, the riparian vegetation has recovered to good or even excellent condition. Parts of these waterways in rural land are in moderate to good condition, especially where there has been some effort to restrict stock access to the river banks. Many areas contain varying levels of exotic vegetation, but there are still sufficient pockets of residual natives to allow improvement of riparian condition with better rural land management. Both the upper Molonglo River in the Kowen Gorge area and the lower Molonglo below Coppins Crossing retain riparian and some hillslope vegetation in good condition. Between Molonglo Gorge and Coppins Crossing, the river and the riparian zone have been severely impacted by urban, infrastructure and other development. A pervasive feature throughout all the river sections surveyed is the encroachment, and in many parts the dominance of weed species, especially blackberries, willows, poplars and pine wildings.

The report identifies those river sections where riparian vegetation condition is very good and/or noteworthy. These high conservation value areas, which contrast with the degraded sections of the streams, justify appropriate management input to retain their natural heritage values. These areas include montane grassland, woodland and wetland communities in the upper reaches of the Naas and Gudgenby rivers; the black cypress pine community along Paddys River; the mountain mires at the headwaters of the Cotter River; the ribbon gum community along the Cotter River below Corin Dam; the snow gum – candle bark woodland along the Molonglo River in the Kowen area; and cypress pine woodland in the lower reaches of the Molonglo River.

1 INTRODUCTION

1.1 Background to this Report

On completion of the Murrumbidgee River riparian vegetation survey (Johnston et al. 2009), the decision was made to acquire similar information for the major tributaries of the river in the ACT. It was beyond the scope of the project to undertake on-ground surveys, similar to that for the Murrumbidgee River, across such a wide and diverse area. However, the mapping techniques used in the Murrumbidgee survey could be adapted and applied to a GIS-based desk-top investigation of the tributaries. The aerial photography utilised in the Murrumbidgee survey and connection to satellite imagery provided suitable bases for a remote survey, combined with targeted ground survey. The project covers the Naas, Gudgenby, Paddys, Cotter and Molonglo rivers (Figure 1.1). Only the ACT section of the Molonglo River is included.

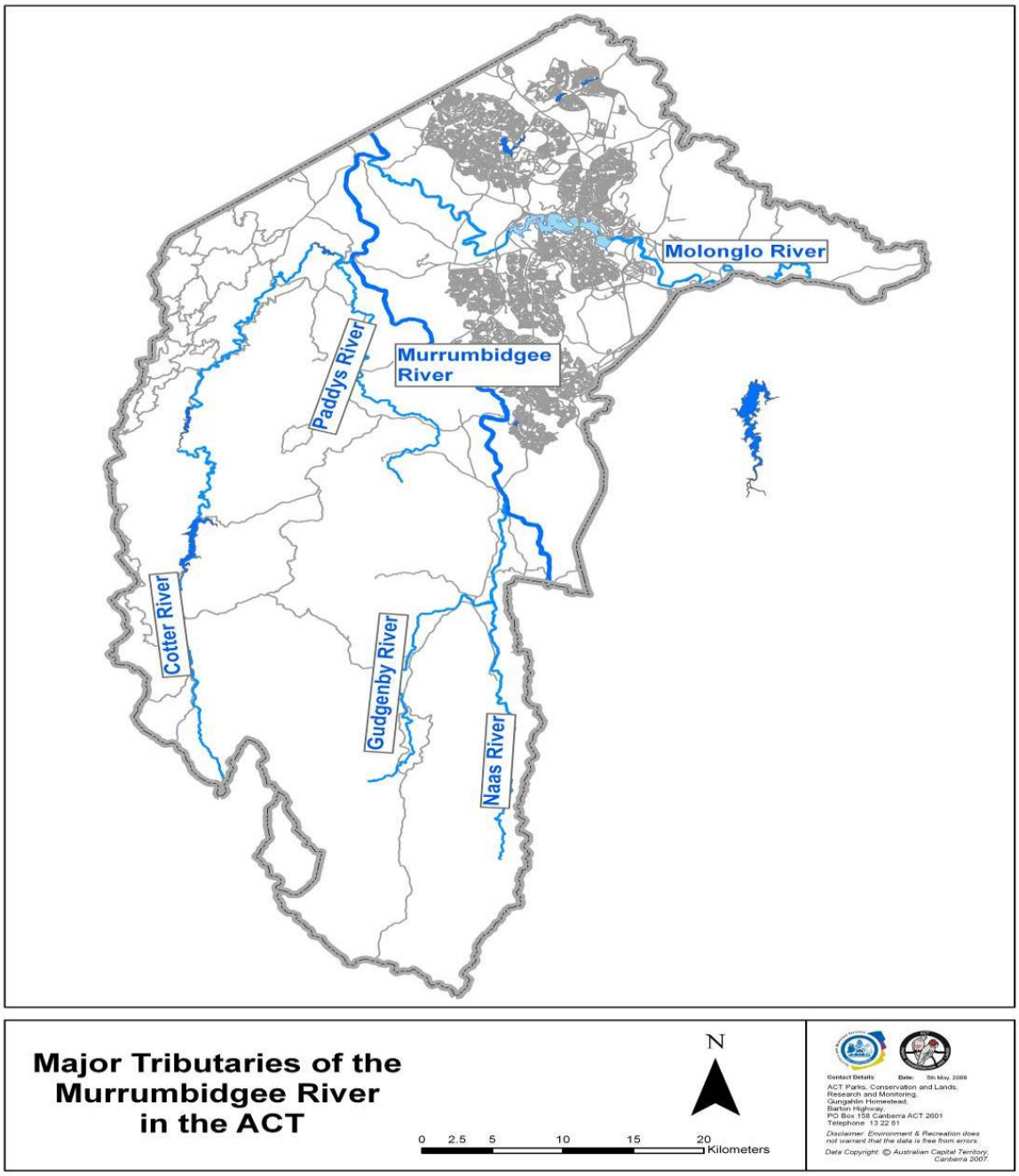

Figure 1.1: Study area in a regional context

In January 2003 a bushfire burnt 70 per cent of (164 914 ha) of the ACT, including most of the area west and south of the Canberra urban area. The fire was of high intensity (see Glossary) in many areas and had a severe impact on vegetation communities, flora and fauna, as well as built infrastructure. Subsequent heavy rainfalls resulted in significant gullying, erosion, sediment deposition and deleterious impacts on water quality in rivers, streams and water reservoirs. This fire and its impacts are referred to throughout the report.

1.2 The Murrumbidgee River and its Tributaries

The Murrumbidgee River and its tributaries are key geomorphic, hydrological and ecological features of the ACT. The Naas, Gudgenby, Paddys and Cotter rivers are located west of the Murrumbidgee River and rise in the ranges that make up the western part of the ACT. The Molonglo River is located east of the Murrumbidgee River. From its source in the Captains Flat area, the Molonglo enters the ACT near Burbong. The Queanbeyan River is not included in this report as it flows almost entirely in New South Wales, entering the ACT just before its confluence with the Molonglo River. These rivers are described, with changes over time, in the *ACT Aquatic Species and Riparian Zone Conservation Strategy* (ACT Government 2007).

Before European settlement, a feature of low elevation tributary streams was the presence of 'chains-of-ponds' morphology, which were permanent pools separated by shallow or ephemeral areas. The European pastoral economy brought rapid changes to rivers and streams, following clearing in catchments, intensive stock grazing, and cultivation of some areas. Increased runoff, following clearing and grazing, resulted in stream channel incision, gully erosion and loss of the 'chain-of-ponds' structure, as well as substantial sedimentation of the rivers, thereby filling the deep pools (Eyles 1977a,1997b; NSW DLWC 2000; Sebire 1991). The drainage system within low elevation parts of 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 (Starr et al. 1999). These are evident along the Naas, Gudgenby, Paddys, Cotter, Molonglo (and Queanbeyan) rivers. More recently, better land management has seen improvements in land stability, an increase in naturally stabilising gullies, and the redevelopment of incipient chains-of-ponds in some areas (Starr 2000a). Urban development, with more planned, has had a major impact on the Molonglo River valley.

In the mountains, snow melt and winter rainfall provided an annual flow cycle with high flows in spring and reduced warmer flows in summer, except for temporary rises with summer storms. The potential for water supply from the forested mountain catchment of the Cotter River was recognised in choosing the site for the national capital and protection of the catchment was formally initiated in 1914. Some of the upper catchment was grazed prior to Commonwealth acquisition and 3600 ha of the lower catchment was planted to radiata pine from 1926. These plantations were destroyed in the 2003 bushfire. To provide for domestic water supply to Canberra, the Cotter, Bendora and Corin dams have been constructed. The pine plantations and water reservoirs have had a major impact on the river valley and riparian zones.

1.3 Objectives

The objectives of the project were to:

- define riparian vegetation community distribution along major tributaries of the Murrumbidgee River in the ACT
- assess the condition of riparian ecological communities along major tributaries of the Murrumbidgee River in the ACT

- provide management recommendations on riparian zone management; including conservation of threatened species and ecological communities, presence of significant weed species, and identification of priority sites for vegetation rehabilitation.

1.4 Riparian Vegetation Communities

Riparian vegetation communities are those groupings of plants that occupy the margins of permanent or ephemeral waterways, and facilitate life in the aquatic ecosystems they adjoin. Riparian land and associated riparian vegetation communities are 'the "last line of defence" for aquatic ecosystems against the impacts of land use elsewhere in the catchment' (Lovett and Price 2007). For the purposes of this survey, the riparian zone is defined as 'an area of terrestrial land adjacent to a water body that is affected by periodic inundation and hydrological influence' (Johnston et al. 2009).

1.5 Condition Assessment

Condition assessment is a tool for appraising the vitality of the living organisms and their habitat within a site to evaluate their health. In this survey, as in Johnston et al. (2009), the distribution and condition of vegetation communities was assessed within the riparian land of the tributaries. The riparian zones and adjacent hillslopes of each tributary were divided into discrete units of homogeneous vegetation and each was surveyed using a combination of interpretation of satellite and photographic imagery and on-ground survey. Information on species dominance and condition was collected as a baseline for future monitoring and to inform management and conservation planning.

The techniques utilised in this survey were based on condition assessment scales used by Johnston et al. (2009), which were derived from the Rapid Assessment of Riparian Condition (RARC) method of Jansen et al. (2005). Refinements were made to suit the predominantly remote nature of this survey. These modifications were necessary due to the limitations of satellite imagery and aerial photography, primarily: (a) they are not able to provide sufficiently detailed information that would enable descriptions of species diversity in understorey or groundcover comparable to on-ground survey; and (b) the temporal limitations of satellite and aerial photography. The canopy, understorey and groundcover structures are clearly visible with remote sensing, but individual plant identification is less precise. Conversely, some vegetation condition factors such as percentage cover and longitudinal continuity are enhanced by the aerial view of the survey areas.

1.6 Report Structure and Project Results

In relation to the objectives, the report contains descriptions and maps of riverine vegetation communities along defined lengths of the major tributaries of the Murrumbidgee River in the ACT (Chs 3 to 7). Following the vegetation descriptions for each of the river sections, the chapters conclude with an assessment of the condition of riparian ecological communities in their landscape context, and recommendations on riparian zone management. The concluding chapter (Ch. 8) contains an overview of riparian vegetation condition in relation to land use and land tenure, and briefly describes river sections with the highest level of natural integrity (see Glossary).

Plates (photos) are included in the text. Maps of riverine vegetation communities have been placed in appendices that relate to each river (e.g. Appendix 3 covers maps of the Naas River. Appendix 3A contains the Maps of Vegetation Communities. Appendix 3B contains the Maps of Vegetation Dominance Change and Appendix 3C contains the Maps with Management Recommendations).

2 METHODS

2.1 Mapping and Survey Techniques

This section outlines the mapping and survey techniques used in this project. Limitations and constraints are discussed in s. 2.4.

2.1.1 Aerial photography and satellite imagery

Interpretation and delineation of the distribution of riverine vegetation communities was initially made by heads-up digitisation, using a combination of satellite imagery (ACT Region_50cm: Digital Globe 2005) and high resolution, low altitude oblique aerial photographs (Mon Aero® 2008). Digital Globe 2002 was used to compare pre-fire vegetation. With the use of ESRI ArcGIS® 9.2 a series of polygons were overlaid onto satellite imagery at a scale of between 1:3000 and 1:5000 as per Johnston et al. (2009). The polygons were intended to represent homogenous vegetation communities in similar apparent condition.

Polygon boundaries were determined by systematically viewing photographic imagery along each river system, and outlining where vegetation community changes occurred. Where cloud cover or dense vegetation prevented an accurate view of the riparian zone, the relevant topographic map for the area was overlaid and drainage and contour lines were used to determine river riparian polygon boundaries.

Presumed pre-European vegetation community distribution was ascertained by observation of existing and remnant trees, and review of available literature and previous surveys. The Southern CRA (Comprehensive Regional Assessment) pre-1750 report and model also provided a useful reference tool where no previous information was available (Thomas et al. 2000). Where vegetation communities no longer represented the presumed pre-European dominance, the current vegetation dominance was mapped to show changes in vegetation distribution and current community condition.

In cases where interpretation of aerial photos failed to adequately distinguish instream vegetation and the lower vegetation strata, other information sources such as previous surveys, anecdotal evidence and site visits were used to inform conclusions about vegetation community type and condition.

In cases where polygons encompassed large sections of river and vegetation community type and condition remained relatively similar for long distances, subtle changes in community were not delineated and polygon units were left intact. More detailed on-ground survey may resolve subtle vegetation community changes that were not delineated by this remote survey.

2.1.2 Polygon identification and assessment

Riparian polygons were created to encompass homogenous vegetation communities in similar apparent condition within riparian zones. Boundaries were based on visual assessment of vegetation community, distance from the river, observable inundation zones and topography, to represent the best interpretation of the actual riparian zone allowable by the remote nature of the survey. Hillslope and valley slope polygons were created at a distance of approximately 100 m from the outer border of the riparian zone, to delineate the adjacent riverine community type. Additional information obtained during ground truthing was collated and a series of on-ground photographs taken for further reference.

Site information collected within each polygon was simplified from that in Johnston et al. (2009) and included: vegetation community and distribution (Sharp et al. 2007); current species

dominance; vegetation condition; woody weeds; map and reference data; predominant polygon directional aspect; large scale riverine geomorphology; land use; and evidence of recent fire (although in grassland sites and areas recovering rapidly from fire this was difficult to define).

2.1.3 Calculation of condition scores

Condition ranking techniques used by Johnston et al. (2009) were modified to suit remote survey and mapping (Appendix 1). The current survey followed a similar methodology but referred to Jansen et al. (2005) for condition values. Each polygon was allocated a condition score based on interpretation of the vegetation community as observed in remote imagery. Additional information from ground surveys was used for many sites.

Categories used in the condition ranking included:

- longitudinal continuity (continuity of the tree, shrub or grass layer forming the upper canopy)
- proximity to nearest native vegetation patch (distance)
- native vegetation (%)
- riparian canopy (as opposed to exposed bank and bars)
- presence of tussocks, reeds, bulrushes and submerged and emergent vegetation (within the riparian zone and fringe)
- fire damage and/or standing dead timber (%).

Riparian polygons that utilised all categories of the condition ranking, received a total score out of 18. Hillslope and valley slope polygons were scored out of 12 as they were not scored for riparian associated features. Final calculations were represented as a percentage and then assigned to a condition ranking as 'low' (0-50%), 'medium' (51-80%), or 'high' (81-100%). This ranking was incorporated into the ArcGIS® spatial layer and overlaid onto distribution maps. Inverse calculations of condition rankings were utilised to develop a conservation management priority. In this scheme the most degraded sites achieved the highest numerical scores (Johnston et al. 2009).

2.1.4 On-ground survey to support aerial photograph interpretation

To ensure accuracy of the remote mapping process, on-ground surveys were used at selected points along the river reaches. Rather than comprehensive qualitative or quantitative examination, these surveys were point visits and provided confirmation of mapped vegetation boundaries and floristics. Much of the detail provided for polygons and species information (especially lower strata) was achieved by this ground survey.

2.1.5 Map production

Three sets of maps were produced for the length of each river within the ACT to display presumed pre-European vegetation community distribution, current vegetation dominance and condition, and management priority areas. Maps were produced from the source of each river within the ACT or from the ACT border (Molonglo River), to the downstream confluence with the Murrumbidgee River or a connected tributary.

2.2 Vegetation Communities

The classification of riparian and valley slope communities used in this survey are the same as those used in Johnston et al. (2009). The communities are described in Appendix 2. Some of the community classifications and/or descriptors used in Johnston et al. (2009) and this report differ slightly from those in Sharp et al. (2007) which were used in other recent ACT Government publications e.g. management plans for Public Land. Comparable communities defined in the respective reports are shown below:

Communities in Johnston et al. (2009) and/or this report	Communities in Sharp et al. (2007)
Grasslands	
Tableland Wet Tussock Grassland	River Tussock Tableland Wet Tussock Grassland
Fen Sedge Montane Wet Tussock Grassland/Montane Wet Tussock Grassland	Montane Wet Tussock Grassland
Subalpine Tussock Grassland	Bog Snow Grass Subalpine Tussock Grassland
Forbland – Sedgeland – Mossland Complex	
Montane and Subalpine Fens	Montane and Subalpine Fen
Sphagnum Montane and Subalpine Bog	Sphagnum Montane and Subalpine Bog
Wetlands	
Tableland Aquatic and Fringing Vegetation Complex	Tableland Wetlands, and Montane and Subalpine Wetlands
Shrublands	
River Bottlebrush–Burgan Tableland Riparian Shrubland	Burgan Tableland Shrubland
Burgan Derived Tableland Shrubland	Burgan Tableland Shrubland
Tableland Riparian Shrubland	Burgan Tableland Shrubland
Woodlands	
Yellow Box – Blakely's Red Gum Tableland Grassy Woodland	*Eucalyptus melliodora – Eucalyptus blakelyi* Tableland Grassy Woodland (Yellow Box – Blakely's Red Gum Tableland Grassy Woodland)
Snow Gum – Candle Bark Tableland Woodland	*Eucalyptus pauciflora – Eucalyptus rubida* Tableland Woodland (Snow Gum – Candle Bark Tableland Woodland)
Broad-leaved Peppermint – Apple Box Tableland Woodland	*Eucalyptus dives – Eucalyptus bridgesiana* Tableland Woodland (Broad-leaved Peppermint – Apple Box Tableland Woodland)
Black Cypress Pine Tableland Woodland	*Callitris endlicheri* Tableland Open Forest (Black Cypress Pine Tableland Open Forest)
She-oak Tableland Riparian Woodland	*Casuarina cunninghamiana* Tableland Riparian Woodland (River She-oak Tableland Riparian Woodland)
Ribbon Gum Tableland Riparian Woodland	*Eucalyptus* viminalis Tableland Riparian Woodland (Ribbon Gum Tableland Riparian Woodland)
Snow Gum Montane Woodland	*Eucalyptus pauciflora* Montane Woodland (Snow Gum Montane Woodland)
Snow Gum Subalpine Woodland	*Eucalyptus pauciflora* Subalpine Woodland (Snow Gum Subalpine Woodland)
Forests	
Red Stringybark – Scribbly Gum Tableland Forest	*Eucalyptus macrorhyncha – Eucalyptus rossii* Tableland Forest (Red Stringybark – Scribbly Gum Tableland Forest)
Broad-leaved Peppermint – Candle Bark Montane Dry Forest	*Eucalyptus dives – Eucalyptus rubida* Montane Forest (Broad-leaved Peppermint – Candle Bark Montane Dry Forest)
Narrow-leaved Peppermint – Ribbon Gum Montane Forest	*Eucalyptus robertsonii – Eucalyptus viminalis* Montane Forest (Narrow-leaved Peppermint – Ribbon Gum Montane Forest)

Sometimes communities were difficult to determine as they did not readily fit into a defined community type. For example, the upper reaches of the Cotter, Naas and Gudgenby rivers are often fringed by *Eucalyptus stellulata*, *Poa labillardierei*, and *Leptospermum lanigerum*. These species are included in the Snow Gum Montane Woodland community and were defined as such. There is however a distinct zonation between (a) the riparian fringing *E. stellulata*, shrub and grass species and (b) the *E. pauciflora* and *E. rubida* alliance which is usually set further back from the river on the valley slope. Both these alliances are included in the Snow Gum Montane Woodland community.

The Snow Gum Montane Woodland community is defined not only by the included species but also by altitude. Along the three aforementioned rivers, the *E. pauciflora* and *E. rubida* alliance occurs within the altitude defined montane region but also continues down (with the absence of *E. stellulata*) into the altitude defined tableland region, without any apparent change to the vegetation composition.

For the purposes of this survey, vegetation communities were determined by species composition, but where this remained unchanged, altitude became the determining factor. Thus on the Gudgenby, Cotter and Naas rivers, when the altitude fell below 800 m, Snow Gum Montane Woodland became Snow Gum – Candle Bark Tableland Woodland, with the only apparent species change being the absence of *E. stellulata* in the lower altitude region and the change in tea tree species from *L. lanigerum* to *Leptospermum obovatum*.

Willows (*Salix* spp.), blackberries (*Rubus fruticosus* complex), poplars (*Populus* spp.) and radiata pine (*Pinus radiata*) are common weed species in many of the river sections surveyed. To avoid unnecessary repetition, they are often referred to by common name (e.g. willows) unless specific species are listed.

2.3 Plant Identification

Plants were identified using field guides (Harden 1991, 1992, 1993, 2000; Wood and Wood 2005; Eddy et al. 1998) with updates from online sources such as PlantNET <http://plantnet.rbgsyd.nsw.gov.au>. Nomenclature conforms to that in the *Census of the Vascular Plants, Hornworts and Liverworts of the Australian Capital Territory* (Version 2.0, 2008) (Lepschi et al. 2008).

The threatened species and ecological communities referred to in this report are declared under the provisions of the *Nature Conservation Act 1980* (ACT) and listed in the *Nature Conservation (Species and Ecological Communities) Declaration 2008* (No 2) (Disallowable instrument DI2008—53).

The areas included in this report contain many weed species. The most significant of these have been declared 'pest plants' in the ACT under the provisions of the *Pest Plants and Animals Act 2005* and are listed in the *Pest Plants and Animals (Pest Plants) Declaration 2005* (No 1) ((Disallowable instrument DI2005—256). Two important groups of pest plant species in riparian zones are willows *Salix* spp. and blackberry *R. fruticosus (aggregate)*. Desktop identification and monitoring of these provides a measure of the extent of infestations more rapidly than ground surveying due to their distinctive characteristics and ease of visibility in aerial photography.

2.4 Advantages, Constraints and Limitations of the Methods

By design this survey mainly used remote sensing rather than on-ground surveys. The advantages, constraints and limitations of this approach are briefly discussed below.

2.4.1 Remote sensing and desk top mapping

Desk top mapping provides a useful tool for remote survey of extensive areas, especially those not easily accessible on foot. Areas such as inland river systems, where distances between different vegetation communities may be vast and there is little variation in the landscape, can be quickly and accurately surveyed. The technique allows the assessment of total vegetation cover, recognition of vegetation patterns over large areas, and facilitates the calculation of ecological parameters.

A major benefit is the ability to use the imagery to select locations where on-ground investigation is required and eliminate those locations where assessment indicates that adequate information is available for the purposes of the study. Target areas can be visited as part of the survey or during subsequent management activities, such as weed control.

Layers derived from previous surveys can be overlaid on current mapping to monitor vegetation change over time. This is effective in monitoring post-fire recovery, weed control, revegetation plantings, erosion control and other rehabilitation activities. The technique can also be used to support grant applications for vegetation management projects.

To undertake remote survey, the highest quality, high resolution satellite imagery and aerial photography should be sought, along with an appropriate level of computing and associated software capacity.

2.4.2 Image resolution

Visibility limits
For this survey, the main difficulties for desk top mapping were related to limited visibility or poor resolution of the aerial photography. Although the high resolution images produced by Mon Aero® generally allowed delineation of vegetation community boundaries, this was mainly based on the species in the upper and midstorey. Survey of composition and condition in the lower strata was not the primary aim of the survey and it was not always possible to detect changes where photography was of insufficient resolution or the canopy prevented observation. Remote survey provides limited information on ground condition (e.g. evidence of overgrazing), soil and litter, and animal interactions, which may be important in an overall assessment of the condition of a vegetation community and future management recommendations.

Unlike on-ground survey, remote survey, even with high resolution imagery, often does not allow identification of the predominant eucalypts and the range of shrubs to the species level. In these cases, subtle changes in colour and composition were used to assist the identification of changes in the vegetation.

Internal variability in dominant communities
To the degree that this technique allows, polygons were intended to represent homogenous vegetation communities and changes in community dominance and condition. Longer polygons, especially those on hillslopes, are likely to contain several alliances that are included in the community.

Measurement and quantification using remote images
Measurement and area quantification are not possible on the high quality Mon Aero® photos used in this study due to the oblique photo angle. Therefore measurements and boundaries were visually transferred to the Digital Globe 2005 layer with some potential associated loss of precision.

3 NAAS RIVER

The Naas River rises in the Clear Range in the south-east of the ACT and flows north through Namadgi National Park until it emerges into grazing country at Caloola Farm. It joins the Gudgenby River 1.5 km east of Naas station. Naas River, including its major tributary Naas Ck, is 55 km long.

3.1 Topography

The Naas River, including Naas Creek, traverses granite valleys between the Booth Range on the west and the Clear Range on the east, falling from approximately 1770 m near Mt Gudgenby to 650 m at the confluence with the Gudgenby River. Like the Gudgenby and the Cotter rivers, at higher altitudes the riverine landscape has several valley environments connected through steep sided, narrow outlets with overlapping spurs, before spreading out into an almost flat valley below Caloola (Ingwersen 2001). Flow is highly variable and the Naas can dry up over substantial proportions of its length in extremely dry seasons (ACT Government 2007).

3.2 Background

Starr (2000b) reported on issues associated with soil conservation and riparian condition in the lower Naas valley (mainly Caloola to Gudgenby River junction). The current condition is the product of post-European settlement farming practices and, more recently, storm damage following drought. Starr suggests that prior to European settlement the Naas comprised chains-of-ponds in a wide valley of geologically recent alluvial sediments. Instream vegetation was likely to have been similar to the present composition, but with fen-like tussock sedgeland and *Poa* tussock grassland in the wide valley floor. Starr does not mention riparian shrubland but refers to a former widely spaced and scattered tree cover throughout this landscape. Long Flats and upper Naas Creek, wetland areas that are part of the headwaters for the Naas River, are considered to be significant botanical relics. They preserve wetland/riparian species assemblages that may have been more widespread in the area (Evans and Keenan 1992). Significant natural and cultural sites in the Naas River catchment are described in NCPA (1990).

The absence of historical or photographic records makes assessment of the post-settlement hydrology of the Naas River more inferential than for other tributaries of the Murrumbidgee.

3.3 Naas River: Survey Results by River Section

3.3.1 Upper Naas Creek to Namadgi National Park boundary

This reach is approximately 27 km in length and occurs entirely within Namadgi National Park. The Naas River originates in upper Naas Ck and Long Flats and this survey begins at Mt Clear Campground on upper Naas Ck. Maps for the Naas River are found in Appendix 3.

The river rises in Tableland Wet Tussock Grassland surrounded by Snow Gum Montane Woodland (Plate 3.1; Maps 3.1a, 3.2a, 3.3a). The riparian vegetation has a high condition ranking (see Appendix 3A). The river flows through alternating sections of open tussock grassland in the valley floor and Snow Gum Montane Woodland. Where the river passes through woodland, the riparian zone is dominated by *E. stellulata* with *E. pauciflora* and scattered *E. rubida* on the hillslope.

Riparian species observed during ground surveys along this reach include *Poa* spp., *E. stellulata* (in woodland areas), *L. lanigerum, Gynatrix pulchella*, *Acacia dealbata*, *Carex* spp., *Bolboschoenus* sp., *Eleocharis* sp., *Juncus* spp., and submerged and emergent aquatic species such as *Myriophyllum* sp., *Potamogeton* sp., *Isotoma fluviatilis*, and *Neopaxia australasica* (Tableland Aquatic and

Fringing Vegetation Complex) (Plates 3.2, 3.3). A section of river near Mt Clear also has patches of fringing *Phragmites australis* (Plate 3.4). The only weeds in the open valley appear to be the occasional *Rosa rubiginosa* and *Verbascum thapsus.* The area achieves a high condition ranking, having no visible disturbance and a high density of native vegetation cover.

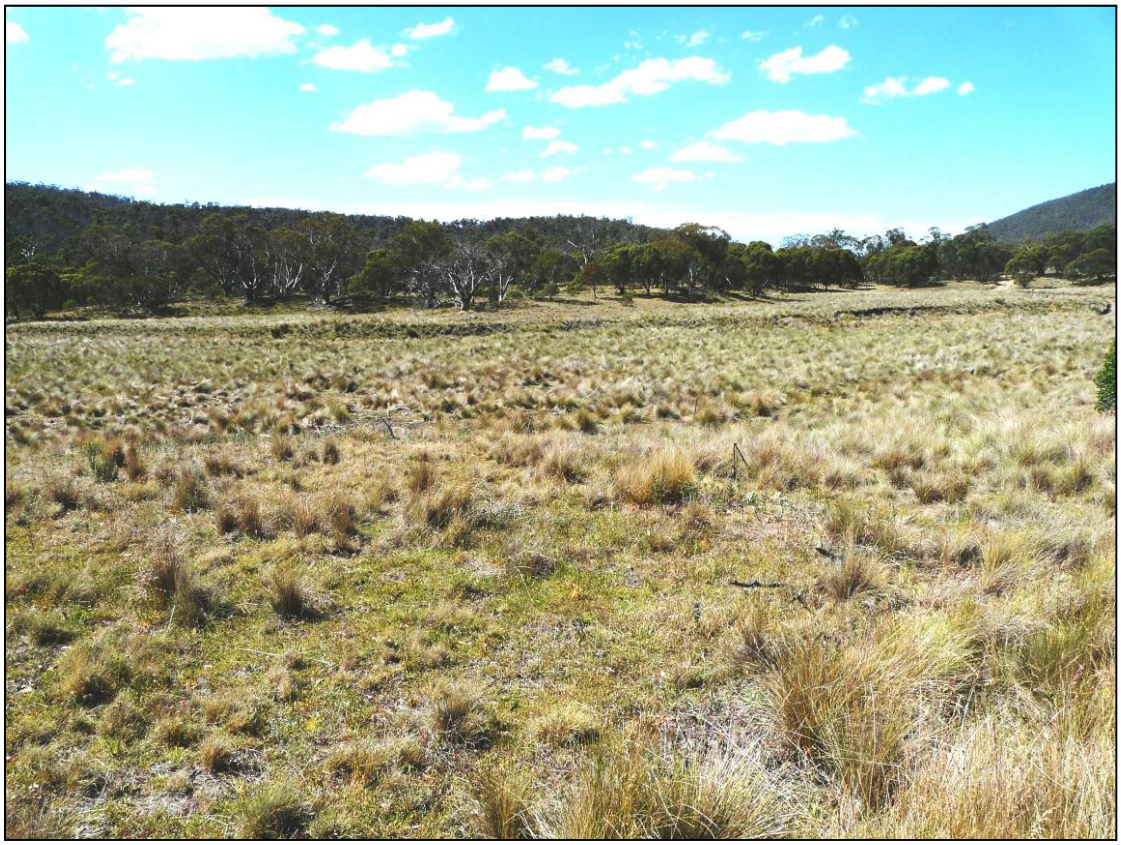

Plate 3.1: Tableland Wet Tussock Grassland in the upper Naas Valley

Plate 3.2: Tableland Aquatic and Fringing Vegetation Complex in the upper section of Naas Creek

Plate 3.3: Tableland Aquatic and Fringing Vegetation Complex in Naas Creek at Mt Clear

As the river flows downstream from the open Montane Wet Tussock Grassland and towards the lowlands it enters dense Snow Gum Montane Woodland in both the valley slope and the riparian zone (Maps 3.2a and 3.3a). The condition remains excellent with patches of *P. australis* (Plate 3.4) and a continuous belt of Tableland Aquatic and Fringing Vegetation Complex (Maps 3.3a to 3.6a). *Eucalyptus bridgesiana* dominates the valley slopes but is also is common near the river. There are patches of mature and juvenile *Eucalyptus viminalis* in sections along the riparian zone and in moister areas of floodplains. The areas of River Bottlebrush – Burgan Tableland Riparian Shrubland contain *Acacia melanoxylon*, *Bursaria spinosa*, *Rubus parvifolius* and *A. dealbata* leading into a more *Callistemon sieberi* dominated shrubland further downstream. *E. stellulata* and *E. pauciflora* remain the dominant tree species in and near the riparian zone with occasional *E. rubida* on the hillslope. Other species on the hillslope include *Austrodanthonia* spp., *Austrostipa* spp., *Poa* spp., *Chrysocephalum apiculatum*, and occasional weeds such as *V. thapsus*, *Hirschfeldia incana* and *Conyza* sp.

Further downstream, at lower altitude, the river flows through Broad-leaved Peppermint – Apple Box Tableland Woodland (Maps 3.6a to 3.8a). The riparian zone vegetation remains the same with an increase in River Bottlebrush – Burgan Tableland Riparian Shrubland where the river widens in rocky floodplain areas. There appears to be a gradient between Snow Gum Montane Woodland and Ribbon Gum Tableland Riparian Woodland. A combination of eucalypts occur at this point, with *E. viminalis* dominating the riparian zone and hillslopes on both sides of the river with some of the lower hillslopes and gullies dominated by *E. pauciflora* and scattered *E. bridgesiana*.

Shrubs in the riparian River Bottlebrush – Burgan Tableland Riparian Shrubland include *A. melanoxylon*, *C. sieberi*, *A. dealbata*, *L. obovatum*, *G. pulchella* (Plate 3.5). On the hillslope the vegetation community remains Broad-leaved Peppermint – Apple Box Tableland Woodland but many *E. blakelyi* seedlings are visible on the hillslope (regenerating post-2003 fire). *Bothriochloa macra* is present in parts and the occasional *E. stellulata*. As in areas upstream, the riparian zone is still in excellent condition with only minor occurrences of weeds such as *V. thapsus*, *Portulaca* sp. and *H. incana* at river crossings and along roadsides.
There is an area of River Bottlebrush – Burgan Tableland Riparian Shrubland on a bedrock floodplain just upstream of the Namadgi National Park boundary (Map 3.7a). Among the rocky pools a diverse range of species were observed during ground survey including *P. labillardierei*, *C. sieberi*, *L. lanigerum*, *R. parvifolius, E. bridgesiana* and *E. dives* (both on the hillslope and encroaching onto the floodplain), *A. dealbata*, *A. melanoxylon*, *Kunzea ericoides*, *Carex* sp., *Bolboschoenus* sp., *Hydrocotyle* sp., *Euchiton sphaericus*, *Persicaria* sp., *Crassula sieberi*, *Centipeda* sp., *Geranium solanderi*, *Cynoglossum* sp. and emerging *Myriophyllum* sp. The hillslope contains *E. bridgesiana* with an understorey of native shrubs such as *B. spinosa*, *Dodonaea* spp. and native grasses.

At the frequent road crossings, along fire trails and close to the park boundary, there is a mixture of weeds associated with disturbance, including *Portulaca* sp., *Echium vulgare*, *Senecio* sp., *Conyza* sp., *Hirshfeldia incana*, *Verbena bonariensis*, *V. thapsus*.

Plate 3.4: Tableland Aquatic and Fringing Vegetation Complex dominated by *Phragmites australis*

Plate 3.5: River Bottlebrush – Burgan Tableland Riparian Shrubland

At the Namadgi National Park boundary, where the Naas Valley fire trail crosses the Naas River the river appears as a dry flood creek. The riparian zone contains characteristic River Bottlebrush – Burgan Tableland Riparian Shrubland with similar shrubs to upstream and additional species such as *Paspalum distichum*, *Cyperus eragrostis*, *Eleocharis* sp., *Rumex* sp., *Juncus usitatus*, *Epilobium* sp., *Persicaria decipiens*, *Persicaria lapathifolia*, *Carex appressa* and *G. pulchella*. The fringing vegetation community, with associated shrubland, merges with the Broad-leaved Peppermint – Apple Box Tableland Woodland on the hillslope. A noticeable increase in weed cover occurs near the Namadgi National Park boundary particularly *Portulaca* sp., *E. vulgare*, *Senecio* sp., *Conyza* sp., *H. incana*, *V. bonariensis*, *V. thapsus* and *R. fruticosus* complex, dispersed from the adjacent agricultural land.

3.3.2 Namadgi National Park boundary to Caloola Farm

This reach is approximately 3 km in length and occurs entirely within rural land (Appendix 3A Maps 3.7a, 3.8a). From the Namadgi National Park boundary downstream to Caloola Farm, the landscape is highly modified, dominated by degraded rural land. The valley is moderately wide, with some low spurs. The valley slopes are largely cleared while the river bank riparian zone has continuous canopy cover with the dominant vegetation being Broad-leaved Peppermint – Apple Box Tableland Woodland and associated understorey species. Pre-European vegetation was probably *E. bridgesiana* in the gullies and riparian zone, possibly with *E. viminalis,* and *E. melliodora* and *E. blakelyi* on the adjacent hill and valley slopes.

Robinia, figs and poplars (*Robinia* sp., *Ficus* sp. and *Populus* sp.) surrounding an old homestead site in the valley east of Caloola Farm crossing have regenerated and formed a thicket post-fire. There are fields of *V. thapsus* and *Trifolium arvense* with pasture grasses and the occasional native grass.

The riverine vegetation near the Caloola Farm crossing is highly degraded and infested by weeds. At the time of the survey there was no surface water in the river bed, resulting in the encroachment of Tableland Aquatic and Fringing Vegetation Complex into the stream bed (Plates 3.6, 3.7). The river bed is very sandy with a strip of fringing vegetation, including a high proportion of remnant *E. bridgesiana* and *A. dealbata*. There are numerous infestations of blackberries, prune trees (*Prunus* sp.) and other herbaceous weeds.

Plate 3.6: Dry river bed on the Naas River near Caloola Farm showing encroaching Tableland Aquatic and Fringing Vegetation Complex

Plate 3.7: Naas River crossing at Caloola Farm showing encroaching Tableland Aquatic and Fringing Vegetation Complex

3.3.3 Caloola Farm to confluence with Gudgenby River

This reach is approximately 9 km in length, all through grazing and agricultural land (Appendix 3A Maps 3.8a, 3.9a). Downstream of Caloola Farm, the river flows through a broad flood plain with several low terraces. Bank slump and gully erosion is common, including in the side gullies (Plate 3.8). The whole reach is grazed by cattle and sheep, with stock access to the river. The floodplain riparian zone is also ploughed in places.

Plate 3.8: Lower Naas River: bank slumping in stream channel, grazed river flats and wooded footslopes

Native riparian and flood plain vegetation has largely been removed. Willows, pine trees (*Pinus* spp.) and poplars are scattered along the river. Floodplain areas are infested with thistle (*Cirsium vulgare* and *Cartamus lanatus*). On the valley slope west of the river there is a good cover of secondary native grassland (*Themeda triandra*, *Austrodanthonia* spp. and *Austrostipa* spp.) with

scattered *E. melliodora*, *E. blakelyi* and the occasional *E. polyanthemos.* Gullies running into the river are highly degraded, eroded and fringed with weeds interspersed with native species including *Juncus* sp. and *Carex* sp.

3.4 Naas River: Condition and Management Recommendations

The major portion of the Naas River is protected within Namadgi National Park and is in moderately high condition (Appendix 3A and 3B). The grassy valleys and adjacent woodlands that are now part of the park were seasonally grazed from as early as the late 1830s until the 1970s and '80s. Impacts varied and included tree removal, changes to burning regimes, trampling of stream banks and riparian vegetation, and introduction of pasture weeds (ACT Government 2010; Helman et al. 1988; Ingwersen 2001). Within the park many of these earlier impacts are not immediately obvious and as grazing pressure appears to have been light in many areas the landscape has recovered. However, the presence of persistent pasture weeds like *R. rubiginosa* and *V. thapsus* is a reminder of the past land use. Areas that are now a focus for recreational activities also provide an opportunity for weed species to maintain their dominance. As noted above, the effects of pastoral and agricultural activites are most evident in the lower reaches of the Naas River.

Management maps for the Naas River are contained in Appendix 3C. These maps indicate locations where management actions are recommended.

3.4.1 Upper Naas Creek to Namadgi National Park boundary

The upper Naas Creek near Mt Clear contains montane and subalpine aquatic and wet ground communities. These communities are species rich and, though the areas were grazed in the past, have a high level of natural integrity (see Glossary). Unlike the upper Cotter and Gudgenby areas, they were little affected by the 2003 bushfire.

There are several different assemblages in the River Bottlebrush–Burgan Tableland Riparian Shrubland community along this section of the river. The main changes appear to be from a *Leptospermum* spp. (tea tree) assemblage in the upper Naas Creek, through various *Acacia* spp. (wattle) dominated assemblages to the widespread *Kunzea*/*Callistemon* assemblage found throughout the Murrumbidgee Catchment in the ACT. The major influences on community type appear to be altitude, the width of the riparian zone and the closeness of the valley slope.

Weeds that occur in the upper Naas area derive from human activity and access, and the list of weeds from around road crossings suggests both residual grazing weeds and those spread by socks, boots and vehicles. The Bicentennial National Trail, used extensively as an equestrian trail, runs for 26 km along the Naas River fire trail through Namadgi National Park. Horse manure has been shown to contribute to weed dispersal (Weaver and Adams 1996).

Management recommendations for this river section (Appendix 3C Maps 3.1c to 3.7c) include:

- weed control at and around vehicle river crossings and at the interface between Namadgi National Park and adjacent rural land
- continuing management of areas in the upper Naas Creek for recovery from fire and past grazing
- management of recreational use to avoid the spread of pest plants
- continuing feral animal control
- management of horse riding to reduce the risk of introduction of weed species.

Policies relevant to the above recommendations are contained in the *Namadgi National Park: Plan of Management* (ACT Government 2010).

3.4.2 Namadgi National Park boundary to Caloola Farm

This short section of the river is in rural land and is distinguished by the gradual broadening of the valley as elevation decreases. Much of the area shows damage from stock grazing and fire trail construction. The condition of this and the next river section (below) was documented by Starr (2000b) and the Gudgenby– Naas Catchment was identified as being affected by land degradation following drought, the 2003 bushfire and subsequent storm rains (ACT Commissioner for the Environment 2003).

Management recommendations for this section (Appendix 3C Maps 3.7c, 3.8c) include:

- erosion control measures at vehicle river crossings
- weed control, focused on pest plants such as blackberry
- rabbit control
- revegetation of riparian areas with appropriate native species
- protection of remnant vegetation.

3.4.3 Caloola Farm to confluence with Gudgenby River

The condition of the lower Naas River derives from a long period of rural use. It is likely that prior to European settlement the valley contained a chain-of-ponds waterway with tussock grassland that graded into Yellow Box – Blakely's Red Gum Tableland Grassy Woodland. This suggestion is based on the presence of remnants of both characteristic woodland and grassland species. Associated with rural land use, windbreaks of pines and deciduous trees have been planted in the area including the riparian zone.

Management recommendations for this section (Appendix 3C Maps 3.8c, 3.9c) include:

- erosion and sedimentation control measures
- fencing out of the river bed and adjacent creeks, with the installation of off-stream stock watering points, to remove stock from the stream
- revegetation of the riparian zone with suitable native species
- review of stocking rates and cultivation.

4 GUDGENBY RIVER

The Gudgenby River rises at the confluence of Bogong and Middle creeks (approximately 1000 m ASL) and is 31 km long. The river flows north-north-east through Namadgi National Park and is fed by a series of lateral tributaries, some with intermittent flows, as well as the Naas River, until it joins the Murrumbidgee River two kilometres south of the village of Tharwa (at 576 m). The river flows through grazing land from five kilometres above the causeway on Orroral Road to the confluence with the Murrumbidgee River.

4.1 Topography

The Gudgenby River develops from a complex fenland created by the confluence of Middle Creek and Bogong Creek that rise on either side of the peak of Yankee Hat. The river runs through a small gorge before the morass, added to by Hospital Creek, at the Gudgenby homestead. Below the junction with Rendezvous Creek, the river enters a long defile between high spurs until the valley widens from Glendale Crossing to Rocky Crossing, opens again below Fitzs Hill and remains so until the hilly area just before the confluence with the Murrumbidgee (Ingwersen 2001).

4.2 Background

There is little specific reporting on vegetation floristics in the Gudgenby River or its tributaries. Evans and Keenan (1992) describe the vegetation at both Nursery Swamp and Rock Flats. Ingwersen (2001) details the vegetation of the whole catchment, with an emphasis on the eucalypt associations, while the valley floor vegetation is also documented. The flora and hydrology suggest the characteristics of chains-of-ponds as the form for the upper watershed of the river. All the flatter river valley areas were grazed from the late 1830s and rural land use continues in the lower part of the catchment. Significant natural and cultural sites in the Gudgenby River catchment are described in NCPA (1990a).

The aerial photographs included in *The Lands of the Australian Capital Territory* (Department of the Interior 1965) allow a unique historical perspective. The view of Glendale Crossing shows scattered trees, extensive areas with little tree cover and less dense riparian vegetation. Rocky Crossing (now referred to as 'Gudgenby Pipes') has little vegetation around the farm buildings and very much more open woodland on both the gentle western slope and the steeper east slope. The vegetation on the west of Fitzs Hill is quite dense. In a view of Top Naas Valley, the Gudgenby is lined with poplars and willows but there are sand bars and open stretches of water.

4.3 Gudgenby River: Survey Results by River Section

Maps for the Gudgenby River are presented in Appendix 4.

4.3.1 Confluence of Bogong and Middle creeks to Boboyan Road

This section is approximately 3.2 km in length and occurs entirely within Namadgi National Park (Appendix 4A Map 4.1a).

The Gudgenby River rises at the confluence of Bogong and Middle creeks in a *Phragmites* reedland sub-community of the Tableland Aquatic and Fringing Vegetation Complex (Johnston et al. 2009; Appendix 4A Map 4.1a). Riverine native vegetation at this point is in excellent condition and contains fringing, submerged and emergent vegetation species including *P. australis*, *Schoenoplectus validus*, *Bolboschoenus* sp., *Ranunculus* sp., *Myosotis caespitosa*, *J. usitatus, J. polyanthemus*, *J. articulatus, Myriophyllum variifolium*, *Epilobium* sp., *Rumex crispus*, *Carex* sp.,

Lythrum salicaria and *Potamogeton tricarinatus*. The riverbanks are fringed with *P. labilladierei*, *R. parvifolius*, and *G. solanderi* (Plates 4.1, 4.2).

Plate 4.1*: Schoenoplectus validus* at the confluence of Bogong and Middle creeks, upper Gudgenby River

The adjacent hillslope vegetation community is Snow Gum Montane Woodland with *E. stellulata* closest to the river and *E. pauciflora* and *E. rubida* further up the slopes. Shrubs and grasses include *T. triandra*, *Cratageous monogyna*, and *Hakea* sp. (Plate 4.3).

Plate 4.2: *Bolboschoenus* sp., upper Gudgenby River

Plate 4.3: Snow Gum Montane Woodland near the source of the Gudgenby River

Below Gudgenby homestead, the riparian flats in the vicinity of the bridge at the Hospital Creek confluence (Appendix 4A Map 4.1a) contain *P. labilladierei* tussock and some non-invasive weed species associated with disturbance. The river forms pools and chains-of-ponds with a sedgeland fringe and *M. variifolium* Submerged and Emergent Herbland sub-community (Johnston et al.

2009) (Plate 4.4). Species present include *Carex gaudichaudiana, C. appressa*, *Lycopus australis, L. salicaria, Epilobium* sp., *Bolboschoenus* sp., *J. usitatus*, *J. polyanthemus*, *Eleocharis alatus* and *S. validus.*

Plate 4.4: Submerged and Emergent Herbland sub-community at Hospital Creek, Gudgenby River

Snow Gum Montane Woodland persists, with *E. stellulata* on the flats closest to the river and *E. pauciflora* and *E. rubida* up the hillslope (Plate 4.5). Excluding the few old willows resprouting along the river and on the flats, willow management has been successful along this section. Although the area was heavily impacted by the 2003 bushfire, the trees are regenerating well and should recover to pre-fire condition with time. There is no sign of fire effects in the grass and shrub layer.

Plate 4.5: Snow Gum Montane Woodland, Gudgenby River near Gudgenby homestead

4.3.2 Boboyan Road to Glendale Crossing

This section is approximately 7.2 km in length and occurs entirely within Namadgi National Park (Appendix 4A Maps 4.2a, 4.3a). This section of river continues through gorge country and is difficult to access. Therefore, with the exception of a site on the Gudgenby Bridge at Boboyan Road (Plate 4.6), it was surveyed entirely using aerial imagery.

The river channel is rocky and has large boulders, among which, are many fringing sedges and aquatic fringing species including *Carex fascicularis, Juncus articulatus*, *Ajuga australis*, *L. salicaria* and several dead and occasional regenerating *Salix nigra*. The vegetation community in the riparian zone is Ribbon Gum Tableland Riparian Woodland although *E. viminalis* is still quite rare at this point.

A narrow shrubland beside the boulders contains a good mix of native species including *Lomatia* sp., *Hakea* sp., *G. pulchella*, *Acacia siculiformis*, *B. spinosa*, *L. obovatum* with some weeds such as blackberries and *R. rubiginosa.* The shrubland merges with the adjacent Snow Gum Montane Woodland at higher elevation on both sides. The ground cover is mostly native, including a *Senecio* sp., but contains some introduced species such as *Phalaris* sp. and *Fescue* sp.

The riparian vegetation above Glendale Depot (Namadgi National Park) changes to River Bottlebrush – Burgan Tableland Riparian Shrubland, dominated by an *A. dealbata* fringe on the river (Plate 4.7). The hillslope community changes to Broad-leaved Peppermint – Apple Box Tableland Woodland, although *E. pauciflora* and scattered *E. rubida* still occur.

This section was impacted by the 2003 bushfire but is regenerating well. Willows within the river, particularly at the bridge, are dead possibly due to fire or willow control work. Some of the weed species present may be a result of the close proximity to the road and the bridge site is used also as a public access point to the river.

Plate 4.6: Willow control on the Gudgenby River at Boboyan Road bridge

Plate 4.7: *Acacia dealbata* shrubland on the Gudgenby River, near Glendale Depot

4.3.3 Glendale Crossing to Fitzs Hill

This section is approximately 11 km in length and occurs within Namadgi National Park and adjacent rural land (Appendix 4A Maps 4.3a to 4.5a). The river in the upstream part of this section flows through a wide open valley. On the north-east side of the river, near the ACT Parks, Conservation and Lands Glendale Depot the vegetation has been partially cleared. It is likely that a Broad-leaved Peppermint – Apple Box Tableland Woodland containing scattered *E. rubida* and *E. pauciflora* (of which a few remnants remain) formerly dominated the valley slope, which now mostly contains shrub species such as *Grevillea lanigera* and *Hakea macrocarpa.*

The river is fringed by dense *A. dealbata, E. viminalis, E. dives* and the occasional *E. pauciflora, E. stellulata and E. bridgesiana* dispersed from the hillslope. The southern end of this reach is similar to the Naas River with *E. bridgesiana* and *E. dives* and a good mix of other eucalypt species continuing down into the lowlands.

Close to the bridge at Glendale Crossing, the riparian vegetation includes *E. viminalis, L. obovatum*, *Bolboschoenus cardwelli* and *J. usitatus, J. polyanthemus*, *Gahnia* sp. *Typha orientalis* and a dense thicket of *A. dealbata* in the sand on both sides of the river. Willows also occur on the river just downstream of the bridge. The valley slope community continues as Broad-leaved Peppermint – Apple Box Tableland Woodland with some *E. rubida* and shrubs such as *B. spinosa, Acacia pravissima*, *A. gunni, A. siculiformis* and the rare *Discaria pubsescens.*

At the Glendale picnic area the vegetation is *A. dealbata* with *E. viminalis*. *E. bridgesiana* and *E. dives* dominate the hillslopes with the occasional scattered *E. rubida* and *E. pauciflora*. The vegetation appears to grade slowly into *E. dives* at the river level towards Orroral Road.

At the boundary of Namadgi National Park and rural land, the valley slope vegetation community is Broad-leaved Peppermint – Apple Box Tableland Woodland in the stony granite rises and Snow Gum – Candle Bark Tableland Woodland in the frost hollows. At the site of an old homestead

there are signs of a former orchard, two *Pinus haloppensis* and a *Robinia sp.* thicket, all within the Snow Gum – Candle Bark Tableland Woodland. There is also a small regenerating thicket of *E. stellulata* near the river. The grasses are mostly native *Poa* sp. and *Austrostipa* sp. Shrubs present include *B. spinosa, Lomatia* sp., *C. longifolia, R. parvifolius, G. pulchella, A. siculiformis,* and the forb *Chrysocephalum apicularis.*

Downstream, River Bottlebrush – Burgan Tableland Riparian Shrubland continues to fringe the river, with weed species including *Salix fragilis, S. nigra*, *R. fruticosus* complex, *R. rubiginosa* (forming thickets in places) and occasional *V. thapsus*. Even though sections of this reach are used for agriculture, vegetation condition is very high and native species are successfully regenerating post-fire.

At the Orroral Road causeway the river becomes an artificially wide pool with a constructed boulder stream below. *Salix babylonica* is growing in the upstream section with the pasture grass, *Phalaris* sp., understorey and native fringing species including *P. australis*, *C. sieberi* and *Bolboschoenus sp.* The adjacent shrubland includes *A. dealbata, G. pulchella*, *L. obovatum, Lomatia* sp., *R. parvifolius, C. longifolia, K. ericoides* and *P. labillardierei* with the occasional *E. bridgesiana, E. dives* and *E. dalrympleana* on the slopes. Valley slope species (especially on the gentler western side) include *E. pauciflora* and or *E. dives* woodland with rich shrub diversity (Plate 4.8).

Plate 4.8: River Bottlebrush – Burgan Tableland Riparian Shrubland (dominated by *Acacia dealbata*) below causeway on Orroral Road

4.3.4 Fitzs Hill to confluence with the Naas River

This reach is approximately 5 km in length and occurs entirely within rural lease (Appendix 4A Maps 4.5a, 4.6a). The river flows into a valley floor grassland with a river incision forming an adjacent terrace. Blackberry is very common in the riparian zone (Plate 4.9).

Two river channels contain *Myriophyllum verrucosum*, the water net *Hydrodictyon reticulatum,* margins of *Carex* sp. and *Bolboschoenus* sp. There are some off-stream wetlands near the previous riverline which contain *Azolla* sp., *Lemna trisulca* and algae (*H. reticulatum* and the silkweeds *Spirogyra* spp. and *Mougeotia* sp.). These wetlands probably become part of the river when flows are high but return to their billabong state in the floor of the new riparian zone soon after. There are probably some ephemeral wetlands and flood runners along the grazed part of the river in this section (Plate 4.10).

On the valley slope, Broad-leaved Peppermint – Apple Box Tableland Woodland is the dominant vegetation community but historically this area may have been an open sedgeland prior to stream incision. Many of the mature trees show signs of fire and several juvenile eucalypts are regenerating near the river. Fringing the river and towards the hilly country on the boulder floodplain are dense thickets of blackberry with *A. dealbata* and *A. melanoxylon*, and some *L. obovatum*.

Overall the entire broad floodplain is covered in pasture grasses and associated weed species (Plate 4.11). The entire valley has been modified by rural land uses and the river is lined almost entirely by exotic tree and shrub species including blackberries, willows, poplars, elms (*Ulmus* sp.), *Prunus* sp. and *Malus* sp. The riverbank has long been used, especially close to homes, for orchards and gardens. The Europeanisation of the riverbank is very pronounced downstream to the confluence with the Naas River

Plate 4.9: Tableland Aquatic and Fringing Vegetation Complex, Gudgenby River below Fitzs Hill, rural lease with large infestations of blackberry.

Plate 4.10: Tableland Aquatic and Fringing Vegetation Complex surrounding offstream wetland Gudgenby River

Plate 4.11: Gudgenby River, old homestead crossing

Plate 4.12: Gudgenby River, rural land with exotic tree species

Plate 4.13: Poplars along the Gudgenby River at Naas Bridge upstream of Naas River confluence

4.3.5 Naas River confluence to the Murrumbidgee River

This section is approximately 10.5 km in length and occurs within rural lease and Special Purpose Reserve (Public Land) (Appendix 4A Maps 4.6a to 4.8a).

The river flows through a wide incised floodplain and the stream channel is braided. The vegetation community in the riparian zone remains River Bottlebrush – Burgan Tableland Riparian Shrubland with Broad-leaved Peppermint – Apple Box Tableland Woodland on the hillslope. There are many scattered willows along the river channel and dense blackberry in parts.

North of the Naas River confluence, in both upstream and downstream directions, both the riparian zone and the valley slope the Gudgenby River appear to be in a fairly intact native condition, with only a few scattered exotic trees. The River Bottlebrush – Burgan Tableland Riparian Shrubland fringing the incised channel includes *K. ericoides*, *L. obovatum*, *C. sieberi* and *A. dealbata* and the sandbars and dry channels contain *P. lapathifolia*, *P. hydropiper*, *Carex* sp., *C. eragrostis* at margins, and *M. verrucosum* and silkweeds (*Spirogyra* or relatives) in drying pools.

The riparian community probably used to be a mixture of River Bottlebrush – Burgan Tableland Riparian Shrubland and Ribbon Gum Tableland Riparian Woodland, while the adjacent valley slope community was probably Yellow Box – Blakely's Red Gum Tableland Grassy Woodland. Currently, only remnant pasture trees remain but there are a few planted *E. viminalis*, *E. blakelyi* and *E. bridgesiana*. The occasional *E. dives*, *Brachychiton populneum* and *Casuarina* sp. were observed higher on the hillslope where the vegetation was in a more natural state.

At the intersection of Sunshine Road and Angle Crossing Road, where the river flows through grazing land, there are many weeds typically associated with pastoral land use and rural settlement. These include *Populus nigra*, *P. alba*, *S. fragilis*, *S. nigra*, *Avena avicularis*, *Echium plantagenium*, *E. vulgare*, *Tragopogon* sp., *C. monogyna*, *Eragrostis curvula, V. bonariensis*, *V. thapsus, Cirsium* sp. and a considerable amount of blackberry. The River Bottlebrush – Burgan Tableland Riparian Shrubland is in poor condition with large amounts of deposited sand and a sparsely colonised bank. A cleared stretch on the western side of the river is actively eroding into gullies often feeding into farm dams.

A good cover of aquatic fringing species does occur; however, including *C. sieberi*, *C. eragrostis*, *Rumex* sp., *Azolla* sp., *Bolboschoenus* sp., *Carex* sp., *L. salicaria*, *Persicaria* sp., *Hypochaeris* sp. *P. labillardierei*, *Euphorbia* sp. and *Juncus* sp.

Overall, the riparian zone downstream of Sunshine Rd through to the confluence with the Murrumbidgee River is in low condition and is highly degraded and modified. The river bank shows signs of trampling and compaction by cattle, which were observed accessing the river (Plate 4.14). Adjacent valley and hillslope vegetation is in moderate condition on the eastern side of the river, while the western side comprises low quality, cleared rural land.

Plate 4.14: River Bottlebrush – Burgan Tableland Riparian Shrubland, Gudgenby River; near Sunshine Road (top); dry river bed (bottom left); stock grazing within riparian zone (bottom right)

4.4 Gudgenby River: Condition and Management Recommendations

The Gudgenby River above Glendale Crossing has areas with limited human access and a subalpine reach where human activity has been minimal in recent years. These two sections of the river are in high condition. While much of the area between Glendale Crossing and Fitzs Hill has been lightly grazed in recent years, there are long term effects of previous rural land use. Below Fitzs Hill, the Gudgenby, like its tributary the Naas, shows the continuing effects of several generations of rural land use. The lower river reaches are in overall moderate condition, but there are degraded sections with significant management issues, such as weed infestation and gully erosion.

Assessment of condition is presented on maps in Appendix 4A. Vegetation dominance change assessment is presented on maps in Appendix 4B. Management maps for the Gudgenby River are contained in Appendix 4C. These maps indicate locations where management actions are recommended.

4.4.1 Confluence of Bogong and Middle creeks to Boboyan Road

Bogong and Middle creeks converge in marshy tussock grassland with healthy riparian vegetation. The relatively flat valley floor is 20 to 50 metres wide with bedrock close to the surface. This has allowed the development of a slightly incised river line with a pool and riffle sequence. The growth form of the instream vegetation indicates that while the water levels may rise and fall, the pools retain water throughout most years, even in prolonged drought. The *Myriophyllum* displayed 5–20 mm of emergent stem with aerial leaves in mid-autumn 2009. The *P. tricarinatus* had well developed floating, as well as numerous submerged leaves.

The small gorge that separates the confluence from the morass in front of Gudgenby homestead is in good condition with the exception of a small number of willows. There is a diverse range, in form and species, of aquatic emergent fringing vegetation at the morass, from where Hospital Creek joins to below the entry of Rendezvous Creek. As the valley narrows, the *E. stellulata* and *L. lanigerum* woodland along the river at the downstream end of the morass is indicative of Snow Gum Montane Woodland

Management recommendations for this river section (Appendix 4C Map 4.1c) include:

- willow management in the gorge and near the morass
- continued planting and management of the margins of the morass.

4.4.2 Boboyan Road to Glendale Crossing

This stretch of river lies in a deep and narrow gorge between the overlapping spurs of the ranges. Typically the river passes through races of large boulders separated by runs of more gentle water. The terrain severely limits access and survey of this section relied on aerial imagery. The valley slope vegetation is diverse. The presence of weed species (*R. rubiginosa, R. fruticosus* complex, *Salix* spp. and others) was notable at both ends of this section, near the Boboyan Road bridge and upstream of the Glendale Depot.

Management recommendations for this river section (Appendix 4C Maps 4.1c to 4.3c) include:

- weed management associated with vehicle access points
- continuation of willow and blackberry control in the vicinity the Boboyan Road bridge.

4.4.3 Glendale Crossing to Fitzs Hill

As this area is a mixture of reserve (Namadgi National Park) and lightly grazed country, it provides an opportunity to compare both the effects of land use and the relative impact of that land use on vegetation recovery following the 2003 bushfire. The Glendale Crossing area may be more heavily timbered now than at any time since the commencement of pastoral settlement and tree clearing in the 19th century. The effects of this pastoral use were evident in the 1960s when the area was open country with widely spaced mature trees (Department of the Interior 1965).

The grazing land from the Glendale picnic area downstream is moderately timbered and the river line defined in most places by River Bottlebrush – Burgan Tableland Riparian Shrubland. At Glendale Crossing this shrubland is floristically rich but presently dominated by a canopy of *A. dealbata*. This is a characteristic species in the riparian shrubland community and is a primary coloniser post-fire. As *A. dealbata* is short lived it can be expected that this post-fire canopy will give way to other characteristic riparian species, including *L. obovatum* and possibly other wattles such as *A. siculiformis* or *A. pravissima*. Over the longer term some Ribbon Gum Tableland Riparian Woodland may re-establish. Further downstream, below the picnic area and out of the National Park, the river flows through rural leases used for grazing. This is in open Ribbon Gum Tableland Riparian Woodland with *E. pauciflora* and *E. stellulata* in frost hollows. The shrubs in this area include *L. obovatum* and *B. spinosa*, and these may form the riparian vegetation where there are long gaps in the tree cover.

At Rocky Crossing on Orroral Road and downstream, the riparian vegetation shows the effects of a history of rural land use and road construction. Occasional widely spaced trees are woodland remnants. Riparian shrubland is dominated by *S. fragilis*, which is very successful at exploiting disturbance and fire damage, and is able to withstand periods of inundation and grow readily from cuttings. In areas with numerous large boulders, like Rocky Crossing and below, *S. fragilis* snags can quickly colonise a reach.

Management recommendations for this river section (Appendix 4C Maps 4.3c to 4.5c) include:

- willow management, especially at and below Rocky Crossing
- management of blackberry and pasture weeds.

4.4.4 Fitzs Hill to confluence with the Naas River

It is likely that the river valley in this area previously contained a chain-of-ponds and extensive tussock grassland, but was irrevocably changed by the incision of the stream channel (as described by Eyles (1977a) for the Southern Tablelands generally). The condition of the reach is poor and there is a significant need for rehabilitation.

Remnants of the riparian and hillslope vegetation occur along the reach. Below Fitzs Hill there is a patch of *E. bridgesiana*, an outlier from the valley above, on the lower river terraces. Associated with these trees are *L. obovatum*, *A. melanoxylon* and *A. dealbata*. Riffles in the stream contain *M. verrucosum* and sedges. In a billabong behind one of the terraces is a well developed wetland with rushes and sedges and the water is covered by *Azolla* and *L. trisulca*. These remnants provide a guide for riparian and stream rehabilitation.

Management recommendations for this river section (Appendix 4C Maps 4.5c, 4.6c) include:

- control of blackberry, willows, English elms and poplars
- management or removal of stone fruit orchards (cultural heritage significance may need to be assessed)
- fencing the river from stock and provision of off-stream watering points
- bank and stream revegetation with suitable local species
- erosion control work.

4.4.5 Naas River confluence to the Murrumbidgee River

This reach of the river skirts the end of the Clear Range in a wide rural valley and then passes through a low gorge-like section before it enters the Murrumbidgee River. The overall condition is low to moderate. The river bed is wide and sandy, leading to braiding of the water channel and then pondages as the river dries up. The Gudgenby–Naas system has a tendency to stop flowing in summer and autumn, although it is presumed the drainage lines continue beneath the sand.

There have been some efforts to manage the riparian condition, especially where roads cross the river. At the Smiths Road crossing, there is evidence of attempted reintroduction of eucalypts and shrubs on the high sandy banks. The success has been moderate given that the area is well drained and follow-up watering is often erratic.

Management recommendations for this river section (Appendix 4C Maps 4.6c to 4.8c) include:

- fencing the river from stock and provision of off-stream watering points
- control of blackberry, willows and pasture weeds
- continuation of replanting and bank restoration
- erosion control work.

5 PADDYS RIVER

The Paddys River rises at the confluence of Blue Gum and Punchbowl creeks, on the north-western side of Mt Tennent, and is 28 km long. The river flows through rural land and former softwood plantation until it joins the Cotter River at the Cotter Recreation Area. It is joined by the Tidbinbilla River, which flows from the Tidbinbilla Nature Reserve, approximately one kilometre upstream of the Discovery Drive crossing. Discovery Drive is the access road to the Canberra Deep Space Communication Complex.

5.1 Topography

The Paddys River has three sections. The headwaters section is in a valley formed on the north-western side of Mt Tennent by Punchbowl and Blue Gum creeks. From there the river flows north across a moderately wide shallow valley until it cuts down into the main valley. The river here is deeply incised (Starr 2000b).

The main valley runs north-west from Tidbinbilla Road (which becomes Paddys River Road north of the entrance to Tidbinbilla), then northerly to the western side of the Bullen Range where the river is deeply incised into the valley floor. The river is joined by Gibraltar Creek and the Tidbinbilla River in the first part of this section. The river has long reaches with bar-ended pools created by either rock outcropping, sandbars from silting, or emergent reeds and rushes.

The third section is a river gorge from near Flints Crossing to the confluence with the Cotter River, which is about 1.5 km above where the Cotter joins the Murrumbidgee River. This section is characterised by overlapping spurs, and the waterway is a series of rapids, riffles and pools.

5.2 Background

The Mt Tennent – Blue Gum Creek area is a major watershed for the Paddys River. Gilmour et al. (1987) report on very detailed vegetation surveys of the Blue Gum Creek and Punchbowl Creek branches of the upper Paddys River catchment. There are only scattered references to riparian communities or their condition. Significant natural and cultural sites in the Paddys River catchment are described in NCPA (1990b).

Starr (2000c) states that with the exception of major flood events, in particular the 1995 flood, the Paddys system has been stable for many years. However, the Paddys River catchment, like others on the Southern Tablelands, went through a period of change following European settlement (NSW DLWC 2000), the effects of which are still evident. Soil erosion following clearing of hillsides and introduction of grazing animals that reduced and changed ground cover resulted in extensive post-settlement alluvial development on a deep alluvial base. More recently, changes in stocking rates and land use have lead to the development of secondary wooded areas in places where tree coverage in pre-settlement times may well have been much lighter. In parts of the catchment, dense *K. ericoides* (burgan) shrubland has developed. Extensive areas in the northern part of the catchment were planted to *P. radiata* through the 20th century. These plantations were destroyed in the 2003 bushfire.

Starr (2000c) outlines the following phases of riparian change:

- Aboriginal use of the land with some (unknown) level of burning
- first selection, with little timber removal after the initial burst, and heavy stocking
- compulsory clearing in the late 19th and pre-war 20th century
- post-1944 pasture improvement and more regulated stocking rates
- the 1995 flood.

Subsequent to Starr's report the catchment was impacted by the high intensity 2003 bushfire and following heavy rainfalls.

5.3 Paddys River: Survey Results by River Section

Maps for the Paddys River are presented in Appendix 5.

5.3.1 Confluence of Blue Gum Ck and Punchbowl creeks to Tidbinbilla Road

This reach is approximately 7.3 km in length and occurs entirely within rural land (Appendix 5A Maps 5.1a, 5.2a). The Paddys River rises at the confluence of Blue Gum and Punchbowl creeks in a sparsely timbered, wide valley of Fen/Sedge Montane Wet Tussock Grassland. The river bed itself is deeply incised, wide and heavily eroded by past flood events, land modification and grazing pressure. This erosion has caused exposure and dessication of the sedgeland and created a new riparian zone within the incised river bed (Plate 5.1).

Plate 5.1: Paddys River, broadening of the channel below confluence of Blue Gum and Punchbowl creeks

Ground cover in the unstable channel of Blue Gum Creek is diverse including *Austrofestuca hookeriana, Grateola peruviana, P. decipiens, Isotoma fluviatilis* subsp. *australis, Isolepis sp.* aff. *montivaga* (although the area is not alpine), *Cyperus (Kyllinga) sphaeroideus, Bolboschoenus fluviatilis, Epilobium tasmanicum, Veronica anagalis-aquatica* and in the soak, *Persicaria hydropiper.* The shrubs in the midstorey include *A. melanoxylon*, *A. siculiformis*, *A. dealbata*, *L. obovatum* and *K. ericoides*. A small coppice of *E. bridgesiana* and *E.viminalis* is growing in the middle of the incised creek bed (Plate 5.2) and further downstream some weeping willows *S. babylonica* and blackberries. Within the surrounding sedgeland/tussock grassland, species present include *Juncus* spp. (possibly *J. usitatus, J. articulatus* and *J. polyanthemus*), *R. crispus,* and some pasture weeds including *V. thapsus*, *C. vulgare* and *R. rubiginosa.*

Plate 5.2: *Eucalyptus viminalis* and *Eucalyptus bridgesiana* saplings above source of Paddys River

The adjacent valley slope is relatively treeless and contains River Bottlebrush – Burgan Tableland Riparian Shrubland. *E. rubida* and *E. bridgesiana* are scattered on the valley floor with coppices of unique assemblages in drainage lines such as *E. bridgesiana, E. viminalis* and the occasional *E. rossii*, *E. stellulata* and *E. pauciflora*. Exotic trees planted near Punchbowl Creek, above the old McKeahnie house 'Blythburn Cottage', are well established. These include *Ulmus procera* and *Pinus* spp. (Plate 5.3).

Continuing downstream the river is moderately incised. The vegetation of the valley floor remains open Fen Sedge Montane Wet Tussock Grassland, highly modified by rural land use. Plantings of *Salix* spp. are scattered throughout the landscape and along the creek line. A stand of *S. babylonica* and *C. monogyna* shrubland has spread across the floodplain, possibly after the 2003 bushfire. Erosion and channel infill, vegetation zonation and tree planting at Booroomba are shown in Plate 5.4.

The riparian vegetation is River Bottlebrush – Burgan Tableland Riparian Shrubland dominated by *K. ericoides* and *A. dealbata* in parts, especially in rocky riffle/run areas. At such locations rocky niches in the adjacent hillslope provide a refuge for many native shrubs. Black Cypress Pine Tableland Woodland occurs on the hillslope north of the Booroomba Road and although heavily affected by fire, appears to be recovering well with many small seedlings and the occasional mature tree visible (Plate 5.5).

Plate 5.3: Blythburn Cottage with exotic tree plantings

Plate 5.4: Paddys River: erosion and zonation at Booroomba.
Note stream bed infill and minor stream incision.

Some *E. viminalis* are present close to the river and Snow Gum – Candle Bark Tableland Woodland lines frost hollows of the adjacent valley slopes with a similar composition of *E. bridgesiana*, a large amount of colonising *K. ericoides* and pasture grasses.

Plate 5.5: Black Cypress Pine Tableland Woodland on Paddys River north of Booroomba

5.3.2 Tidbinbilla Road Crossing to gorge on Paddys River

This reach is approximately 16 km in length and also occurs entirely within rural land use (Appendix 5A Maps 5.2a to 5.5a). A few scattered *E. viminalis* are in the creek bed close to the bridge with *E. bridgesiana* extending down from the adjacent hillside. Ribbon Gum Tableland Riparian Woodland may have previously extended downstream to the gorge, but there is now little evidence of the former vegetation cover, only a few scattered mature trees that dot the creek line and occasionally broad floodplain (Tanners Flat). *K. ericoides* has colonised this area, developing a Burgan Derived Tableland Shrubland. Such dense burgan shrubland appears to develop in secondary grasslands derived from the clearing of previous tree cover, where burgan would have been an understorey shrub (Ingwersen 1985).

Some sections of river contain River Bottlebrush – Burgan Tableland Riparian Shrubland dominated by *A. dealbata* and *K. ericoides* with a high cover of blackberry, many willows in parts, and a long stretch of planted poplars. The adjacent valley slope is highly modified rural land with pasture grasses the dominant ground cover. Some patches of remnant Snow Gum – Candle Bark Tableland Woodland occur in frost hollow areas with Broad-leaved Peppermint – Apple Box Tableland Woodland comprising the remainder. In some sections, the scattered trees may represent remnants of Yellow Box – Blakely's Red Gum Tableland Grassy Woodland (Plate 5.6).

Plate 5.6: Paddys River, upstream from Discovery Road bridge

There is a partially cleared stand of *P. radiata* on 'Miowera' property (now being colonised by Burgan Derived Tableland Shrubland) as well as intact stands of mature trees. As the river continues through to Tanners Flat the landscape remains highly modified rural land dominated by exotic trees and understorey in both the riparian zone (a broad floodplain) and adjacent valley slope. In the riparian zone, native species that do occur include *L. obovatum*, *K. ericoides*, *A. dealbata*, *A. siculiformis*, *Phragmites* sp., *Cyperus* sp., *Schoenoplectus* sp., *Carex* sp., *Mentha* sp., *Persicaria* sp., *Rumex* sp., *Bolboschoenus* sp. Introduced species (including some ACT declared pest pants) include *Eragrostus curvula*, *Cardus nutans*, *Phalaris aquatica*, *V. bonariensis*, *Conyza bonariensis* and *Lactuca serrulata* (Plate 5.7).

A mixture of exotic trees including poplars, willows (*S. nigra*, *S. babylonica*, *S. fragilis*) and elms (*Ulmus* sp.) occur within the riparian zone along with dense blackberries. Plantings of *C. cunninghamiana* and *Eucalyptus globulus* occur nearby on the adjacent valley slope at the edge of the broad floodplain. A solitary remnant mature *E. viminalis* suggests that the area may have formerly been Ribbon Gum Tableland Riparian Woodland. The river continues through this highly modified and degraded rural landscape (Plate 5.8) to the gorge, where the vegetation is in a more native state.

Plate 5.7: Paddys River at Tanners Flat

Plate 5.8: Paddys River in highly modified rural land at Tanners Flat

5.3.3 Gorge on Paddys River to Cotter River confluence

This reach is approximately 9 km in length and includes the gorge. The river passes through former softwood plantation, Bullen Range Nature Reserve and Murrays Corner recreation area (Appendix 5A Maps 5.5a, 5.6a).

The riparian vegetation community at the upstream extent of this section is River Bottlebrush – Burgan Tableland Riparian Shrubland, dominated by *A. dealbata* and in parts *K. ericoides*. The occasional *E. bridgesiana* encroaches into the riparian zone although this is mostly a hillslope species. Willows, some poplars and blackberries are scattered along this part of the reach, although the willows decrease in number downstream. In places, the fringing aquatic vegetation is in very good condition with *Carex* spp. *Schoenoplectus* sp., *Bolboschoenus* sp., *Typha* sp., *Lythrum* sp., *Juncus* sp., *Saponaria officinalis*, *P. australis* and the submerged *Vallisneria australis*.

The bedrock floodplain within the gorge provides many refuge areas for native shrubs including *Pomaderris* sp., *Cassinia quinquefaria*, *C. longifolia*, *Lomandra longifolia*, *Dianella revulata*, *B. spinosa*, *Dodonea viscosa spatulata, D. angustifolia*, *C. sieberi* and *Derwentia* spp.

Continuing downstream, the adjacent hillslope vegetation changes from Broad-leaved Peppermint – Apple Box Tableland Woodland to Red Stringybark – Scribbly Gum Tableland Forest with an area of Black Cypress Pine Tableland Woodland (now dominated by *E. macrorhyncha* and *E. rossii*) towards the end of the gorge. Some regeneration of the black cypress pine *Callitris endlicheri*, following the 2003 bushfire, is evident (Plate 5.9). On the adjacent hillslopes, there is extensive natural regeneration of *P. radiata* following the loss of most of the mature trees in the 2003 bushfire. Amongst these, there are scattered *Eucalyptus polyanthemos* and the occasional *Brachychiton populneus*.

Just downstream of this point the vegetation community changes to She-oak Tableland Riparian Woodland. Many of the *C. cunninghamiana* were killed in the 2003 bushfire and the riparian zone is currently dominated by the primary coloniser *A. dealbata*. A few scattered mature *C. cunninghamiana* remain and some females carried a heavy seed load at the time of the survey. Many seedlings were also visible along the creek line (Plate 5.10).

Plate 5.9: *Callitris endlicheri* seedling regeneration post-2003 bushfire in the gorge on the Paddys River

Plate 5.10: Gorge on Paddys River showing the upstream extent of She-oak Tableland Riparian Woodland

Continuing downstream, the river flows through Murrays Corner recreation area (Plate 5.11). This area was severly burnt in the 2003 bushfire and there are dense stands of *A. dealbata* along the river banks. Some mature *C. cunninghamiana* remain in the recreation area near the river crossing and many trees are regenerating from seed. The river continues as a series of pools with extensive riparian growth of blackberries and willows. A few *E. viminalis* are present in the riparian zone and the occasional *E. polyanthemos*, probably dispersed from the adjacent hillslope. The recreation area is presently being replanted with native and exotic species. In an open area on the eastern side of the river, bulldozed after the fire, poplars and other exotics are regenerating from rootstock (Plate 5.12). There are *E. globulus* plantings at the Blue Gum car park.

Downstream of Murrays Corner, She-oak Tableland Riparian Woodland is the dominant riparian vegetation community. All the mature trees were killed in the 2003 bushfire; however, the community appears to be recovering successfully with many seedlings visible along the riverbank (Plate 5.13). *A. dealbata* currently dominates the river fringe with dense blackberries in some areas. *E. bridgesiana* still encroaches into the riparian zone, with the hillslope community alternating between Broad-leaved Peppermint – Apple Box Tableland Woodland and Red Stringybark – Scribbly Gum Tableland Forest. In places, *K. ericoides* is colonising where *P. radiata* was killed by the 2003 bushfire. *P. radiata* wildings have appeared after the fire and are quite numerous in places. Continuing downstream, the river forms a series of pools, with a completely dry river bed in parts (due to drought at the time of survey). The fringing vegetation remains the same, comprising *A.* dealbata, dead standing *C. cunninghamiana*, and extensive stands of blackberries in places (Plate 5.14). Some *A. rubida* and the occasional *Xanthorrea australis* and *Exocarpus cupressiformis* are present in the eastern hillslope near the confluence with the Cotter River.

Plate 5.11: Murrays Corner recreation area showing dense *Acacia dealbata* growth post-2003 bushfire

Plate 5.12: Murrays Corner showing regeneration of radiata pine and poplars

Plate 5.13: Paddys River downstream of Murrays Corner showing dead standing *Casuarina cunninghamina* and dense growth of *Acacia dealbata* following the 2003 bushfire

This area was severely affected by the 2003 bushfire and this is particularly evident in the loss of mature trees. However, there appears to be epicormic and seedling recovery of *E. bridgesiana* and *E. dives*. *E. macrorhyncha* and *E. rossii* are becoming the dominant recolonising vegetation in the Black Cypress Pine Tableland Woodland after all adult *C. endlicheri* were killed by the fire. Some *C. endlicheri* seedlings are visible among the taller eucalypts but it is unknown whether this species will return to its former dominance, and if so, on what time scale. A similar question applies to *C. cunninghamiana*, but presumably these species have been subject to landscape scale fires in the past.

Plate 5.14: Blackberry fringing Paddys River near confluence with the Cotter River

5.4 Paddys River: Condition and Management Recommendations

Overall the vegetation communities of the Paddys River are in moderate to poor condition. The river has been heavily impacted by rural land use, plantation forestry, recreational use, drought, and a high intensity fire in 2003. The main management issues along the river are erosion, impacts of stock grazing, and weed invasion.

Assessment of Paddys River condition is presented on maps in Appendix 5A. Vegetation dominance change assessment is presented on maps in Appendix 5B. Management maps for the Paddys River are contained in Appendix 5C. These maps indicate locations where management actions are recommended.

5.4.1 Confluence of Blue Gum Ck and Punchbowl creeks to Tidbinbilla Road

This section of the river is on rural lease and is in moderate to poor condition. From the early 1800s, the area has been used for rural purposes (grazing, limited agriculture and associated tree removal on hillsides) (Starr 2000c). The landscape is typical of much of the Southern Tablelands in that 19th century grazing and tree removal changed the hydrological system from a low energy to a high energy one resulting in stream incision and loss of the chain-of-ponds structure (Eyles 1977a). At the confluence of Blue Gum and Punchbowl creeks, the Fen Sedge Montane Wet Tussock Grassland has been replaced by drier grassland with a mixture of remnant native tussock, pasture grasses and pasture weeds. The river bed is heavily eroded because of past flood events, land modification (channels were dug for drainage in the 19th century (Starr 2000c)) and grazing pressure.

Downstream, the former native grasslands are now highly modified, containing mainly introduced pasture grasses. There are some areas of Burgan Derived Tableland Shrubland such as in rocky refuges. Riparian shrubland (e.g. near Tidbinbilla Road) is dense and comprises both native and exotic species. *C. enlicheri* seedling regeneration is occurring in a rocky gorge where the trees

were severely impacted by the 2003 bushfire. Modified Broad-leaved Peppermint – Apple Box Tableland Woodland and Snow Gum – Candle Bark Tableland Woodland remain on the hillslopes throughout the lower end of this section.

Eroded stock trails are highly visible on the aerial photographs and stock have access to the river along the whole reach.

Management recommendations for this river section (Appendix 5C Maps 5.1c, 5.2c) include:

- erosion control work
- strategic planting of native species for river bank stabilisation and for paddock trees that reflect surrounding native remnants
- fencing the river from stock and provision of off-stream watering points with priority to areas that have higher quality native remnant vegetation
- removal of willows that are declared ACT pest plants e.g. *S. nigra*, *S. fragilis*. *S. babylonica* (Weeping willow; not a declared pest plant) may be retained for aesthetic purposes
- control of blackberries (particularly downstream of the rocky gorge) and other weed species, and replacement with local native species
- fire prevention measures around areas of regenerating *C. endlicheri*.

5.4.2 Tidbinbilla Road Crossing to gorge on Paddys River

This section of the river is in poor condition as it flows through highly modified rural land dominated by exotic trees and understorey in both the riparian zone (a broad floodplain) and adjacent valley slope. There are some small remnants that suggest the former tree cover, which is likely to have been Ribbon Gum Tableland Riparian Woodland in the valley with Snow Gum – Candle Bark Tableland Woodland in frost hollow areas and Broad-leaved Peppermint – Apple Box Tableland Woodland on the hillslopes. Burgan Derived Tableland Shrubland has developed in some of the (presumed) former woodland areas.

The riparian zone contains extensive blackberries, willows and poplars. Radiata pine on 'Miowera' property and a range of exotic and non-local native species (e.g. *E. globulus*) plantings throughout the area provide a source for further spread of introduced species into the riparian zone.

Management recommendations for this river section (Appendix 5C Maps 5.2c to 5.4c) include:

- erosion control work
- limitation of stock access to the river
- control of blackberries and other weed species, and replacement with local native species
- removal of willows that are declared ACT pest plants e.g. *S. nigra*, *S. fragilis*. *S. babylonica* (not a declared pest plant) may be retained for aesthetic purposes
- control of radiata pine wildings in the vicinity of the 'Miowera' pine plantation to prevent spread into riparian zone.

5.4.3 Gorge on Paddys River to Cotter River confluence

This section of the river is in moderate condition, though it has been impacted by plantation forestry activities. It contains a high diversity of native species. The upstream part of the reach has a significant weed problem deriving from the previous river section (above). The condition improves inside the gorge where there is a diversity of native shrubs showing strong recovery from the 2003 bushfire. There is also seedling regeneration of *C. endlicheri*; however, *E. macrorhyncha* and *E. rossii* are becoming the dominant recolonising trees in the Black Cypress Pine Tableland Woodland

From the gorge to the confluence with the Cotter River, the adjacent hillslope is former softwood plantation. Following the 2003 bushfire, *P. radiata* is rapidly regenerating and some wildings are

encroaching down the hillslope into the riparian zone. The She-oak Tableland Riparian Woodland, which was heavily impacted by the 2003 bushfire, is now in poor condition, but aerial photographs show extensive seedling regeneration. The pioneer and relatively short-lived species *A. dealbata* has established extensively in the riparian zone post-fire. Shrub and tree species from the local seed bank are able to establish under its canopy. It also is effective in shading the invasive exotic tussock, African lovegrass *E. curvula*.

Bar ended pools have developed in the Murrays Corner area and there is considerable instream vegetation but the riparian species, excluding blackberries, are mostly native. There was considerable deposition of eroded material in the stream in heavy rain following the 2003 bushfire and this has reshaped the river morphology. An important question for this river section is whether *C. cunninghamiana* can re-establish its dominance in the riparian zone and, if so, over what time scale.

Management recommendations for this river section (Appendix 5C Maps 5.4c, 5.5c) include:

- protection of *C. endlicheri* seedling regeneration within the gorge (rabbit control, prevention of high intensity fire)
- control of radiata pine wildings to prevent encroachment into the riparian zone.
- re-establishment of local native tree cover in former softwood plantation areas
- control of blackberries along the entire reach, but especially at the Murrays Corner recreation area and downstream to the Cotter confluence
- control of willows at the upstream end of gorge to prevent dispersal downstream (combined with willow removal in the previous river sections)
- control of weed species and replanting with Casuarina cunninghamiana and native shrubs at the Murrays Corner recreation area
- evaluation of replacing the *E. globulus* at the Murrays Corner recreation area with eucalypt species from the Paddys River Catchment such as *E. viminalis* or *E. bridgesiana*.

6 COTTER RIVER

The Cotter River rises at Scabby Range Lake (1760 m ASL) on the southern border of the ACT and flows north through Namadgi National Park, including the Bimberi Wilderness Area, following the Cotter fault between the Tidbinbilla, Brindabella, Bimberi and Scabby ranges. It leaves Namadgi National Park just above Vanitys Crossing, continues through reserved area described as the Lower Cotter Catchment, and below Cotter Dam flows through the Cotter Recreation Area, before joining the Murrumbidgee River one kilometre above Casuarina Sands (460 m). The river is 77 km long. There are three deep, cold, reservoirs on the river: Corin (75.5 GL), Bendora (10.7 GL) and Cotter (4.7 GL, but in the process of being increased to about 78 GL). Water supply infrastructure in the area is owned by ACTEW Corporation and managed by ActewAGL. Environmental flow releases from these reservoirs are required under the *Water Resources Act 2007* (ACT) and are part of an overall strategy for managing water resources in the Australian Capital Territory set out in *Think Water, Act Water* (ACT Government 2004). Under the Water Resources Act, environmental flow guidelines are established and periodically reviewed (ACT Government 2006a). The catchment has been formally protected for water supply purposes since 1914, when a 'restricted use' policy was established under the *Cotter River Ordinance 1914–1959* (ACT Government 2007).

6.1 Topography

The Cotter River follows a narrow band of soft rock along a major fault, the Cotter Fault, believed to date from Tertiary tectonic processes (Finlayson 2008).

Above Corin Reservoir the river is a series of narrow wooded reaches interspersed with wide wet tussock grasslands and an incised stream channel. Between Corin Dam and the top of Bendora Reservoir the river is a constant flowing stream with pools and riffles cutting between heavily timbered overlapping spurs. The waterway becomes increasingly more open, with floodplains in the bends, between Bendora Dam and Sinclair Circuit Road (road around Condor Hill). The more undulating country above the Cotter Reservoir has allowed the river to cut a series of reaches with a complex of pools, riffles and cascades often with small semi-permanent islands. Below Cotter Dam, the river is regulated in a series of weir pools designed for recreation until it joins with the Paddys River and then the Murrumbidgee River.

6.2 Background

The Cotter Catchment or parts of it have been the subject of a number of previous ecological surveys and studies. These include: a broad environmental survey (Resource and Environment Consultant Group 1973); an environmental analysis (NCDC 1986a); an ecological survey of the upper catchment (Helman et al. 1988); a study of treeless vegetation above 1000 m (Helman and Gilmore 1985); descriptions of vegetation at ACT Government fish sampling sites (Ingwersen and Ormay 1988); a review of the state of Blundells Flat on Condor Creek, a western tributary of the Cotter River, below Bendora Dam (Butz 2004); descriptions of geomorphology and vegetation at a number of sites mainly above Corin Dam (Evans and Keenan 1992); and studies of the mountain mires (Hope 2003; Hope et al. 2009).

The Cotter Catchment is included in the *Namadgi National Park: Plan of Management* (ACT Government 2010) and the *Lower Cotter Catchment: Draft Strategic Management Plan* (ACT Government 2006b). Significant natural and cultural sites in the Cotter River catchment are described in NCPA (1989).

For this survey the descriptions in Ingwersen & Ormay (1988) proved to be highly informative as condition could be inferred from the notes, and the distribution of species and communities extracted from the information included. Evans and Keenan (1992) provided descriptions for

Bendora Reservoir, and for Black Sallee Flat, Cotter Flats, upper Cotter Flats, Rolleys Flat, the upper Cotter River and Scabby Range Lake, which are all above Corin Dam. Ingwerson & Ormay (1988) found that there were numerous vegetation communities within the riparian zone of the upper Cotter, some distinctly alpine or subalpine, as well as a possible example of a chain-of-ponds as recorded by Lhotsky and Cunningham in the early 19th century at Scabby Range Lake (see Eyles 1977a). Butz (2004) included historical descriptions of riparian systems in a valley enclosed by steep mountain sides that were formerly under softwood plantations.

These sources suggest the following distinguishing features of the Cotter River riparian zone:

- the river rising in an alpine chain-of-ponds in sedgeland
- a montane section with tussock grassland, or Snow Gum Montane Woodland (with *E. stellulata*, *E. pauciflora* and *E. rubida*), or *L. lanigerum – A. siculiformis* riparian shrubland
- Ribbon Gum Tableland Riparian Woodland as the elevation drops and the sediments deepen
- She-oak Tableland Riparian Woodland downstream of Cotter Dam, close to the Murrumbidgee River.

6.3 Cotter River: Survey Results by River Section

6.3.1 Source to Corin Reservoir

This reach is approximately 31 km in length and occurs entirely within Namadgi National Park (Appendix 6A Maps 6.1a to 6.5a). At the river source there is a Sphagnum Montane and Subalpine Bog surrounded by low growing Snow Gum Subalpine Woodland. The bog (Cotter Source Bog) has the best developed pool complex of bogs in the ACT (Hope et al. 2009). The waterway then continues through Snow Gum Montane Woodland, notable for *E. stellulata*, until Cotter Flats (Plate 6.1). Below this is a *L. lanigerum* dominated riparian shrubland which covers the narrow channel until Lick Hole Creek Flats (Plate 6.2). There are five significant areas of open Montane Wet Tussock Grassland at points where the valley bottom widens: Rolleys Flat, the Cotter above Little Bimberi Creek, Cotter Hut, Cotter Flats, and Black Sallee Flats. As the river approaches Corin Reservoir it steadily drops in elevation, and the valley slope vegetation grades from Snow Gum Montane Woodland through Snow Gum – Candle Bark Tableland Woodland to Narrow-leaved Peppermint – Ribbon Gum Montane Forest with an increasing diversity of eucalypt species.

The area below the high water mark in Corin Reservoir is dominated by herbaceous species adapted to periodic inundation. At the time of survey, water levels had been below the high water mark for some years, resulting in patchy growth of species (notably *A. rubida* and *Daviesia mimosoides*) derived from upslope communities mainly Narrow-leaved Peppermint – Ribbon Gum Montane Forest (Plate 6.3).

The entire reach, from source to Corin Reservoir, was heavily impacted by the 2003 bushfire with much of the upper canopy killed. Conspicuous numbers of standing dead trees are visible in both the river line and the valley slope. However, from the aerial photography, the entire reach appears to be recovering well post-fire. The Sphagnum Montane and Subalpine Bog complex at the source of the Cotter River (Cotter Source Bog) is one of only six such communities in the ACT. This area was severely affected by the 2003 bushfire and is recovering slowly. Hope et al. (2009) note that *Poa* tussock is colonising peat fire areas in the bog.

Plate 6.1: Cotter Flats with open Montane Wet Tussock Grassland

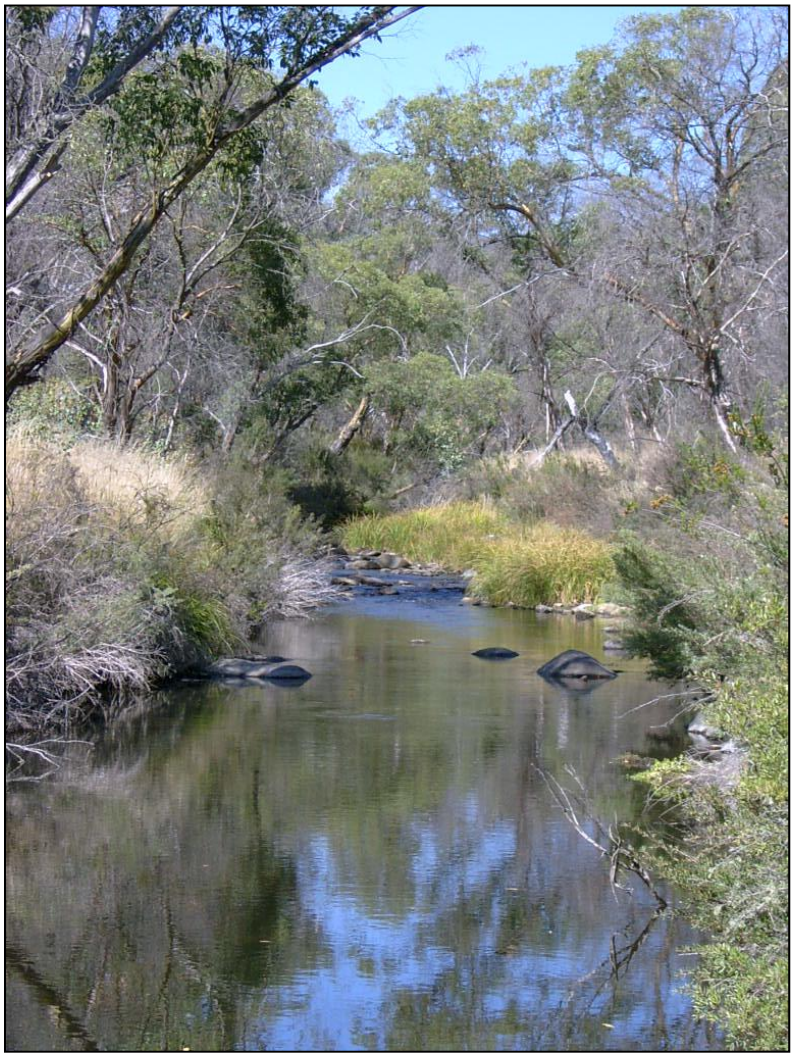

Plate 6.2: Cotter River at Lick Hole Track crossing with Snow Gum Montane Woodland

Plate 6.3: Corin Dam: area below high water mark showing patchy growth of herbaceous species and shrubs derived from upslope Narrow-leaved Peppermint – Ribbon Gum Montane Forest

6.3.2 Corin Dam to Bendora Reservoir

This reach is approximately 20.3 km in length and also occurs entirely within Namadgi National Park (Appendix 6A Maps 6.5a to 6.8a). Very high quality Ribbon Gum Tableland Riparian Woodland occurs along the river from Corin Dam to the Bendora Reservoir (Plate 6.4). The cobbles and riffles just downstream of Corin Dam contain *M. varriifolium*, *Crassula helmsii*, *G. peruviana*, *Elatine* sp., *Nitella* sp. and *Stigeoclonium tenue,* a silkweed, and pink tussocks of *Audouinella hermannii* on nearly all the rocks. The river margins contain *Juncus polyanthera*, *Carex sp., Blechnum* sp., *Polystichum proliferum* and *L. lanigerum.* A cobbled area with occasional *E. viminalis* saplings and a ground cover of *Acaena novae-zelandiae* and introduced grasses like couch (*Cynodactylon* sp.) and Yorkshire fog (*Holcus* sp.) with a little *Poa sieberiana* merges with the Ribbon Gum Tableland Riparian Woodland. Notable understorey shrubs included *Davesia mimosoides*, *L. myricoides*, *Grevillea oxyantha*, *Exocarpos stricta*, *Hovea* sp. and *A. pravissima*, *A. rubida*, *A. siculiformis* and *A. melanoxylon*.

Just above Bendora Reservoir, where the riffles occur, there are complex instream and marginal assemblages. There are patches of *T. orientalis*, and where a small beach forms there is an interesting assemblage of native vegetation and some weeds. Species present include *Gratiola peruviana*, *Wahlenbergia* sp., *Epilobium* spp., *Juncus articularis, B. caldwellii, Nasturtium sp., Elatine sp., Trifolium subterraneanum, A. australis, A. novae-zelandiae* and *P. decipiens*, as well as weeds such as *R. crispus, Holcus lanatus, C. vulgare and Conyza* sp. In the sedge beds above, there are bands of *L. salicaria*.

The deep soil edges of Bendora Reservoir contain a narrow fringe of *Carex s*p. and *S. validus, Juncus* sp*., Cyperus* sp., *P. decipiens* and a wide 'bare' band with scattered *A. rubida* and *D. mimosoides, A. pravissima* and some *A. dealbata.* The shallow soil edges contain *Juncus* sp.,

Cyperus sp. and *Persicaria* sp. while directly above is the Narrow-leaved Peppermint – Ribbon Gum Montane Forest (Plate 6.5).

The valley slope between Corin Dam and Bendora Reservoir and continuing along the western side of the reservoir is Narrow-leaved Peppermint – Ribbon Gum Montane Forest, while on the eastern side the dominant vegetation is Broad-leaved Peppermint – Apple Box Tableland Woodland. This section of the river, although affected by the 2003 bushfire, has recovered well.

Plate 6.4: Cotter River below Corin Dam showing Ribbon Gum Tableland Riparian Woodland

Plate 6.5: Upper Bendora Dam: Tableland Aquatic and Fringing Vegetation Complex with adjacent hillslope Narrow-leaved Peppermint – Ribbon Gum Montane Forest

6.3.3 Bendora Dam to Cotter Reservoir

This reach is approximately 30 km long and occurs within Namadgi National Park to just above Vanitys Crossing, below which point it flows within the Lower Cotter Catchment (Public Land: reserved for protection of water supply) (Appendix 6A Maps 6.8a to 6.12a). Immediately below Bendora Dam wall the vegetation in the riparian zone consists of Ribbon Gum Tableland Riparian Woodland. The midstorey includes *A. dealbata*, *A. melanoxylon* and *L. lanigerum* with some *E. viminalis* saplings (Plates 6.6, 6.7). The river fringe is mainly *C. gaudichaudiana* and a suite of 'mudworts'. This continues down to just above Cotter Reservoir. At lower elevations *L. lanigerum* is eventually replaced by *L. obovatum*. *A. melanoxylon* becomes rare below Vanitys Crossing.

The hillslope community at the Bendora Dam wall is Narrow-leaved Peppermint – Ribbon Gum Montane Forest with scattered *Eucalyptus dives* and very occasional *E. dalrympleana* at the range crest. There is a good selection of shrubs including the large-leafed *G. oxyanthera*, *Pomaderris aspera*, *Derwentia derwentiana* and *D. perfoliata, C. longifolia,* and *E. stricta*.

Below Top Flats the hillslope community is replaced by Broad-leaved Peppermint – Apple Box Tableland Woodland and this continues to Cotter Dam. In the former softwood plantation areas mature eucalypt trees are sparse and much of the regrowth vegetation is *A. rubida*. The upper slope through this section of the river valley often contains patches of Red Stringybark – Scribbly Gum Tableland Forest and small remnants of Black Cypress Pine Tableland Woodland. These trees and their associated species (*E. polyanthemos* and *B. populneus*) extend a considerable distance down slope.

The vegetation communities in both the hillslope and riparian zones are more complex from Vanitys Crossing to the upper reaches of the Cotter Reservoir. The valley morphology is open and undulating. Fire damage was highly visible in this area at the time of survey. Recolonisation of the landscape by shrubs such as *A. rubida* has followed the destruction of the *P. radiata* plantations in the area.

The riparian vegetation at Vanitys Crossing is Ribbon Gum Tableland Riparian Woodland with *E. bridgesiana*, *A. dealbata*, *A. melanoxylon*, *L. obovatum*, *P. angustifolium*, *P. aspersa*, *D. mimosoides*, *G. pulchella*, *L. myricoides*, *B. spinosa*, *C. longifolia*, and ground cover of *Lomandra* sp. Tableland Aquatic and Fringing Vegetation Complex, with *Poa* sp. and *Carex* sp., and Tableland Riparian Shrubland with *A. dealbata* occur in the area (Plate 6.8).

The muddy stream edges contain *Hydrocotyle* sp., *Elatine* sp., *Lilaeopsis* sp., *G. peruviana* and even some *Viola betonicifolia*. River margins contain *C. gaudichaudiana, J. usitatus, S. validus* (including an island in the pool), *P. australis* (beds 1–1.5 m deep especially above the causeway and the pool) some *C. sieberi*, *Epilobium* sp., *L. salicaria and C. eragrostis* (Plate 6.9). *Chara* sp. and the algae *Stigeoclonium* sp. and *Phomidium* sp. are also found in the waterway.

Just above the Cotter Reservoir the riparian vegetation community becomes She-oak Tableland Riparian Woodland currently dominated by *A. dealbata.* The river margins contain *Poa* and *Carex* tussock and a riparian fringe with patches of emergent *Persicaria australis*, *S. validus*, *J. usitatus*, *Typha* sp., *Persicaria* sp. (probably *P. lapathifolium*) and the occasional *C. sieberi*. Blackberries are present at this point.

The hillslope vegetation from upstream of Vanitys Crossing is Broad-leaved Peppermint – Apple Box Tableland Woodland close to the riparian zone. The adjacent hillslope includes *E. polyanthemos* and *E. rossii* higher up the hillslope. Prior to the 2003 bushfire there were a number of patches of *C. endlicheri* where rocky spurs occur, especially on the western side of the river bank going through Sinclair Circuit. A remnant of *C. endlicheri* was observed approximately half way between Sinclair Circuit and the Cotter Reservoir. At Vanitys Crossing the hillslope

midstorey includes *A. rubida*, *C. reflexa* and *D. viscosa*. Blackberry cover is high, especially in old flood runners.

Around Sinclair Circuit the midstorey consists of *A. dealbata* with occasional *C. endlicheri* seedling regeneration on the hillslopes. Pine wildings dispersed from the adjacent former softwood plantations are common. There is a lot of standing burnt timber on both sides of the river throughout the former plantation area.

The Cotter Reservoir has a riparian margin of either 1–1.5 m wide belts of *P. australis* (Plate 6.10) or depauperate She-oak Tableland Riparian Woodland (Plate 6.11). Sometimes this woodland is represented by the understorey species (*A. dealbata*) rather than mature *C. cunninghamiana*. The shallow waters of the reservoir contain beds of *V. australis, Chara* or *Nitella* and the margins contain *C. eragrostis* and *Limosella australis* leading into the phragmites belts. Other species in the riparian woodland include *E.viminalis*, *E. cupressiformis*, *R. fruticosus* complex, *A. rubida*, *Cassinia* sp. and *J. usitatus*.

Historically, the hillslope has been managed as softwood plantation which was destroyed in the 2003 bushfire. *A. rubida* is the main colonising species in fire affected areas and there are a few scattered *E. bridgesiana* and *E.dives* higher up the hillslopes. On the northern slope opposite the boat ramp there is a small patch of Black Cypress Pine Tableland Woodland which has been heavily fire affected. Some *C. endlicheri* seedlings are visible beneath the dead standing trees (Plate 6.12).

Plate 6.6: Cotter River at Burkes Creek crossing.

Plate 6.7: Cotter River at Spur Hole.

Plate 6.8: Riparian zone below Vanitys Crossing showing Tableland Aquatic and Fringing Vegetation Complex, with *Poa* sp. and *Carex* sp.; Tableland Riparian Shrubland with *Acacia dealbata*; and Ribbon Gum Tableland Riparian Woodland

Plate 6.9: Upstream from Vanitys Crossing showing Tableland Aquatic and Fringing Vegetation Complex

Plate 6.10: Cotter Reservoir: Tableland Aquatic and Fringing Vegetation Complex

Plate 6.11: Cotter Reservoir: She-oak Tableland Riparian Woodland on the reservoir edge.

Plate 6.12: Cotter Reservoir: fire affected Black Cypress Pine Tableland Woodland

6.3.4 Cotter Dam to confluence with Murrumbidgee River

This reach is approximately 2.7 km long and mainly flows through Special Purpose Reserve (ACT Public Land which provides for public and community use for recreation and education) (Appendix 6A map 6.12a). The vegetation immediately below the Cotter Dam wall consists of a short stretch of She-oak Tableland Riparian Woodland with a shrub layer of *A. dealbata* (Plate 6.13). The hillslope consists of Broad-leaved Peppermint – Apple Box Tableland Woodland, presently being colonised by *A. mearnsii* following the 2003 bushfire. *E. blakelyi* occurs on the northern slope and *E. bridgesiana* on the south. Within the recreation area there is a remnant She-oak Tableland Riparian Woodland and the valley slope vegetation has been replaced largely by European exotic deciduous species such as *P. alba*, *P.nigra* and *U. procera* (Plate 6.14). At the Paddys River confluence the south-eastern hillslope vegetation returns to native vegetation being Red Stringy Bark – Scribbly Gum Tableland Forest containing a notable presence of *X. australis.*

Plate 6.13: Cotter River below Cotter Dam: She-oak Tableland Riparian Woodland with a shrub layer of *Acacia dealbata*

Plate 6.14: Cotter Recreation Area with exotic tree plantings

6.4 Cotter River: Condition and Management Recommendations

The Cotter River is generally in moderate to high condition, with the areas within Namadgi National Park scoring highest in the condition ranking and containing significant vegetation communities such as the Sphagnum Montane and Subalpine Bog complexes (Hope et al. 2009). From Corin Reservoir downstream, the hydrology and vegetation have been heavily modified by the construction of Corin, Bendora and Cotter reservoirs, and further changes are underway with the enlargement of the Cotter Dam. Plantation forestry has had a major impact below Vanitys Crossing, through the establishment of extensive areas of *P. radiata* that commenced in the 1920s. It should be noted that, as well as commercial purposes, this planting was directed to stabilising the lower catchment which had been overgrazed both by stock and rabbits resulting in serious soil erosion (ACT Government 2006; Resource and Environment Consultant Group 1973). The Cotter below Cotter Dam has been modified as a recreation area since the early 1920s. Planting of many European exotic trees and the construction of playgrounds and picnic facilities has significantly changed the landscape character of the lower end of the river.

During the past 100 years there have been several large scale fires which have affected the entire Cotter Catchment (Carey et al. 2003). Fire frequency has also changed. Through dendrochronological studies (dating of past events through the study of tree rings), Banks (1982, 1989) showed how fire frequency in the mountains increased from the mid-nineteenth century with consequent changes to vegetation species composition and structure. The 2003 bushfire burnt almost the entire length of the river to varying degrees of severity. The vegetation is regenerating, but there have been changes in vegetation composition as pioneering species establish. In fire sensitive vegetation communities (e.g. Sphagnum Montane and Subalpine Bog complexes and Black Cypress Pine Tableland Woodland) recovery of the community is likely to take a long time. Much of the vegetation within Namadgi National Park is regenerating well and is likely to return to pre-fire condition with time.

Particular attention has been given to rehabilitating the 'peat-forming mires' in the upper Cotter catchment that were severely impacted by the 2003 bushfire. This has focused on prevention of erosion (by slowing water flow and controlling local gullying), re-wetting of areas that appeared to be drying out, shading of some areas and transplanting *Sphagnum* sp. (Good et al. (in press); Hope et al. 2009; Mire Restoration and Research Group 2010). Feral animal control is also important to avoid trampling that leads to compression of the soft surface of the mire, development of channels, and consequent drying out of the mire. Continuation of this bog rehabilitation is vital, as the bog complexes provide a significant ecosystem service (see Glossary) in providing clean continuous flows within the Cotter Catchment.

Assessment of condition is presented on maps in Appendix 6A. Vegetation dominance change assessment is presented on maps in Appendix 6B. Management maps for the Gudgenby River are contained in Appendix 6C. These maps indicate locations where management actions are recommended.

6.4.1 Source to Corin Reservoir

This section of the river is protected within Namadgi National Park. The most important recent influence on the condition of the section was the 2003 bushfire. As noted above, this impact was severe on the Sphagnum Montane and Subalpine Bog communities which require rehabilitation management to ensure their regeneration. Restoring and maintaining hydrological conditions and protection from disturbance are key elements in this rehabilitation.

Woodland and grassland communities, while severely impacted, are likely to recover over time and this recovery is already evident. The aerial photography shows the extent of fire damage to canopy crowns in woodland areas with dead standing trees visible in both the river line and the valley slope. Site visits noted that although adults have been killed by fire, regeneration is

occurring both by lignotuber, epicormic growth and seedling growth. The Snow Gum Subalpine Woodland near Cotter Source Bog is showing signs of recovery.

The *L. lanigerum* dominated Riparian Shrubland which covers the channel until Lick Hole Creek Flats and the open Montane Wet Tussock Grassland within the valley floor at Rolleys Flat, the Cotter above Little Bimberi Ck, Cotter Hut, Cotter Flats and Black Sallee Flats are recovering very well post-fire, show little weed infestation, and are in very high condition.

Management recommendations for this river section (Appendix 6C Maps 6.1c to 6.5c) include:

- continuation of *Sphagnum* bog rehabilitation programs (for more detail see Macdonald 2009)
- control of feral animals (especially pigs and horses) or cattle that are likely to adversely affect the recovery of the bogs
- continuation of post-fire research and monitoring programs.

6.4.2 Corin Dam to Bendora Reservoir

This section of the river is protected within Namadgi National Park. It was one of the worst affected areas in the 2003 bushfire. The fire burnt all the western facing slopes, as opposed to the mosaic pattern that eventuated in the rest of the catchment. Despite this, the river section appears to be recovering extremely well and current post-fire management should be continued. Condition of vegetation is very high with only a few weed species present around public access areas.

In an area at the upstream end of Bendora Reservoir, where the riffles occur, there is a small beach with an interesting assemblage of native and exotic vegetation. There appears to be a *C. bonariensis* shrubland with other weeds such as curly dock *R. crispus*, *Holcus* sp. and *C. vulgare*. There are also a few *Salix* establishing in the sandy banks. The willows should be removed. The other weeds do not require any treatment and should die out or disappear through competition as the season changes or the water levels increase. Seed may enter the seed bank, and become the pioneer growth following any future fire, but this risk should decrease with time. *Persicaria laprathifolia* and the species of *Epilobium* present may outgrow and replace the exotics with time.

Management recommendations for this river section (Appendix 6C Maps 6.5c to 6.8c) include:

- minor willow control upstream of Bendora reservoir
- continuation of post-fire research and monitoring programs.

6.4.3 Bendora Dam to Cotter Reservoir

This reach occurs within Namadgi National Park to just above Vanitys Crossing, before entering the Protection of Water Supply (Public Land) area of the Lower Cotter Catchment. Immediately below Bendora Dam wall the Ribbon Gum Tableland Riparian Woodland is in excellent condition, and has recovered very well following the 2003 fire. Some minor weeds occur near public access points and along roadside verges which run adjacent to the river between Bendora Dam and Cotter Reservoir

Toward Vanitys Crossing, the condition of the vegetation community is lower because of the 2003 bushfire and the resulting sedimentation and erosion. The number of weed species also increases most likely due to the disturbances associated with the former softwood plantations, roads, and increased public access. Blackberry, an effective post-fire coloniser, is particularly dense, especially in old flood runners and lower parts of lateral creek lines. *P. radiata* wildings are encroaching into the riparian zone below Vanitys Crossing. There is extensive regeneration of *P. radiata* on adjacent hillslopes and the valley floor. The fires have had a severe impact on the vegetation although Red Stringybark – Scribbly Gum Tableland Forest and Broad-leaved Peppermint – Apple Box Tableland Woodland are regenerating successfully. A number of *Acacia*

species are important post-fire colonisers throughout the area. Black Cypress Pine Tableland Woodland was severely affected by the 2003 fire at Sinclair Circuit and above the northern slope of the Cotter Reservoir. A small amount of seedling regeneration is visible in these areas.

Significant changes will occur to the river below Vanitys Crossing with the building of the enlarged Cotter Dam. The current reservoir riparian zone and the river section, to approximately the Condor Creek confluence, will be inundated. The enlarged reservoir will cover an extra 231 ha of land and a further 38 ha will be taken up for ancillary purposes. This enlargement will cover 164 ha of former softwood plantation and 105 ha of native vegetation (ACTEW 2009). The She-oak Tableland Riparian Woodland currently fringing the reservoir and Tableland Aquatic and Fringing Vegetation Complex dominated by *Phragmites* sp. will be inundated.

Management recommendations for this river section (Appendix 6C Maps 6.8c to 6.12c) include:

- erosion and sedimentation control work downstream of Vanitys Crossing
- weed control (especially blackberries, willows, poplars) near Vanitys Crossing and throughout the Lower Cotter Catchment
- control of *P. radiata* wildings in the riparian zone and strategic replanting with appropriate native species, considering habitat values
- evaluation of the potential for planting *C. cunninghamiana* and associated mid and understorey species around new Cotter Reservoir.

6.4.4 Cotter Dam to confluence with Murrumbidgee River

This reach is managed predominantly as a developed recreational area and has long-established mature exotic plantings, some of which were only minimally affected by the 2003 bushfire. There is She-oak Tableland Riparian Woodland immediately below the Cotter Dam, which is in relatively good condition and the hillslopes contain Broad-leaved Peppermint – Apple Box Tableland Woodland which is regenerating well post-fire. Naturalised exotic tree species such as *P. alba*, *P.nigra* and *U. procera* occur on the lower valley slopes.

Management recommendations for this river section (Appendix 6C Map 6.12c) include:

- maintenance of the distinctive native component of the hillside and riparian vegetation in the area, which may involve some supplementary planting
- control of weed species (such as willows and blackberries) and naturalising exotics derived from the plantings in the area.

7 MOLONGLO RIVER

The Molonglo River rises in New South Wales and flows for 58 km in the ACT from where it joins the eastern ACT border at the railway viaduct at Burbong. It flows westward through Molonglo Gorge at Kowen and into Lake Burley Griffin at Molonglo Reach, west of Dairy Flat Road. The river exits Lake Burley Griffin at the base of Scrivener Dam and joins the Murrumbidgee River opposite Woodstock Reserve. The river is flanked by rural land, former softwood plantation areas, public land reserves, and the city of Canberra (in the vicinity of Lake Burley Griffin). Some of the land west of the Tuggeranong Parkway forms the proposed Molonglo urban development. A number of major tributaries wholly or partially drain the Canberra urban area, namely, Sullivans Creek (which flows into Lake Burley Griffin), Weston Creek, Yarralumla Creek and Jerrabomberra Creek.

Lake Burley Griffin is not included in this survey as the lake waters are National Land managed by the National Capital Authority. The foreshores of the lake are a mix of Territory Land (managed by the ACT Government) and National Land (managed by Commonwealth Government agencies). In the formal parts of the lake (East, Central and West basins) much of the lake edge is stone walled while in other areas there are extensive reed beds. A planting design was followed in the original landscaping for the lake which contained mainly exotic species, but included native species in some areas (NCDC 1986b). In the subsequent decades, these species and a range of other species have established in the riparian zone. Some of the species originally planted and other naturalised exotics are ACT declared pest plants (e.g. black alder *Alnus glutinosa*, willows *Salix* spp.) and control programs are undertaken periodically.

7.1 Topography

The Molonglo River rises in upland terrain of the Cullarin Uplift above Captains Flat. Below Captains Flat, the river passes through a narrow gorge to open out onto the Carwoola Plain across which it meanders in an incised bed until it reaches the Cullarin Horst, through which it has cut the Molonglo Gorge (Finlayson 2008). Downstream of the gorge, the Molonglo is joined by the Queanbeyan River and 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 (ACT Government 2007). Below Scrivener Dam the river flows in an increasingly incised channel which becomes a deep gorge below Coppins Crossing. Within the river-line there are long, often rock bottomed, reaches and riffle beds as well as minor alluvial banks and fans, especially at bends and the entry points of tributaries. Where the Molonglo joins the Murrumbidgee River near Uriarra Crossing, it is incised about 80 m below the surrounding land surface.

7.2 Background

The Molonglo River and its riparian zone have been substantially modified since European settlement, which began with the pastoral advance into the Southern Tablelands from the 1820s. These changes are discussed in detail in the *ACT Aquatic species and Riparian Zone Conservation Strategy* (ACT Government 2007; see pp. 26–34) and relate to pastoral and agricultural development; urban and infrastructure development; recreational facility development; weed invasion; changed fire regimes and extractive industry. Aquatic life was almost totally eliminated from the Molonglo River as a consequence of heavy metal pollution from collapsed mine tailings at Captains Flat in the late 1930s and ’40s (Weatherly et al. 1967; Joint Government Technical Committee on Mine Waste Pollution of the Molonglo River 1974). Following the construction of Lake Burley Griffin the long-running Lake Burley Griffin Catchment Protection Scheme (1965–1998) was established. The focus of the scheme was to protect the lake from sedimentation deriving from erosion in the catchment (NSW DLWC 2000). This included extensive areas in the upper Molonglo Catchment.

Riparian vegetation along the river in the ACT has been described in a number of studies. These include: (a) Anway et al. (1975) who presented profiles of the vegetation of the Molonglo River corridor between Burbong and the confluence with the Murrumbidgee River. The annotated cross-sections in the report generally correspond with the current vegetation patterns, especially above Lake Burley Griffin; (b) a National Capital Development Commission report on the ecological resources of the ACT (NCDC 1984) and update to that report (Hogg 1990); a report on the aquatic ecological resources of the ACT (Hogg and Wicks 1989); and a detailed survey and description of the lower reaches of the river by Barrer (1992). Land use and valuable historical photographs are contained in Department of the Interior (1965).

Vegetation descriptions and management approaches are included in management plans for varying sections of the river, including: (a) the management plan for Lake Burley Griffin (NCPA 1995); (b) the management plan for the lower Molonglo River Corridor (ACT Government 2001); the draft management plan for Jerrabomberra Wetlands (ACT Government 2006); the *Lake Burley Griffin Willow Management Plan* (Molonglo Catchment Group 2006).

7.3 Molonglo River: Survey Results by River Section

7.3.1 Burbong to Molonglo Gorge

This reach is approximately 12.5 km in length and encompasses the Molonglo River, from Burbong Bridge (ACT border) (Plate 7.1) to Molonglo Gorge (Appendix 7A Maps 7.1a, 7.2a).

Plate 7.1: Molonglo River downstream of Burbong Bridge with River Bottlebrush – Burgan Tableland Riparian Shrubland and willows *Salix* spp.

Where the river flows into the ACT at Burbong, the riparian vegetation community consists of River Bottlebrush – Burgan Tableland Riparian Shrubland with many willows and poplars. The river contains a varying sequence of this shrubland and bedrock areas with pools where there is limited riparian vegetation. *P. australis* beds (Tableland Aquatic and Fringing Vegetation Complex) line muddy banks and there are a few patches of *Myriophyllum crispatum* among a mixture of riparian shrubs (*L. obovatum, K. ericoides* and *C. sieberi*). In places, the instream vegetation has created a damming effect, contributing to the formation of pools. As the river continues downstream, dead willows line the banks as a result of control work (Plate 7.2).

Where the river flows northward (west of Mt Atkinson), the valley is between areas of *P. radiata* plantation. While the hillslopes have been mostly cleared for plantation, some scattered *Eucalyptus rubida*, *E. polyanthemos* and *E. mannifera* remain and there is some Snow Gum – Candle Bark Tableland Woodland dominated by *E. pauciflora* (Plate 7.3). There is also a patch of *E. cinerea*, the origins of which are not known.

Plate 7.2: Downstream of Burbong Bridge showing successful control of willows

Continuing downstream, the river flows westward before turning sharply southward (all through softwood plantation), until it reaches the eastern extremity of Molonglo Gorge where it flows westward. Both the northern and southern valley sides contain native vegetation, disturbed on the southern side by the railway line which runs parallel to the river.

East of Blue Tiles picnic area, the hillslope community is Red Stringybark – Scribbly Gum Tableland Forest with some Broad-leaved Peppermint – Apple Box Tableland Woodland. The hillslope contains numerous *E. polyanthemos* of all ages, many *E. bridgesiana*, the occasional *E. macrorhyncha* on the spurs, rarer *E. dives* and a scatter of *E. rossii*, *B. spinosa*, *K. ericoides*, *P. angustifolia*, *Davesia* sp., the woody weed *R. rubiginosa* and a scattered groundcover of tussock native grasses.

Plate 7.3: Snow Gum – Candle Bark Tableland Woodland dominated by *E. pauciflora* near Kowen Forest (softwood plantation)

The river flows through a narrow bedrock floodplain with large rock outcrops and boulders in the river line. At a large pool there is much instream vegetation forming a Tableland Aquatic and Fringing Vegetation Complex. Some instream aquatic fringing, submerged and emergent species noted include the algae *Zygnematales* and *Oedogonium* spp., *P. australis*, *C. ragrostis*, *E. alatus*, *C. gaudichaudiana*, *J. usitatus*, *J. articulatus, Hydrocotyle tripatita* and *Isotoma fluitans*. The River Bottlebrush – Burgan Tableland Riparian Shrubland includes *C. sieberi, K. ericoides* and *L. obovatum*, with dead or defoliated *S. fragilis* among the boulders.

Further downstream, a river crossing is fringed with *T. orientalis* and *P. australis,* dead standing willows and a range of native shrubs. The river opens up into a long reach with more gentle sides at Blue Tiles picnic area. The river at this point forms a large pool where willow and blackberry control has had considerable success, with patches of dead brambles and dead standing willows lining the banks. The Tableland Aquatic and Fringing Vegetation Complex is in very good condition at this point with extensive *V. australis* beds instream, fringing beds of *P. australis*, *P. labillardierei* tussock on the banks, and introduced *Phalaris* sp. at the margins. The River Bottlebrush – Burgan Tableland Riparian Shrubland comprising *A. dealbata*, *A. doratoxylon*, *A. rubida*, *K. ericoides* and *L. obovatum* appears to have been largely outcompeted by the (now dead) willows and blackberries (Plate 7.4). *E. bridgesiana* grows on the hillslope close to the river bank with *E. rossii* higher up the slope.

Plate 7.4: Molonglo River at Blue Tiles picnic area

7.3.2 Molonglo Gorge to Lake Burley Griffin

This reach is approximately 27 km in length and begins in the Molonglo Gorge and continues to Lake Burley Griffin (Appendix 7A Maps 7.3a to 7.5a). The section commences at the western end of Molonglo Gorge (Public Land: Special Purpose Reserve). From there the river crosses rural land, is joined by the Queanbeyan River near Oaks Estate, passes the Queanbeyan Sewage Treatment Works, and merges with the backed up waters from Lake Burley Griffin near the Fyshwick industrial area and Pialligo (nurseries, orchards and associated land uses). The river enters Lake Burley Griffin on the eastern edge of East Basin (near the ACT Hospice).

Downstream of Blue Tiles the riparian zone is a complex bedrock floodplain and the vegetation community in the riparian zone is River Bottlebrush – Burgan Tableland Riparian Shrubland with Tableland Aquatic and Fringing Vegetation Complex. The river channel contains emergent fringing *S. validus* and *P. australis* with *K. ericoides*, *A. rubida*, *A. dealbata* and blackberries on the stream banks above.

On the lower hillslopes the vegetation community is Black Cypress Pine Tableland Woodland dominated by *C. endlicheri* and *E. bridgesiana*. Higher up the slopes the tree community changes to Red Stringybark – Scribbly Gum Tableland Forest dominated by *E. macrorhyncha*, *E. rossii* and the occasional *E. goniocalyx* (Plate 7.5). The midstorey contains *A. doratoxylon* (more common on sunnier southern side of the river); other shrubs including *Dodonaea viscosa, C. quinquefaria, P. angustifolia*, *P .eriocephala*, *A. rubida*; undershrubs such as *Pultenaea* sp., *Dillwynia* sp. and *Hibbertia obtusifolia*; and a ground cover of *D. revoluta*, *C. sieberi*, *Stellaria* sp., *Poa* tussock, *Helichrysum* sp., and the fern *Asplenium flabbelifolium*. The cryptogams were well represented by mosses, lichens (including the bronze and golden *Pseudocyphellaria* sp.and some *Cladia* spp. and *Cladonia* spp.) and liverworts (including a very bronze *Fulgensia* sp.).

Plate 7.5: Black Cypress PineTableland Woodland in Molonglo Gorge

At the western edge edge of the gorge, the vegetation comprises Yellow Box – Blakely's Red Gum Tableland Grassy Woodland (with *E. polyanthemos*) and Broad-leaved Peppermint – Apple Box Tableland Woodland. High on the ridges *E. rossii*, *E. dives* and *E. macrorhyncha* occur on the slopes (Red Stringybark – Scribbly Gum Tableland Forest) and *E. blakelyi* and *E. melliodora* in gullies.

At the Molonglo Gorge picnic area the river flows into a broad flood plain, with a variable but often dense River Bottlebrush – Burgan Tableland Riparian Shrubland and on adjacent hillslopes Yellow Box – Blakely's Red Gum Tableland Grassy Woodland, including some individual *C. endlicheri* from the nearby Black Cypress Pine Tableland Woodland. The instream vegetation is dominated by *P. australis*. There are dense infestations of blackberries on the stream margins. The River Bottlebrush – Burgan Tableland Riparian Shrubland contains *L. obovatum* (dominant at mouth of gorge), *A. rubida*, *A. dealbata*, *C. endlicheri*, *C. sieberi*, *K. ericoides*, *B. spinosa*, *D. viscosa angustifolia*, and weeds, especially *R. rubiginosa* and *Hypericum perforatum*. *P. radiata* wildings also occur in this area. The ground cover is mainly native species including *T. triandra*, *L. longifolia* and *P. decipiens* with some introduced canary grass *P. aquatica*.

Downstream from Molonglo Gorge the River Bottlebrush – Burgan Tableland Riparian Shrubland community continues and is in moderate condition. The main weed species are willows and blackberries. Control measures have been applied to both of these with varying levels of success. There are depauperate remnants of Yellow Box – Blakely's Red Gum Tableland Grassy Woodland in the surrounding rural land. At Oaks Estate Road bridge, the river is completely infested with blackberries and willows forming an impenetrable thicket (Plates 7.6 and 7.7).

The river continues through rural land until the Fyshwick–Pialligo areas and the riparian vegetation is almost entirely exotic. Vegetation of the adjacent valley slopes is highly modified with remnants of Yellow Box – Blakely's Red Gum Tableland Grassy Woodland, some *E. polyanthemos* and planted eucalypts. Between the Fyshwick–Pialligo areas and Lake Burley Griffin, the original river morphology has been submerged under the backed up waters of the lake and a new riparian vegetation zone established with the relatively stable water level. This

vegetation is almost completely exotic (plantings, weed species and naturalised exotic species) (Plate 7.8) though there are some planted native species. Control and rehabilitation work has been undertaken recently along Molonglo Reach and near the Monaro Highway bridge. The latter involves the replacement of exotic species with *C. cunninghamiana, E. viminalis*, *E. bridgesiana* and fringing aquatic vegetation including *P. australis, Myositis caespitosa* and *C. eragrostis*.

Plate 7.6: Upstream view of Molonglo River at Oaks Estate Bridge showing blackberries and willows

Plate 7.7: Molonglo River: willows downstream of Oaks Estate

Plate 7.8: Blackberrries on Molonglo River at Pialligo (foreground) and near Fyshwick (opposite bank)

7.3.3 Scrivener Dam to Coppins Crossing

This reach is about 9 km in length and begins at Scrivener Dam where water is released from Lake Burley Griffin (Appendix 7A Map 7.6a). In a downstream direction, the right side of the river for the whole section adjoins former *P. radiata* plantation and pine wildings are common throughout the riparian zone. Open space uses, former softwood plantation and rural land use adjoin the left side. Some of land in this section will become part of the proposed Molonglo urban development.

For some kilometres below Scrivener Dam, the riparian vegetation is dominated by exotic species (Plate 7.9). The main riverbank species are *Salix* spp. (*S. fragilis*, *S. nigra, S. babylonica* and some shrub willows), with *P. nigra, P. albicans*, *Corylus avellana*, *C. monogyna* and *Pyracantha* sp. Blackberries form a thicket along the entire stretch of river and the channel is choked by willow roots and debris (Plate 7.10). Some native shrubs such as *A. rubida, A. mearnsii, A. dealbata, A. parramattensis* and *A. baileyana* remain in the understorey and the lower hillslope, where there is a weedy ground layer of *Bromus* sp., *H. lanata*, and *Avena* sp. and some remnant native grasses (*T. triandra, Austrodanthonia* spp.). There is a high cover and abundance of native semi-aquatic fringing vegetation in the backed-up water created by the willows and low flows due to Scrivener Dam. Substantial beds of the native *Typha dominigensis, S. vallidus* and *L. salicaria,* occupy the channel edge, while native *Hydrocotyle tripartite, Ranunculus amphitrichus* and *Acaena agnipila* grow abundantly on the raised moist rocky areas above the low base flow level. Exotic species such as *V. anagalis-aquatica*, *Nasturtium officinale*, *Ranunculus repens*, *Plantago major*, and *Taraxacum officinale* are common throughout the reach.

West of the Tuggeranong Parkway overpass, the stream channel and banks continue to be dominated by willows which completely choke the river in parts. The aquatic fringing species still have a high native component and include *Schoenoplectus* sp., *Bolboschoenus* sp., *Cyperus* sp., *Persicaria* sp., and algal species (*Spirogyra* spp.) typical of the Tableland Aquatic and Fringing Vegetation Complex. Some *C. sieberi* and *A. mearnsii* remain in the understorey in an otherwise weed infested riparian zone. African lovegrass *E. curvula* and many other ground layer weeds grow down the valley slopes to the river.

Plate 7.9: Molonglo River downstream of Scrivener Dam showing willow infestation

Plate 7.10: Molonglo River below Scrivener Dam showing willows choking the river and some native aquatic fringing species

Along the floodplain below Misery Hill the riparian vegetation returns to more native condition with the beginning of She-oak Tableland Riparian Woodland and a marked decrease in the number of willows (Plate 7.11). The *C. cunninghamiana* trees have been affected by fire but are regenerating well, with many seedlings observed along the river bank. The river opens up into a large, clear pool with Tableland Aquatic and Fringing Vegetation Complex (*P. australis*, *Persicaria*

sp., *Bolboschoenus sp., Schoenoplectus* sp., *Juncus* sp.) on the right bank and a relatively bare bank to the left.

Plate 7.11: Molonglo River below Misery Hill where the riparian vegetation returns to She-oak Tableland Riparian Woodland

Where the river enters a broad bedrock flood plain, stunted *C. cunninghamiana* occur among the midstream boulders. Many fallen willows and broken branches litter the river bed, showing a history of flood events and subsequent recovery. The invasive *E. curvula* (African lovegrass) has established on the sand bars. The adjacent hillslope is mostly cleared grazing land with patchy Red Stringybark – Scribbly Gum Tableland Forest and an understorey of *T. triandra, Austrostipa* sp., *B. spinosa* and *K. ericoides.* As the river nears Coppins Crossing the She-oak Tableland Riparian Woodland is again invaded by willows and other weeds (Plate 7.12).

Plate 7.12: Molonglo River at Coppins Crossing showing willow and blackberry infestation and fire affected She-oak Tableland Riparian Woodland

7.3.4 Coppins Crossing to confluence with Murrumbidgee River

This reach is approximately 13 km long (Appendix 7A Maps 7.7a, 7.8a). From Coppins Crossing the river runs through undulating hilly terrain until it enters the narrow sided gorge below the aqueduct that cuts Belconnen Creek. There is a short reach from the end of the gorge past the Lower Molonglo Water Quality Control Centre (sewage treatment plant) to the confluence with the Murrumbidgee River. This section of the river was surveyed in detail by Barrer (1992) whose report provides a valuable benchmark against which to compare the current state of the riparian and hillslope vegetation. Such a detailed assessment is not included here.

At Coppins Crossing, She-oak Tableland Riparian Woodland is still present but in poor condition following the 2003 bushfire. Prior to the fire this community formed a dense cover in places. The riparian zone is dominated by woody weeds, including willows, blackberries and an assortment of exotic tree species. The margins of the river have patches of Tableland Aquatic and Fringing Vegetation Complex in good condition, containing *P. lapathifolia*, *J. usitatus* and *C. eragrostris*. As the river spreads out among the boulders in the flat-bottomed but quite narrow valley floor, the terraces and river-line have *C. cunninghamiana* with *A. mearnsii* and occasional patches of *S. nigra*, *S. fragilis, P. nigra* and *Acer negundo*. The instream vegetation includes extensive patches of *M. verrucosum* and emergent *P. australis*, *P. lapathifolia*, *J. usitatus* and *C. eragrostris*.

The adjacent valley slope near the crossing and continuing further down stream, contains mostly grassland with remnants of Yellow Box – Blakely's Red Gum Tableland Grassy Woodland with clumps of *E. bridgesiana* and the occasional scattered *E. melliodora*, *E. mannifera*, *E. polyanthemos* and *E. blakelyi*. The grassland is rich in native species, with prominent patches of *T. triandra* and *B. macra*.

Close to the Deep Creek confluence, the river contains sand bars and the riparian vegetation is 3 to 15m wide. This area contains mature, well established *C. cunninghamiana* on the flood plain near the mouth of Deep Creek and in the tributary gullies. The floodplain also includes some *Typha* beds. There has been some blackberry control work in this area with variable success. There are also a few box elder (*A. negundo*), which is a woody weed in the Canberra area. Deep

Creek, running under the aqueduct, is a base-flow creek with *C. helmsii*, *N. officinale*, *J. articulatus* and similar plants in the riparian zone. The stream channel is braided in parts of the flood plain and wetlands have formed in some subsidiary channels.
The right-bank adjacent hillslope (Belconnen side) is treeless, with native pasture (*T. triandra, Austrodanthonia* spp.) on very shallow soils. On the left bank, where steep slopes and rocky spurs occur, there is a patchy Burgan Derived Tableland Shrubland containing *K. ericoides* and *B. spinosa* as well as *P. radiata* wildings. As the gullies and valley slopes become progressively rockier *C. endlicheri* occurs. There are walls of columnar basalt with a light native shrubland and open grassland above.

Just upstream of the gorge there is a stand of She-oak Tableland Riparian Woodland in excellent condition with plenty of mature and regenerating plants (Plates 7.13 and 7.14). On a midstream island there are several ages of *C. cunninghamiana* represented, some with mistletoe. Willows are also establishing in the area, mainly *S. fragilis* with some *S. babylonica*. The adjacent hillslope and some of river bed are fire affected, especially to the east. On the right side, there is a stand of *E. pauciflora* with about three mature and dead standing trees and one regenerating mature tree, and a coppice of perhaps 25 young trees.

Plate 7.13: Molonglo River below Coppins Crossing showing high quality She-oak Tableland Riparian Woodland

Plate 7.14: Molonglo River below Coppins Crossing: She-oak Tableland Riparian Woodland

At the upstream entrance to the gorge, there is a 2–3 ha patch of *C. endlicheri* on the left side commencing a stand of Black Cypress Pine Tableland Woodland across the top of the gorge and continuing into the gorge. No *C. endlicheri* were observed on the more gently sloping right side.

In the upper gorge where the stream channel is a 40–50 m wide bedrock floodplain, the river may cease to flow in drought periods and between releases from Scrivener Dam. Occasional sandbars containing *M. verrucosum* cross the floodplain marking the ends of pools in dry periods. Dead, young *C. cunninghamiana* were observed in the river bed. On the left side, the gorge has high (about 15 m) sides with scattered patches of Black Cypress Pine Tableland Woodland and *A. rubida* shrub understorey. At the foot of the slope, there is a River Bottlebrush – Burgan Tableland Riparian Shrubland containing *A. mearnsii*, *K. ericoides* and occasional *C. sieberi* with marginal beds of stranded *S. validus*. The right bank is lined with She-oak Tableland Riparian Woodland with an understorey of *A. mearnsii*, and *K. ericoides.* The flood terrace is weedy and includes *H. incana, E. curvula* (African lovegrass) and *Nassella trichotoma* (serrated tussock). An occasional *C. cunninghamiana* occurs in the back floodrunner above which is a bare hillslope. Throughout this area the *C. cunninghamiana* grows into the gullies. Occasional willows and box elder *A. negundo* occur in the gorge.

Above the gorge there are a few patches of fire-affected *E. macrorhyncha*, remnants of Red Stringybark – Scribbly Gum Tableland Forest, which are very heavily fire affected. The Black Cypress Pine Tableland Woodland has been destroyed by the 2003 bushfire on shallow soils but has survived on the deeper soils persisting at the bases of gullies. As the slope in the gorge declines, *E. blakelyi* returns and there is a second patch of *E. pauciflora* consisting of perhaps 10 trees. This is a remnant of Yellow Box – Blakely's Red Gum Tableland Grassy Woodland. Towards the end of the grazing land the hillslope on the right side contains a well wooded patch of *E. dives*, which is recovering from the fire. Further downstream the river forms a series of large pools. The fringing emergent vegetation includes some *S. validus* and *P. lapathifolia*. The Tableland Riparian Shrubland of *A. mearnsii* and *B. spinosa,* as well as willows and other weeds, alternates with the She-oak Tableland Riparian Woodland.

Approaching the Murrumbidgee River, the Molonglo opens out into a floodplain with more gentle sloping sides, a short distance above the Lower Molonglo Water Quality Control Centre. The river flows across a broad delta to enter the Murrumbidgee opposite Woodstock Reserve and below the treatment plant. The riparian vegetation community is She-oak Tableland Riparian Woodland with associated understorey species. Occasional patches of willows, box elder (*A. negundo*) and some poplars can still be found. In the deeper soils of the delta region, the floor of the valley supports an extensive She-oak Tableland Woodland with many herbaceous weeds. Around the YMCA there are some plantings of poplars. On the left hillside the Black Cypress Pine Tableland Woodland is gradually replaced by open grassland with scattered exotic trees. On the right there is a remnant of Yellow Box – Blakely's Red Gum Tableland Grassy Woodland, represented by a few *E. blakelyi*.

7.4 Molonglo River: Condition and Management Recommendations

As noted in s. 7.2 the Molonglo River has been substantially modified since European settlement and it is difficult to find any stretch of the river where there is not evidence of that impact. Any rehabilitation of the most seriously degraded areas will involve reinstatement (see Glossary) as there is no, or minimal, native vegetation to form the basis for such work.

Assessment of Molonglo River riparian condition is presented on maps in Appendix 7A. Vegetation dominance change assessment is presented on maps in Appendix 7B. Management maps for the Molonglo River are contained in Appendix 7C. These maps indicate locations where management actions are recommended.

7.4.1 Burbong to Molonglo Gorge

In this section, the river passes through rural land adjacent to Kowen Forest (softwood plantation). The general condition of this section is moderate. The main management issue is control of weed species in the riparian zone, in particular, willows, blackberries and radiata pine wildings. Control programs have been undertaken and appear to be successful. Although the country has been mostly cleared for grazing, there are still intact patches of remnant Snow Gum – Candle Bark Tableland Woodland which should be conserved.

Management recommendations for this river section (Appendix 7C maps 7.1c, 7.2c) include:

- continuation of current willow and blackberry management
- conservation of Snow Gum – Candle Bark Tableland Woodland
- conservation of native vegetation between the Molonglo River and upslope softwood plantation areas.

7.4.2 Molonglo Gorge to Lake Burley Griffin

Within Molonglo Gorge the riparian vegetation is in high native condition. The hillslope vegetation includes patches of Black Cypress Pine Tableland Woodland and Red Stringybark – Scribbly Gum Tableland Forest both leading into Yellow Box – Blakely's Red Gum Tableland Grassy Woodland in less steep areas. The floristics of the gorge communities from the lichens to the trees is varied. This area is reserved as Public Land and continuation of current management practices is recommended.

As the river flows out of Molonglo Gorge and into adjacent rural land between Oaks Estate and Dairy Flat Road, it enters a landscape with a history of European modification dating back to the 1830s. Much of the river bank has been altered to the extent that it now represents a Northern Hemisphere rural landscape with deciduous trees and shrubs. Added to this, many of the grasses and forbs in the river corridor are those of pasture land and cottage gardens. The situation is such

that the vegetation community dominated by willows, elms and poplars, is largely self perpetuating.

In this segment of the river section, the river flows through an almost entirely modified and highly degraded landscape. The riparian vegetation has been influenced by rural and horticultural activities (Canturf turf production, Pialligo nurseries and farmland, grazing), recreational use (waterskiing, public reserves and picnic areas), industry (Queanbeyan and Fyshwick industrial areas), and infrastructure (Queanbeyan Sewage Treatment Works). The resultant high nutrification levels within riparian soils and river water, combined with a history of plantings of exotic species, has greatly contributed to the current disclimax vegetation community.

S. fragilis and S. *nigra* propagate from seed and even more easily from fragmentation. *U. procera* coppices very successfully and also produces large quantities of seed. Neither willow nor elm has any native predators. The recently arrived willow sawfly (*Nematus oligospilus*) is native to the Americas, and is having a clear affect in conjunction with drought (for more information, see CSIRO 2008). Poplar rust is of little effect on local poplar species except cottonwoods and only usually infects *S. babylonica* (weeping willow) of the willows. The canopy created by willows and elms (*Ulmus* spp.) excludes most native shrubbery and almost promotes willows and the *Prunus* spp. and *Malus* spp. wildings that exploit these areas. The deciduous nature of the canopy and the understorey makes it difficult for native ground cover to survive. In this way the disclimax takes over large stretches of riparian reaches and is extremely difficult to control and reduce.

The adjacent hillslope is mostly cleared but contains remnants of the endangered Yellow Box – Blakely's Red Gum Tableland Grassy Woodland, represented by only a patchy distribution of remnant mature adults. The grasses and forbs include a high proportion of native species especially higher up the slope but these must compete with exotic 'pasture improvement' species such as *P. aquatica.*

Where there have been efforts at restoration such as at the water-ski area, the reintroduction of native trees, shrubs and aquatic vegetation has only been partially successful. One of the problems has been the continued aggressive recolonisation by blackberry.

Management recommendations for this river section (Appendix 7C Maps 7.3c to 7.5c) include:

- continued support for the 'Molonglo River Rescue' program
- management of willows including the deliberate promotion of saw fly
- management of blackberries
- revegetation of river margins with local aquatic emergent species, especially in areas of high recreational use
- community education programs to promote native vegetation in parklands
- maintenance of public areas, especially where they potentially contribute to eutrophication of waterways or disturbance of banks
- the design, in line with sustainable urban planning guidelines, of a natural water filtration scheme using aquatic vegetation in the Molonglo River in parallel with that of Jerrabomberra Creek and the Jerrabomberra Wetlands.

7.4.3 Scrivener Dam to Coppins Crossing

Below Scrivener Dam the riparian vegetation is in poor condition and water released from Lake Burley Griffin, from the bottom of the water column, is of poor quality (NCPA 1995). What was once probably She-oak Tableland Riparian Woodland is now almost entirely Northern Hemisphere exotic plant species. This area has similar problems to the Dairy Flat/Oaks Estate reach with activities of the adjacent valley slope affecting the river. In this part of the reach are the National Zoo and Aquarium, public recreation areas, former softwood plantation and urban infrastructure. Yarralumla and Weston creeks drain into the Molonglo River at this point, having crossed the

whole of the Woden and Weston area. The two creeks contribute storm water from the south side suburbs, which may result in heightened nutrient levels and turbidity downstream.

Below the former plantation area where the river passes Misery Hill, the riparian vegetation gradually returns to a more natural state, with the beginning of She-oak Tableland Riparian Woodland and a decrease in woody weed species. In the Coppins Crossing area the river has a significant woody weed distribution.

Management recommendations for this river section (Appendix 7C Map 7.6c) include:

- management of willows including the deliberate promotion of saw fly and removal of instream dead and living willows
- management of blackberries
- restoration of bank areas prior to revegetation and erosion and sedimentation control
- revegetation of river margins with local aquatic emergent species, especially in areas of high recreational use
- community education programs to promote native vegetation in parklands
- maintenance of public areas, especially where they potentially contribute to eutrophication of waterways or disturbance of banks
- should it be necessary to construct wetlands in this area as part of the proposed Molonglo urban development, these should meet sustainable urban design criteria and so be shallow, variable flow pondages rather than artificial lakes
- management of former softwood plantation areas to prevent spread of pine wildings into the riparian zone
- maintenance of environmental flows as a minimum for this section of the river.

7.4.4 Coppins Crossing to confluence with Murrumbidgee River

With the exception of the short reach immediately downstream of Coppins Crossing, this stretch of the lower Molonglo River is in moderate to high condition throughout. There are numerous areas where vegetation communities of high conservation value (e.g. Snow Gum – Candle Bark Tableland Woodland, Black Cypress Pine Tableland Woodland) have survived the effects of the 2003 bushfire. The right bank hillslope, which is most likely to have been Yellow Box – Blakely's Red Gum Tableland Grassy Woodland, may require greater management than hillslope on the left, but both may well benefit from judicious planting and maintenance.

At the confluence with the Murrumbidgee there is an opportunity to restore a section of significant She-oak Tableland Riparian Woodland. The existing access through Camp Sturt would allow the use of such a restored area for educational programs without further disturbance. This would involve considerable rehabilitation and weed control.

Management recommendations for this river section (Appendix 7C Maps 7.6c to 7.8c) include:

- control of willows and blackberries
- continuation of current fire management programs following the 2003 bushfire
- implementation of the Lower Molonglo River Corridor strategy
- restoration of the mouth of the Molonglo River as a demonstration of high condition She-oak Tableland Riparian Woodland
- conservation of areas of high conservation significance
- maintenance of environmental flows as a minimum for this section of the river.

8 CONCLUSIONS

8.1 Objectives of Project

The objectives of this project were to:

- define riparian vegetation community distribution along major tributaries of the Murrumbidgee River in the ACT
- assess the condition of riparian ecological communities along major tributaries of the Murrumbidgee River in the ACT
- provide management recommendations on riparian zone management; including conservation of threatened species and ecological communities, presence of significant weed species, and identification of priority sites for vegetation rehabilitation.

The project followed the completion of the Murrumbidgee River riparian vegetation survey (Johnston et al. 2009) (s. 1.1) and was based on the use of aerial photography, satellite imagery and targeted ground survey.

8.2 Riparian Vegetation Community Distribution

The vegetation community classification used in this survey is outlined in s. 2.2. Under this classification 20 vegetation communities were defined for the rivers surveyed, including adjacent hillslope communities. These communities ranged from subalpine bogs to low elevation river flats containing stands of *C. cunninghamiana*. Many of these communities were impacted to varying degrees of severity by the 2003 bushfire and the report comments on the level of recovery that is now apparent.

The communities are described in sections 3.3, 4.3, 5.3, 6.3 and 7.3 and maps of the vegetation communities and condition are in Appendixes 3A, 4A, 5A, 6A and 7A respectively. Interpretation of the results of the surveys, as provided in the descriptions and the maps, should take account of the methods used and their limitations (see s. 2.4).

8.3 Riparian Vegetation Condition Related to Land Use

As expected there is a close correlation between past and/or previous land use and the condition of the rivers and their riparian zones. In historical times, modifications of the Southern Tablelands landscape began with the European pastoral advance from the 1820s. Subsequent impacts derive from continuing pastoral and agricultural development; urban and infrastructure development; water resource development; recreational facility development; weed invasion; changed fire regimes; mining and extractive industry. A range of protective regimes have also been applied such as the 'restricted use' policy in the Cotter Catchment from 1914, to protect water resources; and much more recently, the reservation of areas incorporating parts of the rivers in ACT reserves (Public Land as defined in the *Planning and Development Act 2007* and delineated in the *Territory Plan*). Catchment management activities involving government, land owners and the community also make an important contribution e.g. through Landcare, Parkcare and Waterwatch groups (see also: ACT Natural Resource Management Council 2009).

Condition of the river sections and management recommendations are discussed and outlined in sections 3.4, 4.4, 5.4, 6.4 and 7.4 and maps with management recommendations are in Appendixes 3C, 4C, 5C, 6C and 7C respectively.

8.3.1 Overview: condition of riparian zones

The construction of three dams on the Cotter River has had a major impact on the hydrology of the River and the orginal riparian vegetation has been lost under the reservoirs. However, in the catchment above Corin Dam and the stream sections below Corin Dam and Bendora Dam (to the Vanitys Crossing area), riparian condition is very good. These areas are protected within Namadgi National Park. The condition of riparian vegetation in the lower catchment is much poorer. This area was subject to early overgrazing, was planted to *Pinus radiata* from the 1920s and subsequently managed as softwood plantation, before the plantations were destroyed in the 2003 bushfire. Significant changes will occur between Condor Creek and the Cotter Dam wall with the completion of the enlarged Cotter Dam. The lower catchment is now Public Land, reserved for the protection of water supply.

The three drought responsive waterways (Naas, Gudgenby and Paddys rivers) demonstrate the long term effects of rural land use in the Southern Tablelands environment. Even so, where these rivers are in Namadgi National Park, the riparian vegetation has recovered to good or even excellent condition. Parts of these waterways in rural land are in moderate to good condition, especially where there has been some effort to restrict stock access to the river banks. Many areas contain varying levels of exotic vegetation, but there are still sufficient pockets of residual natives to allow improvement of riparian condition with better rural land management.

Both the upper Molonglo River in the Kowen Gorge area and the lower Molonglo below Coppins Crossing retain riparian and some hillslope vegetation in good condition. Between Molonglo Gorge and Coppins Crossing, the river and the riparian zone have been severely impacted by the factors listed in s. 8.3 above.

A pervasive feature throughout all the river sections surveyed is the encroachment, and in many parts the dominance of exotic, usually wood weed, species. Blackberries, willows, poplars and radiata pine wildings are the most common. African lovegrass *E. curvula* is a major weed of the Murrumbidgee River Corridor (Johnston et al. 2009) and has established along the lower Molonglo River. Most of the weed species found in this study also occur in the Murrumbidgee River Corridor and the discussion of weed control in Johnston et al. (2009) is also relevant to the tributary rivers in this study.

8.3.2 Namadgi National Park

In general, riparian condition within Namadgi National Park is high. Most areas have probably returned to stream morphology and vegetation that is similar to the period just after European settlement. A small percentage of riparian areas remain in almost pristine condition. Some modifications are still apparent, following the use of the higher elevation grassy valleys for seasonal grazing until the 1920s. For example the Naas Creek area has an incised river-line through wet tussock grassland where once there may have been chains-of-ponds. Most areas have a stable riparian vegetation community and further incision of the waterways is unlikely, as stock are no longer permitted. Stock damage remains potentially problematic in areas where pest animals congregate, as was observed in Rolleys Swamp. A small herd of escaped cattle had trampled the vegetation and compacted the creek-line within delicate wet tussock grassland. Feral horses can cause similar impacts but these animals are not currently present in the area and should be removed if they do invade from elsewhere.

A very significant factor influencing condition in upper catchment areas in Namadgi National Park is the effect of wild fire. This may be severe and recovery is sometimes slow and often patchy. Sphagnum bogs within the upper Cotter were severely affected by the 2003 bushfire and an intensive rehabilitation program has been put in place to aid their recovery (s. 6.3.1, s. 6.4).

8.3.3 Former softwood plantation areas

Parts of the Paddys and Cotter rivers have former softwood plantations in their catchments. These plantations were destroyed in the 2003 bushfire, which denuded much of the landscape and burnt into the riparian zones. The plantations also contained an extensive forestry road network. Following the fire and subsequent storm rains, erosion and soil slip were common in the plantation areas. Vegetation regrowth following the fire mainly comprises natural regeneration of *P. radiata*, pioneering *Acacia* spp. and a wide range of weed species.

In the riparian zones of the lower Cotter River and the gorge on Paddys River there is seedling regeneration of *C. cunninghamiana*. Post-fire, wattle shrubland has developed on the hillsides and over time the eucalypts may return. Drought in the years following the 2003 fire has not promoted the recovery of ground cover vegetation.

8.3.4 Rural land

Where rivers traverse rural land, riparian and stream bed condition varies in response to upstream and adjacent land management. In areas where stocking rates have been progressively reduced and paddock rotation practices have been followed, the valley and hillslope vegetation has returned to more wooded condition than seen in the 1940s aerial photography (Eyles 1977a). Recent fencing of river banks (as in the lower Molonglo) has restricted stock access and increased riparian zone vegetation complexity. In unfenced areas (such as the lower Naas and Gudgenby rivers) bank collapses and the poor condition of fringing vegetation and shrubs mark the riparian zone. The removal of intentionally planted and naturalised species that have become serious weeds, such as willows and pasture grasses, is an ongoing problem. Most weed species are able to exploit disturbed soil and readily available water both of which characterise most riparian zones. Some weeds like blackberry have the capacity to overwhelm all competitors and have the resilience to withstand unfavourable conditions (drought, fire) and recover before most other plants.

8.3.5 Peri-urban development

Although there is only a small amount of peri-urban development (Molonglo River at Pialligo, Canturf near Fyshwick) the intensive agricultural use of the land can modify the river bank away from the native condition without leaving much of a residual seed bank. Disturbance and eutrophication are almost inevitable in such areas. Disturbed areas provide harbours for weed infestation as can be seen on the Molonglo River at Pialligo. The blackberry infestation from the Yass Road Bridge to Dairy Flat Road is a striking example of weed exploitation of the favourable conditions for growth that peri-urban development provides.

8.3.6 Urban areas

The Canberra urban area was developed over a highly modified rural landscape in which there had been extensive tree removal and overgrazing. A major feature of the Griffin Plan was a central ornamental lake involving the damming of the Molonglo River. By the time the lake was completed the ecological condition of the river had been severely impacted by heavy metal pollution from the former Captains Flat mine (s. 7.2). The landscape design for the lake edge parkland was formal and involved mainly exotic and some native species. In the 35 years since the filling of the lake, a wide variety of tree and shrub species have become established along the lake edge and downstream. Much of the Molonglo River below Scrivener Dam shows the invasion of what was probably She-oak Tableland Riparian Woodland by exotic tree species (e.g. willows, poplars, elms and stone fruit trees). These plants and woody debris have blocked and choke the stream channel for some kilometres below the dam. In 2010 the vegetation for a few hundred metres immediately below the dam was cleared to allow the flow of water under high volume release conditions.

In urban areas the capture and containment of storm water is a matter of normal planning. Storm water is distributed in drains and modified creek lines from which residual pockets of riparian vegetation in suburban areas have been removed. Storm water also carries a high nutrient content and a rich assortment of exotic plant propagules. These potential weeds turn up at outlets of drains and down stream, and further exacerbate the degradation of the riparian zone. While gross pollution traps and other methods of collection of storm drain litter limit the amount of free floating urban debris, much still reaches the rivers. While log jams and snags are of great benefit to the complexity of life of riparian ecosystems, much of the urban debris is unsuitable for aquatic life habitat.

8.3.7 Recreational areas

At Murrays Corner (Paddys River), Molonglo Gorge Recreation Area and the Cotter Recreation Area the public access has lead to compaction and deformation of the riverbank geomorphology through picnicking, camping and other recreational activities. The riverbank and adjacent valley slope is further modified with parking areas and infrastructure to accommodate public use. These modifications remove the original native vegetation and its seed bank.

In older developments of recreation areas, the landscape design has reflected northern hemisphere fashions for manicured parks and gardens, with the use of block plantings of white poplar, english plane, various elm and oak species and willows. The understorey is either left open or replaced with garden shrubs while the lawn grasses are those preferred for mowing and easy maintenance. In the Cotter Recreation Area this parkland is considered of heritage value and will require on-going careful maintenance to prevent the spread of some of the species used in the parkland.

It is notable that in the water ski area of Molonglo Reach at Fyshwick, recent bank restoration work has included the deliberate use of locally sourced aquatic fringing and riparian vegetation. This restoration has been found to provide protection from undercutting of the banks and has been successful in limiting the spread of blackberries.

8.3.8 Reservoirs

As noted above, the Corin, Bendora and Cotter reservoirs have had major impacts on the Cotter River system. However, environmental flows in the river below Corin Dam facilitate the continuation of the riparian systems in good health. Due to fluctuating water levels, Corin and Bendora reservoirs have not developed a genuine riparian fringe and these conditions will apply to the Cotter Reservoir when it is enlarged.

8.4 Riparian Vegetation Condition: Highlights

This section briefly describes those parts of the river sections surveyed in this project where riparian vegetation condition is very good and/or noteworthy because of the type of vegetation present there. The quality of these areas, which contrasts with the degraded sections of the streams, justifies appropriate management input to retain their natural heritage values.

Naas River

The Naas River within Namadgi National Park, especially the Naas Creek area is a floristically rich and picturesque stretch of river. It flows through fine examples of Montane Wet Tussock Grassland, Snow Gum Montane Woodland and well developed instream aquatic vegetation. This is easily seen in the vicinity of the Mt Clear campsite area and along the Naas fire trail.

Gudgenby River
The morass on the Gudgenby River above Boboyan Road at the confluence of Hospital Creek, Rendezvous Creek and the Gudgenby River is the most accessible example of a morass wetland in the ACT. The area below Boboyan Road to Glendale Crossing is protected by the rugged nature of the terrain and lack of public access.

Paddys River
Two sections of Black Cypress Pine Tableland Woodland occur on the Paddys River. The first occurs in a sheltered gorge above Tidbinbilla Road. Several mature trees have escaped the effects of the 2003 bushfire and many seedlings are observed to be regenerating. The second woodland occurs downstream of the gorge on Paddys River and, although severely fire affected may return, as seedling regeneration in the area is quite high.

The recently incised channel at Blue Gum Creek provides a working ecosystem reflecting the destabilisation of tableland waterways following the arrival of European farmers. The stand of *E. viminalis* saplings observed inside the new channel is healthy and it is possible that monitoring this part of lower Blue Gum Ck area may provide information about containment and regeneration following severe erosion events.

Cotter River
The Cotter above Corin Reservoir remains one of the few near pristine river systems in the south-east of the continent. The mosaic of montane and subalpine riparian communities is well preserved in Namadgi National Park and recovery from the 2003 bushfire has been slow but continues.

The Ribbon Gum Tableland Riparian Woodland that fringes the Cotter from Corin Dam to a little below Vanitys Crossing has recovered from the 2003 bushfire and now nestles between valley slopes once again covered by a patchwork of eucalypt woodland. This area is protected by restricted access but remains vulnerable to weed invasion at points where access is possible or former softwood plantation areas provide a seed bank source for invasive species.

Molonglo River
The remnants of Snow Gum – Candle Bark Tableland Woodland in both the upper Molonglo around Glen Burn and the lower Molonglo as the river enters the lower Molonglo Gorge are worth noting and monitoring, especially in the light of the on-going drought. The mature trees and saplings in the lower Molonglo bode well for the future. The upper Molonglo patches are more complex in life stages and were not affected by the 2003 bushfire.

The complexity of riparian and associated valley slope vegetation in the Molonglo Gorge remains impressive. Urban development in the Ridgeway area of Queanbeyan does not appear to have caused impacts. The long term effects of the railway cutting on the valley slope on the south side of the gorge have been to leave open scree fields with scattered shrubs or occasional *C. endlicheri*.

The Black Cypress Pine Tableland Woodland fringing the hillslope and along the gorge in the lower Molonglo show patchy recovery from the 2003 bushfire, but the presence of a large number seedlings indicates that the community may recover over time.

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GLOSSARY AND ABBREVIATIONS

ABBREVIATIONS

ASL = above sea level
ha = hectare
GL = gigalitre (1 000 000 000 litres or 1000 megalitres)

GLOSSARY

Ecological Community
An assemblage of plant and animal species that occur together in space and time.

Ecosystem Services
Functions of natural ecosystems that maintain the atmosphere; provide clean water; control soil erosion, pollution and pests; pollinate plants; and provide many other essential services. The functioning of natural ecosystems provides services essential to human survival. Collectively, these services maintain the earth in a state that can support life (National Biodiversity Strategy Review Task Group 2009). High quality water from well managed catchments is an example of an ecosystem service.

Fire Intensity
Fire intensity is a measure of the energy generated by the burning of the fuels in the fire (Carey et al. 2003).

Fire Severity
Fire severity is a measure of the impact of the fire on vegetation (Carey et al. 2003).

Integrity (natural integrity)
The degree to which a place or ecosystem retains its natural biodiversity and geodiversity and other natural processes and characteristics (Australian Heritage Commission 2002).

Rehabilitation
Rehabilitation refers to the improvement in condition of land and/or ecological communities and their component species following degrading disturbance. Rehabilitation may involve regeneration, restoration or reinstatement representing progressively *greater degrees of human intervention*. These terms are defined in the *Australian Natural Heritage Charter* (Australian Heritage Commission 2002).

> *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.