


SURVEY OF VEGETATION AND HABITAT IN KEY RIPARIAN ZONES: Murrumbidgee River, ACT

Luke Johnston, Stephen Skinner, Lesley Ishiyama and Sarah Sharp

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Survey of vegetation and habitat in key riparian zones: Murrumbidgee River, ACT

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Front cover: The Murrumbidgee River and environs near Tharwa Sandwash recreation area, Tharwa, ACT.

All photographs: Luke Johnston.

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The following TAMS staff directly contributed to the planning, implementation, outputs and review of the project: Luke Johnston, Stephen Skinner, Lesley Ishiyama, Sarah Sharp, Lisa Evans, Felicity Grant, Kevin Frawley, Graeme Hirth, Sharon Lane, Matthew Beitzel and Diwani Velasquez.

Table of Contents

List of Tables

List of Figures

List of Appendices

Executive Summary

The Murrumbidgee River is the major waterway in the Australian Capital Territory (ACT) and flows through the largest inland city in the Murray–Darling Basin. It is known to be in a state of decline and has recently been described as being in very poor condition throughout its length (Murray–Darling Basin Commission 2008). The riparian floodplains in the ACT are no exception, having been affected by land clearing, altered hydrological systems and water quality, major weed invasions, fire and related climatic changes. This project was developed to identify the extent and condition of the riverine vegetation communities along the Murrumbidgee in the ACT. The primary objectives were to: identify and quantify riparian vegetation diversity and fauna habitat; map riparian weed abundance and distribution; map riparian ecological communities and species distribution; assess the health of the vegetation following the high-intensity 2003 bushfire; identify sites for subsequent monitoring under the ACT Biodiversity Monitoring Program; and identify sites for subsequent revegetation. This information has now been collated through a combination of remote mapping and detailed ground survey.

Four true riparian associations and a range of dry riverine valley communities were identified and assessed. The true riparian associations are the Tableland Aquatic and Fringing Vegetation Complex; River Bottlebrush – Burgan Tableland Riparian Shrubland; Ribbon Gum Tableland Riparian Woodland; and She-oak Tableland Riparian Woodland. The Tableland Aquatic and Fringing Vegetation Complex occurs throughout the corridor in wet or moist environments. Gigerline and Red Rocks gorges provide the best examples of intact remnant riparian shrubland vegetation, but this community also occurs on most rocky outcrops along the river banks. Ribbon Gum Tableland Riparian Woodland once occurred extensively between Angle and Point Hut crossings but is today almost locally extinct and in urgent need of protection and enhancement. The landscape in which ribbon gum occurs has been highly modified by pastoral practices and much of its former range has presumably been lost through land clearing. She-oak Tableland Riparian Woodland occurs along the river north of Point Hut. This community has suffered a reduction in area due to the effects of the 2003 bushfire, presumably in combination with low soil moisture from altered river flows and climatic conditions that are likely to have inhibited regeneration across floodplains away from the moist riverbanks.

Aside from where rocky substrates predominate, overall, the riparian zone contains a very high cover and abundance of weed species and is a major conduit for the downstream spread of both registered weeds of national significance and regionally listed exotic species. The reduction of naturally occurring overhead tree and shrub canopy due to land clearing and fire has allowed many of the weed species to thrive on the alluvial substrates. Several species were observed to be causing significant impacts on native biodiversity, especially African lovegrass (*Eragrostis curvula*) and blackberry (*Rubus fruticosus* agg.). Despite this, a small number of rare or uncommon species were documented to persist within the zone, such as Tuggeranong lignum (*Muehlenbeckia tuggeranong*) and Australian anchor plant (*Discaria pubescens*) which require protection from such threats.

The non-riparian associations occupy the incised valley slopes and include: Broad-leaved Peppermint – Apple Box Tableland Woodland; Snow Gum – Candlebark Tableland Woodland; Black Cypress Pine Tableland Woodland; Red Stringybark – Scribbly Gum Tableland Forest; Yellow Box – Blakely's Red Gum Tableland Grassy Woodland and Burgan Derived Tableland Shrubland. The eucalypt and shrub communities have generally shown strong resilience to dry climatic conditions in the fist decade of this century and the effects of the 2003 bushfire. Canopies are reforming and good seed regeneration was observed amongst a native shrub and ground strata. However, Snow Gum – Candlebark Tableland Woodland has a limited distribution and, where it persists, is in a highly degraded state. The Black Cypress Pine Tableland Woodland that once blanketed the steep slopes of the river valley has had very patchy recovery following the 2003

fire, with a future succession to a fire tolerant eucalypt dominated canopy likely throughout much of its range.

During the survey an overall narrowing of the area suitable for floodplain communities was observed, triggered in part by the 2003 bushfire, presumably in combination with ongoing drought conditions and reduction in overbank flows. It is likely that under current conditions and any further alterations to natural river hydrology that the floodplains will continue to become more suitable for species better adapted to dry soils. Evidence for successional dominance change could clearly be seen during the survey, with dry tableland eucalypt invasion of fire affected stands of black cypress pine (*Callitris endlicheri*) and she-oak (*Casuarina cunninghamiana*) communities. Consideration should be given to the effect of altered hydrology and climatic conditions on the several off-stream wetlands recorded throughout the floodplains. These are important refugia for aquatic and semi-aquatic vegetation assemblages either found only in the study area or with limited distribution in the ACT.

Despite the altered nature of the river corridor environment, incidental records indicate that it continues to provide habitat for a diverse range of terrestrial and semi-aquatic fauna. The expected suite of mammals and reptiles were noted, and a large number of bird species were observed, ranging from woodland species utilising secondary and exotic shrub thickets through to migratory honeyeaters and large raptors. While the altered habitat supports these faunal assemblages, the further spread of weed species and continued altered hydrology are important threats to the natural biodiversity of the riparian ecosystem. Remnant pockets of native vegetation still exist and there is a range of uncommon and rare vegetation species throughout the corridor. An immediate priority is to ensure that they are protected from current and future threats, including clearing, high fire frequency, spread of weeds and altered surface flow. In other areas re-establishment of structured multi-layered native vegetation corridors is a good way to ensure connectivity within that environment. This is also likely to result in a long-term reduction in the effort required to address management issues such as weed control.

The information gathered from this study provides an increased understanding of the ecological functioning of Murrumbidgee River riparian floodplains and valley slopes, which can be used to guide management and improvement of the riverine environment in the ACT. Accurate spatial and descriptive information relating to the distribution and condition of vegetation communities and assemblages is now available, along with an increased understanding of the extent of invasive species, and the impact of climatic conditions and natural resource management on the functioning of ecosystems associated with the Murrumbidgee River. As a result, government, private entities and community groups now have an enhanced ability to undertake urgently required management and remediation activities within the river valley. This survey was undertaken during the early recovery from the 2003 bushfire, which had major impacts on the river environment. The information provides, therefore, an important baseline for the early post-fire recovery phase that will be relevant for current and long-term planning and management.

The major recommendations detailed in this document include:

- protection and enhancement of remnant vegetation
- implementation of an ongoing vegetation monitoring program and expanded survey
- further investment in strategic and integrated weed management
- structured re-establishment of native vegetation
- full wetland appraisal and management
- further investment in the management of fauna and habitat (native and introduced)
- careful planning of water resource allocation to include the requirements of riparian ecosystem function.

The Murrumbidgee River near Guises Ck, an altered but functioning ecosystem.

Rocky secondary grasslands known to support the threatened Aprasia parapulchella *(Pink-tailed worm lizard) can be seen in front of high quality remnant black cypress pine. Dense burgan regrowth is invading the open space following the 2003 bushfire. Here the river passes remnant stands of ribbon gum before being joined by Guises Ck where an expansive open River Bottlebrush – Burgan Shrubland straddles a bedrock controlled floodplain*

PART 1 – BACKGROUND

Chapter 1: Introduction

In 2007 the *ACT Aquatic Species and Riparian Zone Conservation Strategy* (ACT Government 2007) was released which takes a regional approach to the protection and management of rivers and riparian areas in the ACT. The strategy is an Action Plan (No. 29), required under the *Nature Conservation Act 1980* (ACT), for species and ecological communities that have been declared threatened under the Act. A key recommendation of this action plan was the need to improve the knowledge of vegetation and habitat in riparian zones. Such knowledge would inform existing and future management actions in these zones including: the recovery of riparian areas affected by the 2003 bushfire; protection of river corridors from urban expansion; maintenance and improvement of linear and upslope connectivity; restoration of riparian habitat including control of weeds; and maintenance and protection of wildlife corridors and aquatic ecosystem processes and water quality (ACT Government 2007). Importantly it would also provide a snapshot of the extent and condition of the vegetation communities occurring in riparian and adjacent valley slope environments. This would provide a baseline against which future change could be assessed.

Funding was provided by the Australian Government National Action Plan (NAP) under the 'Working Waterways' package to conduct a survey of vegetation and habitat to assess condition and management issues over a total length of approximately 100 kilometres of ACT riparian zone. This survey and assessment was aimed at enhancing the information base upon which community groups and government agencies could make management decisions and undertake appropriate management activities.

The riparian zone has been defined in various ways but is always inextricably linked to standing or flowing water bodies. A commonly used definition is 'the area immediately alongside small creeks and rivers, including the river bank itself; gullies and dips which sometimes run with water; areas surrounding lakes; and wetlands and river floodplains which interact with the river in times of flood' (Land and Water Australia 2009). Riparian zones are characterised by a suite of vegetation that is tolerant of the physical conditions typically found in the riparian zone, including increased soil moisture, physical disturbance by flooding, and the gradient that occurs with distance from the water body. For the purpose of this study the riparian zone was defined as *an area of terrestrial land adjacent to a water body that is affected by periodic inundation and hydraulic disturbance. As such it contains a suite of landforms and groups of associated vegetation communities that are different to the broader adjacent terrestrial lands*.

As the highest order stream in the ACT, the Murrumbidgee River was the primary focus of this survey. Flowing for approximately 66 kilometres south to north through the Australian Capital Territory, this section of the river contains close to 132 linear kilometres of riparian land. Associated with the true riparian ecosystems, the drier riverine valley slopes above the riparian zone that are deeply set into the surrounding tablelands play an integral role in the functioning of riverine ecosystem processes. In strong contrast to the riparian zone that is variously degraded due to disturbance factors, these steep dry rocky slopes often harbour a high diversity and cover of native vegetation. For this reason the project aimed to describe the distribution, composition and condition of the riparian environments, as well as the adjacent riverine valley slopes.

Objectives:

The aim of this project was to survey vegetation and habitat in key riparian zones along the Murrumbidgee River in the ACT to identify the extent and condition of the riverine vegetation communities. The primary objectives were to:

1. Identify and quantify vegetation diversity and fauna habitat.
2. Map weed abundance and distribution.
3. Map ecological communities and species distribution and condition.
4. Assess the health of the vegetation and sites following the 2003 bushfire.
5. Assist in the identification of sites and methodology for subsequent monitoring under the ACT Biodiversity Monitoring Program.
6. Identify sites for subsequent revegetation.

This report presents the methodology use and the findings and recommendations from this project.

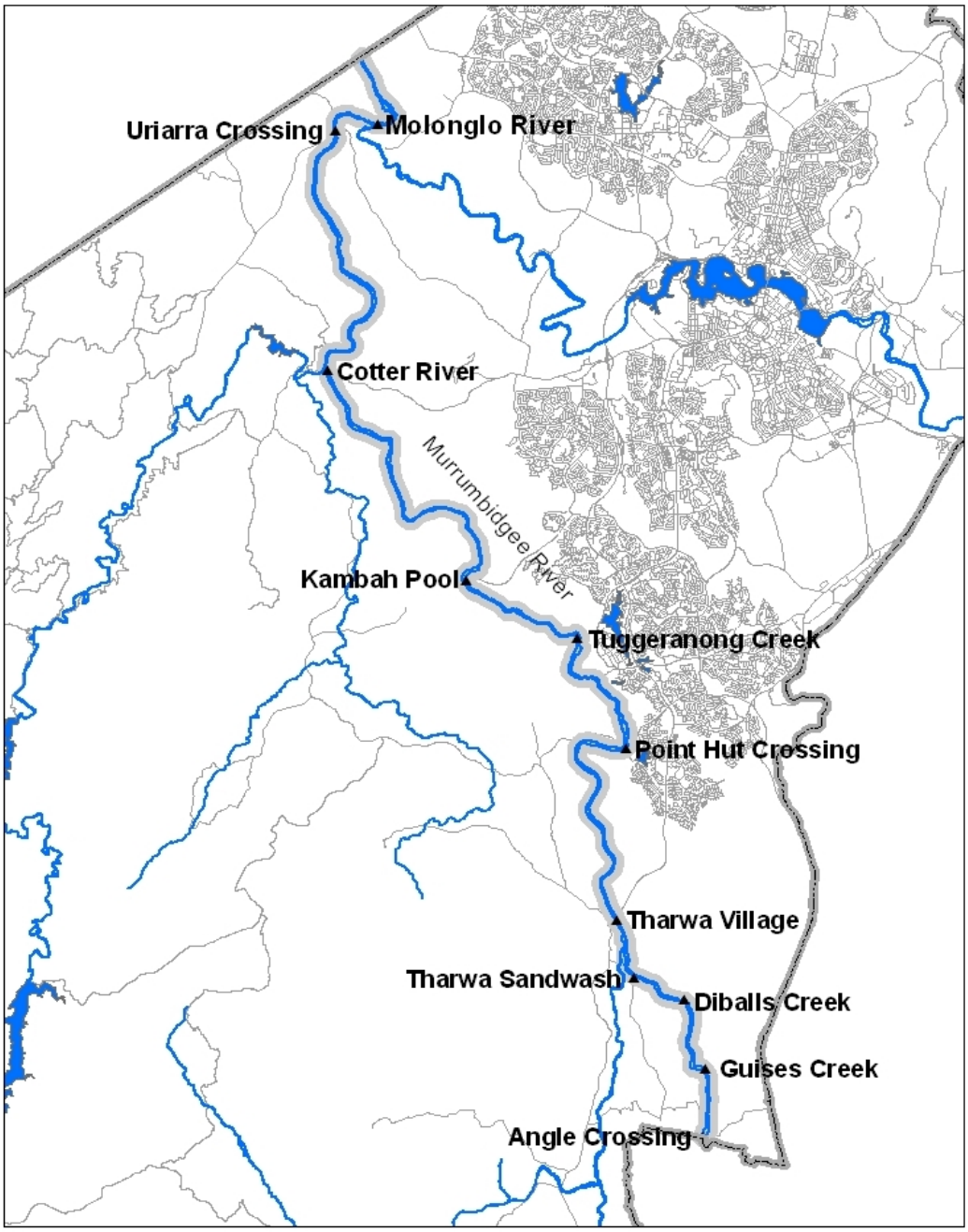

Figure 1: The Murrumbidgee River study area map
The Murrumbidgee River in the ACT showing selected localities referred to within the report.

Chapter 2: The Murrumbidgee River Environment – Overview

The Murrumbidgee River is the major waterway within the ACT and is a significant part of the Murray–Darling Basin. Its headwaters are located in the Fiery Range (NSW Snowy Mountains) at approximately 1500 m above sea level (a.s.l.) (Edwards and Johnston 1978) and the river falls to 60 m a.s.l. (Google Earth ®) over its 1600 km journey to the junction with the Murray River near Balranald, New South Wales (ACT Government 2008a). The river and its catchment incorporate montane, tableland and lowland areas and provide valuable water resources for ecological, urban, rural and recreational purposes. Within the ACT, the Murrumbidgee River is seen as a highly valuable natural asset and is protected within the Murrumbidgee River Corridor (MRC), management of which is guided by the *Murrumbidgee River Corridor Management Plan* (ACT Government 1998). The MRC includes a collection of nature reserves, special purpose reserves, a European heritage conservation zone and a number of rural leases. Within the ACT, the Murrumbidgee is typical of rivers on the Southern Tablelands with much exposed bedrock amongst sandy alluvial channels and both moderate erosion and deposition. The ACT section is intermediate between the steep, rocky, high gradient upland reaches in the New South Wales headwaters, and the broad flat sandy depositional zone occurring from downstream of the ACT border to its confluence with the Murray River.

Over the 66 kilometre northward journey through the ACT, the river falls 171m, from 600 m a.s.l. at its entrance near Angle Crossing to 429 m a.s.l. at its northern exit point downstream of Uriarra Crossing, with an average gradient of –2.4 m/ kilometre (–0.24%). The channel contains a large amount of bedrock interspersed with high sediment bed loads and has a riparian zone dominated for the most part by She-oak Riparian Tableland Woodland. In contrast, an equivalent highland river section below Tantangara Reservoir has a steeper gradient (–4.0 m/ kilometre, –0.40%) with a channel lined by montane black sallee (*Eucalyptus stellulata*) and ribbon gum (*E. viminalis*). Beyond the ACT study area, the lower Murrumbidgee River catchment begins downstream of Burrinjuck Reservoir (CSIRO Land and Water 2008) where it emerges onto the NSW western plains as a typical mature lowland river with broad meandering channels and gradients of between –0.03 m/ kilometre (-0.003%) and -0.05 m/ kilometre (-0.005%). In this area it contains highly sandy channels, broad depositional floodplains and associated levee banks dominated by river red gum (*E. camaldulensis*) and she-oak (*Casuarina cunninghamiana*). (All gradient information calculated using altitudes and distances obtained from Google Earth ® 2008).

Vegetation communities and distribution

The vegetation occurring along the riparian zone and immediately adjacent valley slopes of the Murrumbidgee River in the ACT has previously been assessed to varying levels of botanical detail by Ingwersen and Johnson (1992), National Capital Development Commission (1981) and Evans (2003). The river features in various historical accounts e.g. Margules (1994*)* and Moore (1999). The vegetation community assemblages and their distribution along this tableland section of the river are diverse. Highly varied riparian geomorphology (at both broad and fine scales), impacts of historical and current land uses; bushfires and climatic events have contributed to the establishment of a patchwork of vegetation assemblages that are in varying condition. Extensive sections of the Murrumbidgee River riparian zone are dominated by She-oak Tableland Riparian Woodland and remnant Ribbon Gum Tableland Riparian Woodland. High bedrock outcrops and other physical constraints tend to preclude tree growth in some areas and these sections of the riparian zone favour the establishment of natural River Bottlebrush – Burgan Tableland Riparian Shrubland. Recently deposited sand accumulations are ideal sites for the establishment of the colonising Tableland Aquatic and Fringing Vegetation Complex, which often lines the river banks and wetlands associated with woody riparian communities. Large stretches of the dry riverine valley slopes are occupied by fire affected Black Cypress Pine Tableland Woodland, Apple Box – Broad Leaved Peppermint Tableland Woodland and Red Stringybark – Scribbly Gum Tableland

Forest, with minor remnant occurrences of Snow Gum – Candlebark Tableland Woodland in areas of cold air drainage.

Vegetation condition

Overall the state of the riparian zone vegetation in the ACT section of the Murrumbidgee River is assessed as poor. Within gorge environments bedrock dominated areas do retain intact riparian shrubland, however the structural integrity of most of the riparian zone has been compromised in various ways. The ground layer is invariably dominated by introduced species and mid-strata species are often absent from areas with established canopy species. In other places, canopy species survive only as remnants of what were likely to have been extensive ecological communities, such as the former Ribbon Gum Tableland Riparian Woodland which dominated floodplains in the southern reaches. Catchment land use and altered water resource allocation continues to affect river hydrology and base flows have become lower and flooding more infrequent compared to pre-European levels. This in conjunction with land clearing, nearby broad acre land use, as well as urban and peri-urban settlement has created an environment conducive to the dominance and spread of weed species. Native riparian zone vegetation is naturally adapted to highly variable flows that often inundated the floodplains. The increasingly irregular nature of these events, lack of overhead canopy cover, and presence of deep sandy soils have provided ideal conditions for the establishment of weed species and invasion by native woody species, normally occurring on drier sites outside the riparian zone.

Evidence for long-term change

Overall the Murrumbidgee River riparian zone and river valley environments appeared to be under significant stress at the time of this survey and are likely to be the subject of continued change over the coming decades. Changes in flow regimes, more frequent drought conditions, agricultural land use, and water extraction are likely to be contributing to the geographic boundaries where plant and animal species and communities exist. This has been noted extensively throughout the Upper Murrumbidgee River catchment (NSW EPA, 1997). It is widely believed that regional changes in climatic conditions will exacerbate this further. The Murrumbidgee River valley has a natural lateral ecological zonation whereby: a) eucalypt assemblages typically occupy the upper slopes of the river valley; b) Black Cypress Pine Tableland Woodland occurs on the middle to lower slopes; c) riparian woodlands and shrublands extend from the base of the valley slope across the floodplains to the riverbank; d) a typical riverbank margin of semi-aquatic species occurs at the water's edge; and e) where conditions are appropriate submerged aquatic vegetation exists in the river channel.

During this study, evidence was found of an overall 'downhill successional migration' pattern on both the valley slopes and riparian zone proper where dominant species further down this lateral gradient were observed being replaced by those from higher up the gradient. The two most obvious examples are where fire sensitive black cypress pine on valley slopes and she-oaks, which formerly dominated high soil moisture floodplains, are being replaced by eucalypt assemblages that are fire and drought tolerant. Although the river valley is generally more protected than the surrounding dry tableland woodland and forest environments, the high intensity 2003 bushfire had a major influence on the vegetation. The fire sensitive black cypress pine (*Callitris endlicheri)* has survived in the river valley, possibly due to low frequency and low intensity fire regimes in combination with conditions suitable for recovery through seed regeneration. However in 2003 almost the entire Murrumbidgee River Corridor was affected by fire. Observations were regularly made where canopy species were killed by fire and/or subsequent drought conditions, with little or no significant regeneration observed other than of fire tolerant species.

Extensive stands of black cypress pine such as those on the steep western river slopes of the Bullen Range have been completely killed and the combined effect of the fires and subsequent drought conditions, together with weeds and grazing pressure from introduced species such as rabbits may reduce seed regeneration (Figure 4). Black Cypress Pine Tableland Woodland naturally hosts a range of emergent or subdominant eucalypts. Following the 2003 bushfire, these eucalypts are all that remain in many places of the upper stratum. It is very likely that there will be a change in dominance in this community with a shift toward the eucalypts present within, or occurring upslope of, the community prior to the fire that have both regenerated vegetatively and germinated from seed. Evidence of this successional change can be clearly seen where these surviving fire tolerant eucalypts and kurrajong (*Brachychiton populneus*) are surrounded by dead standing black cypress pine. The surviving canopy assemblages often do not correspond to other described communities and may for example contain a mixture of scribbly gum (*E. rossii*) – Blakely's red gum (*E. blakelyi*) – red box (*E. polyanthemos*) – apple box (*E. bridgesiana*). A number of well established sites along the steep slopes that are naturally suited to black cypress pine have long been dominated by these eucalypt assemblages, indicating possible succession from fires in previous decades or centuries. One slope near Kambah Pool has dense Blakely's red gum seed regeneration on a site historically suitable for black cypress pine. This site is down slope of a Yellow Box – Blakely's Red Gum Tableland Woodland and provides further possible evidence for the suggested downhill successional migration concept.

Large stands of mature she-oak naturally occur where riparian soil moisture is suitable to support them. Following disturbances such as the 2003 bushfire and ongoing dry climatic conditions, many of the previously healthy stands have been heavily impacted and to date have only recolonised or survived particularly well on the margins of the main water body. This has left the way open for the succession of valley slope species onto the dry floodplains. This indicates that the environment on the floodplains away from the immediate riverbanks has presumably become less suitable for recovery or regeneration of the naturally occurring she-oak stands. This riparian woodland is becoming restricted to the wettest parts of the floodplain, essentially narrowing the community's pre-fire extent. In the absence of she-oak seedling regeneration on the floodplain, apple box, which is a generalist with wide tolerance of soil moisture, is becoming established. This eucalypt may be better suited to the parts of the riparian floodplain with low flood frequency.

This successional process is likely to be a combined result of the impact of fire and altered hydrological processes. It is likely that if flood and high rainfall events become less frequent due to climatic conditions and increased pressure on natural flow regimes, these riparian environments will degrade further through lack of inundation and competition from introduced species. Under these circumstances fire and drought tolerant native species are likely to replace the former communities and species, and this succession was occasionally observed during the survey.

Figure 2: The impact of the 2003 fire

The impact of the 2003 bushfire on Black Cypress Pine Tableland Woodland in the ACT Murrumbidgee River Corridor. Fire-killed adult black cypress pine *(Callitris endlicheri)* being vigorously replaced by red stem wattle (*Acacia rubida*) (top left). Fire-killed black cypress pine being successionally replaced by fire tolerant eucalypt woodland (top right). One of a very small number of black cypress pine seedlings located on the Bullen Range (bottom left) which are under pressure from rabbit grazing. Dead black cypress pine on slopes above narrow band of she-oak (*Casuarina cunninghamiana*) at the southern end of Bullen Range (bottom right).

Figure 3: Succession in She-oak Tableland Riparian Woodland
Apple box (*E. bridgesiana*) is a species with the ability to regenerate from seed on the dry weed dominated floodplains following the death of the former tall, dense she-oak canopy. Note the height of the dense weeds relative to the researcher in the lower image. The Bullen Range can be seen in distance (bottom).

In Chapter 5 the presumed broad patterns and distributions of the vegetation communities that historically occurred within the river valley are described, based on systematic survey observations. The historic and current dominance, current condition and habitat suitability was recorded for each discrete mapped vegetation unit along the corridor. Distinct major zones based on dominant riparian vegetation communities occur in association with broad geomorphic zones and will be described as part of the 'river typology sequence' (Chapter 4). This typology description outlines the distribution of vegetation communities and provides some general information about each zone. This is then followed by detailed descriptions of each vegetation community as they occur within the ACT Murrumbidgee River Corridor (Chapter 5).

Murrumbidgee River near Mt Tennent with cleared Yellow Box – Red Gum Tableland Woodland and Ribbon Gum Tableland Riparian Woodland replaced by agricultural and environmental weeds.

PART 2: SURVEY

Chapter 3: Methods

Background

The central objective of this project was to identify and map the distribution of the vegetation communities along the Murrumbidgee River riparian zone and valley slopes within the ACT. In doing so the land area adjacent to the river was divided into discrete units of homogeneous vegetation and landform characteristics. Each was surveyed to collect information on species dominance, overall composition and condition of vascular vegetation for the purpose of informing future management decisions and as a baseline for future monitoring. The objective was met through a combination of remote vegetation mapping and on-ground survey to collect representative information on the major vegetation communities. The vegetation distribution was initially resolved by aerial photographic interpretation and then verified through on-ground polygon based surveys. This resulted in the production of high resolution vegetation community spatial information with descriptions of structure and composition. Additionally, information was also collected on vegetation and habitat condition, fauna habitat suitability and incidental fauna records.

The Murrumbidgee River riparian zone is a dynamic environment that is variable in width, contains ecotonal clines between aquatic and terrestrial environments, and often displays strong internal heterogeneity. Floristic composition may vary with geomorphic position and the associated effect of both fluvial processes and soil moisture within a site. Within complex wide floodplains a mosaic of environments occur including flood channels, wetlands and water shedding zones. Each of these produces specific environmental conditions that influence the distribution of vegetation forms at a site. Alternatively, a site can be narrow and take the shape of a simple channel and bank adjoining a non-riparian hill-slope.

During the planning phase of this project detailed consideration was given to whether statistically repeatable methods or a spatial approach (eventually used) would be more appropriate for the desired outcomes of the study. The difficulty in resolving this question lay in developing a survey method that was suitable for the heterogeneous mosaic of riparian widths, geomorphologies and within-site variability. It was considered important at a site to accurately characterise the overall vegetation community composition, structure and condition as well as to provide a measure of the lateral variation across each site. Three existing survey techniques were considered,, namely, the standard ACT government forest and woodland vegetation monitoring design (Sharp et al. 2007), the Sustainable Rivers Audit pilot vegetation protocol (Murray Darling Basin Authority) that was under development at the time of designing this study plan, and Evans' (2003) study into the effect of fluvial geomorphology on riparian vegetation riparian vegetation. The first two collect information using standard dimension base plots. The sampling design of Evans employs an interrupted belt technique that specifically samples small scale associations between woody vegetation and fluvial-geomorphic units. With each of these techniques, concerns were raised regarding the representativeness of the large scale patterns and ability to widely identify and prioritise management concerns. The lack of knowledge of spatial vegetation distribution within the river corridor influenced the design toward the mapping and polygon based ground assessment survey that was undertaken. However, an additional method was also designed that would allow for riparian site monitoring and a description (see Appendix 4).

Mapping and survey techniques

The Murrumbidgee River riparian zone and valley slopes were surveyed to define the distribution, composition and condition of the component definitive ACT riverine vegetation communities (Johnston et al. 2008) using mapped polygons that were generated from a combination of low

altitude oblique aerial photography and satellite imagery. The initial remote mapping aimed to define polygon boundaries that encompassed uniform vegetation communities in similar apparent condition occurring on uniform broad geomorphic units. Between spring of 2007 and autumn 2008 the southern two thirds of Murrumbidgee River within the ACT between Angle Bend (southern entry point of the river into the ACT) and Bulgar Creek was ground surveyed. In spring of 2008 the remaining third of the riverine zone was surveyed between Bulgar Creek and Retallack's Hole (the northern exit point of the river from the ACT).

Remote Photographic Interpretation

Interpretation of the distribution and condition of riverine vegetation communities was initially conducted using a combination of Digital Globe 2004 satellite imagery, supplemented by overlapping low altitude oblique aerial photographs (MonAero) and three-dimensional Google Earth ® imagery. A series of polygons were then overlaid onto Digital Globe 2004 satellite imagery, using ESRI ArcGIS ® 9.2 at a scale of 1:5000 or less, that were thought to represent relatively homogeneous areas of vegetation community composition, structure, condition and geomorphology (Figure 2). These polygons were then ground surveyed, to both confirm the accuracy of their boundaries and to provide a detailed description of the vegetation and habitat features that they contained. Any observed inaccuracies in polygon boundaries were corrected in the field and later rectified in ESRI ArcGIS ® 9.2.

Field Surveys

Surveys were conducted at one of four levels of detail depending primarily on landscape position and accessibility of sites. The riparian zone vegetation was usually targeted for detailed on-site surveys. These were undertaken by two or more staff who provided assessments of the dominant vegetation community structure, general species composition, habitat complexity, riverine reach type characteristics, incidental fauna records and site management concerns. Sites that were judged as unsafe or very difficult to access were often described from nearby locations using field binoculars. In some cases these offsite descriptions were undertaken from long distance positions. Finally, three highly degraded sites were remotely described using low altitude visual aerial photographic interpretation. In all offsite surveys the priority was to document or confirm major species, broad vegetation condition, the accuracy of polygon boundaries and any visible fauna or habitat features. To coarsely indicate the reliability of each polygon assessment each was classified as a) on-site, b) offsite-near, c) offsite-long distance, and d) remote aerial interpretation, or any combination thereof. For all offsite descriptions, a simplified version of the standard data set was used and only measures that could be accurately assessed were recorded.

Plant Identifications

The nomenclature used conforms to that in the 2008 ACT flora list provided by the Australian National Herbarium, Black Mountain, Canberra.

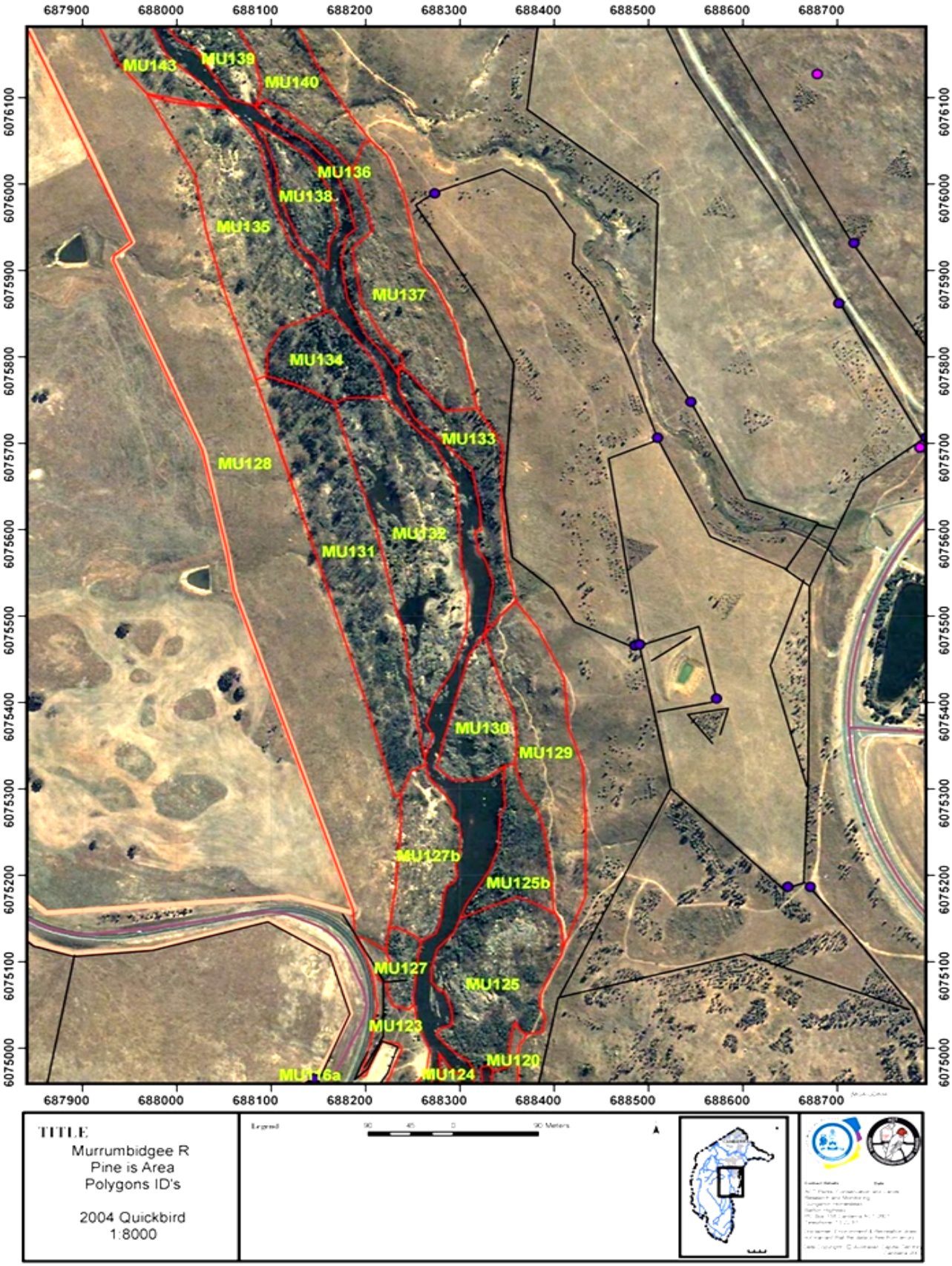

Figure 4: Example field map with polygon overlays

Example field map with polygon overlays shown in red. Each is coded using unique identifiers. This area is immediately to the north of Point Hut crossing.

Polygon Assessments

Each polygon was inspected by a minimum of two surveyors and information was recorded onto standard datasheets. Polygon site information included: map and reference data; site aspect/s; riverine geomorphology and geomorphic sub-units (see below for further explanation); geology and soil descriptions; land use/s; identification of climax vegetation community (where possible) (Johnston et al. 2008); and evidence of recent fire. Written observation notes and associated sketches (plan form and profile) were often made of the site. These notes attempted to encompass aspects of overall site and/or vegetation condition, vegetation structure and composition, management issues, evidence of grazing pressure and any other unique polygon attributes. Local geomorphology is an important factor in determining the suitability of areas for particular vegetation associations. In riverine ecosystems hydrology also plays a very important role in determining plant distribution (Evans 2003). A brief description of the geomorphic units that were recorded along the Murrumbidgee River in the ACT is provided in Table 1.

Where accessible, the length and width of each polygon was traversed on foot to assess species structure and composition. Where practical and useful at least two passes were made of each polygon (one way and then the reverse in a different part of the polygon). Attention was given to anomalous sections of a polygon such as the riverbank (where present), or isolated rocky outcrops amongst flat sandy floodplains, as these often contain species not found elsewhere within a polygon. All observed species were recorded and each was designated as either common or patchy across the polygon. Common species were those that occurred frequently or regularly across a polygon, whereas patchy species were those that occurred infrequently with either patchy or restricted distribution. A further denotation was made for all species observed occurring in the riverbank geomorphic sub-unit. The structural dominance of each polygon was documented for each stratum which included assigning dominant species (up to 5) to predetermined height and cover classes. The dominance within each stratum was determined by the relative horizontal projective foliage cover between species and classed as either: dominant; co-dominant; or sub-dominant. See Table 3 for details of height, stratum and cover classes.

Habitat and fauna assessment

Incidental fauna sightings, evidence of fauna activity and the suitability of polygons as habitat for fauna groups was recorded. Habitat features were divided into i) terrestrial features common to both riparian floodplain (including wetlands) and adjacent slopes of the riverine zone, and ii) aquatic features adjacent to polygons bordering permanent water. In the latter case, features within the water body proper were recorded for all aquatic areas adjacent to the riparian polygon. Where a site appeared suitable for particular fauna (e.g. steep earthen banks for platypus home sites; rocky and sandy sites for water dragons, shrub thickets for birds) it was recorded as descriptive habitat notes. Any perceived priorities for future surveys were noted where it was thought that a significant investment of resources was warranted. Impacts or evidence of stock and anthropogenic factors were also documented.

Vegetation condition ranking

The overall condition of the vegetation within each polygon was assessed using features modified from the Rapid Appraisal of Riparian Condition (RARC) technique (Land and Water Australia) (Jansen et al. 2004).The condition of vegetation within each polygon was ranked based largely on: qualitative assessments of proportion of native cover within each strata; evidence of regeneration and the regeneration stages present; assessments of the impact of the 2003 bushfire on the standing native canopy crowns; the level to which weeds were present; and number of regeneration stages observed. Although quantitative vegetation cover is commonly used as a measure of condition ranking, it was excluded from this study as it did not form part of the simplified offsite assessments due to the difficulty of accurately estimating it over large scales and in remote surveys.

The RARC methodology is apparently designed for tree dominated ecosystems. The ranking system is dependant on the historic occurrence of trees at a site and where trees are absent a lower condition score is recorded. However, in this tableland study area zones of naturally treeless riparian shrubland or other aquatic and fringing non-woody communities occur. To avoid false ranking based on vegetation type each polygon was first classified as: a) tree dominated woodland/forest; b) shrubland; or c) herbland and/or grassland. The total score achievable for each polygon decreased with each lower number of naturally occurring strata (19 for woodland/forest; 16 for shrublands and 8 for grasslands) (Table 2). Values for each vegetation type were standardised as percentages and classified into a broad three-point ranking system: 0 – 50% low condition; 50 – 80% moderate condition; and greater than 80% high condition. This skewed ranking system was used to reduce the 'noise' associated with the very large number of degraded sites in the river corridor study area. The ranks were incorporated into the ArcGIS ® spatial information layer associated with the vegetation community distribution and current dominance and overlaid onto the final climax vegetation distribution maps (appendix 5).

The condition rankings were then manipulated to produce a conservation management priority hierarchy. A five-point scale was created using the inverse calculation for vegetation condition (i.e. highest scores were achieved by the most degraded sites). This vegetation management ranking was then adjusted on an individual site-by-site basis and then minor modifications were made using the following conditions (Figure 3):

- *Vegetation community type*. The Ribbon Gum Tableland Riparian Woodland has significantly declined and was upgraded in all cases where remnants remain or are believed to have existed prior to European settlement. Upgraded priorities were assigned for the protection of remnant Black Cypress Pine Woodland and Snow Gum Tableland Woodland which are both in states of decline.

- *Geomorphology*. Sandbars naturally contain low vegetation cover and early colonising species and are not seen as a high priority for management unless significant weed infestations occur.

- *Socio-economic use*. Sites ranked as requiring high level conservation action, but where land-use does not support conservation outcomes, (broad acre farms, townships or high recreation use) were downgraded in conservation management priority.

Output maps

A series of maps was produced for the entire length of the incised Murrumbidgee River valley in the ACT to display the perceived climax vegetation community, current vegetation dominance, condition, and vegetation management priority for each polygon surveyed. Further spatial information relating to the distribution of all high priority species (listed under ACT legislation, uncommon, or restricted to the study area) was also produced (Appendix 7).

Figure 5: Examples of landscapes in the study area
Examples of rural broad acre and urban development near Tuggeranong (top); sand slug with colonising fringing vegetation (middle); and one of the only remnant stands of ribbon gum (*E. viminalis*) near Tharwa Sandwash which is highly degraded – note high ground weed load (bottom).

Table 1: Definitions of Geomorphic Units

(a) geomorphic sub-units, and (b) broad landform units recorded during the study of the Murrumbidgee River valley in the ACT.

(a)

GEOMORPHIC SUB-UNITS	DESCRIPTION
Riverbank	The part of the river channel immediately adjacent to the zone of permanent inundation. The riverbank is regularly inundated and usually contains a suite of hydrophilic aquatic/semi-aquatic vegetation.
Floodplain Surface	Any part of the flood zone above the level of the riverbank that does not retain surface water following flood. This is the 'water-shedding' part of the flood zone.
Flood Runner	A channelized part of the floodplain that contains flowing water during flood. Often evidenced by coarser grain particles that settle out following the recession of flood conditions. May contain small areas that retain water (wetlands/puddles) following the retreat of flood water.
Wetland	The part of a floodplain that retains water following flood or rain periods. Often contains fine silt / mud particulate substrate and semi-aquatic fringing vegetation. Can be ephemeral or permanent.
Bedrock Outcrop	In situ bedrock outcrop. Often remains emergent during flooding of riparian areas and therefore may host flood intolerant vegetation species that are different to the surrounding floodplains.
Terrace	A mostly flat ancient floodplain surface elevated above the zone of regular flood inundation.
River Valley Slope	The slope above the riparian zone proper confined to the incised river valley (as opposed to extending to the broad tablelands that dominate the region). Never inundated during flood and contains variations of vegetation common in terrestrial ecosystems. Contains colluvial rather than alluvial soils.

(b)

BROAD GEOMORPHOLOGY	DESCRIPTION
Simple Floodplain	Riverbank adjoining a floodplain surface with little or no variation.
Complex Floodplain	Riverbank adjoining a predominantly loose earthen floodplain surface with channelled flood runners and associated wetlands and some bedrock outcrops with distinctive vegetation suites.
Bedrock Floodplain	Riverbank adjoining a floodplain surface that contains a high proportion of exposed bedrock (often >50%) amongst an otherwise sandy substrate. Where bedrock outcrops, ridges often occur with channels between, often forming combination of ridges and flood runners.
Bedrock Platform	Predominantly solid bedrock outcrop floodplain surface, often where river narrows through gorges. Usually well-elevated above river base flow level with steep high sided rocky banks.
Bank-Slope-Terrace	Riverbank adjoining valley slopes that are interrupted by elevated terraces (ancient floodplains) above the zone of regular flooding.
Bank-Hill Slope	Riverbank immediately adjoining river valley slope (zone where no regular flooding occurs). Often where surface bedrock precludes floodplain development. Also common at high altitudes.
Sandbank/Sandbar	Emergent sand deposition zone on edge of river channel or mid-channel where stream flow is low. Often contain early colonizing species (e.g. *Acacia dealbata*, aquatic fringing species).
Rocky Island	Singular isolated emergent mid-channel rocky outcrop.
Cascade	Complex of emergent mid-channel rock outcrops.

Table 2: Criteria for Vegetation Condition Ranking

The criteria used to calculate vegetation condition rankings. Note the decreasing number of available criteria with naturally decreasing structural diversity (a – c).

a) Woodland / Forest (naturally tree dominated vegetation)

FEATURE	0	1	2	3	4
Proportion of Native Species Upper Stratum	Absent	Low	Moderate	High	
Proportion of Native Species Mid Stratum	Absent	Low	Moderate	High	
Proportion of Native Species Ground Stratum	Absent	Low	Moderate	High	
Total Weed Cover	High	Moderate	Low	Absent	
Regeneration Stages (cumulative for number of stages)	N/A	Early	Advanced	Mature	Old Growth
Evident Canopy Fire Damage	Strong, little recovery	Strong, good recovery	Light	None	

Maximum Total Possible* = 19** ***RANKED SCORE = [actual score (N) / Total* (19)*] x 100

b) Shrubland (shrub dominated vegetation – often in high bedrock outcrop flood zones)

FEATURE	0	1	2	3	4
Proportion of Native Species Upper Stratum					
Proportion of Native Species Mid Stratum	Absent	Low	Moderate	High	
Proportion of Native Species Ground Stratum	Absent	Low	Moderate	High	
Total Weed Cover	High	Moderate	Low	Absent	
Regeneration Stages (cumulative for number of stages)	N/A	Early	Advanced	Mature	Old Growth
Evident Canopy Fire Damage	Strong, little recovery	Strong, good recovery	Light	None	

Maximum Total Possible* = 16** ***RANKED SCORE = [actual score (N) / Total* (16)*] x 100

c) Grassland and Aquatic and Fringing Vegetation Complex (Natural herbaceous dominated vegetation)

FEATURE	0	1	2	3	4
Proportion of Native Species Upper Stratum					
Proportion of Native Species Mid Stratum					
Proportion of Native Species Ground Stratum	Absent	Low	Moderate	High	
Total Weed Cover	High	Moderate	Low	Absent	
Regeneration Stages (cumulative for no. of stages)	N/A	Early	Advanced	N/A	
Evident Canopy Fire Damage					

Maximum Total Possible* = 8** ***RANKED SCORE = [actual score (N) / Total* (8)*] x 100

Abundance

Measure	Definition	Cover
Low	Present but uncommon	< 33%
Moderate	Common & noticeable, but patchy or not widespread	33–67%
High	Presence very common and widespread	>67%

Evident Canopy Fire Damage

Measure	Crown scorch	Canopy regeneration
Strong, little recovery	> 33%	>33%
Strong, good recovery	> 33%	> 66%
Light	< 33%	0–33%
None	No evidence	N/A

Table 3: Attributes of Structural Dominance Measures

(a, b) Structural and (c) life form attributes used for structural dominance. Note that Height Class (a) is adapted from the National Vegetation Inventory System (NVIS) but does not strictly adhere to it (class 5 has been removed).

a)

Height Class (adapted from NVIS)	Height range (upper and lower) (m)
1	< 0.5
2	– 1
3	1 – 2
4	2 – 3
6	3 – 10
7	10 – 30
8	> 30

b)

Strata boundaries	Height range (upper and lower) (m)
Upper	> 3
Mid	1–3
Lower	< 1

c)

Life forms: Tree, Shrub, Grass, Sedge, Tussock Grass, Herb, Vine, Reed, Fern, Parasite

PART 3: SURVEY RESULTS AND RECOMMENDATIONS

Chapter 4: Murrumbidgee River Riparian Typology Sequence

This chapter describes the broad patterns and distributions of the vegetation communities that the evidence, based on systematic survey observations, suggests historically occurred within the river valley. Both the historical and current dominance, current condition and habitat suitability was recorded for each discrete mapped vegetation unit along the corridor, which contribute to the broad patterns described. Distinct major zones based on dominant riparian vegetation communities occur in association with broad geomorphic zones and are described as part of a 'river typology sequence'. This typology description outlines the distribution of vegetation communities and provides some general information about each zone. This is then followed in Chapter 5 by detailed descriptions of each vegetation community that occurs within the ACT Murrumbidgee River Corridor.

The ACT Aquatic Species and Riparian Zone Conservation Strategy (ASRZCS) (ACT Government 2007) divided the Murrumbidgee River Corridor into five units called river sections. These are readily identifiable sections based on road crossings, topographic features, settlement and the ACT–NSW border. These river sections are functional but do not always correspond with the ecological or landscape typologies observed. The current survey has classified the river corridor into a series of seven typological zones based primarily on the three dominant riparian vegetation communities along the river (see Chapter 5), as well as the local variation in floodplain and river valley form. In a broad sense the southern extent of the Murrumbidgee River between Angle Bend and Point Hut Crossing contains highly degraded remnant Ribbon Gum Tableland Riparian Woodland, interrupted by the steep sided Gigerline Gorge, with its large tracts of naturally occurring River Bottlebrush – Burgan Tableland Riparian Shrubland. The northern river extent between Point Hut Crossing and the ACT–NSW border is dominated by She-oak Tableland Riparian Woodland, which is interrupted at Red Rocks Gorge where narrow patchy bands of she-oak line the riverbank amongst tracts of River Bottlebrush – Burgan Tableland Riparian Shrubland.

The relationship of the ACT ASRZCS river sections to the typology sequence described herein is shown in Table 4. Although some outliers occur such as small stands of ribbon gum north of Point Hut Crossing and patches of natural shrubland throughout the river corridor outside of the gorges on low lying rocky floodplains, the overall typologies can be best represented in this way. The current study also includes a description and detailed distributional map of the vegetation communities occurring on the valley slope adjacent to the riparian zone floodplains. The communities occurring along these slopes are closely correlated with landscape position and quite distinct from broader woodland and forest communities occurring above and beyond the incised river valley. These valley slope communities do not necessarily correspond with the riparian typologies and as such could not be included in the description of individual reaches or sections. However, in the descriptions of the sections that follow, the valley slope communities occurring within each of the riparian typological sections will be described.

Table 4: River Typology Sequence

The relationship of the described river typology sequence in this study to the ACT Aquatic Species and Riparian Zone Conservation Strategy (ASRZCS) river sections. Each of the typologies (left column) list: the dominant riparian vegetation community (1–7); followed by generalised riparian geomorphology (a) and river valley form (b) in italics.

River Typology Sequence Reach	Location	ASRZCS River Sections
1. Ribbon Gum Tableland Riparian Woodland a) *Alluvial floodplains, occasional terracing* b) *Strongly undulating river valley slopes*	Angle Bend to Guises Ck	MU 1: Angle Bend to Tharwa
***2.* River Bottlebrush – Burgan Shrubland** a) *Bedrock platform & complex floodplains* b) *Steep sided gorge*	Gigerline Gorge *Between Guises Ck & Diballs Ck*	
3. Ribbon Gum Tableland Riparian Woodland a) *Extensive river terraces & broad simple floodplain* b) *Gentle undulating hill slopes*	Diballs Ck to Point Hut Crossing	MU 2: Tharwa to Point Hut Crossing
4. She-oak Tableland Riparian Woodland a) *Complex floodplains* b) *Undulating slopes, occasional steep sided sections (e.g. Pine Island)*	Point Hut to Tuggeranong Ck	MU 3: Point Hut Crossing to Kambah Pool
5. River Bottlebrush – Burgan Shrubland *with* She-oak Tableland Riparian Woodland a) *Bedrock platform & complex floodplains* b) *Steep sided gorge*	Red Rocks Gorge *Between Tuggeranong Ck & Kambah Pool*	
6. She-oak Tableland Riparian Woodland a) *Long narrow complex floodplains* b) *Bullen Range (forming significant steep western valley slope. Otherwise undulating eastern slopes).*	Bullen Range *Between Kambah Pool & Cotter River*	MU 4: Kambah Pool to Cotter River
7. She-oak Tableland Riparian Woodland a) *Complex floodplains with wetland formations* b) *Steep dissected valley slopes*	Cotter River Confluence to northern ACT Border	MU 5: Cotter River to ACT Border

1. Angle Bend to Guises Creek: Ribbon Gum Tableland Riparian Woodland

This reach is approximately 3.3 km in length. Apart from one section of non-riparian valley slope near the Lobbs Hole track, the entire reach was found to be in poor or moderate condition. The valley slopes are generally open and dissected and mostly modified by previous clearing. The reach was heavily impacted by the 2003 bushfire, which caused damage to much of the existing remnant canopy in both the riparian zone and the valley slopes that remain uncleared. The riparian zone in this reach predominantly contains simple floodplains with occasional low lying bedrock floodplains and some river terraces. The riparian soils are often very sandy and deep and as such are suitable for establishment of ribbon gum (*Eucalyptus viminalis*). One of the best intact stands of this species on the Murrumbidgee River in the ACT exists immediately upstream of the mouth of Guises Ck (GDA grid 691250 / 6062600). This small stand has a dense ribbon gum canopy between ten and twenty metres tall, with a small amount of seed regeneration noted amongst an understorey of burgan (*Kunzea ericoides*) and bracken fern (*Pteridium esculentum*). The stand was probably more extensive prior to 2003 as there are fire-killed adult ribbon gums in the adjacent stretch upstream with good native shrub recovery, typically discrete patches of burgan, silver wattle (*Acacia dealbata*), red stem wattle (*Acacia rubida*) and *Cassinia spp*., with scattered ribbon gum seed regeneration. Other sites that appear suitable for the establishment and/or occupation of ribbon gum in this reach are degraded and host blackberry (*Rubus fruticosus* agg.) and willow (*Salix* species), or regenerating shrubby native riparian vegetation. Exposed sand banks and bars are common and contain early successional herbaceous river fringing species.

The valley slopes adjacent to the riparian zone were either cleared or highly affected by the 2003 fire and as such much of the dominant pre-European vegetation is either highly degraded or absent. The eastern river slope immediately downstream of Angle Bend contains modified stands of snow gum (*E. pauciflora*), indicating that cold air drainage once played an important role in this area and possibly further upstream. Otherwise degraded Apple Box – Broad Leaved Peppermint Tableland Woodland occupies the majority of the slopes, with Red Stringybark – Scribbly Gum Tableland Forest, in varying condition. Much of the western slope that was previously cleared has regenerated to a burgan dominated disclimax.

Figure 6: Lobb's Hole
Murrumbidgee River at Lobbs Hole with ribbon gum stand on the left behind the river bottlebrush. A single remnant ribbon gum can be seen amongst degraded riparian zone vegetation on the right.

2. Gigerline Gorge: River Bottlebrush – Burgan Tableland Shrubland

This reach is close to 3.3 km in length, and the section that has the highest condition of the seven defined reaches along the Murrumbidgee River in the ACT. The valley slopes are steep sided and enclose the narrow bedrock dominated river channel and floodplains within a gorge. Although fire has had an impact within the reach, some areas remained unburnt leaving occasional old growth patches of the fire sensitive Black Cypress Pine Tableland Woodland. Like the channel itself, the riparian zone contains large amounts of exposed bedrock and where sands occur they are typically shallow over underlying rock. The river channel narrows through the gorge where the banks rise to form steep-sided bedrock platforms. There are several significant off-stream wetlands scattered throughout the zone, both within secondary channels and perched bedrock pools. Shrubs mostly form the dominant canopy layer on the bedrock substrate, as is typically the case where rocks occur throughout the study area. Almost the entire Gigerline reach floodplain is dominated by River Bottlebrush – Burgan Tableland Riparian Shrubland. Currawang (*Acacia doratoxylon*) is common on the slopes in the northern end near Diball's Creek. Some of these patches appear long established and contain old growth canopy currawang trees. Large swathes of the fire affected portions of the valley slope in the northern end of the reach contain dense 1–2 m tall currawang seed regeneration.

Figure 7: Gigerline Gorge views
Narrow channel flowing through elevated bedrock platforms with heathy shrubland (left), currawang wattle regeneration (top right) and some mature trees on the floodplain (bottom right).

It is probable that much of the valley slopes was once completely dominated by Black Cypress Pine Tableland Woodland. This is still the case on many of the slopes where black cypress pine tends to dominate over a mid-story of currawang. However, much of the area contains an assemblage of dominant canopy species that is a mixture of scribbly gum (*E. rossii*), red box (*E. polyanthemos*) and apple box (*E. bridgesiana*), over a mid-storey commonly containing burgan and hop bush (*Dodonea viscosa*). It was noted throughout the survey that several steep rocky slopes suitable for Black Cypress Pine Tableland Woodland contain an atypical mixture of eucalypts as described above (Figure 4) with either minimal remnant stands of cypress pine (as in this instance) or their complete absence. Evidence of recent successional change toward eucalypt woodlands has been seen elsewhere in the Murrumbidgee River Corridor where the 2003 bushfire severely burnt extensive patches of the fire sensitive black cypress pine, leaving only the existing fire tolerant eucalypts and kurrajong. It is possible that fire events in the previous century have had similar effects and that areas such as those on the slopes of the Gigerline Gorge underwent successional change long ago. The stands of currawang wattle near the northern end of this reach may have also succeeded previous existing Black Cypress Pine Tableland Woodland, given that it is present as an understorey component elsewhere.

Figure 8: Black Cypress Pine Tableland Woodland
Old growth Black Cypress Pine Tableland Woodland (left), and dense currawang regrowth beneath nearby dead standing black cypress pine that was killed by the 2003 bushfire (right).

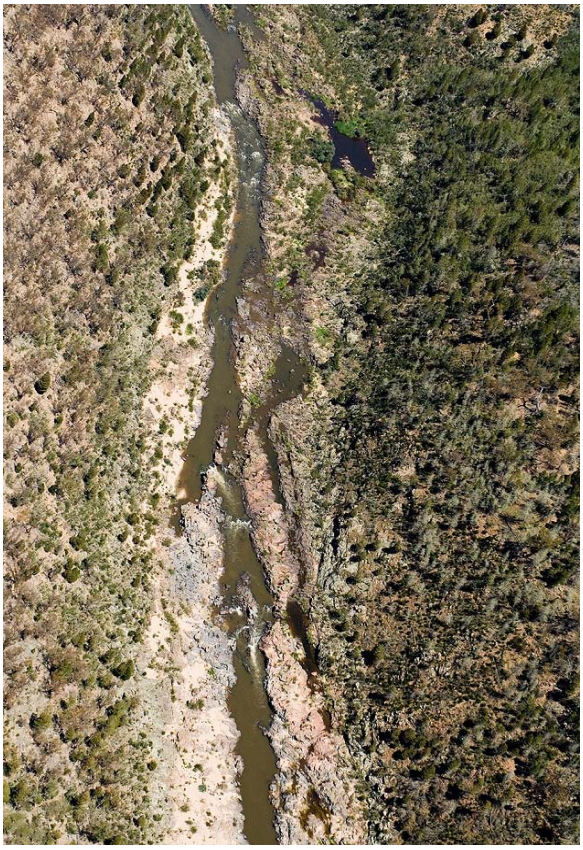

Figure 9: Gigerline Gorge

Aerial view of Gigerline Gorge (top and lower left) where vegetation patterns can be seen trending from eucalypt woodland above the steep slopes, to bands of black cypress pine on the steep lower slopes, above the rocky floodplains dominated by riparian shrubland and off-stream wetlands. The wetlands contain fringing vegetation reliant on access to wetted soils (lower right) and are ideal breeding or refuge sites for aquatic fauna.

3. Diballs Creek to Point Hut Crossing: Ribbon Gum Tableland Riparian Woodland

This reach is approximately 13.4 km in length. The vegetation has been extensively changed since European settlement, mainly through clearing for grazing and some agriculture. This section contains Tharwa village and Lanyon Homestead, in the current Lanyon Landscape Conservation Area. The Lanyon–Lambrigg area was an important focus of early European settlement of the Limestone Plains from the first half of the 19the century. The riparian and valley slope vegetation communities were found to be in low to moderate condition and all the remnant pre-European vegetation communities were highly degraded. In contrast to the Gigerline Gorge area upstream, the valley slopes are increasingly gentle and broad in this reach and have favoured pastoral and agricultural development. Much of the reach was affected by the 2003 bushfire, compounding the existing poor condition of the natural vegetation communities.

Terraced floodplains are well developed through this reach and evidence exists in the form of remnant vegetation that these terraces once hosted extensive Ribbon Gum Tableland Riparian Woodland. One of the best examples of ribbon gum on the Murrumbidgee River occurs at the Tharwa Sandwash recreation area, south of Tharwa village. The stand on the east bank contains large mature hollow bearing trees over a highly degraded mid- and understorey, although little ribbon gum seed regeneration was noted at the time of the survey. Highly degraded stands of ribbon gum with otherwise isolated trees and stags occur in the Lanyon Landscape Conservation area adjoining Castle Hill, Lambrigg and Lanyon rural leases. Suitable geomorphologies and deep soils suggest that the community would have occupied much of the riparian zone in this reach as far downstream as Point Hut Crossing. Other small rocky outcrops in the riparian zone have, as usual, favoured the establishment of natural riparian shrubland. Several exposed sandbanks and sandbars have been colonised by pioneer riparian fringing species. Secondary acacia shrublands and large expanses of African lovegrass (*Eragrostis curvula*) are common, and there are some patches of dense adult willow (*Salix* species).

The surrounding landscape is dominated by Yellow Box – Blakely's Red Gum Tableland Woodland in low to moderate condition. Much of this landscape has been cleared for pastoral improvement and agriculture. The understorey recorded is variable in its condition, in places containing a high native composition and in others very poor. There is evidence that the low steep sections immediately adjacent to the riparian zone may have once comprised narrow bands of Black Cypress Pine Tableland Woodland. One remnant example occurs just upstream of the Lambrigg homestead where surface bedrock outcrops across the slope and river channel. Another very small remnant of black cypress pine also occurs on the east bank just upstream of the Point Hut river crossing. One remnant patch of degraded Snow Gum Candlebark Tableland Woodland was recorded near the northern boundary of Castle Hill rural lease, which consists of five individual trees in a 0.3 hectare area. This occurs in a gully where the non-vascular plant assemblage indicates cold air drainage.

Figure 10: Murrumbidgee River at Tharwa
Murrumbidgee River at Tharwa showing mostly cleared surrounding slopes and riverbank. Introduced species are widely naturalised as can be seen in the foreground where Patterson's curse (*Echium plantagineum*) and wild oats (*Avena* sp.) dominate. Plantings of Lombardy poplars occur near the bridge where ribbon gum would have once stood.

Figure 11: Lanyon Landscape Conservation Area
Typical scene downstream (north) of Tharwa township in the Lanyon Landscape Conservation Area. Denuded flat, broad hills dominated by exotic grasses, often African lovegrass, with cleared riverbanks dominated by wattles or willows. One of the only remnant stands of ribbon gum in the reach can be seen on the opposite riverbank here, which is just downstream of Coffey's Cottage on Castle Hill rural lease. Some of the river flats currently used for grazing show evidence of having been ploughed in the past.

4. Point Hut to Tuggeranong Ck: She-oak Tableland Riparian Woodland

This reach is approximately 5.5 km in length and is in overall low to moderate condition. The 2003 bushfire, and the following drought had a significant impact on the ability of the fire affected vegetation to recover. The topography of the surrounding valley is fairly open to moderately steep in places and has been extensively cleared for rural purposes. The riparian zone is mostly rocky with loose surface sand and has some minor sand bank development. The riparian geomorphology is fairly diverse, with predominantly complex floodplains and bank-terraces as well as occasional bedrock controlled floodplains, and a short section of bedrock platform in a small gorge-like section near Pine Island Reserve. The predominant riparian vegetation community is the She-oak Tableland Riparian Woodland. Although observed above this reach in small patches in tributaries and plantings, this is the most upstream continuous occurrence of the community along the Murrumbidgee River. Within the reach, the floodplain vegetation is highly degraded because of the impact of fire and the high weed component. However, the mid-channel cascades appear the least affected by fire and because of their rocky nature tend to preclude many of the weeds common to the sandy disturbed floodplain soils. Silver wattle often forms dense colonising thickets on the disturbed floodplain soils while red stem wattle has widely colonised the drier rocky slopes in association with other woodland shrubs. Occasional intact stands of she-oak occur but in these cases the understorey is predominantly exotic and often dominated by African lovegrass which thrives on the exposed sandy soils throughout the reach. River Bottlebrush – Burgan Tableland Riparian Shrubland is a less common component of this reach where exposed bedrock occurs just north of Point Hut. The endangered Tuggeranong lignum (*Muehlenbeckia tuggeranong*) occurs within this reach.

The river valley slopes are highly degraded. The recreation areas at Point Hut and Pine Island contain a highly modified suite of introduced and non-local provenance native species. The presence of remnant isolated black cypress pine individuals throughout the reach indicates that the species may have once dominated the short steep rocky slopes, as it once had upstream of Point Hut crossing. There is also evidence of historical overlap, or encroachment of Blakely's red gum (*E. blakelyi*) into the areas of former Black Cypress Pine Tableland Woodland from the bordering degraded Yellow Box – Blakely's Red Gum Tableland Woodland community, which is often dominated by African lovegrass. The notable exceptions are where rocky outcrops or mounds of dense loose rock occur, where low native shrubs are able to survive. Rocky areas in general tend to preclude the establishment of African lovegrass and act as small 'island' refuges for a range of native species and are ideal habitat for reptiles.

Figure 12: She-oak Tableland Riparian Woodland
She-oak Tableland Riparian Woodland with intact canopy fringing the Murrumbidgee River near Pine Island reserve.

Figure 13: Typical fire affected woodlands

Typical fire affected woodlands in a broadly modified landscape. Most individual she-oak that recovered vegetatively from the 2003 bushfire occur close to surface water (top, Pine Island Reserve south). Most seed regeneration in these stands is by either colonising shrubs such as silver wattle or common ground weeds, often African lovegrass (bottom).

5. Red Rocks Gorge (Tuggeranong Ck to Kambah Pool): River Bottlebrush – Burgan Tableland Riparian Shrubland and She-oak Tableland Riparian Woodland.

This reach is a little over 5 km in length. Overall its condition is one the best along the Murrumbidgee River in the ACT and the reach commonly contains moderate to high condition riparian areas and riverine valley slopes. This is probably due in part to the steep rocky nature of the substrate which tends to preclude many of the more common and widespread weeds that are most abundant on deep and sandy soils. The valley slopes are steep and form a gorge through which the river narrows. The riparian zone is composed primarily of solid bedrock platforms and narrow complex floodplains, with occasional terraces and low lying bedrock floodplains. This reach contains one of three significant riparian wetland areas recorded during the study. Whilst enclosed gorges are commonly regarded as being relatively protected from fire events, little of Red Rocks Gorge remained unaffected by the 2003 bushfire. The dominant riparian vegetation is quite variable depending on landscape position, but with a high degree of outcropping rock there is a good representation of River Bottlebrush – Burgan Tableland Riparian Shrubland, amongst very narrow and often sparse bands of She-oak Tableland Riparian Woodland. Interestingly there is a small stand of ribbon gum at Kambah Pool, indicating that it may have once been more widespread than at present.

Black cypress pine occurs on elevated rocky patches in the riparian zone where it is probably protected from regular flooding and even appears to be the successional riparian zone climax vegetation in places. However, the species is more common on the riverine valley slopes where it is probable that it once dominated the steep dry rocky landscape. Following the 2003 fire the majority of adult trees remain only as dead standing timber, and dense stands of colonising red stem wattle, and in one location a thicket of currawang, have regenerated in their place. Evidence of down-slope vegetation succession was seen where Blakely's red gum extends down into slopes that were formerly likely to have been dominated by black cypress pine. This is down-slope of the open tablelands where it usually occurs in combination with yellow box (*E. melliodora*) and it now dominates a 600 m stretch of the east facing valley slope. This down-slope successional migration is likely to increase in all areas of the river valley and riparian zone with increased drought, more frequent fires and lower frequency and duration of flooding of riparian communities. Toward the downstream (north-western) end of this stretch the valley slope contains Apple Box – Broad Leaf Peppermint Tableland Forest and the most upstream record of red stringybark (*E. macrorhyncha*), representing a transition to the valley slope communities in the section downstream (Bullen Range).

Figure 14: Red Rocks Gorge scenes
Red Rocks Gorge where the Murrumbidgee River narrows as it passes through steep walled solid bedrock platforms. These rock platforms predominantly host riparian shrubland except where occasional narrow patchy bands of she-oak lodge in rock cracks or occasional sandy deposits.

6. Bullen Range: She-oak Tableland Riparian Woodland

This reach is approximately 12.5 km in length and is in overall moderate to low condition. The valley has a variable gradient, but is generally moderate to steep, with the very steep slopes of the Bullen Range rising close to the western side of the river. The reach was severely burnt in the 2003 bushfire, resulting in successional change which is affecting fire sensitive communities. The riparian vegetation occurs on narrow complex floodplains with variable rock outcrops and sandy soils. Several rocky islands and cascades occur within the river channel on which low shrubland and woodlands and riparian fringing species are established. Low lying bedrock floodplains were recorded at the mouths of Bulgar Creek and Cotter River. Historically, the river banks and floodplains were all dominated by She-oak Tableland Riparian Woodland. While this is still the case, many trees away from the riverbank have died since the 2003 fire. The understorey is dominated by exotic species, in particular African lovegrass and blackberry, along with a suite of common riparian weeds. This reach contains the most widespread and aggressive blackberry infestation along the Murrumbidgee River in the ACT. Extensive parts of the floodplain contain impenetrable thickets that also extend up many of the moister gullies, and can clearly be seen from aerial or high resolution satellite imagery. This is a weed of national significance (Australian Government 2008) that should be a priority for long term integrated management.

The river valley slopes are likely to have been dominated by long stretches of Black Cypress Pine Tableland Woodland, particularly on the steep slopes of the Bullen Range, along with Red Stringybark – Scribbly Gum Tableland Forest. Red stringybark and scribbly gum are likely to replace the black cypress pine in the recovery of the Bullen Range vegetation adjoining the river. Certain sections of the steep face of the range have long been dominated by either one of these species, presumably due to the effect of previous fire events on the black cypress pine. Away from the steep sided face of the Bullen Range, where the river meanders and on the opposite side of the river, there are patches of Yellow Box – Blakely's Red Gum Tableland Woodland that are in particularly poor condition. Remnant canopy trees are sparse or even non-existent and what remains is very open woodland or secondary native grassland in places. Of note are the kurrajongs that have survived the recent fire. Large swathes of burgan occur adjacent to Huntly rural lease with the occasional remnant she-oak up to fifty vertical metres above the riparian zone. These factors indicate potential shallow water tables in this reach. Thickets of wattles (silver wattle on the floodplain and red stem wattle on the dry slopes), along with sweet bursaria (*Bursaria spinosa*), *Cassinia* species and occasionally *Pomaderris* spp. are thriving in the post-fire disturbance environment.

Figure 15: Bullen Range views

Bullen Range environment where the slopes to the west of the Murrumbidgee River rise sharply above the surrounding terrain. These rocky harsh slopes hosted extensive stands of black cypress pine prior to the 2003 bushfire that now remain mostly as dead standing trees. The slopes to the east of the river also rise sharply but taper off to cleared pastoral land, often with native pasture such as near Fairvale rural lease (top). Narrow bands of the She-oak Tableland Riparian Woodland fringe the river and were heavily affected in places by the 2003 fire (bottom). Large swathes of ground weeds, particularly blackberry and African lovegrass are major problems in this reach.

Figure 16: Blackberry in the Bullen Range
Blackberry (*Rubus fruticosus* agg.) in the Bullen Range reach. Large light green patches can be seen from aerial photography (top) that form impenetrable thickets that outcompete native groundcover, especially in the absence of dense overhead canopy cover (below).

7. Cotter River Confluence to ACT Border: She-oak Tableland Riparian Woodland

The main difference between this section and section six is the change in valley topography. Although similar in nature, the Bullen Range ends at the confluence of the Cotter and Murrumbidgee rivers and in its absence the river valley slopes gradually tends more toward undulating the further to the north the river flows. The reach is approximately 7 km in length, and contains long uniform stretches of complex floodplain riparian geomorphology and associated vegetation mosaics. It contains stretches of fire affected She-oak Tableland Riparian Woodland, but also has some of the longest reaches of unburned she-oaks with intact canopy, particularly at the northern end beyond the junction of the Molonglo River. The influence of the Molonglo catchment on the Murrumbidgee River riparian zone can be clearly observed, with willow infestations dominating much of the east river bank extending immediately downstream of the confluence, as well as the common presence of Pacific azolla (*Azolla filiculoides*), an indicator of aquatic nutrient enrichment. One of the three significant off-stream wetland areas recorded during the survey occurs in the Woodstock Reserve, which contains a variety of otherwise uncommon herbaceous species assemblages in the Murrumbidgee River Corridor. The rolling valley slopes support variously modified and fire affected Red Stringybark – Scribbly Gum Tableland Woodland, with apple box common in places, particularly the lower slopes. One of the best examples of unburnt black cypress pine in the river corridor occurs beneath Shepherds lookout on the steep rocky slope downstream of the confluence with the Molonglo River. Otherwise burgan dominates much of the previously cleared slopes, amongst occasional isolated black cypress pines, or even remnant she-oak up to forty vertical metres above the riparian zone, indicating shallow water tables in this reach. Although there was evidence of recent fire throughout the reach, much of the canopy of the two fire sensitive tree species, black cypress pine and she-oak, remains intact. The she-oak mistletoe (*Amyema cambagei*) was quite prevalent and in full flower during the survey of this reach in October 2008.

Figure 17: Complex Flood Plain
Complex floodplain at Camp Sturt downstream of Uriarra Crossing. This is one of the broadest floodplains in the ACT section of the Murrumbidgee River and contains relatively intact she-oak canopy, although the ground strata is highly disturbed

Figure 18: Woodstock Reserve Wetlands These can be seen being recharged by increased river volume in November 2007 (top). These wetlands contain distinctive vegetation assemblages in the Murrumbidgee River riparian zone (middle), and provide ideal breeding and refuge sites for aquatic and semi-aquatic fauna (right).

Chapter 5: Murrumbidgee River Vegetation Communities

Nine definitive ACT vegetation communities, and one vegetation complex, were recorded within the riparian zone and associated river valley slopes of the Murrumbidgee River Corridor. The riparian zone hosts four of these, of which two are typically discrete woodland communities for the most part separated longitudinally along the watercourse. There is one true riparian shrubland, and an herbaceous aquatic and fringing vegetation complex with relationships to all three wooded riparian communities. The aquatic and fringing vegetation complex is comprised of nine described sub-communities that can and often do intergrade. The remaining six communities comprise four woodland assemblages and one forest community that all occupy the dry riverine valley slopes.

Ribbon Gum Tableland Riparian Woodland is likely to have once dominated long sections of the riverbanks upstream of Point Hut Crossing but is now variably degraded and in need of urgent conservation action. While uncommon, patches of ribbon gum do occur on the floodplains downstream of Point Hut Crossing among long reaches dominated by she-oaks. The She-oak Tableland Riparian Woodland remains common downstream of Point Hut Crossing but has been impacted by the 2003 bushfire and ongoing dry climatic conditions. River Bottlebrush – Burgan Tableland Riparian Shrubland dominates the Gigerline Gorge and Red Rocks Gorge where extensive elevated bedrock outcrops occur, as well as occasional locations on low lying rocky floodplains, and occurs as a riverbank fringe associated with the riparian woodland communities. The Tableland Aquatic and Fringing Vegetation Complex is widespread and diverse where surface water or high soil moisture occurs, and contains significant sub-groups with uncommon species or habitats. To some extent all of the riparian ecosystems have altered vegetation structure and a high weed component due to historical and recent impacts and the overall landscape position and have management concerns that are alluded to within this document.

The riverine valley slopes have been variably impacted by rural land management and fire, but the overall impression is of higher vegetation community resilience than the riparian zone vegetation, with the exceptions of the Black Cypress Pine Tableland Woodland and Snow Gum – Candlebark Tableland Woodland. All other vegetation communities are either stable primary eucalypt communities or secondary native shrublands. In most cases even the less robust communities tend to be in moderate to high condition, even when there have been documented impacts on the dominant canopy species. In the case of the Black Cypress Pine Tableland Woodland, concerns have arisen about the long term viability of the community due to its susceptibility to fire. The limited distribution and low condition observed within the few populations of Snow Gum – Candlebark Tableland Woodland are also a cause for concern. Where the Apple Box – Broad Leaved Peppermint Tableland Woodland and Red Stringybark – Scribbly Gum Tableland Forest occur they appear to be relatively intact, even after having been heavily impacted by the 2003 bushfire. However, it is not known how further drought and/or unsuitable fire regimes may impact on these communities. The Burgan Derived Tableland Shrubland is a secondary colonising shrubland that has taken hold in previously cleared valley slopes and gullies where suitable physical conditions occur such as increased soil moisture.

The following is a description of each community recorded within the study area with notes on vegetation components, the physical environment in which the community typically occurs, associated fauna and habitat, locations where each may be observed, and overall condition of each community.

1. Tableland Aquatic and Fringing Vegetation Complex

This is a complex of aquatic and semi-aquatic species assemblages, herein called sub-communities, which may either be stable through time or vary with seasonal conditions. The dominant vegetation is typically herbaceous and contains species of both vascular and non-vascular plants, including thallose liverworts (*Riccia* species), rushes (e.g. *Juncus usitatus, Typha* species), sedges (e.g. *Schoenoplectus validus*, *Carex* species,), grasses (e.g. *Phragmites australis*, *Paspalum distichum*), herbs (e.g. *Persicaria* and *Lythrum* species), aquatic floating leaf species (e.g. *Marsilea* species) and aquatic submerged vegetation (e.g. *Vallisneria americana, Myriophyllum* species). The range of sub-communities often intergrade and can therefore usually be defined as a single 'Tableland Aquatic and Fringing Vegetation Complex'. However, depending on the scale of description the component sub-communities may at times be sufficiently extensive to be described as individual entities.

Almost all species represented in these sub-communities show anatomical and physiological adaptations to inundation and many have seasonal growth bursts and also become senescent for periods of the year. The physical habitat alone may determine zones of vegetation found in any one environment and the same spectrum of species is generally available for all. Associated woody riparian communities that are dominated by shrubs and trees with similar anatomical and physiological adaptations such as river bottlebrush (*Callistemon sieberi*) and she-oak (*Casuarina cunninghamiana*) are not included in the complex, although the communities dominated by them often contain floristic elements in common with the predominantly herbaceous units defined here. Due to inundation of this complex during high flow events it is possible that several areas were not adequately described and it is possible that further associations or species may still occur that have yet to be recognised.

Physical environment

This complex occupies inundation prone areas within the Murrumbidgee River Corridor, usually between the margins of the woody riparian bank vegetation and permanent water associated with the river and its tributaries. Importantly, it also occupies the small but significant permanent wetlands documented throughout the study, as well as many areas that may hold water for short periods after a high river flow or rainfall event. Many occurrences of the flora of these assemblages are within waters of, or marginal to, streams or contained water bodies that are subject to changes in level.

The environments commonly associated with this community complex include:

- the main channel of the Murrumbidgee River and tributary gullies with base-flow levels
- flood-and-dry tributaries
- secondary channels (flood-runners) and riparian wetlands
- perched rock-pools (mainly in the Gigerline and Red Rocks Gorges).

The floristic composition of aquatic and fringing vegetation assemblages varies in a continuous way although relatively abrupt changes in the habitat conditions encountered within a local area may tend to give an impression of somewhat distinctive types. Factors that influence the range of species present in an area include: the duration of inundation (and subsequent exposure); flow hydrology; depth of water; composition of the channel or bank substrate; and temperature and chemical composition of the water (although not noted in the study area salt content is an important chemical factor). In most situations, where the range of depth or flooding regime allows, assemblages of species form recognisable zones which are usually linear along the river channel or somewhat concentric around wetlands.

Thus two or more sub-communities may be represented within one vegetation unit. Zonation that might otherwise occur can often be truncated by variation in the submerged topography of a pond or stream. Short lived sandbars and bank undercuts created by storm events may leave

patches in the succession. Such zonation may also reflect the potential succession of species that will occupy the same area if conditions change over a long time. Some degree of zonation is normal and renders the problem of classifying an area of aquatic and fringing vegetation more difficult. Ephemeral species may add to this complexity (Briggs 1981), although in the ACT these are not a prominent element in lowland waters such as the Murrumbidgee River. *Isotoma* spp. and *Pratia* spp.(and perhaps river margin species of *Hydrocotyle*), while not strictly ephemeral, are responsive to river height and flow for the stimulus to flourish and, as such, are examples of riparian species that come and go over short periods of time. It should be noted that apparent new species arising in areas subject to flooding may arise from degraded remnants of rhizomes or the hidden seed store that is held in the substrate. Desiccated banks also become colonised by terrestrial species that in turn senesce on inundation.

The *Riccia–Nostoc* sub-community is found on mud or sandy mud. The *Isoëtes–Isolepis* sub-community develops on shallow sediment-filled rock crevices as do some forms of the Floating and Floating-leaved Herbland. Otherwise the remaining sub-communities exploit sandy or muddy substrates with or without cobbles and rocks. Depth and flow are the other main factors that determine the spatial distribution and zoned gradations of sub-communities. The Rushlands are usually at, or above, mean high water level. *Phragmites* sub-communities will extend from moist patches toward the top of the bank into the waterway until the bank slope and channel current combine to undermine retention of substrate. Cumbungi (*Typha* spp.) has a similar pattern of growth and may favour fine sediment substrates and lower velocity channel flow. Ribbon weed (*Vallisneria sp.)* favours deeper pools but may be found close to or intergrading with the emergent sub-communities. There can be zonation from Sedgeland or Swamp Herbland to the Submerged and Emergent Herbland, but occasionally in sandbar areas this zonation may be interrupted by lenses of open sand.

Characteristic trees
Emergent she-oak (*Casuarina cunninghamiana*)

Characteristic shrubs
Emergent river bottlebrush (*Callistemon sieberi*), silver wattle (*Acacia dealbata*)

This complex often occurs in association with these trees and shrubs, as they share many of the same anatomical and physiological adaptations to waterlogged environments.

Characteristic Sub-communities

(i) Swamp Herbland: Sub-Type Riccia–Nostoc Cryptogam Submerged Ephemeral Herbland

Common species in the study area include liverwort (*Riccia* spp.); snot (*Nostoc commune*); vegetable shot (*N. pruniforme*); *Phormidium autumnale* complex; and *Oscillatoria* spp. These species form on recently deposited mud in flood-runners and persist as the water recedes into the soil. Both *Riccia* and *Nostoc* are examples of 'resurrection plants' that will rapidly become active following inundation, even after long periods of dry. While *Centipeda cunninghamiana* and *Alternanthera denticulata* and similar plants may subsequently germinate and appear to dominate the habitat, the initial cryptogamic vegetation is the persistent and perennial flora. This situation may persist where the introduced African lovegrass (*Eragrostis curvula*) or other weeds or occasional native tussocks shade the floor of secondary channels. This sub-community is common in the secondary channels, especially between Point Hut Crossing and Woodstock Reserve. Outside the study area it is frequently destroyed by rural land use activities. This sub-community plays a similar role to soil crusts formed by blue-green alga (cyanoprokaryota) and lichens in rangelands or disturbed areas in other terrestrial ecosystems.

Figure 19: *Riccia–Nostoc* Cryptogam Submerged Ephemeral Herbland
Swamp Herbland: Sub-Type *Riccia–Nostoc* Cryptogam Submerged Ephemeral Herbland in Red Rocks Gorge (above left), with close view of *Nostoc commune* (snot) in hand (lower right).

(ii) Swamp Herbland: Sub-Type Floating and Floating-leaved Herbland

Common species include Pacific azolla (*Azolla filiculoides*), *Ricciocarpus natans*, nardoo (*Marsilea* spp.), *Lemna* species, *Wolffia australiana*, curly pond weed (*Potamogeton* species), *Ludwigia peploides* ssp. *montevidensis*; *Elatine gratioloides*, *Myriophyllum* spp., buttercup (*Ranunculus papulentus*) and *Nymphoides montana*. These species favour still-water habitats such as the shallow off-stream wetlands at Woodstock Reserve, but may be found in slow moving creeks such as New Station Creek or other river backwaters such as those that occur near the Jews Harp Bend area (Fairvale rural lease). This sub-community can also be found in the farm dams on the alluvial terraces near Lanyon homestead, and natural perched rock pools of the main river channel and associated floodplain wetlands. Most of these wetlands are small, shallow and discrete (3 to 45 m^2), vary in shape with geology from little more than a lens amongst solid bedrock outcrop, through to broad shallow basins. The best examples of *Nymphoides* pools are in the Red Rocks Gorge, while *Ludwigia* fringed wetlands are common below Uriarra Crossing. One spectacular lens shaped water body was recorded in a rock crevice at Woodstock Reserve, where the standing dead stems of the previous season's common reed (*Phragmites australis*) fringed a dense surface cover of *Ricciocarpus natans*.

Figure 20: Floating and Floating-leaved Herbland

Swamp Herbland: Sub-type Floating and Floating-leaved Herbland, which is often found at the mouth of small tributaries of the Murrumbidgee River. Pacific azolla below the junction of the Molonglo River (top left), watercress in the mouth of New Station Creek (top right) and *Nymphoides montana* (right).

(iii) Swamp Herbland: Sub-type *Vallisneria–Myriophyllum* Submerged and Emergent Herbland

Common species include ribbon weed (*Vallisneria americana*), *Myriophyllum* species, *Elatine sp.*, *Juncus* species (non-dominant rushes), water plantain (*Alisma plantago-aquatica*), brook lime (*Grateola peruviana)*, *Crassula helmsii*, watercress (*Nasturtium officinale*), curly pondweed (*Potamogeton crispus*), non-dominant sedges (Cyperaceae) *Ranunculus spp., Limosella australis, Isotoma fluviatilis* and filamentous alga (*Cladophora* sp.and *Rhizoclonium*, Zygnemaceae, Characeae).

The structure of this sub-community can range from open, as a fringe of milfoil and ribbon weed in a riffle, to densely closed, as when watercress clogs a reach of a slow-flowing tributary creek. In the Murrumbidgee River Corridor this sub-community is often evident at the mouth of base-flow creeks such as New Station and Bulgar Creeks, and sandbar islands and cascades that are best seen in the Pine Island and Kambah Pool (north) areas. There may be two forms of this sub-complex, the deep water sub-community dominated by *Vallisneria* or *Potamogeton* and the emergent community where *Crassula*, *Elatine*, *Limosella* and *Grateola* grow in the riffle beds above the more usually submerged *Myriophyllum*.

Figure 21: *Myriophyllum* and *Vallisneria* Herbland
Swamp Herbland: Sub-type *Vallisneria–Myriophyllum* Submerged and Emergent Herbland. *Myriophyllum verrucosum* in perched rockpool (top left) and *Vallisneria americana* in the main river channel near Fairvale rural lease (bottom right). This sub-community is more common in larger impoundments such as the artificial urban lakes, but is present in a small number of suitable locations that have slow flowing water and fine particulate substrate along the Murrumbidgee River.

(iv) *Isoëtes–Isolepis* Dwarf Swamp Sedgeland

Common species include quillwort (*Isoëtes muelleri*), *Isolepis* spp., *Cyperus* species and Mudwort (*Limosella australis*). The quillwort, mudwort and the sedges form fields of submerged and emergent tussock under 30 cm tall, and favour semi-permanent perched pools rather than combining with *Eleocharis acuta* or *Paspalum distichum* as the leading edge of swamp sedgeland in sites with a higher water flow. A very good example can be found in a perched wetland on a rock platform just below the lower chute in the Red Rocks Gorge. *Isoëtes muelleri* is an uncommon species in the ACT, but is plentiful at this site.

(v) *Schoenoplectus–Bolboschoenus* Swamp Sedgeland

Common species include *Schoenoplectus validus*, *Bolboschoenus fluviatilis*, *and Eleocharis plana*. The sedgeland usually contains *Cyperus* species and/or *Carex* species (excluding *Carex gaudichaudii* which occurs in montane fens). Towards the northern (downstream) end of the river in the ACT the diversity of species may increase, as several smaller *Carex* and similar species were noted in both the river and the off-stream wetlands downstream from the mouth of the Cotter River. This sub-community rarely forms extensive continuous patches but forms the 'emergent riparian fringing' vegetation along most riffles and cascades along the whole corridor, especially in the Point Hut Crossing to Pine Island area and below Uriarra Crossing.

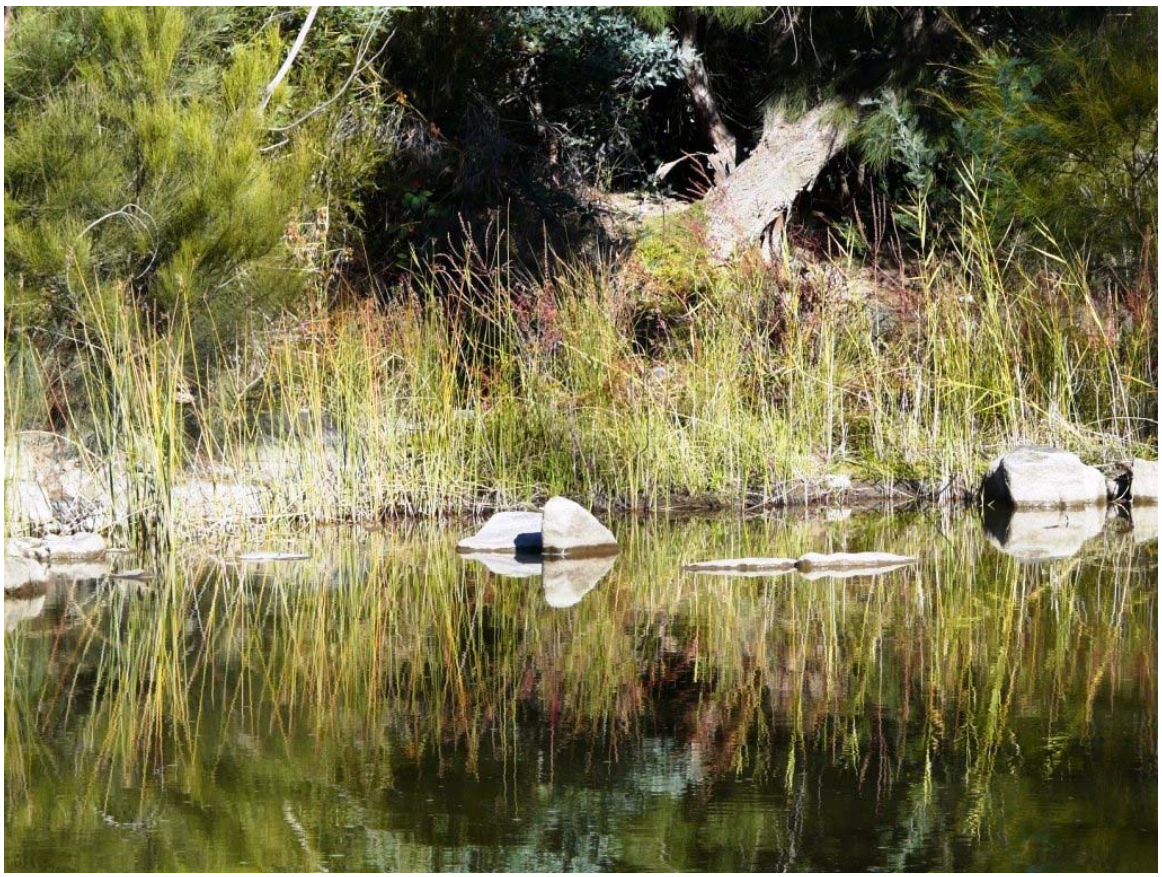

Figure 22: *Schoenoplectus–Bolboschoenus* Swamp Herbland
Schoenoplectus–Bolboschoenus Swamp Sedgeland sub-community, intergrading with Swamp Grassland sub-type *Phragmites* grassland and *Persicaria–Lythrum* Swamp Herbland. This very narrow fringe is bordering *Casuarina cunninghamiana* Tableland Riparian Woodland next to the Bullen Range.

(vi) Swamp Grassland: Sub-type *Phragmites* Grassland

This sub-community is dominated by common reed (*Phragmites australis*). The other common species is water couch (*Paspalum distichum*). The water couch usually occurs as low lying ground cover at the margins and close to water level, while the common reed may grow to 3 m especially when in the water channel. This is common in the sandy mouths of tributaries such as the Gudgenby River at Tharwa and New Station Ck, below Kambah Pool, and as fringes of sandbars and strandlines throughout the Murrumbidgee River Corridor.

Figure 23: *Phragmites australis* Grassland
Swamp Grassland: Sub-type *Phragmites* Grassland that is typically established on muddy flats on the riverbank. Note the associated woody riparian species, *Callistemon sieberi*, *Casuarina cunninghamiana* and *Acacia dealbata*, all common on the river fringe.

(vii) Swamp Bushland: Sub-type *Typha* Rushland

Cumbungi (*Typha* species) dominate this sub-community. Above Tharwa Sandwash there are few suitable sites for development of large concentrations of cumbungi, although it does fringe some of the off-stream wetlands in the Gigerline Gorge. Below Tharwa Sandwash, belts of cumbungi often occur in association with *Phragmites* grasslands as well as exploiting the deeper rock based, silt filled, off-stream wetlands as at the mouth of Freshford Ck. In the broader alluvial areas where off-stream wetlands occur in secondary channels these may contain patches of cumbungi in the area that dries up last. At Woodstock Reserve, where the alluvium has built up over gently sloping rock, the deeper off-stream wetlands may be dominated by extensive fringes of cumbungi.

Figure 24: *Typha* Rushland
Swamp Bushland: Sub-type *Typha* Rushland sub-community. This occurrence occupies a riparian wetland associated with a flood channel some distance from the main river channel in the Gigerline Gorge.

(viii) Swamp Bushland: Sub-type *Juncus* Rushland

This sub-community is dominated by *Juncus* species, with a range of forbs. It is common on sand banks and among rocks in cascades throughout the Murrumbidgee River Corridor. It frequently occurs on margins of both natural and artificial still water bodies in the river corridor.

Figure 25: *Juncus usitatus*
Juncus usitatus fringing an off-stream wetland in Gigerline Gorge.

(ix) *Persicaria–Lythrum* Swamp Herbland

Common species include *Persicaria decipiens, P. hydropiper*, *P. lapathifolia*, *Lythrum salicaria*, *Alternanthera denticulata*, *Polygonum* species, *Epilobium* species, *Centipeda cunninghamii*, *Portulaca oleracea*, *and Hydrocotyle* species. This sub-community contains a high dominance of forbs, many with perennial root systems, rather than grasses and sedges. Most components are perennial but die back to rhizomes between autumn and winter. It is often associated with secondary channels and the strand areas of embayments of the Murrumbidgee River above and below the causeway at Point Hut Crossing, at Pine Island and Kambah pool, and the Cotter Mouth–Casuarina Sands areas. Although it may last only a few seasons it does stabilise the strand margins so that swamp sedgelands, grasslands or shrubland may succeed it. It can be found on low-lying floodplains, in ephemeral wetlands and in depressions in tableland country.

Figure 26: *Persicaria* and *Lythrum* Herblands
Persicaria – Lythrum Swamp Herbland dominated by *Persicaria lapathifolia* (top) and *Lythrum salicaria* (below)

Tableland Aquatic and Fringing Vegetation Complex: Fauna notes

This vegetation complex provides habitat and food for a range of aquatic and amphibious species. Native fish seek this complex for refuge, for example, the Swamp Grassland: Sub-type *Phragmites* Grassland is known to form an integral part of the life cycle of the threatened Macquarie perch (*Macquaria australasica*) in the Cotter Reservoir, and similar grasslands along the Murrumbidgee River provide habitat for other species. Waterbirds such as the reed warbler, coot, moorhen, swamp hen and bittern seek reed beds as a preferred ecological niche for breeding and shelter. Invertebrates with aquatic life stages thrive in this complex, as the component plants provide food, shelter and building materials that the aquatic stages require. For instance, many caddis fly larvae are bottom feeders that consume fresh and decaying vegetable matter, use pieces of vegetation as a protective home and move among the water plants to hide from predators. When reaching the imago stage, they again use the vegetation to allow them to break into the air. As caddisfly, dragonfly and damselfly larvae, and nymphs of numerous other insects make up a high proportion of amphibian and fish diet, the presence of suitable habitat for them ensures that the potential for the higher order consumers is present. Amphibians are regularly associated with these environments. While the common eastern froglet (*Crinea signifera*) was regularly heard during this daytime study, other frog species are known to occur in the Murrumbidgee River Corridor.

Representative site locations

This vegetation complex is widespread and extensive where flowing or still water occurs in the tableland environments of the ACT. The Murrumbidgee River Corridor presents a mosaic of the components of this complex throughout its length and many of the less frequently encountered sub-communities can be found there. Accessible examples of several sub-communities can be found at Angle Crossing, Point Hut Crossing, Pine Island, north Kambah Pool, the mouth of the Cotter River through to Casuarina Sands, and Woodstock Reserve. Examples of specific sub-communities are given above.

Condition of the vegetation complex

Overall this community complex is common and widespread, with many local area species thriving in the various environments that they occupy within the study area. To a large extent introduced weed species have become naturalised within this complex, but without apparent effect on its functioning. Notable weeds and exotic species that can outcompete native species in this complex include, but are not restricted to, canary grass (*Phalaris aquatica*), drain sedge (*Cyperus eragrostis*), purple top (*Verbena bonariensis*), couch grass (*Cynodon dactylon*), water speedwell (*Veronica anagalis-aquatica*) and African lovegrass (*Eragrostis curvula*). Water Speedwell, sometimes accompanied by *Mentha* species, will be found thriving in the *Persicaria–Lythrum* Herbland or overshadowing the emergent forms of the Submerged and Emergent Herbland to such an extent that it is the dominant species. In the *Juncus* Rushland drain sedge often thrives as well as the native *Juncus*. Couch grass extends into the Emergent Herblands from the sand banks, particularly where the sub-community is subject to a 'wetting and drying' cycle.

There is no evidence that any species has been eliminated and there is also no baseline with which to compare the findings of this survey. The off-stream wetlands in the Murrumbidgee River Corridor present an interesting mosaic of diverse sub-communities. Many have species associations that are singular for the water body and may be one of a kind within the ACT. With changes in water flows since European settlement, particularly as a result of upstream dams, the nature and dynamics of these communities will have been changed over time.

This complex is identified in part as Tablelands Wetlands in Sharp et al. (2007) for which conservation action is required.

Threats or threatening processes

- Degradation of water quality.
- Changes in flow regimes and water storage management.
- Impacts of land management, particularly urban and agricultural.
- Noxious weeds.

Changes in flow regimes and water storage management may represent the worst long-term threat to this complex. Waterways in the Murray–Darling Basin all experience dramatic drought and storm based changes in flow regime, and the organisms in the Basin show adaptation to such events. Consequences of reduction in flow, and flow variation, within the river include longer periods of channel pond formation, narrowing of the width and depth of the main waterway, and changing of depositional constituents. This leads to floristic changes in the Tableland Aquatic and Fringing Vegetation Complex in favour of species with preferences for finer sediment substrate and shorter periods of inundation.

In some observed off-stream wetlands the water level is dependent on both flooding and groundwater from the main stream. Less frequent high flow events in the Murrumbidgee River has likely lead to more frequent drying of the off-stream wetlands that support this complex and in turn created longer intervals between regeneration and seeding events and causing lowered floristic diversity in favour of the more drought adapted species. The species and floristic associations that are uncommon in the corridor, such as the *Isoëtes–Isolepis* Sedgeland and the pools of *Nymphoides* Floating and Floating-leaved Herbland, are at risk of being lost from the ACT.

A number of exotic plants that favour saturated or partly saturated soils in riparian areas may potentially become problematic if not managed or eradicated. Soapwort (*Saponaria officinalis*) can take over large areas of strand and sandbars in flood runners, spreading rapidly by stoloniferous rhizomes through the sand. It regenerates quickly from these rhizomes both after flood or frost, and also seeds profusely. The mints, *Mentha spicata* and *M. piperita*, are both rapid and successful colonisers of exposed river or creek bank, reproduce easily from fragments and seed in profusion. There are numerous other examples among the exotic species.

2. River Bottlebrush – Burgan Tableland Riparian Shrubland

This community usually consists of a fairly continuous dense shrub layer, commonly dominated by river bottlebrush (*Callistemon sieberi*), burgan (*Kunzea ericoides*), silver wattle (*Acacia dealbata*) and tea-tree (*Leptospermum obovatum*). Other low shrubs such as fringe myrtle (*Calytrix tetragona*) and *Micrantheum hexandrum* also occur in specific riparian environments containing high proportions of exposed bedrock, and elevated above the stream level. Emergent, low trees including the true riparian she-oak and woodland eucalypts such as apple box (*Eucalyptus bridgesiana*) and Blakely's red gum (*E. blakelyi*), and occasional black cypress pine (*Callitris endlicheri*) are either sparse or absent but can extend down-slope from the adjacent woodland or open forest into the shrub community. The ground layer is often sparse but frequently contains species associated with riparian aquatic and fringing vegetation sub-communities.

Physical environment

This community is commonly associated with river fringes on rocky river banks, gravel beds and elevated bedrock platforms adjoining rapidly flowing water. It commonly occupies a specific ecological niche upon the rocky, or sometimes sandy, riparian fringe and low lying bedrock floodplains prone to regular inundation. The community is most prevalent in gorge environments below approximately 600 m elevation along the Murrumbidgee River in the ACT, but is also presumed to be quite common within the extensive gorges upstream of the ACT between Bredbo and Williamsdale. Due to the flood prone environment it occupies, this community is strongly associated with the Tableland Aquatic and Fringing Vegetation Complex, most often containing a ground cover dominated by components of this complex. Elevated bedrock platforms such as those that occur in Gigerline and Red Rocks gorges support a type of this community dominated by occasional individuals of burgan and river bottlebrush amongst a range of low myrtaceous and epacrid shrubs, commonly fringe myrtle.

Characteristic shrubs

Callistemon sieberi, Kunzea ericoides, *Acacia dealbata, Leptospermum obovatum, Bursaria spinosa, Calytrix tetragona, Micrantheum hexandrum, Acacia rubida, Cassinia* species and *Grevillea lanigera.*

Characteristic groundcover

Geranium species, *Juncus usitatus*, *Persicaria* species, *Polygonum* species, *Epilobium* species, *Rubus parvifolia*, *Phragmites australis*, *Elymus scaber, Dichelachne rara, Schoenoplectus validus.*

Fauna notes

This community contains shrub thickets that provide important cover for birds and nectar sources for terrestrial macro-invertebrates that were observed utilising a range of species such as river bottlebrush during flowering seasons. The high proportion of rocky substrate that this community occupies provides habitat for a range of riverine reptiles.

Representative site locations

This community is well developed along the Murrumbidgee River on riverbanks and where rocky outcrops occur north of Casuarina Sands and along some sections between Angle Crossing and the junction with the Naas River. Angle Bend on the southern entrance of the Murrumbidgee into ACT, the Gigerline and Red Rocks Gorges host high quality examples of this community.

Condition of the community

The majority of sites where this community is known to occur in the river corridor are in good condition, with a high diversity of native species and relatively few introduced species compared with other riparian communities. Because the community occupies predominantly rocky substrates, exotic groundcover has difficulty establishing and common riparian weeds other than aquatic and fringing species tend to be in low abundance. Sites burnt by the 2003 bushfire have

regenerated well; however, due to the proximity of these communities to wetter areas it appears that many were not burnt.

Threats or threatening processes

- Reduced environmental flows and flood frequencies associated with reduced rainfall and increasing water extraction.
- Fire may be a threat to some of the species of this community.
- Weeds; the most common and widespread, potentially requiring resource allocation include willows (*Salix* species), blackberry (*Rubus fruticosus* agg.), African lovegrass (*Eragrostis curvula*) and *Paspalum dilatatum*.
- Recreation (minor).

Figure 27: River Bottlebrush – Burgan Tableland Riparian Shrubland

River Bottlebrush – Burgan Tableland Riparian Shrubland: at the mouth of Bulgar Ck. (above right), a typical bedrock floodplain dominated by scattered river bottlebrush and a large amount of surface rock; and in Gigerline Gorge (below left) where the narrow rocky river floodplain is dominated by closed riparian shrubland.

3. Burgan Derived Tableland Shrubland

Burgan Derived Tableland Shrubland is a community that usually consists of a fairly continuous dense shrub layer, dominated by burgan species (predominantly *Kunzea ericoides* with the exception of *K. parvifolia* downstream of the junction with Tuggeranong Ck). Commonly associated are species of *Acacia*, *Bursaria*, *Cassinia* and *Grevillea*. Emergent, usually low, trees are either sparse or absent but eucalypts including red stringybark (*E. macrorhyncha*), snow gum (*E. pauciflora*), Blakely's red gum (*E. blakelyi*), kurrajong (*Brachychiton populneus*) and black cypress pine often occur with the shrub community. These trees either extend from the adjacent woodland or open forest, or are remnants that have survived the secondary establishment of the burgan. In the absence of trees in the site the community remains stable over long periods of time (Kirschbaum and Williams 1991), and tends to preclude the development of natural biodiversity and structure.

Physical environment

Burgan Derived Tableland Shrubland is commonly found on southern to easterly slopes that have been previously cleared of trees, and in fire affected zones where it is an early colonizer that recovers to form a dense layer precluding establishment of trees. It is quite extensive along the northern reaches of the Murrumbidgee River Corridor valley slopes where terrestrial soil moisture appears higher than in the south. In this environment the community occasionally supports large remnant she-oak (*Casuarina cunninghamiana*) well above the usual riparian zone.

Characteristic shrubs

Kunzea ericoides, *Acacia dealbata*, *Acacia rubida*, *Bursaria spinosa*, *Cassinia* spp., *Grevillia juniperina*, *Correa reflexa* and *Kunzea parvifolia*. The climbing *Clematis leptophylla* is also commonly found.

Characteristic groundcover

The dense shrub layer often precludes much ground flora. Kangaroo grass (*Themeda triandra*) was the most commonly recorded species. Other species were infrequent and included *Ajuga australis*, *Euchiton sphaericus*, *Dichondra repens* and *Hydrocotyle* sp. More prevalent were non-vascular plants (mainly mosses) which were not recorded during the study.

Fauna notes

These thickets provide important cover for small birds. In rocky habitats the shrubland provides habitat for reptiles and other small fauna.

Representative site locations

Burgan Derived Tableland Shrubland is well developed along the slopes of the Murrumbidgee River Corridor north of Casuarina Sands and along some sections between Angle Bend and the junction with the Naas River. A stand dominated by *Kunzea parvifolia* occurs north of the junction of Tuggeranong Ck and the Murrumbidgee River.

Condition of the community

It is assumed that this community did not occur extensively prior to European settlement. Instead, the shrub species involved are likely to have been part of the understorey of open forest and woodland (Ingwersen 1985). Following clearance of trees, and after the reduction of intense grazing pressures, burgan becomes dominant (often forming a single species canopy) with a dense cover that essentially out-competes trees that would otherwise shade and probably ultimately out-compete the dominant shrubs (Kirschbaum and Williams 1991). This is essentially a 'disturbance' community that establishes following events that have occurred over various time scales. Successional change in this community may only occur over decades or centuries (Allen et al. 1992; Doherty 1998). Where the community has been fire affected in the river corridor it has recovered well and is likely to persist, whereas the communities that it replaces continue to decline.

Threats or threatening processes

- Excessive burning may be a threat to some of the species of this community but there is little specific information on which to base an assessment. Burgan has the ability to sprout from lignotubers after fire (Kirschbaum and Williams 1991).
- Mono-specific stands of these shrubs may be considered threats to agricultural land use.
- In the case of *K. ericoides*, a derived community with weed status in many situations, any reduction in its vigour is to be supported by replacement with species that are endemic to the sites affected.
- Significant weeds recorded in this community include blackberry (*Rubus fruticosus*), hawthorn (*Crataegus monogyna*), horehound (*Marrubium vulgare*) and African lovegrass (*Eragrostis curvula*).

Figure 28: Burgan Derived Tableland Riparian Shrubland
Burgan Derived Tableland Riparian Shrubland downstream of Angle Bend (above left) where dense burgan dominates a remnant patch of Snow Gum (*Eucalyptus pauciflora*) along the steep valley slope. Derived burgan shrublands are common along the previously cleared moist slopes of the Murrumbidgee River Corridor following major fire disturbance as can be seen adjacent to the Huntly rural lease (below right).

4. Ribbon Gum Tableland Riparian Woodland

Ribbon Gum Tableland Riparian Woodland is dominated by Eucalyptus viminalis, with the very occasional presence of candlebark (E. rubida). A shrubby mid-storey is typically present, over a ground stratum comprising riverine tussock grasses and forbs.

Physical environment

This riparian community typically occurs on the alluvial soils of river floodplains between the high water mark and the edge of the zone of regular inundation on river and creek flats. Along the Murrumbidgee River the soils it occurs on are deep alluvial silty sand and clay deposits usually lying over Silurian volcanic bedrock. This community is known to occur between 550 and 700 m altitude, but the Murrumbidgee River within the ACT extends only to around 600 m where remnants of this community are present. This community also occurs in suitable habitats upstream of the ACT, but much has been cleared.

Characteristic trees

Eucalyptus viminalis, occasional *E. rubida*

Characteristic shrubs

Acacia dealbata, *Callistemon sieberi*, *Leptospermum obovatum*, *L. brevipes*, *L. lanigerum*, *Kunzea ericoides*, *Cassinia longifolia, Dodonea viscosum*, *Lomatia myricoides, Pomaderris* species, *Acacia melanoxylon*, *Acacia pravissima*, *Bursaria spinosa*, *Dodonaea viscosum*, *Gynatrix pulchella*, *Cassytha pubescens*, and *Exocarpus stricta*.

Characteristic groundcover

Poa labillardierei, *Pteridium esculentum*, *Dianella revoluta*, *Epilobium hirtella*, *Geranium* species, *Acaena novae-zelandiae*, *Acaena agnipila*, *Rubus parvifolius*, *Cynoglossum australe*, *Epilobium hirtella*, *Euchiton sphaericus*, *Blechnum* spp, *Poa labillardierei*, *Wahlenbergia* sp., *Lomandra longifolia, Lomandra filiformis*, *Stellaria pungens*, *Derwentia derwentiana* and *Dianella revoluta*.

Fauna notes

Large trees and shrub thickets within this community provide excellent bird habitat. Both living and dead standing mature trees contain hollows and nesting places, and the dead standing trees are used as resting and vantage points for woodland birds, birds of prey and water birds. Earthen alluvial soils favour the emplacement of wombat burrows which are extensive along the Murrumbidgee River Corridor, and other mammal grazers recorded include macropods and rabbits. The steep earthen riverbanks provide ideal habitat for platypus burrows which have been observed feeding in the waterway adjacent to this community. Skinks and water dragons have also been recorded.

Representative site locations

Representative sites are very limited in the Murrumbidgee River valley, although good quality sites occur in the narrow riparian zone of the Cotter River and its tributaries including Condor Ck, between Bendora Dam and the former Lower Cotter River forestry plantation area. It is presumed that this community once occupied close to 22 km of the Murrumbidgee River riparian floodplains in the ACT but is now restricted to degraded remnant stands and isolated trees. The few sites where canopy can be observed occur at Lobbs Hole, Tharwa Sand Wash recreation area, Castle Hill rural lease, Lanyon rural lease and a small regenerating patch at Kambah Pool amongst She-oak Riparian Tableland Woodland.

Condition of the community

Most of this community has been cleared with the estimated proportion of intact canopy in the ACT section of the Murrumbidgee River as low as 9.5% of the likely pre-European extent. It has been extensively cleared and where it remains the mid- and ground- strata are often highly degraded. It is probable that this community once occupied the majority of both banks between

Angle Crossing and Lobbs Hole (~2.5km), but now only several small stands remain. There is also a very sparse remnant of scattered trees over exotic understorey covering 7 km of the Murrumbidgee River downstream of Tharwa village. The community is identified in Sharp et al. (2007) as requiring conservation action.

Where an intact upper stratum remains, the mid-storey is often in poor condition or recovering and the ground stratum is almost devoid of native vegetation. Occasional ribbon gum seedling regeneration was recorded, mainly in stands affected by the 2003 bushfire. The best example of this occurs upstream of Lobbs Hole where the remnant canopy has been almost entirely killed by fire and seedlings are competing with the local emerging shrubs. Elsewhere, where the community has been cleared, African lovegrass often dominates the landscape. Silver wattle (*A. dealbata*) provides the only strong mid-stratum recovery and where it, and the better quality remnant ribbon gum stands occur, African lovegrass is less common. In these areas species such as Patterson's curse (*Echium plantagineum*), viper's bugloss (*E. vulgare*), hemlock (*Conium maculatum*), thistle (e.g. *Cirsium vulgare*) and blackberry (*Rubus fruticosus* agg.) tend to be the most common understorey components.

Threats or threatening processes

- Destruction of remaining mature trees.
- Dieback (as the remaining trees age).
- Lack of regeneration and competition from weeds.
- Inappropriate fire regimes.
- Reduced river flows.

Figure 29: Ribbon Gum Tableland Riparian Woodland

Ribbon Gum Tableland Riparian Woodland in the Tharwa area. The stand of ribbon gum (left) opposite the Tharwa Sandwash recreation area is one of three that retain an intact canopy in the study area. The understorey is highly disturbed, with occasional regenerating native shrubs over an almost entirely non-native ground layer. Also uncommon are remnant mature lone individuals (right) such as this one adjacent to the Lanyon rural lease.

5. She-oak Tableland Riparian Woodland

She-oak Tableland Riparian Woodland is dominated by the river she-oak (*Casuarina cunninghamiana*), typically in pure stands in narrow belts along watercourses and commonly with silver wattle (*A. dealbata*) on the river flats (Barrer 1992). Ribbon gum (*Eucalyptus viminalis*), apple box (*E. bridgesiana*) and to a lesser extent Blakely's red gum (*E. blakelyi*) were also recorded within the community but are uncommon and tend to extend from nearby areas.

Physical environment

The community occurs on alluvial soils and exposed rock, including frequently inundated coarse textured sandy banks and margins along the northern half of the Murrumbidgee River in the ACT. It grows on river and stream banks between normal water levels and maximum flood levels, in particular on sandy and shingle terraces (National Capital Development Commission 1981) as well as among boulder areas within a sandy or silty matrix of alluvium. It can establish in small cracks in solid bedrock and regularly establishes on in-stream rocky islands where old trees display stunted growth due to regular mechanical flood action. In the far northern reaches of the ACT Murrumbidgee River Valley remnants of this community were observed occurring up to 70 m upslope of the riparian zone amongst burgan patches, indicating potentially higher valley slope soil moisture levels in that area.

Characteristic trees

Casuarina cunninghamiana

Characteristic shrubs

Acacia dealbata, A. rubida, Cassinia longifolia, Cassinia aculeata, Callistemon sieberi, Kunzea ericoides, Leptospermum obovatum, Bursaria spinosa, Dodonea viscosum, Hakea microcarpa, Lomatia myricoides, Amyema cambagei, Gynatrix pulchella, Leptospermum obovatum, Rubus parvifolia. Melaleuca parvistaminea is an uncommon shrub that was encountered at Kambah Pool and then on several occasions below Uriarra Crossing.

Characteristic groundcover

Rubus parvifolia, Lomandra longifolia, Dianella revoluta, Geranium solanderi, Einadia nutans, Poa labillardierei, Dichondra repens, Microlaena stipoides.

Fauna notes

Large trees and shrub thickets within this community provide excellent bird habitat. The common dead standing trees resulting from the 2003 bushfire are used as resting and vantage points for woodland birds, birds of prey and water birds. Some of the sandy alluvial soils are favoured sites for wombat burrows. Reptiles were commonly sighted feeding and basking on the abundant rocks, in particular, the Gippsland water dragon (*Physignathus lesueurii howittii*) was regularly sighted. Skinks were also regularly recorded. Although not common, the she-oak mistletoe (*Amyema cambagei*) was sighted, particularly in the northern end of the ACT indicating the presence of the mistletoe bird. The earthen riverbanks provide ideal sites for platypus burrows and platypus have been observed feeding in the waterway adjacent to this community.

Representative site locations

This community occurs along the Murrumbidgee River riparian zone north of Point Hut Crossing to the northern ACT border, and is hosted by several small tributaries.

Condition of the community

Based on current distribution it is estimated that She-oak Tableland Riparian Woodland once occupied approximately 40 km of the Murrumbidgee River riparian zone in the ACT downstream of Point Hut Crossing. This community was heavily impacted by the 2003 bushfire. Many scorched she-oak individuals have resprouted in zones of high soil moisture including riverbanks and in-stream emergent habitat. The majority of trees situated away from the water body, on the

alluvial floodplains have subsequently died. Seedling regrowth has been observed mainly on the river banks and in-stream habitat, with very little on the floodplain where the small number of seedlings that do occur are facing competition from vigorous weed species, especially blackberry. Large swathes of African lovegrass thrive where there is an open canopy and dominate large tracts of the understorey of this community, particularly on the sandy soils where trees have been killed or removed. Many other weed species are established in this community, commonly but not restricted to: Patterson's curse (*Echium plantagineum*), viper's bugloss (*E. vulgare*), thornapple (*Datura stramonium*), burr (*Xanthium* spp.), Californian poppy (*Eschscholzia californica*), fat hen (*Chenopodium albens*), deadly nightshade (*Solanum nigrum*), fennel (*Foeniculum vulgare*), couch grass (*Cynodon dactylon*) and mustard weed (*Hirschfeldia incana*).

The lack of regular flooding and lower rainfall, in combination with weed competition are causing continuing stress to this community. Evidence already exists that successional change is being driven by the combined effect of the 2003 bushfire and the drought conditions that have occurred since then. Where apple box, and to a lesser extent Blakely's red gum, occur on the adjacent valley slopes they are the only tree species recorded to be regenerating by seed on the dry alluvial floodplains, including beneath dead standing she-oaks. In this sense it is possible that in places the only canopy species on the middle to rearward side of the floodplains may soon be eucalypts. Information such as this suggests the need to assess the long term viability of this community in the corridor if climate change results in drier, hotter climatic conditions that will likely result in more frequent fires. It is assumed that the community will successfully persist as very narrow bands in the zones of higher soil moisture; however, a vast reduction in the physical area suitable for the community is the likely result of fewer and smaller magnitude flood events and increased abstraction of water from the river. The community is identified in Sharp et al.(2007) as requiring conservation action.

Threats or threatening processes

- Reduced vigour and resilience to impacts such as fire caused by reduced river flows and overbank flooding due to drier climatic conditions and abstraction of water from the river.
- Inappropriate fire regimes are a potential threat in some circumstances as high intensity fires kill adult trees and increase the ability of weeds to establish.
- Weeds are a threat to the establishment of she-oak seedling and native understorey species.

Figure 30: She-oak Tableland Riparian Woodland
She-oak Tableland Riparian Woodland occupies the riparian floodplains that can be quite broad (top) or relatively narrow consisting of as little as a single band of trees (Figure 15). Healthy mixed age stands typically occur only on riverbanks and more commonly rocky cascades (centre) and mature stands with intact canopy (bottom) are rare following the 2003 bushfire.

6. Broad-leaved Peppermint – Apple Box Tableland Woodland

This is a woodland and low open forest vegetation type in the ACT that occurs on sheltered tableland hill slopes and gullies where aspect or low rainfall create relatively dry conditions. The dominant tree species are apple box (*Eucalyptus bridgesiana*) and broad-leaved peppermint (*E. dives*). Pure stands of apple box also occur and were noted along the river valleys in the northern end of the ACT during this survey. The understorey varies but there is generally a diverse shrub layer and a ground cover of sparse to medium density tussock grass and associated forbs.

Physical environment
This community is widespread in the ACT and occurs on a range of soils, geology and altitude. Within the Murrumbidgee River valley it was often found on the lower slopes and along tributary gullies on shallow volcanic derived soils. Apple box was also observed to be establishing on alluvial floodplains where the previously dominant She-oak Tableland Riparian woodland was affected by the 2003 bushfire.

Characteristic trees
Eucalyptus bridgesiana, E. dives, E. polyanthemos, E. blakelyi, Callitris endlicheri, Brachychiton populneus

Characteristic shrubs
Cassinia longifolia, Bursaria spinosa, Acacia rubida, A. falciformis, Kunzea ericoides, Pomaderris angustifolia, Dodonea viscosum, Clematis leptophylla, Rubus parvifolia, Correa reflexa, Bursaria spinosa.

Characteristic groundcover
Themeda triandra, Poa species*, Austrodanthonia* species*, Hibbertia obtusifolia, Lomandra* species*, Hardenbergia violacea, Dichelachne* species*, Lomandra longifolia, Geranium solanderi, Wahlenbergia* species*, Cheilanthes* species*, Chrysocephalum* species*, Stellaria pungens, Einadia nutans*

Fauna notes
This is a rich habitat with highly diverse flora and fauna. Large trees provide habitat for birds, bats, and arboreal animals. The trees have a relatively reliable nectar flow and foliage growth, which are valuable resources for invertebrates, nectar-feeding and insectivorous birds and bats. The grassy understorey, shrub patches, rocky outcrops and fallen timber provide habitat for mammals, reptiles, birds and invertebrates.

Representative site locations
This community occurs extensively on the tableland slopes and valleys flanking the Murrumbidgee River. It is best developed in the northern half of the ACT Murrumbidgee River valley with good examples on the lower slopes of the Woodstock Nature Reserve.

Condition of the community
Where it occurs within the Murrumbidgee River valley slopes, it has been commonly affected by the 2003 bushfire. However, in all circumstances it was seen to be recovering well, both in terms of canopy regeneration and a high cover of native mid- and ground- layer species. Altered conditions on the riparian floodplain zone may actually favour the long term establishment of apple box in place of true riparian woodland species such as the river she-oak.

Threats or threatening processes

- Grazing by feral animals and inappropriate fire regimes, recreation impact and fire trail construction.
- Weeds are not a major issue in this community but hawthorn (*Crataegus monogyna*), Patterson's curse (*Echium plantagineum*) and African lovegrass (*Eragrostis curvula*) were recorded in some dense patches.

Figure 31: Broad-leafed peppermint – Apple Box Tableland Woodland
Broad-leaved peppermint – Apple Box Tableland Woodland is often in high native condition within the Murrumbidgee River Corridor.

7. Snowgum – Candlebark Tableland Woodland

Snowgum – Candlebark Tableland Woodland is open grassy woodland that fringes low-lying frost-prone areas. Although not observed within the Murrumbidgee River valley, candlebark (*E. rubida*), and less frequently, black sallee (*E. stellulata*) may form part of the canopy structure. In communities that are in good condition, the understorey species are mainly sub-shrub and epacrid species and groundcover is dominated by grasses, typically kangaroo grass (*Themeda triandra*), with a high forb component. All occurrences recorded within this study were in moderate to poor condition and lacked significant native diversity.

Physical environment
This woodland community occurs on moderately deep fertile colluvial soils in central and southern parts of Southern Tablelands and on shallow sedimentary soils in broad valleys from south of Moss Vale to the Monaro region. The community usually occurs on the boundary between woodland and grassland areas where cold air drainage prevents the growth of other eucalypt species. Along the Murrumbidgee River Corridor it was observed occurring in only a few locations, usually on steep valley slopes or small cold air drainage lines.

Characteristic trees
Eucalyptus pauciflora.

Characteristic shrubs
Bursaria spinosa, Acacia dealbata, Grevillea lanigera, Rubus parvifolius, Leucopogon hookeri.

Characteristic groundcover
Poa species*, Austrodanthonia* species*, Austrostipa* species*, Themeda triandra, Brachyscome rigidula, Bothriochloa macra, Lomandra longifolia, Hibbertia obtusifolia, Hovea hetrophylla, Acaena novae-zelandiae, A. ovina, Geranium* spp.

Fauna notes
Understorey and groundcover of this community should comprise the shrub and herbaceous species of adjacent natural grassland or woodland margins. However, it was seen to be variably degraded where observed in the Murrumbidgee River valley and exotic species are common. Thickets of *Kunzea ericoides* near Angle Crossing are suitable for small birds, otherwise very little fauna was recorded during the survey.

Representative site locations
Angle Crossing, Castle Hill rural lease, Red Rocks Gorge. At none of these locations is the community in good condition; however, remnants may still be seen.

Condition of the community
Snowgum – Candlebark Tableland Woodland was extensively cleared during the early pastoral phase on the Limestone Plains, and later, as a result of development of urban Canberra across the grasslands and surrounding woodlands. Clearing has removed all but a few scattered trees in many locations. It is unclear if it was ever extensive within the ACT section of Murrumbidgee River valley; however, it currently only exists in small isolated pockets in fairly poor condition. The area immediately to the north of Angle Crossing is likely to have once hosted the largest patch of the community along the river valley, as evidenced by its occurrence on the river valley slopes and isolated pockets further upslope by the Angle Crossing roadside. However, it is highly fragmented at this location, and in places remains as remnant sparse trees amongst burgan shrub thickets and occasional apple box trees. Weed species and pasture grasses are prevalent in many sites across the ACT, including the remnant patch on the Castle Hill rural lease. This community has been identified in Sharp et al. (2007) as requiring conservation action and is in preparation for nomination as an endangered ecological community in both the ACT and NSW.

Threats or threatening processes

- Dieback (as the small number of remaining trees age).
- Weed invasion.
- Inappropriate fire regimes.

Figure 32: Snowgum – Candlebark Woodland

Snowgum – Candlebark Tableland Woodland in the Murrumbidgee River Corridor is often comprised of highly degraded remnant individuals or stands. The structural integrity is often lacking and the shrub layer may be comprised of aggressive native species such as burgan (Kunzea ericoides) (see figure 28).

8. Black Cypress Pine Tableland Woodland

Black Cypress Pine Tableland Woodland is characterised by low woodland or open forest where black cypress pine (*Callitris endlicheri*) is the dominant species. It is often associated with eucalypts of adjoining areas. There is usually a sparse mid-storey present over a sparse to open herbaceous ground cover.

Physical environment

Black Cypress Pine Tableland Woodland was observed mainly on dry, rocky, steep slopes with skeletal soils. It occurs extensively within gorge sections of the ACT Murrumbidgee River valley but remnants exist in several places where even small narrow slopes occur. These relatively dry, rocky, steep slopes close to the river that are now dominated by eucalypts and shrub species, such as *Bursaria spinosa* and *Grevillea juniperina*, may have once carried more extensive stands of black cypress pine. Its range includes sites that may tend to act as natural fire refuge areas along riparian rocky scarps in relatively warm, low rainfall or topographically dry sites.

Sub-communities

Black cypress pine may be recognised in association or combination with several other dominant trees in woodland stands. Along the Murrumbidgee River Corridor, it occurs as a dominant upper stratum species in the following associations:

Callitris endlicheri – E. bridgesiana
Callitris endlicheri – E. blakelyi – E. bridgesiana
Callitris endlicheri – E. bridgesiana – E. rossii
Callitris endlicheri – E. rossii
Callitris endlicheri – E bridgesiana – E. melliodora
Callitris endlicheri – Acacia doratoxylon

Characteristic trees

Callitris endlicheri, Brachychiton populneus, *E. polyanthemos, E. blakelyi, E. bridgesiana, E. rossii, E. melliodora*.

Characteristic shrubs

Acacia rubida, Acacia doratoxylon, Bursaria spinosa, Acrotriche serrulata, Bossiaea buxifolia, Brachyloma daphnoides, Calytrix tetragona, Cassinia quinquefaria, C. longifolia, Correa reflexa, Dillwynia sericea, Dodonaea viscosa, Daviesia mimosoides, Hibbertia obtusifolia, Kunzea ericoides, Leucopogon species, *Melichrus urceolatus, Pomaderris angustifolia, Pultenaea procumbens, Rubus parvifolius, Clematis leptophylla.*

Characteristic groundcover

Einadia nutans, Dianella revoluta, Brachyscome rigidula, Joycea pallida, Pimelea curviflora, Wahlenbergia species, *Poa sieberiana, Xerochrysum viscosum, Chrysocephalum semipapposum, Leucochrysum albicans, Stellaria pungens, Gonocarpus tetragynus, Stypandra glauca, Cheilanthes* species.

Fauna notes

Very little fauna was recorded in this community during the survey. Much of the area identified as belonging to the community has been severely affected by the 2003 bushfire, with much original canopy having been killed or reduced. Shrub thickets replacing the community provide ideal habitat for small birds, and larger common woodland birds such as the currawong and raven were occasionally encountered. The skeletal soils and abundant rock outcrops provide ideal basking sites for reptiles, although little leaf litter exists to support a high abundance of prey items. A scorpion was observed at one site at the northern end of Gigerline Gorge. Occasionally macropods were observed, with wombat burrows common on the lower slopes adjoining the riparian zone.

Representative site locations

Gigerline and Red Rocks gorges host extensive stands of Black Cypress Pine Tableland Woodland that have been affected to varying degrees by the 2003 bushfire. The eastern slopes of the Bullen Range hosted one of the most extensive stands of this community, but this was severely affected by the 2003 bushfire. The upper riverine slopes north of Casuarina Sands are likely to have also hosted large tracts of this community, but the best remaining example is below Shepherds Lookout near the mouth of the Molonglo River.

Condition of the community

Within the ACT this community was considerably disturbed in the past by rabbit and sheep grazing and clearing during pasture development. Some local use was also made of the timber in fencing and possibly rural buildings (as the timber has some resistance to termite attack). The extent to which this occurred in the ACT Murrumbidgee River valley is not known. The high intensity 2003 bushfire had a major impact on the community, killing a large proportion of the mature trees. When trees are 100% fire scorched, black cypress pine is dependant on seed regeneration. At least 70% or more of adult trees within the Murrumbidgee River Corridor were killed in 2003 and have been replaced by a high cover of successional shrubs, in particular dense red stem wattle (*Acacia rubida*) thickets. Within the river valley black cypress pine seed regeneration was observed but was patchy throughout the river corridor overall. Grazing by rabbits and the drought conditions since the fire appear to be affecting the success of regeneration in several of these areas. In these environments large numbers of dead standing black cypress pine remain amongst associated adult eucalypts that survived, or regenerated after the fire and it is likely in places that these eucalypts will form a new successional dominance. The community is identified in Sharp et al. (2007) as requiring conservation action.

A number of plants uncommon in the area were recorded in this community during the survey:

River Wattle (*Acacia cognata*)
Calandrinia (*Calandrinia eremaea*)
Dryland Purslane (*Calandrinia eremaea*) – an arid zone, western forb
Yellow Burr Daisy (*Calotis lappulacea*) – a western inland forb

Threats or threatening processes

The main threats to recovery of this community include:

- Another severe fire event prior to the re-establishment of mature canopy.
- Inappropriate fire regimes.
- Grazing of recovering seedlings by rabbits (or stock).
- Competition from dense shrub regrowth that may minimise or prevent regeneration.
- This community has an overall native understorey component, but blackberry (*Rubus fruticosus* agg.) and African lovegrass are the most widespread and aggressive weeds and should be contained or controlled. Serrated Tussock (*Nassella trichotoma*) was also recorded.

Figure 33: Black Cypress Pine Tableland Woodland

Black Cypress Pine Tableland Woodland typically grows on the steep rocky slopes of the Murrumbidgee River Corridor. It often contains a largely native mid- and ground-layer and emergent trees such scribbly gum (*Eucalyptus rossii*) may be present (top). Old growth stands (lower left) are very rare and often contain a very sparse, low diversity native mid- and ground-layer. The majority of standing individuals in the ACT Murrumbidgee River valley were killed by the 2003 bushfire and are being successionally replaced by dense shrub growth, particularly red stem wattle (*Acacia rubida*) (lower right).

9. Red Stringybark – Scribbly Gum Tableland Forest

Red Stringybark – Scribbly Gum Tableland Forest is an open forest vegetation type, usually dominated by a sparsely continuous tree stratum of red stringybark (*Eucalyptus. macrorhyncha*) and/or scribbly gum (*E. rossii*). A combined canopy of both species was only occasionally observed along the ACT Murrumbidgee River valley slopes, tending more to patches dominated by one or the other species. The community usually has a well developed shrub understorey and herbaceous groundcover of tussock grass. Bare ground can be extensive on dry exposed sites.

Physical environment
This community can occur between about 550 m and 1130 m in altitude on various substrates, and is common on the exposed, dry, steep, well drained, rocky valley slopes with poorly developed or skeletal soils along the Murrumbidgee River valley.

Characteristic trees
Eucalyptus macrorhyncha, E. rossii, E. mannifera, E. dives, E. polyanthemos, E. melliodora, Brachychiton populneus and *Callitris endlicheri*.

Characteristic shrubs
Acacia rubida, Kunzea ericoides, Bursaria spinosa, Daviesia mimosoides, Cassinia aculeata, Pomaderris angustifolia, Hibbertia obtusifolia, Clematis leptophylla, Pomaderris angustifolia, Pomaderris eriocephala, Rubus parvifolius, Acacia dealbata, Melichrus urceolatus.

Characteristic groundcover
Joycea pallida, Poa sieberiana, Themeda triandra, Hardenbergia violacea, Dianella revoluta, Einadia nutans, Stellaria pungens, Dichondra repens, Acaena novae-zelandiae, Chrysocephalum semipapposum, Hardenbergia violacea.

Fauna notes
As intact woodland this community has the potential to support a range of ground and arboreal mammals and birds. Wedge-tailed eagles were observed nesting within it at a site upstream of the Lobbs Hole track.

Representative site locations
The steep river valley slopes north of Red Rocks Gorge.

Condition of the community
The areas that this community originally occupied had limited grazing value on poor soils but they were often cut for firewood, fencing and rough construction timbers. Where it occurs along the riverine corridor it tends to have a high native species component. Although affected by the 2003 bushfire it is a resilient community that is recovering well and should remain intact with appropriate fire regimes. Two uncommon plant species were recorded in this community during the survey, the Australian anchor plant (*Discaria pubescens*) and *Bossiaea bracteosa*.

Threats or threatening processes

- Inappropriate fire regimes can alter the structure of this community, particularly the shrub and ground flora, and consequently the suitability of it as habitat for particular faunal groups.
- A number of the common weeds were infrequently recorded in this community. Blackberry (*Rubus fruticosus* agg.) was recorded in a number of moist gullies traversing the community, but is unlikely to spread to the usually dry slopes that the community occupies.

Figure 34: Red Stringybark – Scribbly Gum Tablelands Forest
Red Stringybark – Scribbly Gum Tableland Forest often contains pure stands of one or the other dominant canopy species such as scribbly gum (*E. rossii*) (top). The community is common along the dry exposed environment along the Bullen Range (bottom) where it appears to be successionally replacing former Black Cypress Pine Tableland Woodland. The community has a mostly high native understorey component.

10. Yellow Box – Blakely's Red Gum Tableland Grassy Woodland

This woodland community is typically non-riverine and is more common on open and undulating tableland environments. As such a complete description is not included here. In high condition sites, trees form an open canopy above a species-rich understorey of native tussock grasses, herbs and scattered shrubs. It is often transitional between grassland and forest and is frequently interspersed with other vegetation types. Within the incised river valley study area Blakely's red gum (*E. blakelyi*) was recorded more frequently than yellow box (*E. melliodora*) and appears to be more tolerant, or better adapted, to the conditions prevailing on the steep rocky slopes than yellow box. It was occasionally recorded intergrading with Broad-leaved Peppermint – Apple Box Tableland Woodland and Red Stringybark – Scribbly Gum Tableland Forest. For a more comprehensive account of this community refer to the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004).

Physical environment

This community generally occurs throughout the central Southern Tablelands on deep colluvial soils on lower slopes and with loamy soils of moderate fertility on hilly to undulating terrain. Within the Murrumbidgee River Corridor this is true, but Blakely's red gum was often recorded within the incised river valley on steep rocky exposed slopes with shallow skeletal soils.

Characteristic trees

Eucalyptus melliodora, E. blakelyi, E. bridgesiana, E. mannifera, E. polyanthemos, Brachychiton populneus.

Characteristic shrubs

Bursaria spinosa, A. dealbata, Exocarpus cupressiformis, Cassinia longifolia, Kunzea ericoides, Correa reflexa.

Characteristic groundcover

Austrodanthonia sp.*, Austrostipa* sp.*, Themeda triandra, Poa sieberiana, Einadia nutans, Chrysocephalum apiculatum, Chrysocephalum semipapposum, Brachyscome rigidula, Dianella revoluta.*

Fauna notes

The grassy understorey, shrub patches, rocky outcrops, fallen timber and large trees with hollows of all sizes provide habitat for birds, bats, and arboreal animals.

Condition of the community

Much of the community recorded in the survey area contained scattered 'paddock' trees, either Yellow Box or Blakely's Red Gum over highly disturbed understorey components above the river valley proper. On the steep riverine valley slopes, fire and drought tolerant native understorey species occurred beneath Blakely's Red Gum. Within the incised river valley that constituted the focus of the study, the community is marginal at best. It is possibly expanding down into areas more suited to black cypress pine. However, it is unlikely that the characteristic combination of Blakely's red gum and yellow box will establish on the valley slopes and trees establishing there will remain as outliers of a once more extensive community above the river valley proper.

Threats or threatening processes

Further loss of this woodland and threats to the integrity of the ecological community derive from: grazing (including rabbits); dieback; firewood and other timber cutting including 'tidying up'; fire; introduced pests and changes in native species abundance (ACT Government 2004). Weed invasion is common due to the suitability of the environment that it occupies for productive rural land use and this undermines the integrity of the ground strata. The most commonly recorded weeds in this community were African lovegrass (*Eragrostis curvula*) and blackberry (*Rubus fruticosus* agg.), with *Pinus radiata*, hawthorn (*Crataegus monogyna*), saffron thistle (*Carthamus lanatus*), nodding thistle (*Carduus nutans*), Mexican poppy (*Argemone ochroleuca*), Patterson's curse and viper's bugloss (*Echium* spp.) encountered on several occasions.

Figure 35: Yellow Box – Blakely's Red Gum Tablelands Grassy Woodland

Yellow Box – Blakely's Red Gum Tableland Grassy Woodland typically occurs outside of the deep-set Murrumbidgee River valley. It once formed extensive tracts of open woodland.

Non-Vascular Plants and their Contribution to the Murrumbidgee River Corridor

Although they were not recorded during the survey, it would have been impossible not to have noticed the many contributions to habitat made by the non-vascular plants throughout the Murrumbidgee River Corridor. Probably the most readily noticeable contribution, especially in areas with large amounts of exposed rock, was the cover of usually foliose lichens in that arid, hot and hostile habitat. Lichens were present on the crumbly valley slope soils, frequently as crusts holding the otherwise mobile skeletal soils in place. Lichens (particularly *Usnea* spp.) also covered the stems and trunks of shrubs and trees in unburned patches of the river corridor.

Another noticeable group of cryptogams, including an aquatic one, was the Charophyta, or stoneworts with good examples occurring near the mouth of New Station Creek. *Chara* and *Nitella* both occur in low numbers in many of the tributaries of the Murrumbidgee in the ACT and may contribute to the clarity of water where they occur. Other green algae were encountered both in-stream, and in off-stream wetlands, throughout the river corridor. Many riffle banks, noticeably those between Point Hut Crossing and Pine Island, had seasonal flushes of the tufted *Stigeoclonium*, and rafts or clouds of *Spirogyra*, *Oedogonium* and their relatives. The chutes in Red Rocks Gorge and the cascades below Kambah Pool, being poorly shaded and with plenty of oxygenated water, had streamers of blanket weed (*Rhizoclonium* and *Cladophora*). Many riffles and snags are also encrusted with diatoms.

Cyanoprokaryota (blue-green algae) are usually associated with the undesirable planktonic bloom-formers, some of which are toxic. In the Murrumbidgee River Corridor semi-terrestrial encrusting representatives were encountered often contributing positively to the health of the ecosystem. *Nostoc commune* and more frequently *Phormidium* or *Oscillatoria* crusts were found in the base of shallow flood-runners as the pioneers that, with *Riccia* and other liverworts and mosses, hold the freshly deposited sediments in place. So common and prominent were these cryptogam lined flood-runners that it was thought necessary to describe them as one of the sub-communities in the ACT Tableland Fringing and Aquatic Vegetation Complex (see Chapter 5, Part 1).

Mosses and liverworts, like the lichens, contribute to soil stabilization throughout the river corridor. *Grimmia* and similar habit mosses are commonly associated with the foliose lichens on the large areas of exposed rock in the gorge country. Other soil mosses form patches that combine with the leaf litter on the floors of the valley slope woodlands to slow and direct rainfall runoff. In the joints and crevices of the cliff faces and rock outcrops moss 'gardens' were encountered, often with a rich mixture of species. Notable among the mosses were patches of *Dawsonia*, *Polytrichum* and similar large xeric-leafed species. Among the liverworts were *Asterella drummondii*, *Targionia* and several species of *Riccia*. On a seepage-line above one of the off-stream wetlands in Woodstock Reserve an extensive field of a *Fossombronia* species occurs. One wetland in the Woodstock Reserve also had a dense cover of *Ricciocarpus natans*.

Apart from the vivid presence of barmaids blush (*Pycnoporus coccineus*) on burnt fallen wood and stumps, fungi were usually overlooked, but 'puff balls' were noted at times. One striking example was the xerophytic stalked *Tulostoma* sp. aff. *albicans* indicating signs of aridification.

The cryptogams of the Murrumbidgee River Corridor deserve to be included in future survey work.

Figure 36: Examples of non-vascular plants
Examples of non-vascular plants observed in the study area. Moss and lichen 'garden' including *Dawsonia* and *Asterella* (top left); *Usnea* sp. and a foliose lichen (top right); blanket weed (*Rhizoclonium riparium*) in splash zone of cascade (bottom left); foliose and crustose lichens painting a boulder (bottom right).

Chapter 6: Fauna and Habitat in the Murrumbidgee River Valley

River corridors are diverse ecosystems that support a range of fauna including aquatic, semi-aquatic, riverine and terrestrial species associated with the river channel, floodplains and dry slopes. Animals use different parts of the river valley depending on habitat requirements with some groups restricted to particular habitats (particularly river channel species), while others are more transient. Environmental factors such as vegetation community type and condition, landform and geomorphology may also determine the distribution of organisms. Although this was not a targeted fauna survey, incidental records were made of the fauna present and the availability of suitable habitat. Observations and evidence of common species included sightings, home shelters, scats, tracks and organic remains of mammals, birds, reptiles, fish, amphibians and terrestrial and aquatic invertebrates.

Previous fauna surveys of the river valley and its tributaries provide more detailed records of the pre-fire abundance of various species and fauna groups (e.g. Barrer 1992; Rauhala 1993; Rauhala 1995; Rutzou et al. 1994; Osborne et al. 1991; Osborne & Coghlan 2004). The following account provides a summary of incidental records made throughout this survey and can be used as a guide to fauna groups and species that are likely to be encountered within the study area.

Mammals

Common native mammals included three species of macropod: eastern grey kangaroos (*Macropus giganteus*), wallaroos (*Macropus robustus*) and swamp wallabies (*Wallabia bicolour*). Eastern grey kangaroos were seen, usually in groups, in a range of habitat types along the river. Swamp wallabies and wallaroos were recorded less frequently and usually as solitary individuals. Wombat (*Vombatus ursinus*) scats and active burrows were frequently recorded in all habitat types along the river, but most commonly on the sandy riparian soils and lower valley slopes. Past wombat densities within the river valley are not known; however, anecdotal observations by local rural lessees suggest that they have increased in number during recent times. Their excavating activity was one of the few observed causes of soil collapse within the riparian floodplains along with rabbit burrowing and soil slip associated with denuded riverbanks.

Echidnas (*Tachyglossus aculeatus*) and platypus (*Ornithorhynchus anatinus*) were rarely observed but are thought to be common in the study area. A single observation of an echidna was made at New Station Creek, while the only observation of a platypus was made in the Red Rocks Gorge. No accurate measure of platypus abundance has been documented in the study area; however, it is expected that they are common, based on known sightings, public reports and the availability of suitable habitat, particularly consolidated alluvial banks and in-stream complexity. In a separate ACT Government study in February 2008 a single platypus was captured in the Stoney Ck reserve area (Matthew Beitzel pers. comm.). Platypus have also been observed at Pine Island in 2006 and Tharwa Sandwash recreation area in 2006 and 2008 (Luke Johnston pers. comm.).

Although not observed during the study because of their nocturnal behaviour, bats are known to be common along riverine corridors including the Murrumbidgee River due to the range of suitable habitats. Future targeted survey of this area may be useful.

Figure 37: Wombats
Wombats are common in the riparian zone and evidence of their activity can be easily observed. Burrows are very numerous in the sandy soils that dominate the flood zone. Occasional subsidence was observed in the river corridor where both rabbit and wombat burrow sites have undermined the integrity of the soil in the absence of suitable vegetation cover (bottom).

Figure 38: Monotremes
Members of the Monotremata, echidnas inhabit dry slopes (left) and platypus (right) are a top order predator that use the riparian zone for home sites and the water body for feeding and breeding. Platypus population density is a good indicator of ecosystem function.

Rabbit (*Oryctolagus cuniculus*) scats, diggings and burrows are widespread throughout the survey area in all habitat types. Individuals were only observed on a small number of occasions, but damage from their activity was evident across all reaches of the corridor. Rabbit grazing appears to have a detrimental effect on native seedling regeneration, of particular concern is the black cypress pine (*Callitris endlicheri*). Rabbits are a species of major management concern that contribute to soil collapse, erosion and native seedling damage. Fox (*Vulpes vulpes*) scats and tracks were observed across several habitat types, although most commonly along the riverbank. Cat (*Felis catus*) scat and a portion of a cat skull were also recorded. Two observations of possible deer scats were made and a single sighting of what appeared to be a large male fallow deer (*Dama dama*) occurred outside of the river valley in the southern Bullen Nature Reserve. Pig (*Sus scrofa*) diggings and scats were observed at Guises Ck, Upper Gigerline Gorge, New Station Ck, Stoney Ck and Winslade rural leases. Recent pig sightings were reported by rural lessees near the Bullen Range.

Grazing of domestic stock is not allowed within the river corridor. However, domestic stock (or evidence of recent activity) were frequently seen within the river corridor exclusion fencing. Sheep were observed on several occasions and have caused damage to vegetation and soils on the floodplains, particularly near Point Hut Crossing. Cattle were recorded less frequently. Horses are used recreationally along the river corridor, particularly around rural leases and agistment sites.

Figure 39: Other mammals
Sheep grazing is common in rural lands adjoining the Murrumbidgee River Corridor. Historically graziers in the ACT could graze stock to the river front but with the creation of the Murrumbidgee River Corridor this activity is precluded. However, on a number of occasions stock, or evidence of stock activity, were observed on riparian floodplains and hill slopes within the exclusion zone of the study area.

Birds

A diversity of bird species was recorded in all available habitats of the river corridor. A complete list of observed bird species can be found in Appendix 3. Common water birds observed included Pacific black ducks, wood ducks, reed warblers, great cormorants, little pied cormorants and white-faced herons. Wood ducks were often encountered where suitable bank grazing was available. Pairs of foraging white-faced herons were seen within almost every reach. At Tharwa Sandwash and other places where tall standing dead trees were close to the bank, roosts of great cormorants were noted, occasionally accompanied by darters and little pied cormorants. Great cormorants were more frequently encountered above Point Hut Crossing, while little pied cormorants were more common below the crossing except in Red Rocks Gorge. .Reed warblers were heard calling from *Phragmites* and *Typha* beds, both in-stream and in off-stream wetlands, and were common throughout the corridor. Less commonly observed water birds included pelicans, moorhens, banded dotterels and masked lapwings.

Figure 40: Birds I
Great cormorant, pied cormorant and white faced heron on dead ribbon gum stag (top left); rainbow bee-eater (top right); corellas in rare tree hollow of mature ribbon gum at Tharwa Sandwash (bottom left); Pacific black duck (bottom right).

Common woodland species observed included Australian ravens, magpies, crimson rosellas, currawongs, white cockatoos, galahs, thornbills (mostly yellow-rumped) and red browed finches. Various honeyeaters, including noisy minor, red wattlebird and little friarbird, were encountered. Migrating groups of yellow-faced honeyeaters were seen flying upstream through Kambah Pool and Red Rocks Gorge towards Tuggeranong over a three week period between late March and early April. Each group contained about thirty small birds, following closely one behind another. Scarlet, rose and red-capped robins were observed at various times. Both pallid and fantailed cuckoos were heard, and occasionally seen, in the corridor especially in spring. Peaceful doves were recorded near Casuarina Sands, crested pigeons around Pine Island, and brush bronze-wings were seen high on the slopes at Camp Cottermouth.

White-throated treecreepers occurred mainly among the she-oak stands downstream of Point Hut Crossing. Grey fantails and superb fairy wrens used the abundant shrubland and blackberry thickets throughout the corridor, while rufous whistlers and the grey shrike-thrush were commonly heard calling. Both crimson and eastern rosellas and the corvids (Australian raven, black-backed magpie and magpie larks) were often seen in the riparian woodlands as well as the surrounding valley slopes. Rainbow bee-eaters were found in small groups at various places including Tharwa Sandwash, Lanyon Station, Stoney Creek Nature Reserve and Woodstock Nature Reserve. They often used standing dead shrub timber and hunted for prey in localities close to off-stream wetlands as well as the river.

Figure 41: Birds II
White-throated treecreeper (left); pallid cuckoo (right).

Predatory birds observed within the study area included wedge-tailed eagles that were recorded soaring on thermals rising from the river corridor at several locations including Angle Bend, Point Hut Crossing, Lobbs Hole and Stoney Creek Nature Reserve. A large eagle nest was observed in a mature scribbly gum (*Eucalyptus rossii*) on the hill slope near Lobbs Hole. Nankeen kestrels and black-shouldered kites were a common sight in the study area. A nesting pair of peregrine falcons was observed utilising a cliff face and crevice at Shepherds lookout and a further pair at Red Rocks Gorge in the well known nesting area. Brown falcons were observed at Stoney Creek Nature Reserve.

Few records of introduced birds were made other than Indian mynas at a number of sites near urban areas. Blackbirds were heard infrequently throughout the corridor.

Figure 42: Birds III
Cormorants on a sandbar at Tharwa Sandwash (top left); scarlet robin (bottom left); peregrine falcon perches in Red Rocks Gorge (right).

Reptiles

The river corridor contains ideal habitat for reptiles. The valley and hill slopes have a high abundance of both loose rock and bedrock close to floodplains and channels. Rocks provide basking sites for thermoregulation, positions from which to locate prey and sheltered areas for predator avoidance. The sandy alluvial soils provide nesting sites and the river and wetlands with their associated invertebrate species provide both a reliable water source and optimal foraging grounds.

The most commonly observed reptiles were water dragons and skinks. Gippsland water dragons (*Physignathus lesueurii*) were mainly observed in areas close to and within the river channel. They were often seen basking in direct sunlight on bedrock outcrops, using the river as a refuge under threat of predation, or using tree and shrub limbs as sites from which to await prey.

Figure 43: Gippsland water dragons (*Physignathus lesueurii*).

Skinks are common in the river corridor and several species were recorded including the southern water skink (*Eulamprus heatwolei*); copper-tailed skinks (*Ctenotus taeniolatus*); striped skinks (*Ctenotus robustus*); and on one occasion the three-toed skink (*Hemiergis decresiensis*). Although also considered common within the ACT, Cunningham's skink (*Egernia cunninghami*) was only observed at one site near Pine Island. Single observations were made of a jacky dragon (*Amphibolurus muricatus*), a small colony of nobbi dragon (*Amphibolurus nobbi*) and a bearded dragon (*Pogona barbata*). Trails and tracks of what appeared to be large monitor lizards were observed on several occasions. Only two individual snakes were observed during the survey period, a brown snake (*Pseudonaja textilis*) and a red belly black snake (*Pseudechis porphyriacus*). Both species are common in the river corridor and it is assumed that disturbance associated with the survey activity limited further observations. Several eastern long-necked turtles (*Chelodina longicollis*) were observed in permanent off-stream wetlands in the Gigerline Gorge.

Figure 44: Lizards
Cunningham's skink (*Egernia cunninghami*) (top left); bearded dragon (*Pogona barbata*) (top right); striped skink (*Ctenotus robustus*) (bottom left); southern water skink (*Eulamprus heatwolei*) (bottom right).

Figure 45: Eastern long necked turtle
Eastern long necked turtle (*Chelodina longicollis*) in Gigerline Gorge wetlands.

Fish and Amphibians

Frog calls heard during the survey included the common eastern froglet (*Crinia signifera*), the plains froglet (*Crinia parinsignifera*) and the eastern banjo frog (*Limnodynastes dumerilii*). Calls were usually heard around wetlands and areas with an abundance of macrophytes and fringing vegetation. Although several species of frog are common in the river corridor, observations were limited by the daytime survey which is outside usual peak calling times. The froglets were observed in off-stream wetlands, notably in the wetlands at Woodstock Reserve.

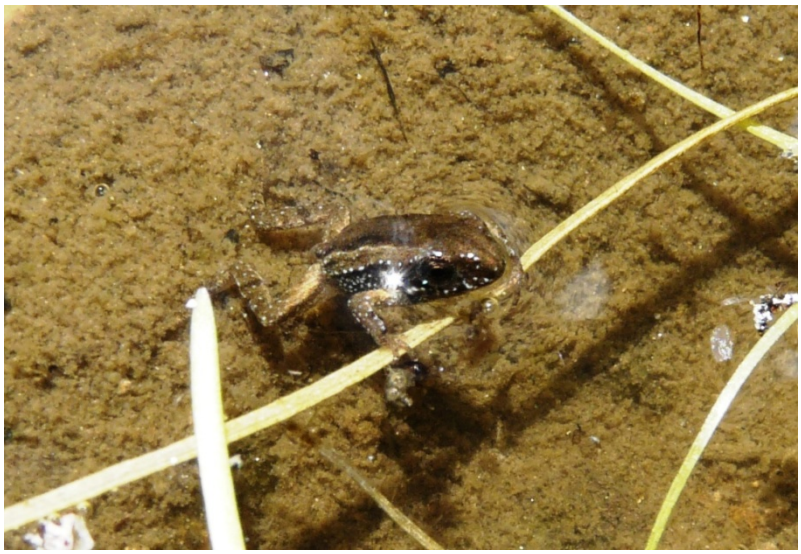

Figure 46: Froglet
Common eastern froglet (*Crinia signifera*) in Woodstock Reserve wetlands.

Both native and introduced fish occur in the Murrumbidgee River. The nature of this survey allowed incidental sighting of fish breaching the river surface including golden perch (*Macquaria ambigua*) and European carp (*Cyprinus carpio*). One Murray cod (*Maccullochella peelii*) was seen when it was caught by boat based fishers at Kambah Pool. Eastern gambusia (*Gambusia holbrooki*) were frequently observed in the shallow water near shore.

Macro-invertebrates

Both aquatic and terrestrial invertebrates were seasonally observed throughout the river corridor. Commonly observed terrestrial invertebrate species included cicadas (Cicadidae), flies (Diptera), ants (Formicidae), a large number of beetle groups (Coleoptera), and moths and butterflies (Lepidoptera). Identifying invertebrate groups below their taxonomic order, and in some cases family, is often difficult. However, given the importance of invertebrates to the overall functioning of the riverine ecology, and limited documentation for the river corridor, the best sub-classifications of observed macro-invertebrates possible are given with some general observations on their ecology or behaviour during the survey period. Observations were restricted to groups with visible terrestrial or water-surface life stages.

In the summer months, when the tea-tree (*Leptospermum obovatum*), bottlebrush (*Callistemon sieberi*), burgan (*Kunzea ericoides*) and sweet bursaria (*Bursaria spinosa*) were in flower, large numbers of flower visiting beetles were observed. Probably the most numerous of these were red-shouldered lycids (*Trichalus ampliatus*), usually in mating pairs. There were also many pairs of nectar scarabs (*Phyllotocus* sp. aff. *apicalis*) along with spotted flower chafers (*Polystigma punctata*); fiddle beetles (*Eupoecila australasiae*); metallic green cockchafers (*Diphucephala* sp.) and a Belidae weevil (*Rhinotia haemoptera*) that mimics the lycids for colour and form. Golden stag-beetles (probably *Lamprima aurata*) and tiger longicorn beetles (*Aridaeus thoracicus*) were observed.

Figure 47: Beetles
Red-shouldered lycid beetles (*Trichalus ampliatus*) (left); golden stag-beetle (*Lamprima* sp.) (centre); longicorn beetle (right).

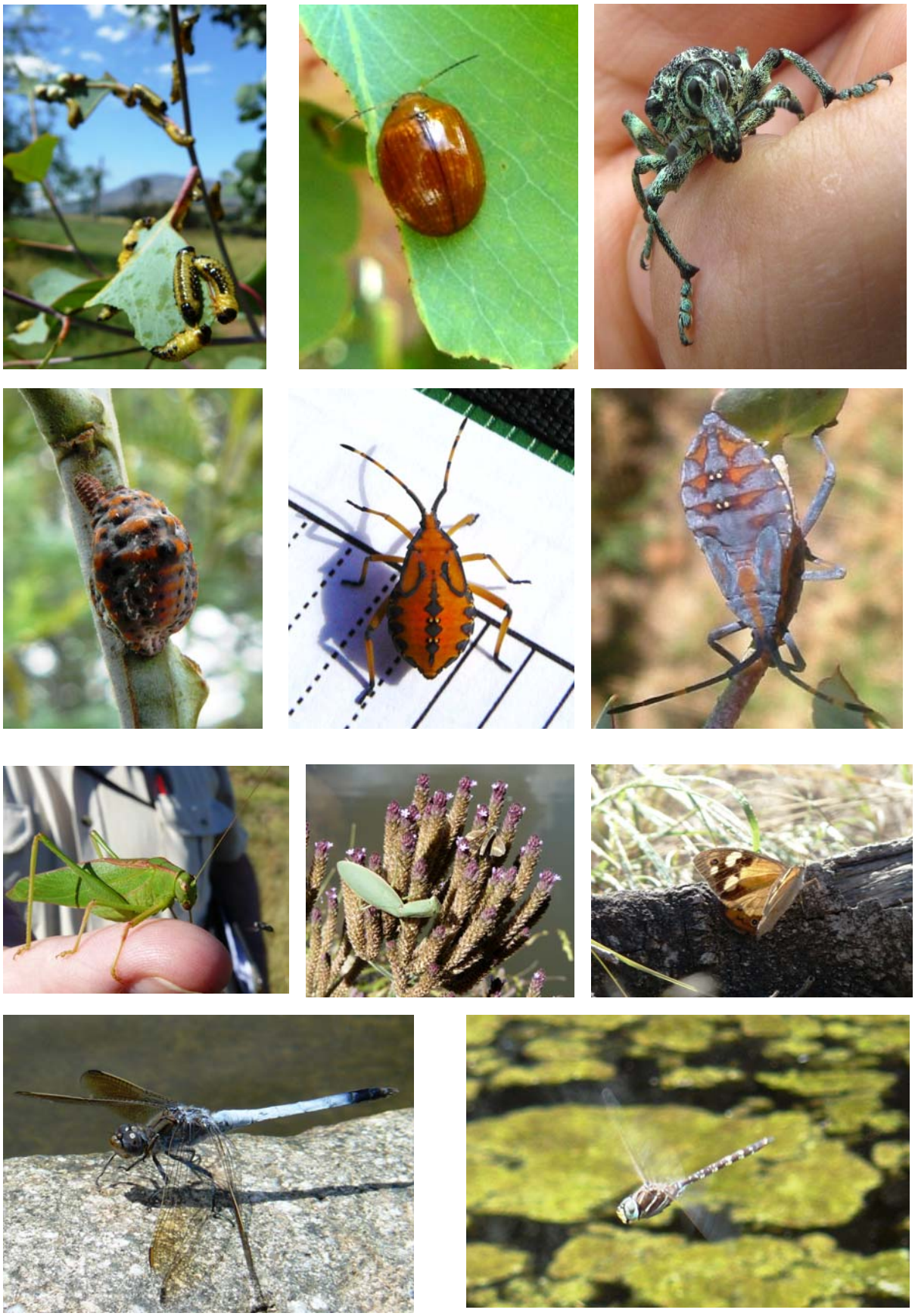

Figure 48: Insects

Eucalypt leaf beetle, larvae and adult (top left & middle); Botany Bay diamond weevil (*Chrysolopus spectabilis*) (top right); wattle mealy bug (second row left); two instars of Eucalyptus bug (*Amorbus alternatus*) (second row middle &right); katydid (*Caedicia* sp.) (third left); garden mantis (*Orthodera* sp.) stalking skipper (third middle); Painted Lady (*Vanessa* sp.) (third right); blue dragon fly (*Orthetrum* sp.) (bottom left); large dragonfly (bottom right).

Figure 49: Arachnids
Bird lime spider (*Celaenia kinbergi*) (top left); trapdoor spider burrow (top right); leaf-curler spider web (bottom left); marble scorpion (lower right).

An array of beetles and bugs were found on the silver wattles (*Acacia dealbata*). These included the spectacular Botany Bay diamond weevil (*Chrysolopus spectabilis*); lurid orange and blue Margarodidae mealybugs and another of the Belidae 'cigar' weevils (*Rhinotia semipunctata*). On occasions large numbers of very tiny metallic green-blue weevils, very like small Botany Bay diamond weevils, were observed pruning new growth on the wattles. Many of the eucalypts had leaf beetle (Chrysomelidae) egg clusters, spitfire-like larvae and ladybird-like adults demolishing the new foliage. One common species was the finely mottled caramel, perhaps a *Paropsis* sp. Another, often on the silver wattle, had a tan head and thorax and black-brown elytra. The other common eucalypt pruning insect was a true bug similar to *Amorbus alternatus* in colour and form. These bugs have vividly coloured 'fiddle back' instars, lemon tipped and spotted with red, red tipped with blue, until the imago appears as an adult crusader bug. The small beetles that produce numerous small holes in the leaves of the native hemp bush (*Gynatrix pulchella*), and to some degree *Adriana tomentosa*, appear to be leaf beetles also.

There were many grasshoppers and katydids encountered during the survey, possibly including Key's matchstick grasshopper (*Keyacris scurra*) in the regenerating ribbon gum woodland at the south end of the Tharwa Sandwash. The most frequently seen grasshopper was the yellow winged grasshopper (*Gastrimargus musicus*), but gumleaf winged katydids (possibly *Caedicia* sp. or *Terpandrus* sp.) were observed on many occasions.

The late spring of 2007 was a very good year for cicadas, especially those often referred to as 'black prince cicadas'. In the woodland above Gigerline Gorge at the margins of the old Ingledene Pine Forest the air in November was thick with them, flying between eucalypts almost without regard to the presence of predatory birds. Although probably widespread throughout the region, cicadas were also recorded in high numbers at Tharwa Sandwash and Pine Island Reserve in the same period of 2007.

The most commonly noted of the Lepidoptera was the introduced cabbage white butterfly (*Pieris rapae*). There were many sightings of jezebels (*Delias* spp.), various browns (*Vanessa* and *Heteronympha* spp.) and small blue butterflies (probably often *Zizina otis*) and even some skippers. One skipper was observed being 'stalked' by a garden mantid (*Orthodera* sp. aff. *miistralis*) (Figure 48).

Commonly observed aquatic invertebrate species included whirlygigs (*Macrogyrus striolatus*); water-boatmen (*Corixidae*), water-striders (*Gerridae*), dragonflies (*Anisoptera*), damselflies (*Zygoptera*) and mayflies (*Ephemeroptera*). The diversity of colour and size among the damselflies and dragonflies is worthy of note. During the survey, green and brown dragonflies, sky blue and black dragonflies (*Crocothemis* sp. or *Orthetrum* sp.), often with duller females, and scarlet dragonflies were seen. The damselflies included an orange threadtail (*Nososticta* sp.) and various combinations of metallic blue and black, sometimes with red individuals. This group could be worth future survey along the Murrumbidgee.

Large number of spiders were observed along with mouse spider burrows and trap-doors, weavers, and webs. Noteworthy was the birdlime or death's head spider (*Celaenia kinbergi*) encountered below the Cotter Pump House near the junction with the Cotter River. Although observed only once, a scorpion was recorded beneath loose rocks in the Gigerline Gorge. Yabbies and freshwater mussels (mostly basket shells, *Corbicula* sp.) and traces of their remains were recorded throughout the survey.

Fauna Habitat Management

The Murrumbidgee River Corridor has been highly modified since European settlement. Introduced weeds such as African lovegrass (*Eragrostis curvula*), willows (*Salix* sp.) and blackberries (*Rubus fruticosus* agg.) in particular have altered the landscape, in some areas out-competing native species in all strata. This has resulted in large scale biodiversity loss from the system with a more uniform suite of exotic species assuming the functional roles of the previously diverse native assemblage. This reduction in diversity presumably has had a negative impact on native fauna diversity, and most of the species currently present are those that have been able to adapt to the altered situation. Blackberry forms extensive thickets in high soil moisture areas and provides suitable bird nesting habitat for small species. Many bird species were observed using willows for refuge and some may also use them for nest sites. Wombat trails were frequently observed beneath and through exotic thickets, which were utilised as sheltered highways, linking home and grazing sites and access to the river. Wombat burrows and trails were also commonly found in the large areas of African lovegrass, which in itself acts to bind the highly erodible floodplain sand and silt, albeit excluding almost all native ground dwelling flora.

Ensuring diversity of habitat

The Murrumbidgee River Corridor supports many resident and visiting fauna species whose continued appearance in the area will only be supported by maintaining the range of integrated habitats that the river provides. These include submerged aquatic habitat and riparian fringes, shrublands and woodlands, ephemeral and permanent wetlands, valley bottom floodplains and various forms of valley slope. Changes in flow regimes and in land use can potentially disturb this dynamic equilibrium of foraging areas, shelter sites and secure positions for everything from Botany Bay diamond weevils grazing on silver wattle to grey kangaroos feeding and drinking. Management should aim to maintain and enhance this equilibrium which is important for building resilience to future bushfires and droughts.

Sensitive programming including top-ups for natural flows rather than setting artificial minimum and maximum intervention levels will keep the critical water table balance in place. This has flow-on for both maintenance of off-stream wetlands (where these are water table dependent) and riparian vegetation (where falls or rises in water table can result in changes in species richness and area of growth).

There will always be drought induced short term changes, and as droughts increase in frequency and intensity along with climatic changes, longer term floristic successions. Both of these changes can be included in maintenance regimes by securing the seed bank of native species taking care to promote local genetic provenance.

A fire maintenance regime that takes into account the biology of both the plants and animals in the river corridor is essential to promote the dynamic equilibrium of the habitats. The frequency and seasonality of burning and fuel load levels need to reflect the life histories of the plant community and its interdependent fauna. This may involve the development of a mosaic burning program that fits in with fire sensitivity, seeding times and lengths of post-fire recovery. There will be pressure for fuel load reduction as perceived by the general public, which requires sensitive handling in areas of the corridor in frequent use or adjacent to urban development.

The corridor forms an important connected series of ecosystems that contain the biological stock for the maintenance of biodiversity and genetic diversity in the immediate hinterland as well as preservation of several uncommon ecosystems and species. The animals, vertebrate and invertebrate, that exploit the vegetation and the biogeography of the system are very much part of this linear continuity. Into the future the conservation of biodiversity needs careful attention, with both a program of reintroduction of locally sourced plants, and a weed reduction regime that maintains habitat while removing pest plants from the seed bank.

Revegetation and Weed Control

There are some key considerations for revegetation programs including the sourcing of suitable seed with preference to local provenance where feasible, defining appropriate locations for plantings, and deciding upon an appropriate planting list in association with rehabilitation of the native components already remaining on the site. Questions to ask include ‘was this vegetation here or highly likely to have been here in the immediate past (150 years)', and then 'has the stock been obtained from a genetically compatible source'. Thereafter, the planting regime should be set up to recreate as much of the whole system as possible, incorporating the range of life forms and as much diversity as possible, with thought given to how well the vegetation will survive in the altered ecosystem and also how well it will cope with the ongoing pressure from introduced species. Plantings should incorporate natural structural diversity to encourage and maintain fauna diversity. Thus it is not enough to plant the tree species, but rather planting must include the mid-storey plants, both low and tall shrubs and climbing or scrambling woody vegetation, and native ground cover plants. This has two important outcomes for reinstating suitable fauna habitat: a) the range of food and home site sources reflects the indigenous flora and so encourages the

indigenous fauna; and b) the indigenous canopy, shrub and ground cover will out-compete invasive plants.

Weed control should be undertaken with an awareness of follow-on effects for fauna. Blackberry thickets are a very real threat to local floral biodiversity. At the same time they provide food, cover and roosts for small bird species, and may also provide cover for smaller macropods and similar native fauna. This means that in some instances, the plants should be killed but the thickets left so as to retain the structure while suitable native replacements are being encouraged. There is also a problem with soil disturbance where weed species are removed and ground cover, particularly cryptogamic ground cover, is disrupted at sensitive times (such as times of high evaporation, radiation or wind). The cryptogamic ground cover significantly helps with soil crust formation and stabilisation. From the perspective of the fauna, this benefits numerous ground dwelling invertebrates.

Wetlands

Fish, turtles and frogs are likely to use wetlands as sites of refuge for breeding, predator avoidance and foraging. Wetlands are associated with a high abundance of aquatic and terrestrial macroinvertebrate species and provide optimal foraging areas for these species. Future management of water levels in the Murrumbidgee River should take into consideration the effect of reduced flows on wetlands and associated species which are dependent on these ecosystems for survival.

Rain- and flood-fed wetlands, often ephemeral and almost always only semi-permanent, provide habitat for specialist organisms whose lifecycles include a spore-like resting stage. These wetlands face local extinction in the face of climate change and detrimental environmental water resource management unless a beneficial microclimate sustains their long-term viability. Thus restoration and maintenance of appropriate riparian vegetation in the immediate vicinity is most important. The perched rock pool wetlands of the Red Rocks Gorge are perhaps the most vulnerable: their biology is designed to persist between flood events or downpours but these events may become fewer and more widely spaced, and at catastrophic levels, without the microclimatic modifications brought about by surrounding riparian and valley slope ecosystems. Of note, the unique shield shrimp (*Lepiduris apus*), one of the oldest living organisms, have been recorded in only two locations in the ACT, one of which are those very wetlands in Red Rocks Gorge (Lintermans & Osborne 2002).

If flow regime modification reduces the minor flows that flush the semi-permanent and permanent off-stream wetlands and maintain the water table that helps keep the wetlands from too rapidly drying out, these diverse and unique ecosystems may either fail altogether, or become increasingly species uniform. While the reedwarblers, water hens and water rats that live in the emergent reed beds may be little affected, the macroinvertebrate larvae that thrive in the diverse marginal communities may reduce both in numbers and variety and so lead to changes in the food web, even to the reduction or disappearance of iconic species such as Murray River crayfish, platypus and certain frog species.

Special note: *Aprasia parapulchella*

The pink-tailed worm lizard (*Aprasia parapulchella*) has been declared vulnerable under the *Nature Conservation Act 1980* (ACT) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth). The species is thought to be patchily distributed along the Murrumbidgee Corridor hill slopes with populations known to occur at Woodstock, Stoney Creek, Bullen Range and Gigerline reserves and also in the lower Molonglo River corridor between Coppin's Crossing and the junction with the Murrumbidgee River (Osborne & Jones 1995). In the ACT, the pink-tailed worm lizard is generally found in open, non-shaded grasslands, particularly with a good cover of native grasses such as kangaroo grass (*Themeda triandra*). Less commonly, the species have been found in woodlands and exotic, pasture improved grasslands, although this usually occurs when native grasslands are located nearby. The lizards shelter beneath shallowly embedded rocks in burrows formed by ants (Osborne et al. 1991). As such, the rocky scree slopes present at several locations along the river corridor are considered suitable habitat and should be managed for conservation of the species. While pink-tailed worm lizards were not observed during the survey, rocky hill slopes with good native grassy vegetation are common and targeted survey within these areas is strongly justified.

Consideration must be taken before planting trees in areas known to support pink-tailed worm lizard populations, as increased shading may negatively affect the lizards. Areas within the riparian zone which are predominately on sandy alluvial soils should pose no problem however rocky hill slopes and open secondary grasslands should be avoided or surveyed extensively prior to planting. It is therefore suggested that revegetation projects within the river corridor target sites with exotic understorey with plantings of native shrubs and trees. This will have multiple benefits in terms of providing canopy to suppress exotic weeds such as African lovegrass (*Eragrostis curvula*), promote biodiversity and healthy ecosystem structure, and avoid impacting areas of native secondary grassland that may support a threatened species.

Chapter 7: Wetlands in the Murrumbidgee River Corridor

It is in the nature of rivers to have secondary channels, flood runners and swampy short term wetlands. All of these are either seasonal or flood and rain filled systems, with deeper, slower drying pools. The Murrumbidgee is no exception and the flow regime reflects its Southern Tablelands location, with spring freshes (and occasional floods) and unpredictable summer storm events.

Surface water in the secondary channels of the Murrumbidgee River Corridor is usually short lived and drains readily through the alluvial soils. The channels themselves occur in sand or mud deposits and may include cobble beds. They dry out quickly but may retain swampy patches in the shallow depressions following the recession of floodwaters. The floor of many of these develops a cryptogamic soil crust, with either *Phormidium*-like or *Nostoc commune* cyanoprokaryota growing alongside patches of thallose liverworts, particularly species of *Riccia* or *Lunularia*. While this flora association is comprised of resurrection-style plants, some native and exotic sedges, grasses and wetland forbs exploit the moist soil patches. Occasionally there are small patches of *Typha* Herbland or *Bolboschoenus* Swamp Sedgeland that persist where the watertable is presumably close to the surface. These environments may be invaded by species of *Mentha*, *Rumex*, *Persicaria,* and *Cyperus eragrostis*.

Within the ACT Murrumbidgee River Corridor three significant groups of wetlands occur that are rather different from the floodplain swampy flood runners described above. The Gigerline Gorge contains perched off-stream wetlands, Red Rocks Gorge has smaller specialised perched wetlands, and there is a wetlands complex at Woodstock Reserve upstream of the Molonglo River confluence.

Gigerline Gorge Wetlands

In the Gigerline Gorge there are flood- or fresh-fed permanent wetlands that form in the perched, secondary river channels (Figure 50). These wetlands are rock bottomed with loose sediment and are seldom directly connected to the main stream. They range in depth from a few centimetres to perhaps 2 metres, are between 1 and 15 metres long, and frequently have a river bottlebrush (*Callistemon sieberi*) fringe. Several had well developed *Typha* Herblands or *Schoenoplectus* Swamp Sedgelands while the shallows supported an interesting mixture of small emergent forbs and sedges including *Alternanthera* sp., *Crassula helmsii*, *Grateola peruviana*, *Centipeda cunninghamii* and *Carex fascicularis*. Willows and weeds like purpletops (*Verbena bonariensis*) and dock (*Rumex* species) also exploit the pool edges. These pools harboured turtles, water dragons and black snakes as well as froglets and numerous aquatic invertebrates.

Red Rocks Gorge Wetlands

The mouth of Freshford Creek in Red Rocks Gorge has a 5 m drop to the river, and the surrounding gorge has perched banks with a narrow river channel including two 2–3 metre long chutes. On the porphyry rock surface of the banks there are quite a number of semi-permanent rock bottomed wetlands. These range in depth from 30 to 500 centimetres and may be lens-shaped and less than 500 centimetres wide, or oval shallow and approximately 1 x 2 metres. The water sources appear to be floods from the river, freshes and seepage from the creek, and rain. Several of the shallow basins have remarkable sedgelands with emergent vegetation to 30 centimetres high, and floristics that include the quillwort *Isoëtes muelleri* and several low growing sedges including species of *Carex*, *Isolepis inundata* and the button sedge *Lipocarpha microcephala* that is only known in the ACT from these wetlands. While one of the lens-like pools has a small but well developed *Typha* Herbland, most are too shallow to support this sub-community. Several pools at the mouth of Freshford Creek, and on the opposite bank, also contained marshwort (*Nymphoides montana*), mudwort (*Limosella australis*) and white purslane

(*Neopaxia australasica*). These extremely small vegetation associations are not common in the ACT, and may only be otherwise found in the high granite country.

Woodstock Reserve Wetlands Complex

The wetlands in the Woodstock Reserve have developed on a complex floodplain with sand bars and flood runners over bedrock. Many of the wetlands are interconnected and open into the main river channel at points. These are commonly oval and 10–25 metres long by 5–15 metres wide and possibly up to 5 m deep. Where the wetlands meet the river channel there is often a sandbar with small gaps. Some of these wetlands show a succession of aquatic and fringing sub-communities. The shore often contains a *Crassula helmsii* – *Persicaria* species association which leads in to *Phragmites australis* Swamp Grassland or a *Bolboschoenus* Swamp Sedgeland and then patches of *Schoenoplectus* Swamp Sedgeland or *Typha* Herbland. On the deep water inside the wetland the locally uncommon water primrose (*Ludwigia peploides*) and floating pondweed (*Potamogeton tricarinatus*) association occurs. There are some shallow low-growing sedgelands and one *Phragmites* Swamp Grassland where the water surface was covered with the floating liverwort *Ricciocarpus natans*.

The delta mouths of New Station, Stoney, and Bulga creeks (the main basal flow creeks in the corridor below Point Hut Crossing) have all developed *Phragmites* Swamp Grassland at the junction with the river. The pools upstream near the junction with the main river have thick beds of watercress (*Nasturtium officinale*) and, in New Station Creek, well developed carpets of stonewort (*Chara* sp.).

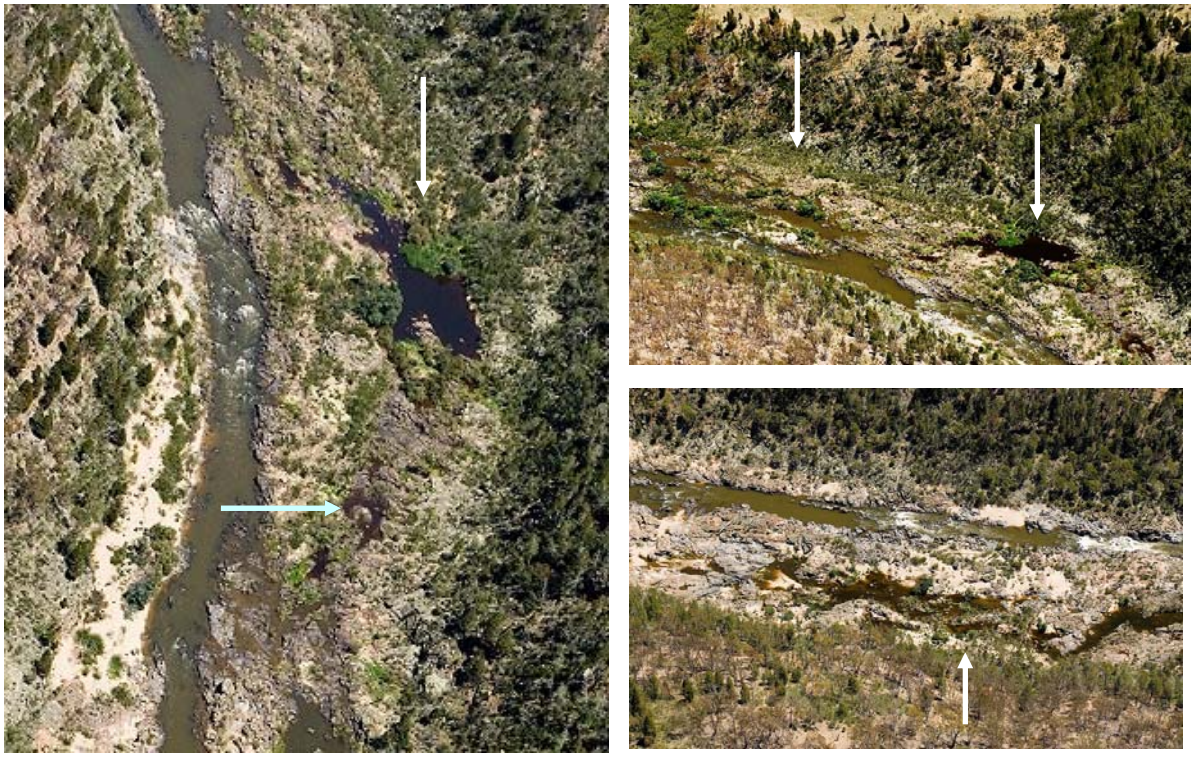

Figure 50: Gigerline Gorge, aerial views of wetlands
Aerial views of off stream wetlands in Gigerline Gorge during higher than usual river level following rain.

Figure 51: Gigerline Gorge wetlands
On ground view of a small number of off-stream wetlands in Gigerline Gorge. These areas support a range of aquatic and fringing vegetation and are faunal refuges providing habitat, food and water.

Wetland Management Issues

Possibly the most confronting aspect of wetland research and management is the apparent individuality of each wetland encountered. For the Murrumbidgee River in the ACT the main wetland management issues are management of flows and invasion by exotic and native plant species.

Management of Flows

Variations in flow provide the dynamics in temperature, water chemistry and water clarity that characterise the wetlands. Flows also result in changes in substrate architecture and refresh raw materials (sand, cobbles or snags). This promotes both animal and plant diversity and also allows the wetland to gradually change in shape and form. Long term reduction in flow leads to various management concerns within the wetland areas. The most immediate is the shrinking of wetlands dependent on watertable level persistence to maintain size. Not only is there a consequent loss or change of both aquatic and riparian vegetation, but the freshly exposed nutrient rich soils may well provide a suitable medium for subsequent weed infestation.

The failure or restriction of minor freshes in the system may have consequences for both the animals and the plants in the system. While there is documentation of animal, particularly fish, responses to such fluctuations in water levels, it is evident that further research into growth patterns in aquatic vegetation may demonstrate similar patterns.

Any management strategy including environmental flows should be designed to allow the river to show both seasonal and incidental variations in flow, both of a level and intensity/duration that meets the requirements of the off-stream wetlands. These wetlands are usually the sources for recruitment and regeneration of both plants and animals after major perturbations (storm floods, droughts and fire damage). The engineering of flows close to the calculated minimum to just keep the system going will not allow the system to thrive, let alone refresh itself after major perturbation. It is a recipe for species depletion in favour of the most hardy and uniform, many of which are likely to be exotic to the system.

Weeds

Aquatic weed species are not usually a problem in the Murrumbidgee River Corridor, and those which do occur were not observed to be invading aggressively. *Cyperus eragrostis* (drain sedge) can be a successful pioneer in the river margins, at the expense of native species such as *Juncus usitatus*, but rarely dominates sites. In the marginal and emergent herblands there are a number of exotic species that have almost become naturalised: *Rumex obtusifolius* and *R. crispus*, *Veronica anagalis-aquatica*, *Mentha piperita* and *M. spicata* and similar species tolerant of high soil moisture and inundation. They often make up a substantial part of the standing vegetation at a site, but blend in to the sub-community rather than overwhelm the native species diversity. One or two species, such as the rush *Juncus articulatus* and watercress *Nasturtium officinale*, are known to dominate and replace native sub-communities, and may require control. This intervention may be as non-intrusive as developing shading from riparian vegetation so that the sun tolerant watercress can no longer survive and the previous stonewort carpet is able to reform, because it is shade tolerant. Sometimes active removal may be necessary.

Sandbars and fresh alluvial deposits are readily colonised by agricultural and wasteland weeds such as the burrs (*Xanthium* spp.), purpletops (*Verbena bonariensis*), hemlock (*Conium maculatum*), fennel (*Foeniculum vulgare*) and many others. These are tolerant of high soil moisture and inundation and will invade the margins of wetlands at the expense of both the low marginal plants (*Crassula helmsii, Limosella australis* and similar sized sedges) and even the emergent plants such as *Bolboschoenus* spp. and *Phragmites australis*. Soapwort (*Saponaria officinalis*) is a specific invader of sandbars that is locally problematic, as it has a stoloniferous

woody root system. It does stabilise many banks and sandbars, but was also observed growing over and out-competing even tree saplings.

Figure 52: Soapwort
Soapwort (*Saponaria officinalis*): smothering sandy soils in the riparian zone, a common sight throughout the river corridor (top left); growing in shade with *Marrubium vulgare* where African lovegrass is shaded by overhead canopy (lower left); and out-competing a ribbon gum seedling within a tree guard near Point Hut – demonstrating the need for follow up action in revegetation plots (right).

The most aggressive and destructive weed species in wetlands, as in creek lines and the rear of floodplains, is blackberry (*Rubus fruticosus* agg.). Given the opportunity this bramble will enter the wetland margins and gradually surround the water body, restricting access to non-avian fauna and choking out the native vegetation cover. It is imperative that wetland margins affected by this weed are managed for its removal. Care may need to be taken in the use of sprays because individual wetlands may not be flushed frequently enough to avoid accumulation of spray residue and there may be ensuing effects on other plants.

Invasive Native Species

Great clubrush (*Schoenoplectus validus*), common reed (*Phragmites australis*) and particularly the bulrushes (*Typha orientalis* and *T. domingensis*) are well represented as marginal reed beds both along the channel and in the wetlands. All of these plant forms are integral in the food chains and nursery habitats for native fish and provide vital natural resources and deserve careful management. Expansion of reed beds in the river channel is usually controlled by dynamics of the flow regime with constant variations in erosion and silting, as well as by flood pruning. Most wetlands are silt traps with nil or minimal flow. Thus the opportunity arises for the reed beds to expand with the deposition of silt or the gradual lowering of water levels. Once reed beds have spread across an area of wetland there is little, except for a major scouring flood, which will curtail the development of single species stands of the reed.

Schoenoplectus and *Phragmites* go through an annual winter dieback, and return with a late spring flush of growth. They are able to be mechanically reduced in winter, and can be restricted in expansion by digging out in front of the patch to a depth that stolons or runners will not exploit. While the same may be done with small patches of *Typha*, the actual bulk of the standing crop and the depth in the water body make bulrushes very difficult to manage mechanically. Early intervention or regular dredging/flushing may be necessary.

Other indigenous aquatic plants may at times reach high densities. This may not be aesthetically pleasing when it occurs but is rarely a major management issue. Ribbon weed (*Vallisneria americana*) and curly pondweed (*Potamogeton crispus*) may seasonally fill the open water of a wetland, but will reduce after flowering. *Azolla* may blanket the surface of a wetland and display pollock-like colourings of reds, purples and greens but will be banked up by the wind and compost to recycle their nitrogen back into the system. This 'problem' will either solve itself, or a minor fresh will move it on, with beneficial nutrient distribution. *Ludwigia peploides* ssp. *montevidensis* is only found below Uriarra Crossing. While it can ‘boom’ it is usually kept in check by insects and climatic conditions.

Blooms of green algae and stonecrops can develop in off-stream wetlands especially in nutrient rich, still, shallow water with little shading. Most of these blooms are transient responses to nutrient flushes. These are unlikely in the Murrumbidgee River Corridor as the geology is not suitable. However, blanket weed (*Cladophora* and *Rhizoclonium*) is persistent and requires management. The usual recommendation where this occurs is to mechanically remove the bulk of the algal blanket and to modify the pH of the wetland by the addition of hay bales.

Cyanoprokaryotic (blue–green algal) blooms in wetlands should be reported and dealt with appropriately. The common causative organisms in the ACT are *Anabaena* (especially *A. circinalis*) and *Microcystis* spp. These cyanoprokaryotes may be toxic to both stock and humans. In the ACT the Environment Protection Authority has responsibility for assessing risks associated with and managing blue-green algae blooms.

Chapter 8: Vegetation Management

The vegetation of the Murrumbidgee River Corridor is highly altered from its original composition and condition. This survey has identified a range of management issues for native vegetation throughout the corridor, in particular, the loss of native biodiversity, the increasing presence of exotic species, and vegetation communities with altered structure and depleted composition. A number of the native vegetation communities are in states of decline, in particular the Ribbon Gum Tableland Riparian Woodland, which exists as only a few remnant stands and isolated trees amongst largely cleared tracts along the riverbank and terraces in the southern river reaches. Land clearing and fire have reduced the tree canopy cover and altered the structural integrity of most of the vegetation communities. Altered river flow, lack of flooding and reduced annual rainfall are likely to continue to impact on riparian vegetation communities and are important considerations in the management of these areas. Over time it will become clearer if successional change will become widespread on the floodplains where dry tolerant eucalypts (such as apple box) will replace areas formerly dominated by riparian communities. Most of the dry valley slope eucalypt communities themselves are well adapted to fire and drought and as such are recovering well from the 2003 bushfire. Other than where they have been cleared, they are usually in high native condition. Only the Snow Gum Tableland Woodland and Black Cypress Pine Tableland Woodland are seen as major valley slope management issues.

Protecting and Enhancing Remnant Vegetation

Protecting and enhancing remnant native vegetation should be seen as the priority action for vegetation management of the Murrumbidgee River Corridor. Much of the original vegetation has been lost from the riparian floodplains and in places from the valley slopes. Once it has disappeared it can never be returned to a natural state and the pool of local stock is either narrowed or lost. Protecting what still remains may include fencing and enhancement through weed control or re-establishing missing structural elements (e.g. native grass, forbs, climbers or shrubs beneath remnant canopy trees). Remnant vegetation provides a valuable source of local genetic stock that can be enhanced by encouraging natural regeneration or through seed collection for use in revegetation projects. Remnant ribbon gum stands on the floodplain, isolated snow gum patches throughout the corridor, and black cypress pine on the valley slopes should all be promoted as priorities for protection, and the state of the She-oak Tableland Riparian Woodland should be monitored.

The long-term ability of Ribbon Gum Tableland Woodland to survive is now under threat from lack of self-regeneration, increasingly unsuitable climatic and environmental conditions, competition from exotic species, and reduced environmental river flows. Protection and enhancement of remnant stands, and re-establishment in areas it once occurred, should be seen as a priority. The ribbon gum stands near Guises Ck, Tharwa and Castle Hill rural lease, as well as isolated trees near Lanyon, Castle Hill and Lambrigg rural leases should be conserved as soon as possible. The snow gum stand immediately east of the river valley just north of Angle Crossing is at present densely invaded by burgan, which poses threats to future regeneration. The snow gum stand in the north of Castle Hill rural lease requires protection from grazing if future generations are to establish. The area that was dominated by Black Cypress Pine Tableland Woodland prior to the 2003 bushfire has seriously declined due to the widespread loss of trees following full scorch of adult black cypress pine. There is an ongoing threat to remnant stands from future fire and lack of suitable regeneration conditions. Removal of rabbit grazing pressure will aid the recovery of existing and future regeneration. Strategic revegetation of the lower slopes throughout the corridor that historically held the community will enhance its ability to persist over time. The She-oak Tableland Riparian Woodland also suffered significant loss of mature trees in the 2003 bushfire but continues to exist, much reduced in vigour, throughout its range. The observation in this survey that it is persisting and reproducing only in the wettest parts of the riparian zone

suggests that the dryness of soil across the floodplains is likely to result in a smaller distribution than the pre-European extent of this community.

Figure 53: Fire and Weed Stress of Communities
Black Cypress Pine Tableland Woodland remnant; half fire-scorched individual tree opposite large-scale fire killed woodlands on the Bullen Range (top left), and small stand at southern end of the Bullen Range that escaped the fire (top right). Ribbon Gum Tableland Riparian Woodland remnant opposite Tharwa Sandwash with weed dominated ground and shrub layers (lower left) and the only ribbon gum seedling observed emerging through the Patterson's curse and mustard weed beneath the large mature trees

The protection of individuals of rare or threatened vegetation species in the river corridor is already seen as a management priority. The only species currently listed as threatened under ACT legislation is the Tuggeranong lignum (*Muehlenbeckia tuggeranong*) which occurs in the Pine Island area. This was recorded at both the south and central areas of the Pine island Reserve on the east (right) riverbank floodplain. The action plan for the species (ACT Gov 2007) lists recommended management actions that are already being undertaken. The uncommon Australian anchor plant (*Discaria pubescens*) was observed at seven locations in the vicinity of Point Hut crossing, Pine Island, Bullen Range and Uriarra crossing, each site with between two and fifteen individuals. At some locations individuals are almost completely engulfed by African

lovegrass. Pale pomaderris (*Pomaderris pallida*) was occasionally seen on valley slopes near Red Rocks Gorge and New Station Creek, but not at all known locations due to the focus of survey effort on the riparian zone. The wetland species, *Lipocarpha microcephala*, or button rush, was recorded in the ACT for the first time during this survey. It was observed at only one location on the perched rock pools in Red Rocks Gorge upstream of the mouth of Freshford Creek. It is unclear if the lack of a previous record for this species is due to lack of survey effort or if it is a recent introduction from coastal New South Wales where it is common. The quillwort (*Isoëtes muelleri*) was also recorded in association with the button rush in Red Rocks Gorge, as well as in the mouth of Freshford Creek. This is a rare species in the Murrumbidgee River Corridor but is likely to be common at higher altitudes. Further intensive surveys of the off-stream wetland vegetation would be likely to uncover other new or rare species or at least a wider range of micro-sedges, in particular species of *Isolepis*, *Carex* and *Schoenus* genera.

Figure 54: Tuggeranong lignum and Australian anchor plant
Tuggeranong lignum (Muehlenbeckia tuggeranong) individual seen in the north of Pine Island reserve (top left) with closer view of male flowers (top right). Australian anchor plant (Discaria pubescens) amongst continuous African lovegrass cover near Point Hut crossing (lower left) and closer view of inflorescence (lower right).

Intervention: Re-establishing Native Vegetation

Although protection of remnant and declining native species and communities should be a high priority, much of the riparian zone requires intervention and re-establishment of native vegetation. Riparian zone floodplains are conduits for the successful colonisation and spread of highly invasive weed species that often out-compete many local native species. Weeds thrive in the altered environment of the Murrumbidgee River Corridor, in particular, without shading and competition from large woody native species. It is known that the fencing-off of areas and removing stock also removes grazing pressure on weed species. The removal of grazing in the Murrumbidgee River Corridor is likely to have contributed to the weed management issue, which now relies on resource intensive physical and chemical treatment. The enormous scale of the riparian weed issue and requirement to replace exotic species with native vegetation requires an ongoing integrated approach. Combining weed control with the appropriate re-establishment of native vegetation is already seen as a major priority that has lacked adequate resources.

The establishment of self-sustaining blocks, or 'islands', of native vegetation with as much structural diversity as possible will complement any weed control activity. The ability of dense blocks of native vegetation, or even simple canopy cover, to out-compete widespread pest plants was observed regularly throughout this study. Re-establishing such blocks requires greater initial investment of time and resources to ensure success than alternative methods of revegetation such as direct seeding or sporadic ripping and planting. However, the long term benefits include the reduced area that requires follow-up visits to control invasions of new weeds, added habitat complexity, and establishment of self-sustaining blocks that can later be expanded using a Bradley style vegetation regeneration concept (Bradley 1988). While deriving from more general principles, decisions regarding revegetation methods need to be tailored to the land in question, the management issues on that land, and the desired outcomes (objectives).

In the initial planning phase of a revegetation project it is important to know which vegetation community it is intended to reconstruct at a site, and the suitable species, based on the information in the tables (Appendix 1). Doing so will ensure a greater success rate for the project and at the same time maintain and enhance ecological integrity. The vegetation community maps provided in the appendices of this report provide detailed spatial information about where each vegetation community should occur, any observable vegetation dominance change and priority sites for management (Appendix 5). Careful consideration needs to be applied to selecting suitable parts of the riparian zone for planting with appropriate species during revegetation projects. In the case of riparian restoration work it is likely that the greatest success for many species will be where soil moisture allows plants to establish, including the riverbank, the base of secondary channels, flood runners and ephemeral wetlands, and adjacent to permanent wetlands. Information is provided in the tables (Appendix 1) about the particular parts of the river valley where each species is likely to occur. This information is included to assist with the matching of species to locations and landscape positions. Such information has applicability to both plantings and direct seeding. At the same time, care should be taken when removing existing weed species that currently bind the soils, and provide structural stability, as well as habitat and riparian filtering functions. The following are examples. Deep rooted exotic trees on the riverbank should be replaced with other deep rooted local native trees. Native river tussock (*Poa* sp.) is a suitable replacement for riparian African lovegrass. On the dryer slopes and elevated outcrops, any of the local dry tussocks (wallaby grasses, spear grasses and kangaroo grass) are suitable replacement species. Native shrubs should be considered when replacing blackberries to provide habitat for small birds and other species.

Intervention: Weed Control

Riparian areas are particularly vulnerable to invasion by weed species because of disturbance associated with floods, and recurrent input of large amounts of weed propagules from adjoining land, upstream and tributary waterways. Weeds in the Murrumbidgee River Corridor are one of the largest and most resource demanding environmental management issues. It is beyond the scope of this document to provide detailed management actions for the comprehensive handling of such an issue. However, based on the survey, an outline of the key problem species and suggestions for their management actions are provided below.

It should be noted that there is a growing body of literature on riverine weed management, with a focus on temperate south-east Australian waterways and the Murrumbidgee River in particular. Starting points include the CRC for Australian Weed Management riparian habitat management guide (Ede and Hunt 2008); riparian vegetation management techniques for the upper- and mid-Murrumbidgee catchment (Wilkinson et al. 2004); the Australian Government online weed resource (Australian Government 2008); and *Bush Invaders of South-east Australia* (Muyt 2001). A strategic framework for weed control in the ACT is provided by the *ACT Weeds Strategy 2009–2019* (ACT Government 2009). A number of the ACT Department of Territory and Municipal Services Parks and Conservation staff, particularly some of the ranger staff based at the Murrumbidgee River Corridor and Namadgi National Park have excellent first hand knowledge of tried and tested management techniques. Observations and notes on facets of individual species recorded during this survey may be found in Appendix 1.

The *Pest Plants and Animals Act 2005* (ACT) provides regulatory authority for the management of pest plants in the ACT. Under this legislation the ACT has established the *Pest Plants and Animals (Pest Plants) Declaration 2005* (No 1) (DI2005–256) which contains a list of declared pest plants and prescribes the management actions required. A number of species on that list were recorded in the study area and are listed below:

Plant species in the study area that must be suppressed:

> Nodding thistle (*Carduus nutans*), African boxthorn (*Lycium ferocissimum*), briar rose (*Rosa rubiginosa*), all willows except for the weeping willow (*Salix* spp.), Noogoora burr (*Xanthium occidentale*) and Bathurst burr (*X. spinosum*).

Plant species in the study area that must be contained:

> Saffron thistle (*Carthamus lanatus*), hawthorn (*Crataegus monogyna*), Paterson's curse (*Echium plantagineum*), viper's bugloss (*Echium vulgare*), African lovegrass (*Eragrostis curvula*), St John's wort (*Hypericum perforatum*), serrated tussock (*Nassella trichotoma*), radiata pine (*Pinus radiata*) and blackberry (*Rubus fruticosus* agg.) except for certain permitted cultivars.

Plant species in the study area whose propagation and supply is prohibited:

> Cootamundra wattle (*Acacia baileyana*), box elder (*Acer negundo*), tree of heaven (*Ailanthus altissima*), cotoneaster (*Cotoneaster* spp.), English ivy (*Hedera helix*) white poplar (*Populus alba*), Lombardy poplar (*Populus nigra*), firethorn (*Pyracantha angustifolia*), black locust or false acacia (*Robinia pseudoacacia*) and periwinkle (*Vinca major*).

Listed weeds of national significance (WONS) (Australian Government 2008) within the study area include blackberry, serrated tussock and all willows (except *Salix babylonica*, *S. x calodendron* and *S. x reichardtii*). Prior to its completion the preliminary WONS list was reduced from seventy-one nominations to a final twenty. Several species that were nominated but not included in the final list occur within the river corridor that are just as significant management issues including: St.

John's wort (*Hypericum perforatum*); Mexican poppy (*Argemone ochroleuca*); Paterson's curse (*Echium plantagineum*); African lovegrass (*Eragrostis curvula*); broad-leaf privet (*Ligustrum lucidum*); Scotch thistle (*Onopordum acanthium*); broomrape (*Orobanche* spp.); wild mignonette (*Reseda luteola*); Bathurst burr (*Xanthium spinosum*) and Noogoora burr (*Xanthium strumarium*). The ACT Weeds Strategy (ACT Government 2009) provides the framework for control of these species in the river corridor. Other weeds that occur along the river corridor are listed as declared noxious weeds in neighbouring New South Wales and their control in the ACT should be considered in a regional framework.

Overall, the weeds observed in this study that most dominate and suppress native vegetation are African lovegrass and blackberry. These species have caused serious damage to native biodiversity in the river corridor as well as spreading to neighbouring rural lands adjoining the study area. Together with other weeds spreading from within the corridor, they cause productivity and other economic impacts. Willows are an ongoing management concern. To a certain extent they are being successfully managed in the corridor. Unfortunately, even if willow numbers are controlled within the Murrumbidgee River Corridor in the ACT, there is a large stock in tributaries and upstream from which future infestations can arise. Therefore, an integrated approach across sub-catchments and jurisdictional boundaries is necessary. In the case of willows, until upstream and tributary problems are sufficiently dealt with, ongoing resources will be needed in the ACT to control new infestations. Throughout the survey, many superficially willow-free areas were found to contain seedlings that will require future control.

African lovegrass occurs throughout the entire river corridor on both the valley slopes and, prolifically, on the riparian flood plains where it thrives in the sandy soils in the absence of canopy cover. In only a few places is it unable to get a foothold. These areas are mainly where the surface is predominantly exposed solid bedrock (although it establishes within small cracks where soil occurs) and beneath the shade of dense overhead canopy, either tree or shrub. Plantings of ribbon gum near Tharwa Sandwash contain a dense mid-storey of silver wattle beneath which most common ground weeds, including African lovegrass, appear suppressed. Likewise areas with intact she-oak canopy contain very few ground weeds, including African lovegrass, even where all adjacent exposed ground is dominated by the species. Initial control (fire, chemical) and follow up, with dense plantings or direct seeding of canopy forming species, could be a key guiding concept in the eventual exclusion of the species from areas within the corridor and beyond.

Blackberry forms dense thickets wherever soil moisture is moderately high (riverbanks, floodplains, gullies on hill slopes). Like African lovegrass, blackberry can suppress all but the hardiest native vegetation. The extent of the problem is such that a major commitment of resources is required not only to treat the thickets, but also for subsequent follow up treatment and revegetation. This is exacerbated by the difficult locations of many thickets. One alternative cost effective solution that has been considered and used elsewhere is grazing and browsing by goats within temporary fenced areas. This is only appropriate where native vegetation at the sites is minimal or has been totally removed. Observations elsewhere of old man's beard (*Clematis microphylla*) climbing and outcompeting blackberry thickets may also be worth considering as an alternative experimental technique (Luke Johnston pers. comm.).

There are numerous woody weeds that exploit riparian areas, and in the MRC these are all northern hemisphere deciduous species no longer permitted to be sold in ACT nurseries. The poplars and cottonwoods (*Populus* spp., especially *P. nigra*) were often planted for landscaping and bank management in the Tharwa area and around most recreation areas. Management and eradication is often difficult as these trees readily coppice, especially after the main trunk is removed. Biological controls like poplar rust slow down growth and affect vigour rather than killing the tree. Poisoning is the main option, but needs several applications.

Box elder (*Acer negundo*) and Chinese tree of heaven (*Ailanthus altissima*) both invade the riparian zone after floods, by seed or cuttings. Both require management as they can coppice

readily, and *Ailanthus* does so as a matter of course. Seed loads are considerable and viability is high. Poisoning is likely to be the most reliable method of control.

English Elm (*Ulmus procera*) was once a regular garden tree in rural Australia along with *Salix babylonica*, *Prunus* spp. and the privets (*Ligustrum* spp.). The elms and plums readily coppice, and plums and privets are spread by seed. Management requires vigilance, and early intervention.

Figure 55: The Effect of Shade on African lovegrass
The effect of shade on African lovegrass. Lovegrass was rarely observed beneath dense remnant she-oak (top left and bottom) and thickets of silver wattle (top right). Replacement of native ground cover is still important to prevent establishment of other shade tolerant weeds such as *Saponaria officinalis* (see Figure 52).

Although not listed as pest plants in the ACT, a number of other species occur in the corridor that dominate sites and suppress native regeneration and biodiversity. These include: wild oats (*Avena* sp.), skeleton weed (*Chenopodium album*), couch grass (*Cynodon dactylon*), mustard weed (*Hirschfeldia incana*), white horehound (*Marrubium* vulgare), elm (*Ulmus* sp.), purpletops (*Verbascum thapsus*) thornapple (*Datura stramonium*), canary grass (*Phalaris aquatica*) and drain sedge (*Cyperus eragrostis*) among others. Although not listed as requiring action these should be considered as invasive as many of those listed under legislation and be treated in the same way. The exotic cutleaf water parsnip (*Berula erecta*) was recorded for possibly the first time in the ACT; however, it is a species rarely seen in New South Wales and is presumably of little

management concern. Potential sleeper species such as three-corned jack (*Emex australis*), caltrop (*Tribulus terrestris*) and spiny burr grass (*Cenchrus longispinus*) were also recorded in a small number of sites, but are known to be difficult to eradicate once established.

As the river corridor contains many weed species, it is important to decide whether to take a site based approach and create strongholds of remnant and revegetated native vegetation, or whether management actions should focus on key weed species across the entire area. In any case establishing core areas that are resilient to weed re-invasion should be seen as important. Techniques involving physical, chemical or biological control are each effective, but also have limitations. Within the Murrumbidgee River Corridor many areas are difficult to access by vehicle, on foot or by boat depending on the reach. Many of the core infestations occur in these areas and although this presents a challenge, will need to be overcome if holistic rehabilitation of the riverine corridor is to be achieved. This will require careful planning and greater-than-normal resources. Biological control can be effective in these situations, for example, the blackberry rust may be appropriate for dealing with the thickets that are choking the inaccessible reaches along the western river banks of the Bullen Range. In the case of biological control, it is always important to ensure that the decline of a dominant weed species does not result in an increase in others and should be part of a site or reach remediation plan.

The extent to which these issues affect the health of the river system can be viewed in several ways. The system is to a certain extent functional, with a good cover of vegetation in most places, which maintains soil stability and provides fauna habitat. The highly erodible riparian soils are bound predominantly by African lovegrass with a suite of other weed species. Exotic shrub thickets, in particular blackberry (*Rubus fruticosus* agg.) provide structure in which native birds readily shelter, although these also harbour introduced pests such as rabbits and foxes. In addition, as a consequence of disturbance, native shrub thickets are widespread, in particular silver and red stem wattle which, along with other profusely flowering native shrubs, provides nectar sources for invertebrates and in turn other species higher up the food chain. The health of the aquatic habitat is closely linked to the health of the riparian environment and the present lack of intact riverbank canopy is likely to be impacting on water temperature as well as the levels of in-stream woody debris that provides habitat and substrate diversity. However, the biggest issue with the present high density of exotic species is the loss of native plant diversity and abundance. At present it is merely a functional ecosystem rather than a healthy one. Competition from exotic species affects natural regeneration of native species, and in turn communities that are already under threat of future collapse. Altered vegetation structure and a changing climate that leads to stands of single exotic species are likely to have negative impacts on native fauna assemblages.

Chapter 9: Summary of Management Recommendations

Various recommendations have been made throughout this document regarding different aspects of the study area. The information gathered throughout the study can be seen as a guide for contribute to future planning and management of the Murrumbidgee River valley in the ACT. Following is a summary of the major recommendations:

- **Protection of remnant vegetation communities**
- **Implementation of vegetation monitoring and further survey**
- **Weed management**
- **Re-establishment of indigenous vegetation**
- **Wetland appraisal and management**
- **Fauna and habitat management**
- **Appropriate water resource management**

Protection of remnant vegetation

The protection of remnant vegetation is a major priority, in particular the Ribbon Gum Tableland Riparian Woodland, Snow Gum Tableland Woodland and Black Cypress Pine Tableland Woodland. Patches of remnant vegetation should be seen as core zones from which to enhance and expand existing or remnant vegetation (see Chapter 8).

Implementation of vegetation monitoring and further survey

The development and implementation of a long term monitoring plan to statistically describe the patterns observed from this mapping study would provide a basis from which to assess long term change as well as to measure the success of on-ground improvement works. Belt transects (Appendix 4) could provide information on changes within and across sites such as vegetation succession. Fixed area plots are required to benchmark vegetation communities and provide a statistical representation of changes within them. The ability to select sites for monitoring has now been greatly enhanced through resolving the spatial distribution of the vegetation and geomorphology of the river corridor. Sites could be monitored on a seasonal or annual basis. The cryptogam component in the vegetation communities play an important role and could also be included (Eldridge et al. 2003).

River catchments are diverse and dynamic and it is important not to consider the small section of the Murrumbidgee River within the ACT in isolation. The river upstream of the ACT and its major tributaries all contribute to the patterns observed during this study. An understanding of the types of vegetation communities and their condition is important. Defining priority areas for conservation management, especially weed control, is central to managing the Murrumbidgee River environments within the ACT. Vegetation patterns and simplified condition assessments could be conducted remotely to define conservation management priority areas using a scaled back model of the methods used for this study. A combination of remote aerial photographic interpretation and rapid ground assessment would efficiently provide the desired information within the major tributaries and upper catchment.

Weed management

The occurrence and magnitude of weed invasions have been highlighted throughout this document (in particular Chapter 8). Priority should be given to nationally and regionally listed weeds (ACT Declared Pest Plants, Weeds of National Significance, NSW Declared Noxious Weeds). The two species observed to be causing the most significant negative impact on native biodiversity are African lovegrass and blackberry. Other species, such as Paterson's curse and viper's bugloss (Appendix 1), are out-competing native species as well as causing economic impacts on surrounding rural lands as they spread from the river corridor. Where resources allow, all weed control should be undertaken in an integrated manner incorporating aspects of physical removal, safe chemical application, fire (possibly), and most importantly the re-introduction of indigenous native vegetation most suited to the local habitat and micro-climate (Appendix 1). A regional approach will often be necessary (e.g. for willows). Adequate, ongoing follow up is required.

Re-establishment of indigenous vegetation

The combination of spatial information relating to vegetation community distribution and condition (Appendix 5), priority areas for conservation action (Appendix 6) and provision of species suitable for each area (Appendix 1) provides a baseline for a well informed and planned program to reintroduce native vegetation of suitable provenance into appropriate sites within the river valley. Well structured native vegetation (forbs, grasses, shrubs and tree species), rather than just trees or shrubs, will provide greater long-term habitat values and more resilience against future weed invasion (Chapter 8). Possibly the way to achieve the greatest benefit will be to work from existing stands of native vegetation gradually into degraded areas, creating corridors or habitat belts. Some difficulty may be encountered planting into the rapidly draining sandy soils of the riparian zone and measures should be taken to ensure survival of potted plants. Alternatively direct seeding in combination with appropriate site preparation may be suitable. Follow up should always be undertaken to ensure survival of reintroduced native vegetation and control of the inevitable ensuing weed re-establishment.

Wetland appraisal and management

Three concentrations of off-stream wetlands were documented in this study (Chapter 7), along with several tributary creeks that have wetland functions. Knowledge of the vegetation, especially seasonal species, endemism of both flora and fauna, and the hydrological processes that maintain these habitats is limited at present. A high priority action arising from this study is the need for a full assessment of the component wetland vegetation composition and dynamics, as well an understanding of the hydrological processes that support them.

Fauna and habitat management

The native fauna within the survey area is diverse (Chapter 6) and adapted to the highly altered environmental conditions. When managing invasive plant species, attention should be given to carefully replacing these species with functionally similar native species to re-establish habitat to sustain existing fauna populations (e.g. replacing blackberry with native raspberry, African lovegrass with river tussock). Future surveys and monitoring of aquatic and terrestrial fauna should be undertaken to fully assess the diversity within the corridor. Management of feral animals such as rabbits, pigs and potentially deer should be a high priority.

Improvement of environmental flow allocation for riparian health

Surface water flows in the upper Murrumbidgee River and its tributaries have been significantly altered since European settlement. The building of Tantangara Dam and associated transfer of water to Eucumbene Reservoir, as well as extraction for commercial and domestic purposes, have resulted in reduced surface water discharge and flow variability in the upper Murrumbidgee River (NSW EPA 1997). Environmental flow regulations are already in place within the ACT (ACT Government 2006) and modelling of surface water availability has been undertaken (CSIRO 2008a). The reduction in flow in the ACT as a result of upstream extraction (99% of inflow to Tantangara Reservoir) has left the Murrumbidgee with reduced base flows, lower flood peaks and floods of shorter duration. This presumably has led to a reduction in overbank flows in the ACT, which has likely reduced the resilience of its riparian vegetation communities. This has been evidenced during this survey by the lack of recovery of riparian woodland from the 2003 bushfire, along with associated incursion of non-riparian canopy species onto the dry floodplain margins. Further negative impacts on the health and resilience of the riparian zone as a result of reduced overbank flows should be minimised.

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