Donnelly River
River Action

2006

SOUTHERN FORESTS LANDCARE

WARREN CATCHMENTS COUNCIL

action
Salinity & Water
AUSTRALIA

Natural Heritage Trust
Helping Communities Helping Australia

"While other catchments in south western Australia are faced with costly Recovery Management Plans, principally salinity and decreased water quality, those of us associated with the Donnelly are in the very fortunate position to inhabit a catchment that is in very good health. The development of the Donnelly River Action Plan is an opportunity for landholders, appropriate government departments and the community to focus on a joint effort to preserve and enhance our current unique position. A genuine and committed collaboration of all beneficiaries, an equitable contribution of resources and really in the greater scheme of things- minimal input, we will be able to sustain a river system that encourages productivity, profitability and a diversity of human activities without compromising a highly valued natural resource"

- Eric, Yvonne and Jane Phillips, upper Donnelly catchment landholders

Donnelly River
Action Plan

2006

Prepared for Warren Catchments Council- Southern Forests Landcare
and
the Manjimup Land Conservation District Committee

Funded by the Natural Heritage Trust and the National Action Plan for
Salinity and Water Quality

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How to use this river action plan

How to use this river action plan

This report was prepared for the Manjimup Land Conservation District Committee (LCDC), government agencies and landholders in the Donnelly River catchment. It is hoped that by providing this summary of Donnelly River foreshore condition and weed presence, future works in the area can be more focused on identified management priorities and issues.

The action plan is separated into eight sections. A brief overview of the river action plan and key findings is given in the summary. The Donnelly River has been divided into nine sections for assessment and reporting purposes. A map accompanying the summary (Figure 1, p. vii) gives an indication of these sections. This overall map relates to smaller, section-specific maps in Section seven.

Section 1 provides background information on the river action plan, including aims and objectives of the study and involvement of various groups and persons.

Section 2 outlines the study area, covering issues such as landscape, climate, flora and fauna, as well as Indigenous heritage values.

Section 3 covers general river processes as well as water quality issues specific to the Donnelly River.

Section 4 provides an overview of the methodology involved in assessing foreshore condition. Section 5 outlines management issues identified as a result of the foreshore surveys.

Section 6 contains recommended management advice.

Section 7 contains section-specific maps, with information concerning general site description, foreshore condition rating, fencing status, management issues and weeds.

Section 8 is a summary of findings.

Section 9 lists references cited within this document.

Acronyms

CENRM	Centre of Excellence in Natural Resource Management
CALM	Department of Conservation and Land Management (now known as the Department of Environment and Conservation)
DAFWA	Department of Agriculture and Food WA
DEC	Department of Environment and Conservation
DIA	Department of Indigenous Affairs
DoE	Department of Environment (now known as the Department of Environment and Conservation)
DoW	Department of Water
LCDC	Land Conservation District Committee
NHT	Natural Heritage Trust
NRM	Natural resource management
SFL	Southern Forests Landcare
SWCC	South West Catchments Council
WRC	Waters and Rivers Commission

Cover photo: Donnelly River, photo Jenni Munro

Acknowledgments

Warren Catchments Council wishes to acknowledge the traditional owners of the South West region, the Nyungar[1] people. Nyungar people have a long-standing and continuing association with the South West area and are recognised as the traditional owners and custodians of the areas referred to in this document.

The Donnelly River Action Plan was an initiative of Southern Forests Landcare as part of a wider SWCC project to develop multiple River Actions Plans across the south west region. The project was funded by the Natural Heritage Trust (NHT) and the National Action Plan for Salinity and Water Quality (NAP). These funding bodies are joint initiatives of the State and Australian Federal Governments, which are administered by the South West Catchments Council. Thanks and acknowledgements go to GeoCatch for planning that went into the current RAP method and RAP template. GeoCatch and Cape to Cape are further acknowledged for developing and managing the RAP project.

Previous river action plans developed for waterways in the South West provided guidance and direction in the development of the Donnelly River Action Plan and these resources were extensively consulted during report preparation. Additional interaction with NRM officers developing river action plans was invaluable. The cooperation of landholders in undertaking foreshore assessments and attending project information meetings is greatly appreciated.

Liesma Kukuls of the Department of Environment Regional Support Branch, Perth, prepared the maps used in this document and thanks must also go to David Morgan and Stephen Beatty from the Department of Freshwater Fish Research at Murdoch University for the fish fauna information that was used in this report.

Reference details

The recommended reference for this publication is: Munro, J. (2006). *Donnelly River Action Plan*, Manjimup Land Conservation District Committee.

[1]Alternative spellings are recognised.

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Summary

The Donnelly River is situated within the Warren subregion and is the sole river system within the Donnelly Drainage Basin. The catchment is in a high rainfall zone and covers an area of 1667 km2. The river flows through the south-east corner of the Blackwood Plateau and the lower south west corner of the Darling Plateau physiographic units (Pen, 1997). Approximately 151 km long, the Donnelly River passes through predominantly forested areas. Only twenty-five private landholdings are situated along the length of the river, with the majority of properties located in the extensively cleared, agricultural upper headwaters.

The aim of developing the Donnelly River Action Plan was to assess the current condition of the Donnelly River, providing landholders and the Manjimup LCDC with more accurate information regarding the condition of the waterway, allowing better informed management decisions to be made. Foreshore assessments were conducted from October- December 2005, during peak river flows. The surveys undertaken followed the Foreshore Condition Assessment methodology of Dr Luke Pen and Margaret Scott (Pen & Scott, 1995).

A summary of foreshore condition ratings for the Donnelly is contained in Table 1 below. Owing to the small proportion of the river that is fronted by agricultural land, the total percentage of fenced river foreshore is low (0.05%).

The Donnelly River is in good condition for much of its length, owing to the fact that the majority of the river catchment flows through protected State Forest or National Park areas.

The Donnelly River seeps from Winnejup National Park as several tiny streamlets. The upper headwaters of the Donnelly River are heavily cleared, predominantly agricultural and with little fringing vegetation remaining to support the banks. Stock grazing is the main land use along this section of the river. Throughout most of this upper area, the Donnelly is little more than an ephemeral drain with defined, cut banks although in some parts no defined channel exists. Natural regeneration is negligible, apart from in two small reserves that the river passes through (portions of Winnejup National Park and Mersea State Forest). *Watsonia* sp. is the dominant weed along this upper section. After leaving the upper headwaters, the Donnelly traverses a lengthy stretch of forest, through the Yornup, Thornton, Carter and Netic State Forest blocks. These State Forest reaches are densely vegetated with predominately native species and are for the most part undisturbed. Access to the river is restricted by dense vegetation growth and lack of access roads, which may have contributed to the quality of the river foreshore area. Minor erosion is occurring throughout the upper area adjacent to road access points. Minor blackberry cane invasion was noted along the State Forest reaches.

The middle reaches of the Donnelly River continue through the Wheatley, Netic, Mack and Gordon State Forest blocks, where river in-stream and foreshore native vegetation remains in excellent condition. Access to the river through these State Forest reaches is again restricted to a few access roads, with minor erosion occurring adjacent to these access points. Minor blackberry thickets were noted along the reach. Near the Graphite Road crossing, the Donnelly passes several private landholdings where there is a reduced amount of foreshore vegetation present, although a good proportion remains to stabilise the riverbanks. However, erosion increases along this section. Public access is possible for several kilometres north of the Graphite Road Bridge, owing to the presence of the Bibbulmun Track walking trail. Discrete blackberry canes were observed along the river foreshore north of Graphite Road. South of Graphite Road, serious blackberry infestations were recorded. Continuing south of the

Table 1: Summary of foreshore condition ratings for the Donnelly River (December 2005)

Foreshore Condition	Total length (km)	Total length (%) of the Donnelly River
A (pristine)	25.85	17.1
B (weedy)	83.24	55.1
C (erosion prone)	38.93	25.7
D (ditch)	2.98	2

landholder properties, the Donnelly continues through the Graphite, Lindsay and Beavis State Forest blocks. Foreshore and bank vegetation is healthy, dense and predominantly native, although blackberry plants are still an issue. Access is again restricted and direct human impact appears negligible.

The lower section of the Donnelly River flows through the Gray, Strickland, Storry, Cleave and Jasper State Forest blocks, with the last section to the river mouth passing through D'Entrecasteaux National Park. River health and foreshore condition remains of a high quality through the forest areas. Near Vasse Highway, the river passes several landholdings and foreshore condition decreases markedly with bank erosion exacerbated by past and in some cases current stock access. The first sightings of Declared species[2] arum lily and apple of Sodom were recorded in this lower section, along with feral olive trees which have become established as serious pests elsewhere in Australia. Beyond these last few landholder properties, the lower Donnelly runs through State Forest, widening out towards the mouth of the river. The Donnelly River flows into the Southern Ocean approximately 50 km south east of Augusta. The majority of the last stretch of the Donnelly is in excellent condition, with densely vegetated foreshore area and minimal disturbance from weeds, although they are present. A small settlement of huts near the mouth of the river is the exception, with erosion, sewage, boat fuels and oil leakage and several weed species including arum lily and bridal creeper noted.

Issues of concern:

- Lack of fringing vegetation in the upper headwaters of the river extensively cleared foreshore area and lack of natural regeneration;
- Common blackberry *Rubus anglocandicans* infestations along middle reaches of the river;
- Emergence of arum lily *Zantedeschia aethiopica*, feral olive trees *Olea europaea* and apple of Sodom *Solanum linnaeanum* in the middle reaches of the river;
- Other weed species present along the lower section of the Donnelly River i.e. arum lily, agapanthus, watsonia, bridal creeper, nasturtium, willows *Salix* sp.;
- Uncontrolled stock access to some parts of the river foreshore; and
- Emergence of feral pigs in the wider area.

Recommendations made in response to the above issues:

- Map occurrence of common blackberry along the length of the river. Target blackberry growth for spraying and removal regimes over the course of a number of years, with continued monitoring to prevent re-establishment along the river;
- Map occurrence of arum lily, feral olive trees and apple of Sodom plants along the river. Implement a multiple-property control system to initially clear the affected reaches of the weeds. Develop a monitoring regime to monitor for re-establishment of the weeds;
- Map, monitor and implement control regimes for any other weeds along the Donnelly e.g. nasturtiums, agapanthus, bridal creeper, watsonia;
- Encourage and assist land managers in high quality areas to maintain and improve foreshore condition through isolated weed control;
- Where possible, integrate weed control activities with work conducted by other departments and groups e.g. DEC, DAFWA, Donnelly Hut Association;
- Actively promote revegetation/agroforestry options in the upper headwaters of the Donnelly River in order to increase the ecological viability of the river and assist channel stabilisation;
- Fence off riparian zones to exclude stock where appropriate; and
- Consider implementing a large scale feral pig control program to minimise possible damage to riparian areas from pigs.

[2]Declared Species refers to plant species that is both serious and invasive and in need of immediate control and eradication. Declared plants are subject to APB (Agricultural Protection Board) legislation and landholders are obligated to control the plant on their property.

LEGEND

River foreshore survey

Highway

Sealed road

Map index

LOCALITY MAP

PERTH
MANDURAH
BUNBURY
BUSSELTON
MANJIMUP

0 2 4 6 8

Kilometres

Map 1
Map 2
Map 3a
Map 3b
Map 4
Map 5
Map 6
Map 7
Map 8
Map 9

SEARS
VASSE
GRAPHITE
ROAD
SOUTH
PERUP
ROAD
MANJIMUP
STEWART
ROAD
HIGHWAY
BLACK POINT ROAD
ROAD
DAY
SEVEN
MUIRS
HIGHWAY
WESTERN
HIGHWAY
ROAD
PEMBERTON
COAST
VASSE
WHEATLEY
HIGHWAY
SOUTHERN
OCEAN

Figure 1: Donnelly River Index Map

1. Introduction

Background

Riverine health has declined State-wide due to a number of factors, mainly resulting from human disturbance. As a result, the impetus to gain a clearer understanding of the health and condition of remaining rivers has increased. Riverine degradation has been exacerbated in recent years due predominantly to the effects of poor catchment management combined with the legacy of inappropriate agricultural regimes (WRC, 2000f). The removal of native fringing vegetation, erosion, declining water quality, encroachment of invasive weeds and feral animals are the main issues facing waterways managers as a result of agricultural practices (WRC, 1999). Most of these problems are mutually causative, with the presence of one making the incidence of another more probable.

The Donnelly River was identified by the Manjimup LCDC as a local priority, given the high quality of the system and its isolated location. The Donnelly River Action Plan was developed as part of a wider program aimed at developing a suite of river action plans across the south west region. The project was funded by the Natural Heritage Trust (NHT) and the National Action Plan for Salinity and Water Quality (NAP); these are joint initiatives of the State and Australian Government which are administered by the South West Catchments Council. Inaugurated in 1989, the Manjimup Land Conservation District Committee (LCDC) is a gazetted group of local farmers, landowners, professionals and interested community members working together to address natural resource management (NRM) issues in the region. The Warren Catchments Council is a committee of the Manjimup LCDC and represents the region in the South West Catchments Council (SWCC). Southern Forests Landcare (SFL) is a trading name formed under the auspices of the Warren Catchments Council. The group employs a number of full-time and part-time staff to coordinate both NRM projects that receive funding from the SWCC and other projects that receive external funding.

Study aims

The principal aims of the Donnelly River Action Plan are to achieve the protection of the Donnelly River ecosystem and to enhance the long term ecological condition of the river. The Action Plan seeks to achieve these aims by firstly ascertaining the current condition of the Donnelly River and having done that, establishing management issues and prioritising restorative measures to deal with those issues. The involvement of landholders along the Donnelly River was a further primary aim of the project, with local community acceptance of the plan and of the need to protect and conserve the Donnelly River being of paramount importance.

This Action Plan is not a statutory plan and does not represent government policy or regulation, nor does it have legal status. This Action Plan provides direction for future management and seeks to provide a benchmark against which any future works implemented by the Manjimup LCDC or local community to protect and rehabilitate the Donnelly River can be assessed. Associated objectives of the Action Plan are that it should be used as the foundation for further works and funding applications, and for the plan to act as an initial source of technical advice.

2. Study area

The Donnelly River was surveyed from the upper headwaters, where it emerges from Winnejup National Park east of Yornup, through to the river mouth ~50 km south east of Augusta. Important tributaries including Barlee and Carey Brook and other wetland systems will be assessed at a later date. The location of the study area is shown in Figure 1 (p. vii). Background information regarding the study area is detailed below.

The Donnelly River

The Donnelly River flows for approximately 151 km and has a full catchment area of ~1667 km^2. It is classed as a T5 river type, meaning that it is a "shorter river contained entirely within the high rainfall karri country or just extending north-east a short distance into jarrah forest" (Pen, 1997). The river runs primarily through State Forest reserves, however, there are a total of 25 landholdings with frontage onto the river. The town of Manjimup and smaller settlement of Donnelly Mill are contained within the catchment boundaries. Aside from forest reserves, the main land uses within the catchment comprise annual and perennial horticulture, dairying and grazing. The small number of landholders combined with the relative isolation of much of the river within State Forest reserves has meant that the Donnelly River has remained in quite good condition and is believed to be one of the best quality rivers in south western Australia (Pen, 1997). Tributaries of the Donnelly include the Fly, Carey, Beedelup, Barlee, Big Easter and Manjimup Brooks. Previous survey work conducted by Water and Rivers Commission classed the majority of the Donnelly River as B1-B3 grade, although the condition was recorded as ranging from A3-C3 (refer to p. 14 for descriptions). Clearing within the catchment is estimated as between 15-20% (Pen 1997; State of Western Australia 2004). The Donnelly catchment also contains Lake Jasper, WA's largest permanent freshwater lake and associated Gingilup Wetlands, as well as several regionally and locally significant wetland systems that link into the Donnelly River system via surface water interactions.

The river originates in extensively cleared agricultural land about 25 km NNE of Manjimup. This upper catchment area contains isolated patches of remnant bushland vegetation, however for the most part the Donnelly constitutes little more than a seasonally modified stream through this area. In this upper section, the South Western Highway cuts across the river. After passing through the cleared agricultural areas, the Donnelly then flows through a succession of State Forest blocks, passing several landholdings along the way. This section through to the middle reaches of the Donnelly is predominantly situated within well vegetated State Forest reserves, with landholdings clustered around the Graphite Road intersection. State Forest blocks through which the river flows in this section include Mersea, Yornup, Thornton, Carter, Netic, Wheatley, Mack, Gordon, Lindsay and Beavis. Blackberry is the main weed species of concern.

In the lower sections of the Donnelly River, landuse is overwhelmingly State Forest reserve, with fewer than ten landholders inhabiting the lower reaches on a permanent basis. The lower section of the Donnelly to the river mouth has a few serious but scattered weed species that are yet to become firmly established and spread beyond localised infestations. The river mouth is located at Donnelly Beach, approximately 50 km south east of Augusta. Natural and stock-exacerbated foreshore erosion is occurring at points along the lower reaches. The Donnelly has a prominent rocky headland at the mouth on the southern bank and supports a broad lagoon of peripheral wetlands some 3.5km upstream from the mouth (Pen, 1997). Approximately 50 squatter shacks are located on the shores of the river estuary within D'Entrecasteaux National Park; these huts are under review as part of the Department of Environment and Conservation (DEC) draft D'Entrecasteaux National Park Management Plan.

Climate

The climate of the south west region is warm temperate Mediterranean, with distinct seasons involving cool, wet winters and hot, dry summers. Median rainfall for the region ranges from 900-1400 mm on the coast and decreases to less than 400 in the upper parts of the Blackwood catchment. The wettest period of the year is from May to September, however prolonged summers are common. Median rainfall for the Donnelly River catchment is 1225 mm. Winter mean temperatures in the region vary with distance from the coast, whereas latitude has a greater effect on mean summer temperatures (DoE 2004a; Pen 1997).

Landforms and soils

The south west of Western Australia is mostly located on the ancient Western Archaean Shield. The shield covers an extensive region and is underlain by Precambrian gneiss and granite rocks, which have been stable for the last 570 million years. The Donnelly River is situated on two main physiographic units; the south east corner of the Blackwood Plateau and the lower south west corner of the Darling Plateau. The river originates on the Darling Plateau, an uplifted (200-300 m above AHD), broadly undulating surface with laterite overlaying Precambrian crystalline rocks. Soils are typically gravely ironstone over a hard lateritic duracrust. Generally found higher in the landscape, lateritic soils support jarrah or jarrah-marri vegetation associations (V. & C. Semenuik Research Group 1997). Around the Pemberton area, soil type changes to predominantly heavy red, or karri, loams. This soil type is of significant horticultural value to the region, supporting high karri forest with jarrah or marri species. These tall karri forests are important landscape character icons for the region and have proved to be a tourist drawcard (Christensen 1992; State of Western Australia 2004; V. & C. Semenuik Research Group 1997).

The Blackwood Plateau is an area of gently undulating, moderately raised land (~80-180 m above AHD), further characterised by broad depressions with swamps. Soils of the plateau are lateritic and sandy, overlaying Mesozoic rocks in the upper areas of the plateau, with sandy yellow soils on the slopes (State of Western Australia 2004; V. & C. Semenuik Research Group 1997). The mouth region of the Donnelly River is situated on the Scott-Coastal Plain, which is characterised as generally low lying, swampy land with windswept parabolic dunes. Vegetation generally comprises eucalypt, peppermint and wattle species on the slopes and heath and sedge species in lower areas. Soils are sandy (State of Western Australia, 2004).

Water quality

Clearing within the Donnelly catchment is estimated to be around 20%. The predominantly forested status of much of the Donnelly River contributes significantly to maintaining water quality. Monitoring of water quality along the Donnelly River has not been continuous for most sampling sites since the period 1971-1979 (DoE, 2004a). The most recently available snapshot water quality information obtained from Department of Environment data repositories was for the period 2001-2003. The data indicate that the Donnelly River exhibits the following median values: low Total nitrogen (0.25 mg/L), neutral pH (7.53), stained water colour (60 TCU[3]), low turbidity (3.61 NTU[4]) and low dissolved oxygen levels (7.79 mg/L). The Donnelly River is considered fresh, with a mean annual salinity of 22 mg/L TDS for the period 1993-2002 (DoE, 2004b). Only one tributary of the Donnelly, Manjimup Brook, is considered to be of marginal water quality, having been extensively cleared for horticultural and grazing purposes. The remaining tributaries are considered fresh (Public Works Department 1984; State of Western Australia 2004).

Flora

The south west of Western Australia has long been recognised as a biodiversity 'hot spot', connoting very high biodiversity values. The process of continental drift is in part responsible for this phenomenon. Palaeobotanical studies provide evidence of the existence of vast rainforests across much of the Australian continent approximately 50 million years ago. Climate change to a much drier environment resulted in adaptive changes among the flora and a reduction in the spread of rainforests across the continent. The south west corner was isolated as a result, and flora and fauna evolved unique adaptations to allow them to survive (Christensen, 1992). Native vegetation varies greatly over the south west and is largely determined by the rainfall in the area and soil type. The most important genera in the region include *Acacia*, *Stylidium*, *Caladenia, Leucopogon*, *Eucalyptus* and *Drosera*. Indicative proportions of native vegetation found in the local region are (Christensen, 1992):

50% - Open jarrah-marri forest
40% - Tall karri forest
10% - Low paperbark woodland

Open jarrah-marri forest dominates the study area. The forests grow on lateritic and podzolic soils and in drier regions. Common understorey species include *Banksia grandis*, sand plain sheoak *Allocasuarina fraseriana*,

[3]True Colour Units, Long term acceptable limits for potable water should not exceed 15 TCU.
[4] Nephelometric Turbidity Unit

snottygobble *Persoonia longifolia* and on damper sites Western Australian peppermint *Agonis flexuosa*. Shrub species include *Xanthorrhoea preissii* and *X. gracilis*, *Acacia pulchella* and *Macrozamia reidlei*.

Iconic tall, open karri forests are also common throughout the area. Understorey tree species include karri oak *Allocasuarina decussata* and *Agonis flexuosa*. Other understorey species include *Bossiaea laidlawiana*, karri hazel T*rymalium floribundum*, *Thomasia quercifolia* and ropebush *Pimelia clavata*. This type of forest association has developed on the most fertile soils in areas of annual rainfall exceeding 1100 mm.

Towards the coast, flora composition shifts as the underlying soils change to swampy flats and consolidated dune systems. Paperbark species *Melaleuca preissiana* and *M. raphiophylla* are common, along with *Agonis flexuosa* and yate *E. cornuta*. Waterways and wetlands in the region are further characterised by vegetation favouring the specialised, permanently moist habitats. Common species noted along the Donnelly riverine area include Warren River cedar *Taxandria juniperina,* swamp willow *Callistachys lanceolatum* and various *Banksia* spp. (Christensen, 1992).

Fauna

Fish fauna

The Donnelly River has a relatively high diversity of freshwater fish species, in all likelihood attributable to the diversity of aquatic habitats available within the river and its tributaries. The Department of Freshwater Fish Research at Murdoch University was contracted to undertake a comprehensive study of past and present fish fauna presence in the Donnelly River and wider catchment. For the purposes of this report, the fish fauna identified are divided into three groups: native freshwater fish species, native estuarine fish species and introduced fish species. Further details of each of these groupings are given below in Table 2. Lampreys were not included in any of these groupings and are therefore considered separately. The majority of information contained within Table 2 is sourced from Morgan and Beatty (2006), *Fish Fauna of the Donnelly River* (Appendix 3). There are restrictions to the kinds of fish fauna that can be introduced or bred for aquaculture in the Donnelly River area. For more information, see the Department of Fisheries website www.fish.wa.gov.au.

Table 2: Fish fauna occurring in the Donnelly River and wider catchment (after Morgan & Beatty, 2006)

Common name	Scientific name	Details
Native freshwater fish		
Balstons pygmy perch	*Nannatherina baltsoni*	Extremely rare, range severely fragmented by development. Only one specimen found
Black-stripe minnow	*Galaxiella nigrostriata*	Generally restricted to ephemeral pools and floodwaters
Freshwater cobbler	*Tandanus bostocki*	Sporadic, unusual distribution. Found within the Donnelly River catchment but not the river itself
Mud minnow	*Galaxiella munda*	One of the rarest south west endemics, found in headwater streams. Three reported sightings from the wider Donnelly River catchment from 1982
Nightfish	*Bostockia porosa*	Found throughout catchment. Nocturnal fish, complex habitat requirements
Salamander fish	*Lepidogalaxias salamandroides*	Restricted distribution, not found in main river channels or main tributaries. Found in swamps, pools and flats
Western minnow	*Galaxias occidentalis*	Most widespread and abundant of south west Australia endemic freshwater fish species. Salt tolerant
Western pygmy perch	*Edelia vittata*	Widespread and relatively common throughout Donnelly River catchment. Relatively low tolerance to dissolved salts, susceptible to attack by invasive *Gambusia* species
Native estuarine fish		
Australian herring	*Arripis geogianus*	-
Black bream	*Acanthopagus butcheri*	Widespread distribution
Cobbler	*Cnidoglanis macrocephalus*	Previously reported as occurring in the Donnelly River
Flathead sp.		Previously reported as occurring in the Donnelly River
Sea mullet	*Mugil cephalus*	Widespread distribution
Silverfish	*Atherinosoma presbyteroides*	Previously reported as occurring in the Donnelly River
South west goby	*Afurcagobius suppositus*	-
Swan River goby	*Pseudogobius olorum*	-
Tarwhine	*Rhabdosargus sarba*	Silver bream
Western hardyhead	*Leptatherina wallacei*	-
Yellow-eye mullet	*Aldrichetta porsteri*	-
Introduced fish		
Eastern mosquito fish	*Gambusia holbrooki*	Prolific breeder. Tolerant of poor water quality, out-competes native fish in areas of declining quality. Introduced under government authority in 1936 to aid mosquito control (CENRM 2004; Pen 1997)
Rainbow trout	*Oncorhynchus mykiss*	Prolific breeder. Susceptible to high temperatures
Redfin perch	*Perca fluviatilis*	Prolific breeder. Introduced for recreational and consumption purposes

By 2004, only ten species of introduced freshwater fish were recorded in Western Australia. A further two species have been added in the last two years. The Donnelly River has been the focus of a long term stocking program for many years now which accounts for the large numbers of introduced species found there. Rainbow trout in particular are of concern to the ecological health of the system. In the period 1999-2004, approximately 500,000 rainbow trout fry were stocked by the Department of Fisheries Western Australia into the Donnelly River. This number accounts for approximately 20% of all rainbow rout fry stocked in Western Australia. Similarly, in the same period, 20,500 rainbow trout yearlings were stocked, equating to 13% of all rainbow trout yearlings stocked within the state (Morgan & Beatty, 2006). The impact of stocking these large predatory fish within the Donnelly River has not been adequately assessed and could be cause for significant concern in the future as native fish stocks become further depleted.

Lampreys

The pouched lamprey, *Geotria australis*, is one of only two surviving groups of jawless fish. They have a complex life cycle, moving from early ammocete (worm-like larval) stage to juvenile, to parasitic adults. Ammocetes were found in multiple areas along the Donnelly River typified by a high degree of shading and organic matter. Juveniles found were located on sandy substrates with high oxygen levels. Lamprey larvae in particular are vulnerable to habitat modification, with specific habitat requirements focusing on well oxygenated, non-saline water. There is substantial evidence that lamprey numbers are decreasing within the south west as well as within the Donnelly River, particularly as a result of larvae losing suitable habitat (Morgan & Beatty, 2006).

Macroinvertebrate fauna

Comprehensive macroinvertebrate sampling was not undertaken for the Donnelly River Action Plan, however reliable and accurate information regarding macroinvertebrate species occurrence was provided by the local Ribbons of Blue project (Table 3). Macroinvertebrate species identified in the Donnelly River are listed below with supplementary information regarding habitat sourced from Gooderham & Tsyrlin (2002).

Ribbons of Blue involvement with the Donnelly River and other waterways within the Warren region is ongoing and further information will be provided regarding the status of macroinvertebrates within the

Table 3: Macroinvertebrate species occurring in the Donnelly River

Common name	Scientific Family/ Order/Class	Habitat
Water boatmen	Order Hemiptera Suborder Heteroptera Family Corixidae	Found in slow moving/still water, among vegetation. Often most common invertebrate found in waterways
Backswimmers	Order Hemiptera Suborder Heteroptera Family Notonectidae	Common in still or slow-flowing water
Non-biting midge larvae	Order Diptera Family Chironomidae	Variety of feeding habits
Freshwater crayfish	Order Decapoda Family Parastacidae drought	Wide variety of habitats, omnivorous. Largest invertebrate in freshwater systems. Can survive
Freshwater prawn	Order Decapoda Family Palaemonidae	Associated with snags and vegetation. Omnivorous
Amphipod	Order Amphipoda Omnivorous	Found in still to slow moving water.
Freshwater mussel	Class Bivalvia Family Hyriidae	Found in lowland river systems. Filter feeders, burrow in finer sediment

Donnelly River. Anyone interested in finding out more information on the local Ribbons of Blue program should get in touch with the organisation; contact details are given in Appendix 2.

Terrestrial fauna

Twenty-seven species of larger land fauna are known to occur in the region, of which six are endemic to the south west of Western Australia (Table 4). In addition, many species of birds have been recorded as occurring in the southern forests region. Generally, the highest numbers of species are supported within open woodland and low open woodland habitats. It is likely that some if not all of these species occur near to the Donnelly River or within the wider Donnelly River catchment.

Table 4: Fauna occurring in the south west of Western Australia (after Christensen, 1992)

Common name	Scientific name	Further details
Macropods		
Western grey kangaroo	*Macropus fuliginosus*	-
Western brush wallaby	*Macropus irma*	Endemic
Tammar wallaby	*Macropus eugenii*	-
Quokka	*Setonix brachyurus*	Endemic, rare/likely to become extinct
Brush-tailed bettong (woylie)	*Bettongia penicillata*	Threatened fauna
Possums		
Common brushtail possum	*Trichosurus vulpecula*	-
Western ringtail possum	*Pseudocheirus occidentalis*	Threatened fauna: rare/likely to become extinct
Western pygmy possum	*Cercartetus concinnus*	Endemic
Honey possum	*Tarsipes rostratus*	Endemic
Dasyurids		
Western quoll (chuditch)	*Dasyurus geoffroii*	Threatened fauna: rare/ likely to become extinct
Brush-tailed phascogale	*Phascogale tapoatafa*	
Yellow-footed antechinus (mardo)	*Antechinus flavipes*	Common on sites unburnt for >10 years
Grey-bellied dunnart	*Sminthopsis griseoventer*	Endemic
Bandicoots		
Southern brown bandicoot	*Isoodon obesulus*	Threatened fauna
Numbats		
Numbat	*Myrmecobius fasciatus*	Threatened fauna: rare/ likely to become extinct
Echidna		
Echidna	*Tachyglossus aculeatus*	-
Rodents		
Bush rat	*Rattus fuscipes*	-
Water rat	*Hydromys chrysogaster*	-
Bats		
Greater long-eared bat	*Nyctophilus major*	Common
Gould's long-eared bat	*Nyctophilus gouldii*	Common
Lesser long-eared bat	*Nyctophilus geoffryi*	Common
Gould's wattled bat	*Chalinolobus gouldii*	Common
Chocolate wattled bat	*Chalinolobus morio*	Common
-	*Falsistrellus mackenziei*	Common, endemic
King River eptesicus	*Eptesicus regulus*	Common
White-striped mastiff-bat	*Tadarida australis*	Common
Little mastiff-bat	*Mormopeterus planiceps*	Common

The south west region also supports several species of exotic mammals (Table 5). Again, it is likely that some if not all of these species occur in the wider Donnelly River catchment.

Table 5: Exotic mammals present in the region (after Christensen, 1992)

Common name	Scientific name
Cat	*Felix catus*
Dingo	*Canis familiaris dingo*
Fox	*Vulpes vulpes*
Pig	*Sus scrofa*
Goat	*Capra hircus*
Horse	*Equus caballus*
House mouse	*Mus musculus*
Black rat	*Rattus rattus*
Rabbit	*Oryctolagus cuniculus*

Feral pig *Sus scrofa* sightings have been recorded from nearby catchment areas and the animals are likely to move closer to the Donnelly River area.

Cultural heritage

Aboriginal heritage

Aboriginal association with the south west area of Western Australia stretches back approximately 50,000 years. Waterways and their associated landscape features are traditionally important foci for their customs, folklore and spiritual beliefs. Aboriginal people inhabiting the area are generally referred to as Nyungar people. Nyungar people utilised the Donnelly and other rivers in the area as food sources and trade routes among other uses (Crawford & Crawford 2003; WRC 2002a). Oral and written histories of the Nyungar people indicate that seasonal movements occurred, predominantly related to the availability of certain food and water resources as affected by seasonal fluctuations. The Nyungar people tended to move inland during the winter months and congregate around river and lake systems during the summer months (Crawford & Crawford, 2003).

The Department of Indigenous Affairs (DIA) maintains a register of officially recognised Aboriginal sites throughout Western Australia; predominantly these are classed as either archaeological or anthropological sites. There are three officially registered sites along the Donnelly River, classed as Artefact/Scatter, Mythological and Historical sites. The mouth of the Donnelly River in particular is known for its Aboriginal heritage; the coastal limestone caves are of historical significance and registered burial sites exist behind the coastal dune system (S. Councillor, pers. comm.). The entire Donnelly River system and associated wetlands hold special mythological significance for the Aboriginal people of the area and Donnelly Well, located adjacent to South Western Highway just north of Manjimup, is significant as a former campsite and water collection point. A further Artefact/Scatter site is registered along Barlee Brook, a tributary of the Donnelly. There may be further Aboriginal heritage sites in the Donnelly River area that are not officially recorded on the Aboriginal Sites register. Laws are now in place to protect Aboriginal artifacts discovered during river assessment and restoration works (Government of Western Australia, undated). Further information can be found on the DIA website at www.dia.wa.gov.au.

European heritage

European association with the south west of Western Australia officially began in 1826, when the first British settlement was established at Albany. The settlement of the Swan River region in 1829 continued European colonisation of the area, with initial reports commenting on the helpful and productive relationship between the settlers and Aboriginal people. However interaction between European settlers and Aboriginal people turned into conflict as settlements and disputes over food sources displaced Aboriginal people (Crawford & Crawford 2003; WRC 2002a).

Donnelly River Mill is located along the mid-reaches of the Donnelly River and has significant European cultural heritage value. The mill was established in the late 1940s by Bunning Brothers. Being in an isolated area, the mill was developed in conjunction with a nearby company town containing workers cottages, a boarding house, general store, butcher's shop, school, social club and other amenities. The mill closed in 1978 subsequent to the timber industry's transition from steam power to electricity. The now-redundant mill equipment was left on site and the associated townsite was developed as holiday accommodation. In 1995, Donnelly River Mill was placed on the State Heritage Register. The mill is the only remaining example of a

steam-powered hardwood timber mill in the State and one of only a few intact mills in Western Australia to retain an associated workers' village. The place is currently vested in the Minister for Tourism and in 2003 the Donnelly River Mill Steering Committee was established to investigate and report on options for the future use of the place (Heritage Council of WA, 1996). Further downstream, a graphite mine was located near to the One Tree Bridge area. Graphite Road was named after this mine.

Zoning

The Donnelly River runs through the boundaries of three local government areas- the Shires of Manjimup, Bridgetown-Greenbushes and Nannup. As outlined by the *Warren Blackwood Rural Strategy* (2004), land use within the Warren-Blackwood region is classed as one of three land use zones which seek to separate desired primary land usage: Agriculture, Priority Agriculture and Rural Landscape Protection zones. The Agriculture zone aims to protect the productive capacity of rural land, by promoting and facilitating the diversification and intensification of sustainable agriculture production. Only a very small part of the Donnelly River is classed within this Agriculture zone. The Priority Agriculture zone provides an increased level of protection to the productive capacity of the land and the key land and water resources underlying it. Again, only a small part of the Donnelly River is classed within this zone. The final zoning unit, Rural Landscape Protection, is used to denote areas where the primary objective is to protect and enhance intrinsic landscapes, environmental and cultural values. The river mouth area falls into this zone (State of Western Australia, 2004).

Economic issues

The economy of the Warren-Blackwood area, where the Donnelly River is located, rests upon three main industries: agriculture, forestry and tourism. Forestry is a major component of the local economy, from native forest logging operations and more recently from commercial timber plantations. In the Shire of Manjimup, annual and perennial horticulture provides more than half of the gross value of agricultural production. The Shire of Bridgetown-Greenbushes is dominated by beef production and the Shire of Nannup by beef and potato production. Tourism is a burgeoning industry in the area. The Warren-Blackwood region is recognised as one of Western Australia's primary tourism zones, owing to the region's varied landscape, forests, remote coastlines and mild climate (State of Western Australia, 2004). Downturns and changes, particularly in the agricultural and forestry fields, have the potential to cause economic hardship for the region, as well as providing opportunities for diversification and growth. Principal land conservation issues with the potential to impact economically on the Donnelly River region include soil salinity, erosion, waterlogging and water quality, as well as protection of agricultural land, soil structure decline and soil acidification (State of Western Australia, 2004).

Existing plans and surveys

Much of the background information on the Warren-Blackwood region and the Donnelly River has been sourced from plans and policies already in existence. These include the *Warren Blackwood Rural Strategy* (2004), *South West Regional Strategy for Natural Resource Management* (2005), *Warren Blackwood Regional Planning Study: Environmental and Landscape Assessment* (1995) and the *Manjimup Town Planning Scheme No.2* (1987). For information regarding the lower Donnelly River, the original *Shannon Park and D'Entrecasteaux National Park Management Plan* (1987) and the revised *Shannon and D'Entrecasteaux National Park Draft Management Plan* (2005) were useful references.

The Donnelly River is divided into two planning units under the *Warren Blackwood Rural Strategy*: planning Units DR1 (Donnelly) and DR2 (Upper Donnelly). These planning units were defined so that land usage within the areas can be controlled in a satisfactory manner and conflicts over competing uses avoided. The strategy contains a detailed breakdown of statistics for each of the regions, demonstrating the predominance of State Forest areas and relatively small amounts of land clearing. Of note is the heavily cleared Upper Donnelly area, near the headwaters of the river, where conflicting land uses and the potential degradation of water and environmental quality due to sedimentation and nutrient transport are major issues of concern (State of Western Australia, 2004).

Future planning proposals

Future planning proposals of relevance to the Donnelly River headwaters area include the proposed siting of a heavy industrial site near the Yornup townsite. The proposal would impact on the area by virtue of the fact that heavy industrial zones are required to have a buffer of approximately 500 m-1 km around them; this requirement would infringe on agricultural land. Water is also proposed to be taken from the Donnelly River. This planning proposal appears however to be in doubt following local opposition. Another planning proposal relates to the development of a tourist icon within the popular One Tree Bridge/ Four Aces recreational areas of the Donnelly River, near Graphite Road. The existing *Manjimup Town Planning Scheme No.* 2 is currently being updated. No significant changes to zoning status of the Donnelly River are currently proposed however several minor changes of zoning to allow tourist development in areas adjoining the river may have a possible flow-on impact on the Donnelly River. The *Shannon and D'Entrecasteaux National Park Draft Management Plan* (2005) will also impact on the existence of estuarine squatter shacks near the river mouth and management of Lake Jasper and associated wetlands.

3. River Ecology

To provide context to the issues discussed later in this document, the following section contains information on the fundamentals of river ecology and habitats, sourced from a variety of publications, details of which can be found at the end of this section. The majority of this information was sourced from Pen (1997). More detailed information on the topic of river ecology can be found in these publications as well as other sources.

Habitats

Habitats exist in the environment as a continuum, with no clear demarcation between distinct 'zones'. However, for the purposes of illustration, different habitats are treated as discrete units. The variety of natural habitats present in a waterway provides the opportunity for a diverse array of flora and fauna to exist. Major habitat zones include permanent river pools, riffles and runs, areas of terrestrial riparian vegetation on embankments and seasonal floodwaters. These zones are discussed in more detail below.

River pools

River pools in optimum condition are well shaded environments, surrounded by dense fringing paperbark and sedge vegetation and containing snags and woody debris. They perform an important refugia role during the drier summer months when they often represent the only source of permanent water in an area. As such they act as a haven for many aquatic fauna. However, conditions may be extreme during this time, with warmer water temperatures and correspondingly lower levels of dissolved oxygen available.

Riffles, rapids and cascades

These habitat types primarily serve to oxygenate the water column and also as a source of noise, enabling some species to locate their favoured habitat. The three habitats are defined as where water flows swiftly over an irregular stream bed, over and between rocks and from one rocky terrace to another, respectively. In the area, riffle zones characteristically are dominated by flooded gum, paperbarks, Warren River cedar and sedges.

Runs and low flow channels

Runs are commonly described as long reaches of unobstructed stream flow where the water surface is flat. In the south west, runs are further defined as the low flow channels that wind across the floodway between pools. Often the low flow channels are well supported and overhung by riparian vegetation.

Floodplains

In general terms, floodplains are broad areas of low flat land adjacent to the main floodway of the river. These areas are characteristically inundated by floodwater to some degree each year, creating a seasonal habitat utilised by a variety of organisms for feeding and reproduction. Floodplains may also form part of wider wetland systems, which become swampy in the winter months, either from rising groundwater or a buildup of rainwater over impervious clay layers. Often considered as distinct from the main river channel, floodplains are an important component of the river ecosystem, allowing for the exchange of water, nutrients and fauna between the two zones.

Habitat elements

Habitat elements are the components of the riverine ecosystem that combine to form different habitats. Some common elements are outlined here.

Riparian vegetation

Riparian vegetation is an important habitat element, providing shading throughout the year. Riparian vegetation in the south west area is commonly composed of eucalypt, peppermints and paperbarks over sedges and rushes, a mixture that serves to contribute oily, tannin-rich leaves and twigs to the water column. As such, riparian vegetation is an important source of energy for the waterbody in the form of organic debris and leaf litter.

Snags and woody debris

Woody debris and snags are collectively described as large pieces of wood (branches, whole limbs, trees) that are either submerged, semi-submerged or exposed within a waterway. Large woody debris serves to alter and slow the flow of water; thereby creating a range of micro-habitats based on eddies and isolated still/turbulent zones generated by altered flow regimes. The presence of woody debris further increases the surface area of the river ecosystem, adding to woody habitat used by certain species for all or part of their life cycle.

Shade

The shading provided by riparian vegetation is a significant habitat element, lowering water temperatures and providing respite from the sun for many aquatic animals.

Aquatic vegetation

Plants that are submerged in, floating on or emerging from the water are classed as aquatic vegetation. Dense riparian tree canopies mean that such vegetation is scarce in south west rivers, with overhanging vegetation shading out aquatic plants. Where present, aquatic vegetation provides a specialist habitat for certain fauna.

Leaf litter

Leaf litter becomes a habitat element in areas of still or slightly flowing water, forming an important microhabitat for a range of aquatic organisms.

Rocks and stones

While not as dominant as vegetation in south west rivers, rock and stone also form an integral habitat element. The presence of rocks and stones in a waterway creates a range of microhabitats, limits the growth of vegetation over the water column, thereby aiding in light penetration, and helps in oxygenation of the water.

The catchment

Waterways do not exist as isolated ecosystems. It is important when considering river ecology to remember the influence of external processes on waterway function. In this sense, the characteristics of the surrounding catchment are important. Inorganic sediment, dissolved organic matter, vegetable matter, salt and nutrients are carried from the wider catchment, ultimately to the waterway. The processes of salinisation and eutrophication are testament to this process.

Useful references

Pen, L.J. (1999). *Managing Our Rivers: A Guide to the Nature and Management of the Streams of South-West Western Australia.* Water and Rivers Commission, Perth.

Water and Rivers Commission (2002b). *Stream and Catchment Hydrology.* Water and Rivers Commission, River Restoration Report No. RR19.

Water and Rivers Commission (2000a). *Floodplain Management*. Water Facts 14. Water and Rivers Commission, Perth.

Water and Rivers Commission (2000f). *Stream Ecology.* Water and Rivers Commission River Restoration Report No. RR7.

Water and Rivers Commission (2000h). *The Value of Large Woody Debris (Snags)*. Water Notes 9. Water and Rivers Commission, Perth.

4. Study Methodology

Community involvement

Involving the local community in the development of the river action plan is instrumental in gaining community support for the project as well as for ease of assessment. Many of the landholders with property containing or bordering the Donnelly River took part in the physical assessment of their river foreshore area. Other community members provided factual and historical information. A community meeting was held prior to the surveys being conducted to inform landholders of the project. Each landholder received a personalised site report based on the site assessment of their property, which detailed individual management issues and recommendations.

River foreshore condition assessment

The Pen-Scott method of riparian zone foreshore assessment was used to evaluate the condition of the Donnelly River foreshore. The Pen-Scott method is a standardised rating technique that allows the user to classify foreshore areas along a gradient from pristine (A grade) through to D grade, connoting a ditch. The four grades are further divided into three sub-categories per grade, i.e. A1, A2 and A3. A description of these grades follows and they are represented pictorially in Figure 2 (Pen & Scott, 1995). Indicative sites representing each grade along the Donnelly River are also included in the following pages (Figure 3).

A grade foreshore

A1: Pristine

The river embankments and/or channel are entirely vegetated with native species and there is no evidence of human presence, or livestock damage. This category, if it exists at all, would be found only in the middle of large conservation reserves where the impact of human activities has been negligible.

A2: Near pristine

Native vegetation dominates but introduced weeds are occasionally present in the understorey, though not to the extent that they displace native species. Otherwise there is no human impact. A river valley in this condition is likely to be the highest quality river found today.

A3: Slightly disturbed

Here there are areas of localised human disturbance where the soil may be exposed and weed density is relatively heavy, such as along walking or vehicle tracks. Otherwise, native plants dominate and would quickly regenerate in disturbed areas should human activity decline.

B grade foreshore

B1: Degraded – weed infested

In this stage, weeds have become a significant component of the understorey vegetation. Although native species remain dominant, a few have probably been replaced or are being replaced by weeds.

B2: Degraded – heavily weed infested

In the understorey, weeds are about as abundant as native species. The regeneration of some tree and large shrub species may have declined.

B3: Degraded – weed dominated

Weeds dominate the understorey, but many native species remain. Some tree and large shrub species may have declined or have disappeared.

C grade foreshore

C1: Erosion prone

While trees remain, possibly with some large shrubs or grass trees, the understorey consists entirely of weeds, mainly annual grasses. Most of the trees will be of only a few resilient or long-lived species and their regeneration will be mostly negligible. In this state, where the soil is supported by short-lived weeds, a small increase in physical disturbance will expose the soil and render the river valley vulnerable to serious erosion.

C2: Soil exposed

Here, the annual grasses and weeds have been removed through heavy livestock damage and grazing, or as a result of recreational activities. Low level soil erosion has begun, by the action of either wind or water.

C3: Eroded

Soil is being washed away from between tree roots, trees are being undermined and unsupported embankments are subsiding into the river valley.

D grade foreshore

D1: Ditch – eroding

Fringing vegetation no longer acts to control erosion. Some trees and shrubs remain and act to retard erosion in certain spots, but all are doomed to be undermined eventually.

D2: Ditch – freely eroding

No significant fringing vegetation remains and erosion is completely out of control. Undermined and subsided embankments are common, as are large sediment plumes along the river channel.

D3: Drain- weed dominated

The highly eroded river valley has been fenced off enabling colonisation by perennial weeds. The river has become a simple drain, similar if not identical to the typical major urban drain.

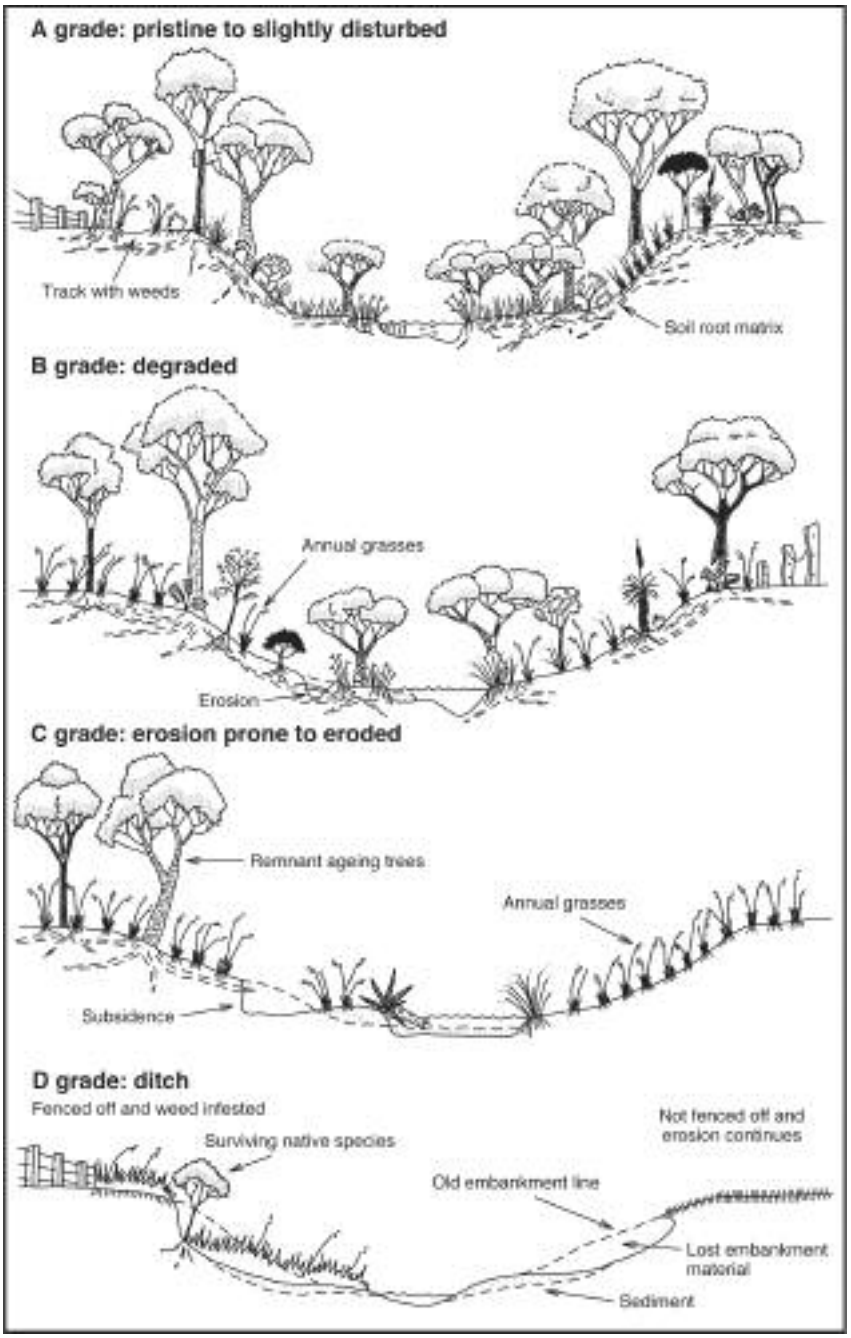


Figure 2: The four grades of river foreshore condition: A (pristine) to D (ditch) (after Pen & Scott, 1995)

A grade section

B grade section

C grade section

D grade section

Bank erosion

Figure 3: Foreshore condition of the Donnelly River (photos- Jenni Munro)

5. Management Issues

The Donnelly River catchment is varied in terms of landforms, soil types, past and current land use and livestock access. As such, there is a range of management issues pertinent to the Donnelly River. These issues are presented below.

Loss of native riparian vegetation

Clearing of native riparian vegetation is not a major issue overall for the Donnelly River apart from the heavily cleared areas mostly located in the upper catchment. Clearing within the catchment is estimated at 20%, as previously noted. As the majority of the Donnelly runs through State Forest reserves, the overall quality, quantity and diversity of riparian vegetation is high. The species composition changes as the river flows from the headwaters to the mouth and is further affected by logging and fire management practices within State Forest, which contributes to ecological disturbance.

The emergent and terrestrial vegetation along the waterway banks essentially defines the riparian zone. The riparian zone serves several important ecological functions (CENRM 2004; Pen 1997; WRC 2000f):

- Woody debris provides both terrestrial and in-stream habitat. Riparian zones provide habitat for aquatic animals and food for native water birds and mammals;
- Acts as a corridor for fauna movements;
- Source of allochthonous (outside of stream) energy;
- Serves in bank stabilisation and aids in dissipating water velocity. The root systems of riparian vegetation increase and reinforce soil cohesion and provide matting to protect the soil from being transported downstream;
- Overhanging vegetation provides shade, influencing light penetration, which in turn lowers the water temperature. This action is beneficial in that high water temperatures act to decrease the level of dissolved oxygen content in waterways, which in certain circumstances can be harmful to aquatic flora and fauna; and
- Dense riparian vegetation acts as a buffer for pollution, sediments and nutrients which flow down the river, effectively stripping nutrients prior to entering the waterway. Grasses, rushes, sedges and shrubs are most effective at buffering.

Native vegetation also has a number of economic and social values, including eco-tourism potential, effects on property values, commercial products and recreation (LWRRDC, 1996). Clearing of riparian vegetation can have several far-reaching implications for a number of waterway processes. Clearing has altered the hydrological balance throughout the agricultural region of the south west¬- more rain filters into the soil, groundwater levels rise and streamflow (runoff) increases (WRC, 2002b). Bank stabilisation and erosion may become issues of concern, as may increased sediment loading in the waterway. Cleared sub-catchments upstream of major waterways are likely to contribute to high nutrient loads downstream (CENRM 2004; WRC 2002b).

Weed invasion

Several weed species of serious concern were identified during the foreshore surveys, predominantly common blackberry (*Rubus anglocandicans*), arum lily (*Zantedeschia aethiopica*) and watsonia (*Watsonia* sp.) as well as feral olive tree (*Olea europaea*) which is becoming of concern. A few landholders expressed concern at the dominance of bracken fern (*Pteridium esculentum*) along their river foreshore area. Bracken is an interesting case, a native of the area which often becomes established as a serious weed on seasonally damp land next to rivers. Blackberry poses the greatest threat to ecosystem health along the Donnelly River, occurring as dense infestations and being relatively widespread. It acts as a pioneer species which dominates disturbed and cleared areas. Other occurrences of serious weeds noted are of isolated spread and relatively small scale; control should be easily achieved. Weeds are an issue for management as they compete with native vegetation, spread quickly and colonise new landscapes rapidly and with ease, preventing regeneration by native species.

Erosion and siltation

Natural bank erosion occurs freely on rivers and this process is evident along the length of the Donnelly River. The erosion process becomes exacerbated and cause for management concern when supporting riparian vegetation is cleared and banks become further destabilised, leading to erosion and sedimentation downstream. Severe erosion is not a significant problem for the Donnelly River; however there are several areas

of concern. Issues associated with erosion and subsequent siltation include loss of soil fertility, poor water quality, infilling of summer pools, increased channel width, further loss of native riparian vegetation, alteration of in-stream vegetation and flow dynamics, macroinvertebrate communities and the potential effects of reduced photosynthesis (WRC, 2000g). Stock access to riparian zones also affects bank stability, vegetation cover and weed infestations and can enhance erosion concerns.

Water quality

Water quality in the Donnelly River is generally high, due in large part to the limited proportion of the catchment that has been cleared. As previously noted, continuous water monitoring has not been undertaken by the Department of Environment since the late 1970s; however, snapshot data from the period 2001-2003 indicate that the Donnelly River has low nutrient and turbidity levels. These water quality parameters may be impacted upon by a number of factors occurring in the Donnelly catchment, most notably further clearing of riparian vegetation, which can lead to increased erosion and bank destabilisation, in turn causing increased sedimentation and turbidity levels. Similarly, especially in the agricultural upper catchment, loss of riparian vegetation is cause for concern given that it allows free movement of excess nutrients into the waterway, increasing the possibility of nutrient enrichment, or eutrophication, and algal blooms. Of related interest here is the increase in dam construction on Donnelly River tributaries within the upper catchment, which will have flow-on effects on water quality downstream.

Salinity

The Donnelly River is considered fresh. Stream salinity is caused in one of two ways: rising groundwater conveying salt to the surface, known as dryland salinity, and by the increased volumes of water carrying dissolved salts directly to waterways. The clearing of native, deep-rooted vegetation and replacement with shallow-rooted annual crops and pastures is a major cause of dryland salinity (WRC, 2000a). Stream salinity has steadily increased in many rivers over the last few decades. The Donnelly River is still considered to be fresh, as are the majority of its tributaries. Studies show that only 44% of streams analysed in the south west are still considered to be fresh (less than 500 mg/L Total Dissolved Solids, or TDS) (DoE, 2004b). Risk factors involved in higher stream salinities include topography (i.e flat, poorly drained land) and geology of the area (i.e. less permeable materials).

The effects of salinity on the landscape are serious. Saline water rising to the surface is harmful to both native vegetation and crops, disrupts soil structure and is unsuitable for stock or human consumption. In waterways, stream salinity increases, resulting in a change in associated ecosystem components, most notably replacement of native riparian vegetation with more salt-tolerant species. The effects of stream salinity are not localised and the repercussions of rising stream and dryland salinity may be evident for a long distance downstream from the initial salinised area. It is estimated that salinity has affected 80% of waterways in the south west region (WRC, 2000e).

Sediment and nutrient retention

Nutrients such as nitrogen and phosphorus are naturally present in most waterways; anthropogenic sources include fertilisers, stormwater drainage and sewage. Problems occur when nutrient levels become elevated, as excess sediment and nutrient loading can be harmful to waterway health. Excess loading can be attributed to several processes, including clearing of riparian vegetation, which leads to altered flow and in-stream vegetation dynamics, altered macroinvertebrate and fish communities, altered stream processes and infilling of natural riverine pools (WRC, 2000f). Excess nutrients in a waterway can cause eutrophication, leading to rapid growth of algae during optimum conditions. Death of algae may cause deoxygenation within the water column. Excess sediment can act to increase turbidity, reducing light attenuation, which in turn influences photosynthetic rates. Infilling of riverine pools may cause the loss of summer refugia for many aquatic fauna and macroinvertebrate diversity is adversely affected by increased sedimentation levels, which in turn has an impact upon fish community structure.

Pollution

Pollutants enter waterways either from point (localised) or diffuse (widespread) sources. Pollutants are often lethal or highly detrimental to aquatic life. Examples of waterway pollutants include excess nutrients, heavy

metals, pesticides and herbicides. Under the right circumstances, excess nutrient loading leads to increased growth of phytoplankton, macroalgae and submerged macrophytes. Algal blooms can cause deoxygenation, a condition that often causes loss of aquatic life (WRC, 2000f).

Stock access

Stock access to the Donnelly River is mainly an issue in the upper headwaters, with isolated points of stock access possible intermittently along the remaining length of the river. In areas where stock access has been or is currently possible, riverbank degradation is evident. No stock crossings were present. Problems associated with unrestricted stock access to waterways include damage to and loss of riparian vegetation, weed invasion, erosion, destabilisation and trampling of banks, compacted soil and poor water quality from faecal matter. The effects of stock access can be evident for many years after access has been restricted, and ongoing monitoring of fenced off areas is required to ensure that native vegetation is regenerating, weeds do not become established and erosion is not further exacerbated (WRC, 2000b).

Stock watering points

There were no dedicated stock watering points located on the Donnelly River; where present, stock were allowed free access to the river. This has had an adverse impact on bank stability, soil compaction and riparian vegetation in affected areas.

Landholder issues, interests and concerns

Landholders voiced several concerns regarding the Donnelly River, namely in relation to the spread of blackberry throughout the catchment. Blackberry plants have formed serious infestations along many parts of the river and landholders expressed frustration at what many consider to be a 'source and sink' scenario, with government-controlled land harbouring blackberry populations. Other weeds of concern to landholders and government agencies along the river include arum lily, watsonia, apple of Sodom and olive trees. With the exception of watsonia in the upper catchment, these weeds are not yet firmly established along the river and it is imperative to control their spread before it escalates. Upper catchment landholders in particular expressed concern over water flows and waterlogging on their properties and many landholders were interested in aspects of river channel management, such as the impacts of sedimentation and large woody debris or vegetation on water flows.

6. Management Advice

Where to start

In river management, priority is given to areas in best condition; attention is then given to areas showing promise of recovery and lastly, to degraded areas. This approach is cost-effective and beneficial to the entire river ecosystem as it is much more efficient to conserve better quality river areas than it is to restore degraded ones. There are a number of ways in which the health and overall integrity of river systems can be enhanced and maintained. How much emphasis is placed on each component is a function of the expected outcomes for that river or reach, i.e. revegetation of the riparian zone, improved water quality etc. Information was sourced from a variety of publications, details of which can be found at the end of the section. Further information on relevant publications pertaining to this section can be found in the Greening Australia publication *Bush Tracks: Shortcuts to Vegetation Information for Natural Resource Management* (2004).

Protection and rehabilitation of native riparian vegetation

The riparian zone is a very important component of the river ecosystem. Obviously, it makes sense both in terms of finance and labour to conserve and protect existing riparian vegetation rather than to have to revegetate cleared areas. Limiting unnecessary access into the riparian zone is recommended, using fencing as required. Restricting access to the riparian zone will act to minimise damage from disturbance and allow natural regeneration to occur. It is important however to effect weed control and ensure stock access is controlled as fenced off areas are prone to weed invasion and stock access will undermine revegetation efforts. Natural regeneration will occur in areas where native trees and a healthy understorey remain. One technique for aiding natural regeneration is known as brushing, which constitutes laying seed-bearing parts of native flora directly onto the ground in revegetation sites, thereby allowing seeds to fall from the plant and germinate in the soil. This technique is appropriate for all habitats apart from the channel zone. However, for many stretches of river, riparian vegetation has been irreversibly damaged or lost, replaced by bare banks or dominated by invasive weeds. In these cases, it is necessary to revegetate the area back to its original state.

Revegetation of an area is commonly employed to achieve erosion control, enhance biodiversity, improve water quality and aid in rehabilitating saline-affected land, apart from inherent aesthetic and recreational benefits (WRC, 1999). Rehabilitation advice varies with each individual case and it is recommended that local environmental agencies and groups are contacted for advice; however some general rules apply when attempting to rebuild the area;

- Try and get a good understanding of the river system and determine the vegetation present before the damage occurred;
- Attempt to treat the cause of the problem, not just the symptoms;
- As mentioned, focus on rehabilitating or protecting areas of better quality before more degraded areas; and
- Weeds should be removed and replaced with native vegetation. In some cases however, it may be necessary to initially colonise an area with weeds to provide stabilisation and then introduce native species.

Site preparation is an essential precursor to revegetating a site. Preparation of the site involves adequately protecting the area to be revegetated, undertaking weed control and preparing the soil surface (e.g. ripping/mounding) prior to planting. Appropriate planting/seeding regimes will also have an effect on the success of revegetation. Ongoing monitoring of weeds is an integral part of the process, as weeds are quick to colonise disturbed habitats and compete with native plants for nutrients and water. There are a number of common revegetation techniques, including brushing (as above), direct seeding, planting of seedlings, pre-seeded matting and in certain cases, transplanting. These are described in more detail below.

Direct seeding

Direct seeding involves the sowing of native seed onto a prepared site. Relatively low cost, it allows for the establishment of a wide diversity of species for less labour investment than is involved in planting tube stock. Direct seeding can be less reliable than other methods due to specific germination requirements not being met and predation of seed. A very high investment in weed and pest control is also required. Direct seeding is best for floodplain and upland zones but is not recommended for embankments, due to loss of seed from soil and water erosion.

Planting of seedlings

Planting of seedlings is appropriate for in-stream and embankment revegetation, as well as for areas unsuitable for direct seeding. Planting should be restricted to local endemic species, and a 500:50:5 planting density for herb/sedges to shrubs and trees should be followed. Planting within the channel and along the lower embankment should be undertaken in spring, whereas other areas are best planted in autumn.

Pre-seeded matting

This technique involves spreading seeds onto an appropriate fibremulch and then laying the mat on-site after germination in early winter. As this technique is effective in both revegetation and erosion control, it is appropriate for steep embankments. Matting usually requires rolling for transport to the revegetation site and hence is suitable for sedges and rushes only, unless matting is transported to the site before seeding, in which case any species may be used.

Transplanting

Transplanting becomes a viable revegetation option in instances where either an appropriate donor site is available or where engineering works require the removal of plants that can be transplanted at a later date to the restored site. Caution must be exercised so as not to transfer weed propagules or soil-borne diseases such as dieback. As a result, the process is labour intensive and costly. Transplanting is most effective for species with fairly shallow root systems and vegetative growth (e.g. sedges and rushes), and should be undertaken in winter to early spring.

Species composition

Species composition is an important part of any revegetation scheme. Composition of vegetation varies with topography and soil characteristics and the choice of species to be used in revegetation should be based upon those native species local to the area or botanic province (local provenance). Apart from matching revegetation species to soil type and hydrological requirements, other factors to consider may include commercial agriculture or floriculture considerations. A suggested list of appropriate species is given in Appendix 1 and further information can be obtained from agencies and groups including Southern Forests Landcare, DAFWA, DEC and Greening Australia (WA).

Useful references for revegetation and rehabilitation

Pen, L. (1999). *Managing Our Rivers: A Guide to the Nature and Management of the Streams of South-West Western Australia*. Water and Rivers Commission, Perth.

Water and Rivers Commission (2001b). *Using Sedges and Rushes in Revegetation of Wetland Areas in the South West of Western Australia*. Water and Rivers Commission, River Restoration Report No. RR 8.

Water and Rivers Commission (1999). *Revegetation: Revegetating Riparian Zones in South-West Western Australia*. Water and Rivers Commission River Restoration Report No. RR4.

Water and Rivers Commission (1997b). *Native Vegetation of Freshwater Rivers and Creeks in South Western Australia*. Water and Rivers Commission, Perth.

Weed control

Weeds are simply plant species that are able to take advantage of certain, usually human induced, conditions to regenerate at the expense of native flora. Furthermore, most weed species reproduce by highly viable seed, vegetative propagule, or both, which can make them very difficult to eradicate. As mentioned, follow up revegetation and monitoring is a crucial component of any weed control program. It is important to note that many weeds thrive on disturbance and are favoured by fire, and some native species may act in ways similar to weed species.

Weed invasion along the Donnelly River and within the catchment is a problem of increasing concern. For management purposes, weeds can be divided into three groups: true aquatic weeds, garden escapees and annual pasture species. It is important to correctly identify your weed and gain an understanding of its biology. Management of annual weeds is in many cases limited to preliminary spraying, while removal or poisoning of garden escapees is necessary to control their growth in the riparian zone. Most major tree, shrub, vine, bulbous, herb and tall grass weeds are classed as garden escapees. As the effort required to remove them is intensive, the emphasis should lie on prevention rather than cure of the problem, necessitating constant vigilance to avoid major infestations becoming established. A further problem in the removal of some garden escapees is that the weed species may actually be supporting bank stability, and their removal would result in

destabilisation. This situation highlights the necessity of always undertaking weed removal in conjunction with revegetation or stabilisation works. True aquatic weeds are less prevalent as major infestations but the consequences can be far more severe.

A coordinated and integrated approach is required to deal with invasive weed species, such as blackberry and arum lily present along the Donnelly River. Some information on weeds designated as priority species along the Donnelly River is given below. The weeds are classified by the Department of Agriculture as either declared plants or pest plants, both of which mean the species in question is both serious and invasive, and in need of immediate control and eradication. Declared plants are under the APB (Agricultural Protection Board) legislation and landholders are obligated to control the plant on their property. Pest plants are not included in the legislation, meaning that there is no legal obligation for the plant to be eradicated.

Common blackberry *Rubus anglocandicans*

Weed of National Significance and declared plant. Perennial, originally introduced from both Europe and America as a fruit crop. Spread by birds, other animals and vegetatively. Found intermittently and in dense infestations along the length of the Donnelly River, although not yet in the lower reaches of the river. Manual control is possible if spread is localised, but larger infestations typically require chemical treatment. Regrowth can be treated with appropriate chemical when plants are actively growing and before seed set; follow up treatment is usually necessary. Biological rust is also in use, for further details contact Southern Forests Landcare.

Arum lily *Zantedeschia aethiopica*

Weed of National Significance[5], declared plant, native to South Africa. A widespread tuberous perennial, leaves are toxic to stock. Spread by birds, water and vegetatively. Flowers mainly spring to early summer and poses a high threat to waterways. Repeated cutting and removal of leaf matter will eventually kill the plant, although spraying with appropriate herbicide may be undertaken prior to flowering between June and October.

Olive tree *Olea europaea*

Believed to be a native from the Mediterranean, the olive tree is of commercial importance in Australia and is now naturalised over some parts of southern Australia. It has been declared in other parts of Australia but is as yet undeclared in Western Australia. A long-lived evergreen tree, it propagates by resprouts or suckers, a profusion of seedlings are often found near old established trees. Birds and mammals also spread seeds. Seedlings can be hand pulled and larger plants chemically treated, either by injecting suitable chemical into the trunk or cutting and painting the tree.

Watsonia *Watsonia* spp.

Pest plant, herb native to South Africa. Grows from a corm (underground stem) with above ground parts of the plant renewed annually. A highly invasive weed, all species are garden escapees and pose a serious threat on any disturbed land. Corms difficult to remove by hand. Larger infestations suitable for chemical control just before flowering (spring to early summer).

Apple of Sodom *Solanum linnaeanum*

Declared plant, pest plant. Shrub native to South Africa, grows to 2 m or more in height and width. Fruit toxic to stock and humans and seeds must be disposed of with care. Distinctive purple flowers with yellow stamen. Small plants can be removed manually, larger plants cut and the stump painted with appropriate herbicide.

Bridal creeper *Asparagus asparagoides*

Weed of National Significance, prohibited plant. Perennial introduced from South Africa. One of the most serious environmental weeds in WA. Extremely invasive, creates a potential fire hazard as it dies over summer. Spread by birds and vegetatively, control difficult. Small infestations may be hand weeded; larger infestations can be wiped or sprayed with appropriate herbicide. Controlled plants should then be destroyed. Follow up treatment necessary. An effective biological rust is currently used for control purposes.

[5]Signifies that the weed has been identified as causing significant environmental damage in Australia. There are twenty weeds of national significance recognised in Australia.

Thistle *Carduus* sp.

Native to Europe, Asia and North Africa. Several species have naturalised in WA. Small growths can be mechanically removed, before seed set. Chemical control is also an option, provided application occurs before flowering, during a phase of active plant growth.

As the weed species in question are located near water systems, physical control is the preferred method of removal, however the size of infestation and growth habit may make this option unviable. Chemical control should then be considered, subject to a number of provisions. Of importance are the possible effects of the chemical on native flora and fauna as well as on water quality. There are a few guiding principles to follow when using herbicides, namely:

- Always read the label and stick to the recommend usage;
- If possible try and spray the plants when the water table is low, as the herbicide will have a smaller chance of contaminating the water table;
- For optimal effectiveness, ensure that the plant is sprayed before seeds have set;
- It may be useful to mix coloured food dye into the spray as this will allow you to monitor progress;
- Where possible and appropriate inject the herbicide into the lower trunk to prevent runoff;
- Do not spray on windy or rainy days, as this will decrease the effectiveness and target accuracy of the chemical;
- Once the plant has died, remove and burn it to prevent any seed spread; and
- If unsure contact DAFWA.

For further information on weeds and their control, agencies and groups such as Southern Forests Landcare, DEC and the DAFWA may be contacted.

Useful references on weeds and weed control

Brown, K. and Brooks, K. (2002). *Bushland Weeds: A Practical Guide to Their Management*. Environmental Weeds Action Network (Inc.), Greenwood, Australia.

CSIRO (2006) (online). *Weedy blackberry and raspberry species in Western Australia and strategies for their management*. Unpublished report submitted to the Department of Agriculture, Fisheries and Forestry. Available World Wide Web: http://www.ento.csiro.au/weeds/blackberry/WABBManPlan2006_draft.pdf

CRC for Australian Weed Management (2003) (online). CRC for Australian Weed Management. Available World Wide Web: http://www.weeds.crc.org.au

Hussey, B.M.J., Keighery, G.J., Cousens, R.D., Dodd, J. and Lloyd, S.G. (1997). *Western Weeds: A Guide to the Weeds of Western Australia*. The Plant Protection Society of Western Australia (Inc.), Victoria Park, Western Australia.

Moore, J. and Wheeler, J. (2002). *Southern Weeds and Their Control*. Department of Agriculture, Perth.

Water and Rivers Commission (2000i). *Weeds in Waterways*. Water Notes 15. Water and Rivers Commission, Perth.

Weeds Australia (undated) (online). *Weeds Australia*. Available World Wide Web: http://www.weeds.org.au.

Water quality

Any waterway in an agricultural catchment is potentially subject to elevated nutrient levels and increased sedimentation as a result of farming activities, impacting on water quality. As noted, water quality within the Donnelly River does not currently pose a significant management issue. However, the following techniques will help to maintain the current quality, avoiding the necessity of management intervention at a later stage.

Management of water quality can be effected in a number of ways, including maintenance of vegetative buffers and appropriate agricultural practices. Maintaining a vegetative buffer between the waterway and surrounding land is beneficial in that the vegetation effectively acts as a biological filter, intercepting and trapping nutrients and sediment before they enter the river. Even a buffer of grass can be effective in areas where foreshore vegetation has been lost, and aquatic vegetation also serves in nutrient and sediment trapping. Agricultural practices in the surrounding catchment have a large bearing on the subsequent amount of sediment and nutrients transported into a waterway. Appropriate practices can reduce the amount of soil erosion and ensure adequate vegetative buffers

are maintained. Cultivating along rather than perpendicular to soil contours will help to reduce soil erosion, as will fencing to keep stock away from waterways.

It may be feasible and beneficial at some point in the future to undertake a 'snapshot' of water quality within the Donnelly River, testing for parameters such as dissolved oxygen, pH, turbidity, salinity, total nitrogen and phosphorus, colour, macroinvertebrates, phytoplankton, nitrates and nitrites. This would enable comparisons to be made over time on the water quality of the river, and management actions to be decided accordingly.

Useful references on water quality

Pen, L. (1999). *Managing Our Rivers: A Guide to the Nature and Management of the Streams of South-West Western Australia*. Water and Rivers Commission, Perth.

Prosser, I., Karssies, L., Ogden, R. and Hairsine, P. (1999). Using buffers to reduce sediment and nutrient delivery to streams. *Riparian Land Management Technical Guidelines Volume Two: On-ground Management Tools and Techniques*. Price, P. and Lovett, S. (eds.), LWRRDC, Canberra.

Rose, B. (2002). *Best Environmental Management Practices for Environmentally Sustainable Vegetable and Potato Production in Western Australia: A Reference Manual*. Potato Growers Association of WA, Inc., Perth.

Water and River Commission (2001b). W*ater Quality and macroinvertebrates*. Water Facts 2. Water and Rivers Commission, Perth.

Stock control

Unrestricted stock access has a number of detrimental effects, such as impeding flora regeneration and compacting soil, increasing erosion and bank destabilisation, transportation of weeds and grazing and trampling of vegetation. Limiting access of stock to waterways is an extremely important management practice in waterway restoration and rehabilitation, achieved by fencing of riparian zones. However the idea of fencing is often negatively received by landholders. Fencing off the riparian zone is contentious for a number of reasons, mainly that the riparian zone often represents good grazing potential, fencing is an expensive undertaking and management of the fenced off area will often require intensive weed control efforts.

Fencing off the riparian zone does not have to be absolute; the quantity of land from which stock are excluded will depend on management objectives. If the aim of fencing is to protect high quality riparian vegetation to maintain habitat, landscape and ecological corridors, all stock should be excluded. However, if the riparian zone has a history of grazing and stock exclusion could lead to the proliferation of weeds and a fire hazard, allowing access for grazing is beneficial. Fences in this instance are used to control the level of grazing so that the dominant native vegetation is able to regenerate. Considerations when planning fence location include the form of the river, presence of riparian vegetation and frequent flood levels, in addition to land tenure and cadastral boundaries. Correct fence placement in relation to river valleys is illustrated in Figure 4.

If a riparian zone is to be fenced off, it is generally necessary to make provisions for stock access to the waterway or to an off-site watering point. The construction of a stock crossing or watering site may be suitable on hard rocky areas or the inside of meander bends, where sediment deposits rather than erodes. Otherwise, small areas of foreshore can be hardened with stones. Crossings should be located on straight sections of the river where velocity is low or the riverbed is hard.

Rehabilitation of old or ineffective stock watering points, which are devoid of vegetation and have compacted soil, may include soil amelioration, such as ripping prior to covering with matting to control erosion, or brushing to assist regeneration. Protection of the regenerating vegetation from predation may be required.

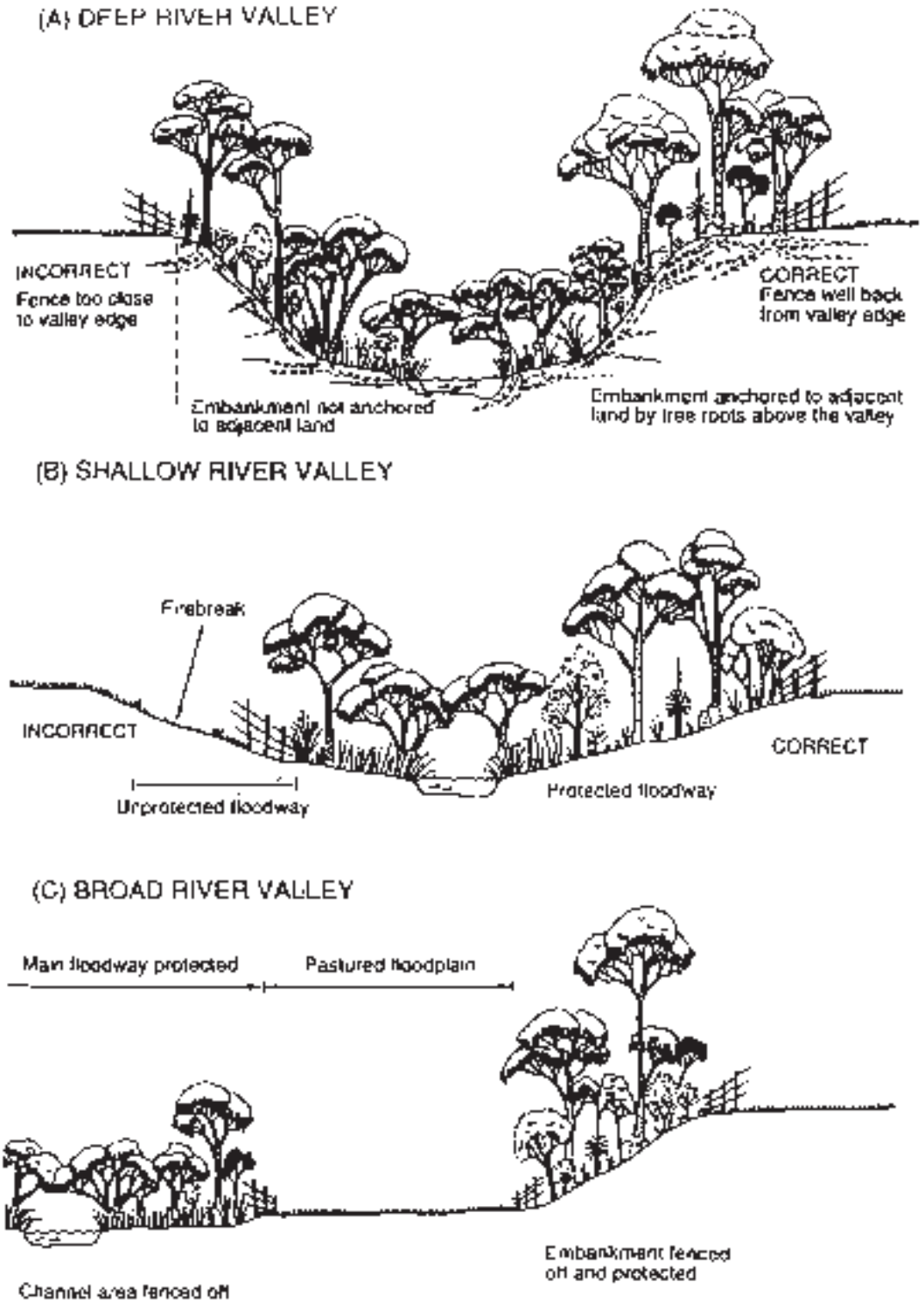


Figure 4: Placement of fences in relation to the river valley (after WRC, 2000c)

Useful references on stock control

Pen, L. (1999). *Managing Our Rivers: A Guide to the Nature and Management of the Streams of South-West Western Australia*. Water and Rivers Commission, Perth.

Water and Rivers Commission (2000b). *Livestock Management: Construction of Livestock Crossings*. Water Note 6. Water and Rivers Commission, Perth.

Water and Rivers Commission (2000c). *Livestock Management: Fence Location and Grazing Control*. Water Note 18. Water and Rivers Commission, Perth.

Water and Rivers Commission (2000d). *Livestock Management: Watering Points and Pumps*. Water Note 7. Water and Rivers Commission, Perth.

Feral animals

Feral animals located within the Donnelly River catchment include foxes, rabbits, cats, and pigs (see also Table 5). Invasive species cause management problems in that they compete with native species for habitat and resources. Feral pigs have been sighted in the nearby Scabby Gully area and are likely to be found in the Donnelly River area. The presence of feral pigs is of concern, given evidence of the damage they can inflict on riparian areas. A large scale control program is recommended to minimise damage from the animals to the Donnelly River area. A coordinated approach to feral animal control is necessary for optimal effectiveness. Advice on feral animal control can be obtained from Southern Forests Landcare, DEC (formerly CALM) or DAFWA.

Erosion control

Serious erosion is not a major problem for the Donnelly River; however there are areas of potential concern where natural erosion has become exacerbated. Much of the river retains a dense and supportive riparian zone and erosion observed is mainly occurring adjacent to access points or in areas of past or current stock access. Revegetation of unstable banks is the easiest way to combat erosion; however engineering solutions involving modification of channel flow may be necessary if revegetation proves inadequate. If deemed necessary, site-specific advice and relevant legal approvals should be obtained prior to instigating any physical modification works on a river and it is important to remember that a detailed river geometry survey and variety of calculations are normally required for the correct design of restorative engineering works. As any engineering works attempted will usually be on a larger scale, it is recommended that landholders approach the relevant authorities (e.g. DEC, DoW, Southern Forests Landcare) for assistance and notify them of issues which are under their jurisdiction to determine. These agencies and groups can also be approached for general advice and expertise to aid in solving specific problems that may be encountered.

Large woody debris

Large woody debris, also known as snags, is an integral and natural part of river systems, fulfilling an important role in river ecology. In the past, management practice has involved removing large woody debris from the water in instances where they may be diverting water flow onto the bank and subsequently causing erosion in vulnerable areas. Preferred management practice has shifted to leaving the greatest amount of large woody debris possible in situ, so as to provide habitat for aquatic flora and fauna. Large woody debris, instead of being removed, should be repositioned at an angle 20°-40° to the stream bank, which will diminish the effect on water flows and direction while maintaining habitat. Large woody debris can also be added to a river system to redirect flows from unstable areas.

Useful references on erosion control

Pen, L. (1999). *Managing Our Rivers: A Guide to the Nature and Management of the Streams of South-West Western Australia*. Water and Rivers Commission, Perth.

Raine, A.W. and Gardiner, J.N. (1995). *Rivercare-Guidelines for Ecologically Sustainable Management of Rivers and Riparian Vegetation*. Land and Water Research and Development Corporation, Canberra.

Rose, B. (2002). *Best Environmental Management Practices for Environmentally Sustainable Vegetable and Potato Production in Western Australia: A Reference Manual*. Potato Growers Association of WA, Inc., Perth.

Water and Rivers Commission (2001). *Stream Stabilisation*. River Restoration Report No. RR 10. Water and Rivers Commission, Perth.

General recommendations

It is recommended that landholders along the Donnelly River consider:

- Prioritising the protection of their riparian land, protecting the river foreshore and restricting stock access;
- Controlling and managing weed species found on their properties;
- Fencing the riparian zone to restrict or exclude stock permanently, utilising available funding to help minimise costs;
- Maintaining and rehabilitating their riparian zone by fencing or revegetation; revegetation options could include either commercial agroforestry or native species; and
- Using management techniques designed to minimise soil disturbance and subsequent erosion.

It is recommended that Southern Forests Landcare consider:

Weed control

- Encouraging an integrated community approach to weed control along the Donnelly River. Work cooperatively with other relevant agencies and departments, e.g. DEC, DAFWA, Shire of Manjimup and landholders to develop and implement a coordinated weed control strategy;
- Mapping the occurrence of common blackberry along the length of the river. Target blackberry growth for spraying and removal regimes over the course of a number of years, with continued monitoring to prevent re-establishment along the river. Implement release of blackberry biocontrol rust at selected infestations along river;
- Mapping occurrence of arum lily, feral olive trees and apple of Sodom plants along the river. Implement a multiple-property control system to initially clear the affected reaches of the weeds. Develop a monitoring regime to monitor for re-establishment of the weeds; and
- Mapping, monitoring and implementing control regimes for any other weeds along the Donnelly, e.g. nasturtiums, agapanthus, bridal creeper, watsonia.

DEC and Shire managed land

- Liaising with DEC and respective Shires to improve weed control and management of foreshore reserves vested with DEC and the Shire; and
- Coordinating a large scale feral pig control program to minimise damage.

Fencing and revegetation

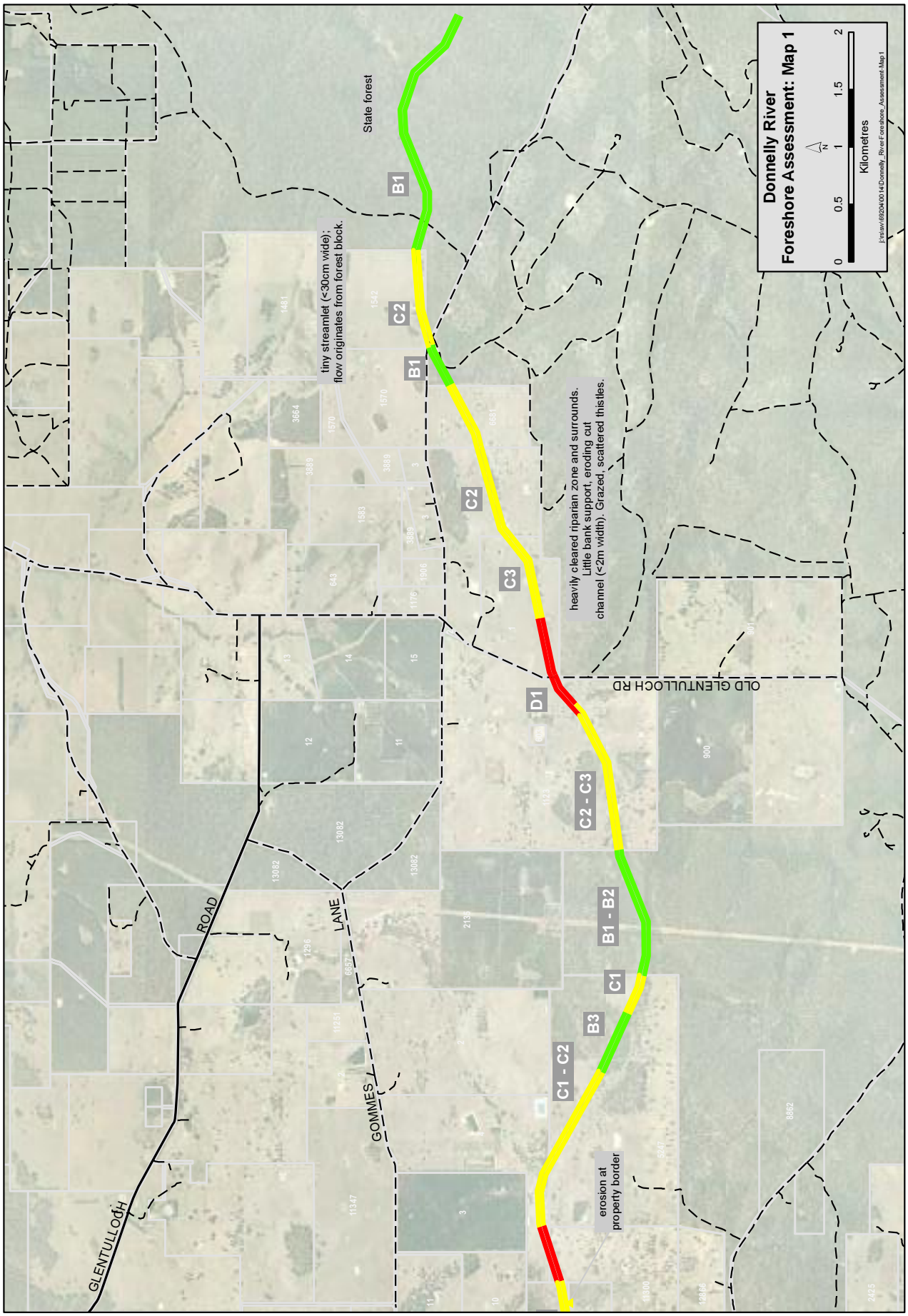
- Actively supporting and encouraging landholders/community groups to fence off areas of the river where stock access is possible and assisting with related funding applications;
- Providing support and encouragement to landholders undertaking revegetation, using local provenance seedlings;
- Actively promoting revegetation/agroforestry options in the upper headwaters of the Donnelly River in order to increase the ecological viability of the river and stabilise the river channel; and
- Undertaking the restoration of a demonstration site along the Donnelly River as a means of demonstrating river restoration techniques.

7. River Foreshore Condition and Recommendations for Management

Overview

The Donnelly River as represented on Figure 1 has been divided into nine sections for the purposes of reporting and surveying. As such, the information contained within this section should be considered along with Figure 1 and Maps 1-9 for spatial reference and clarity. The summarised information includes foreshore condition ratings for the Donnelly River, information on land use, erosion and prevalent weeds, stock access and recommended management advice to address any issues of concern. The information was current at the time of assessment and initial mapping of weed species has been completed.

Southern Forests Landcare bases all information in this section upon personal site observations, interactions with landholders and supplementary weed presence information from the DAFWA. All foreshore assessments took place from October to December 2005 and the majority were conducted with landholders. Management advice and recommendations contained in this report are offered as an indicative guide only. Implementation of any recommendations would be entirely voluntary and represent a cooperative effort between interested landholders and Southern Forests Landcare. However, while this section contains recommendations only, implementation of the management advice is strongly recommended.



Donnelly River Map 1

Map 1

The Donnelly River emerges from the Winnejup State Forest, passing through the upper headwaters as a small, ephemeral stream. Map 1 covers the emergence of the Donnelly just north of Kingston Road in a west south westerly direction to the South Western Highway. The majority of the foreshore covered by Map 1 is located on heavily cleared agricultural land, with little remaining native riparian vegetation. The river also meanders through small three State Forest/National Park reserves, where river foreshore condition is improved by the presence of a well developed riparian zone. In the agricultural areas, the foreshore is dominated by grasses and pastures, most of which is grazed by stock. The section was unfenced and was approximately 11 km long.

Summary Information	
Location/lot numbers of adjacent properties	Winnejup National Park; 1542; 6681; 1; 2; 1123; 5247; 4; 11300; 1396; 1397; Reserve 1672
Foreshore condition rating (as at Dec 2005)	B3 21% C 64% D1 15%
Vegetation cover & health	Largely cleared for agricultural/grazing purposes- little fringing vegetation remains outside of reserves. Foreshore dominated by grasses. Little if any natural regeneration is occurring.
Land use	Agriculture, grazing, viticulture

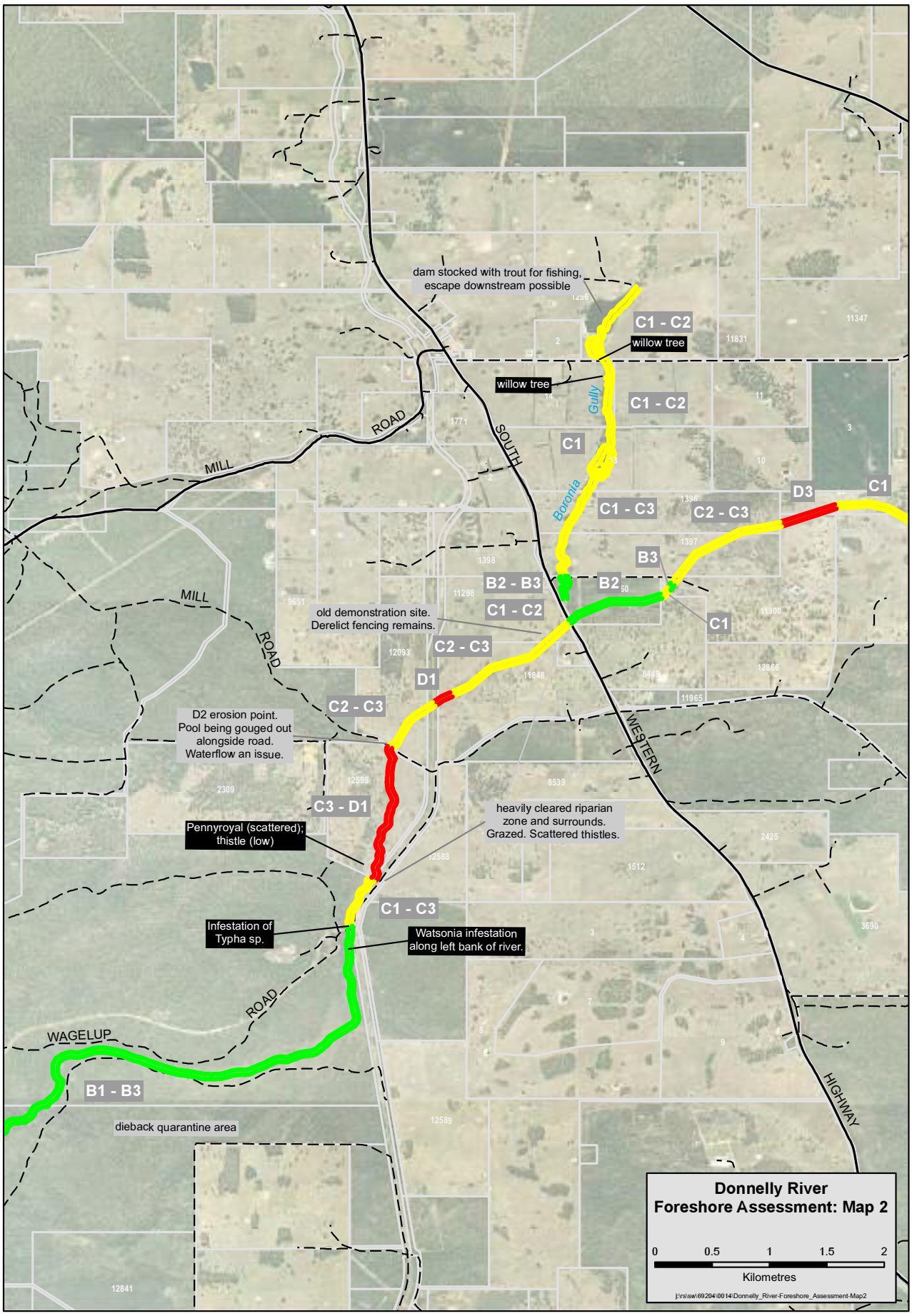
Issues	Comments
General foreshore condition	The Donnelly is ephemeral in the very upper headwaters represented by Map 1 and lacks a defined channel. Further downstream, the river, although still narrow, becomes extremely channelised and in places has been artificially dug out to increase runoff. The area is extensively cleared and little fringing vegetation remains.
Fencing	The entire section is unfenced and stock has free access to the foreshore. 0 km fenced.
Erosion/bank	Significant bank erosion (>45°) begins in the mid-lower reaches of the area. Little **stability** fringing vegetation remains along the entire length of the section to assist in stabilisation. The majority of riverbanks are unstable and prone to erosion, exacerbated by stock access.
Weeds	No serious infestations occur along the predominantly cleared upper section. Isolated weeds include pines, thistles and pennyroyal, which are spot-controlled by landowners. Watsonia observed in some State Forest reserves.
Other comments	Erosion is the most serious management issue in this section, with the lack of fringing vegetation directly contributing to existing and potential bank instability. Revegetation is recommended to assist with bank stabilisation, which would require protective measures, e.g. fencing, tree guards, to allow for establishment.

Prioritised management actions recommended

1. Continuation of landholder weed control activities. Control Watsonia in Reserves. Initial weed mapping completed.
2. Advocating of commercial riparian agroforestry and revegetation options to landholders along the upper reaches to promote bank stabilisation.

Long term management actions recommended

1. To improve the ecological health and viability of this predominantly agricultural section of the river, fencing off sections of the river where it forms a defined channel is recommended, accompanied by revegetation with native plants which would significantly help to stabilise the erosion-prone banks.



Donnelly River Map 2

Map 2

Map 2 extends from the top of Boronia Gully, an ephemeral tributary of the Donnelly River, to the convergence of Boronia Gully with the main channel of the Donnelly. From there it continues through the last few agricultural properties in the upper headwater area, ending just inside the Yornup State Forest at the Wagelup Rd intersection. The majority of the foreshore is located on heavily cleared agricultural land, with little remaining native riparian vegetation. On passing into the Yornup State Forest, the river foreshore condition is improved somewhat by the presence of a riparian zone although bank erosion is significant. In the agricultural areas, grasses dominate the foreshore. The majority of this section was unfenced. Only one property had erected fencing; however this was derelict and the property was being actively grazed. This property was a former demonstration site; this site has been restored as part of this River Action Plan. The entire section covered approximately 7 km.

Summary Information	
Location/lot numbers of adjacent properties	1880; 1256; 1845; 1907; 4/126; 4/125; 11298; 11848; 12093, 12595; Yornup State Forest
Foreshore condition rating (as at Dec 2005)	C 81% D 19%
Vegetation cover & health	The majority of this section is extensively cleared for agricultural and grazing purposes. Mature trees over grass remain, but little fringing vegetation exists. Natural regeneration is limited.
Land use	Agricultural, grazing, State Forest

Issues	Comments
General foreshore condition	Boronia Gully becomes channelised as it nears the confluence with the Donnelly River and remains narrow. The Donnelly is still ephemeral in this section but gains significant velocity to carve a small channel. Little fringing vegetation remains and banks are actively eroding in properties west of the South Western Highway. The entire section with the exception of the State Forest is grazed.
Fencing	With the exception of one property, the entire section is unfenced. Fencing on the one property however is largely defunct and does not restrict grazing. In effect 0 km fenced
Erosion/bank stability	Significant bank erosion (>45°) begins in the mid reaches of the section. Little fringing vegetation remains along the entire length of the section to assist in stabilisation. Riverbanks are unstable and prone to further erosion, exacerbated by stock access.
Weeds	No serious infestations occur along the predominantly cleared section. Isolated weeds include thistles and pennyroyal, which are spot-controlled by landowners. Moving into Yornup State Forest, isolated watsonias were observed. At the end of the section (Wagelup Rd crossing), a significant *Typha* infestation (suspected to be. *T. domingensis*) is present, as well as further watsonia infestations and isolated tagasaste *Chamaecytisus palmensis* growths.
Other comments	Erosion is the most serious management issue in this section, with the lack of fringing vegetation directly contributing to existing and further bank instability. Some revegetation is recommended to assist with bank stabilisation, which would require protective measures, e.g. fencing, tree guards, to allow for establishment. Boronia Gully passes through a landholder dam stocked with trout for recreational fishing before meeting with the Donnelly and trout have been observed to pass into the Donnelly system in this way.

Prioritised management actions recommended

1. Spray to control isolated and dense watsonia plants.
2. Investigate possible *Typha* control options.
3. Control isolated tagasaste growths.
4. Investigate options and feasibility of restoring previous demonstration site.

Long term management actions recommended

1. To improve the ecological health and viability of this predominantly agricultural section of the river, fencing off sections of the river where it forms a defined channel is recommended, accompanied by revegetation with native plants which would significantly help to stabilise the erosion-prone banks.
2. Investigate engineering options to ameliorate drainage and velocity issues towards the end of the section.

Map 3

This section of the Donnelly meanders through the Yornup, Thornton, Carter, Netic and Wheatley State Forests. No private properties are present. Map 3 begins at the Wagelup Rd crossing and continues past Donnelly Mill to the Penny Rd crossing. Access is limited as Yornup, Thornton and Carter State Forests are *Phythopthora cinnamomi* (Dieback) disease risk areas. The section is densely vegetated with predominantly native species such as flooded gum *Eucalyptus rudis*, swamp willow (wonnich) *Callistachys lanceolata* and grey honey myrtle *Melaleuca incana*. Some disturbance is observable at access points; however the quality of intervening areas is high, with minimal if any disturbance. The section is unfenced; however grazing by stock is unlikely due to location. Map 3 covers approximately 27 km.

Summary Information	
Location/lot numbers of adjacent properties	Yornup; Thornton, Carter, Netic/Wheatley State Forests
Foreshore condition rating (as at Dec 2005)	A2-A3 35% B1 65%
Vegetation cover & health	Healthy vegetation exists both fringing and surrounding the river. A diverse, predominantly weed-free assemblage exists, free from grazing stock.
Land use	State Forest conservation areas, silviculture.

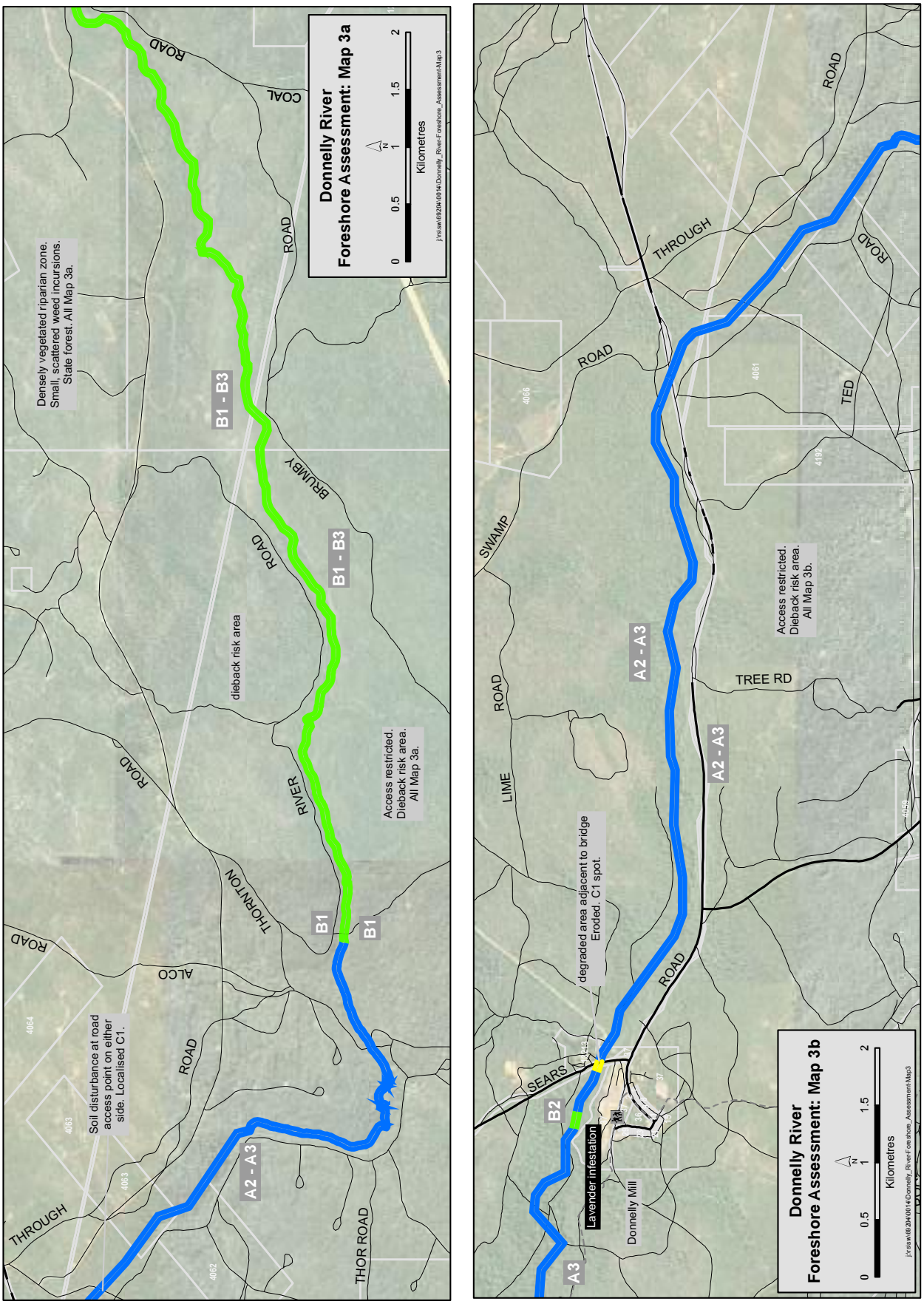
Issues	Comments
General foreshore conditions	Flow through this area has increased in velocity and a healthy, native assemblage of fringing and in-stream vegetation exists. Flow remains ephemeral and channel width widens. Good foreshore condition overall.
Fencing	The section is unfenced; however the chances of stock accessing river foreshore are remote as there are no landholder properties within the section. Access to the foreshore is restricted by dense vegetation growth. 0 km fenced.
Erosion/bank stability	No serious erosion present, minor points of natural, dynamic undercutting and bank de-stabilisation present. Erosion appears to be naturally occurring due to flow regimes, not exacerbated by human intervention/clearing. Banks stabilised by dense vegetation.
Weeds	No serious invasive weeds were noted along the area surveyed. Thistles noted, blackberry was not observed.
Other comments	Situated in State Forest and disease-risk areas, the Donnelly as covered by Map 3 is not freely accessible to the general population and so shows little evidence of human disturbance. The river is in good condition and needs little if any works to maintain its condition.

Prioritised management actions recommended

1. Continue to monitor section for weed presence to avoid establishment. Initial weed mapping completed.

Long term management actions recommended

1. As a significant part of the Donnelly River covered by Map 3 is located within disease risk (Dieback) areas, continuing to enforce restricted access measures for vehicles, which spread the disease, is recommended.
2. Continue to monitor section for weed presence to avoid establishment.



Donnelly River Map 3

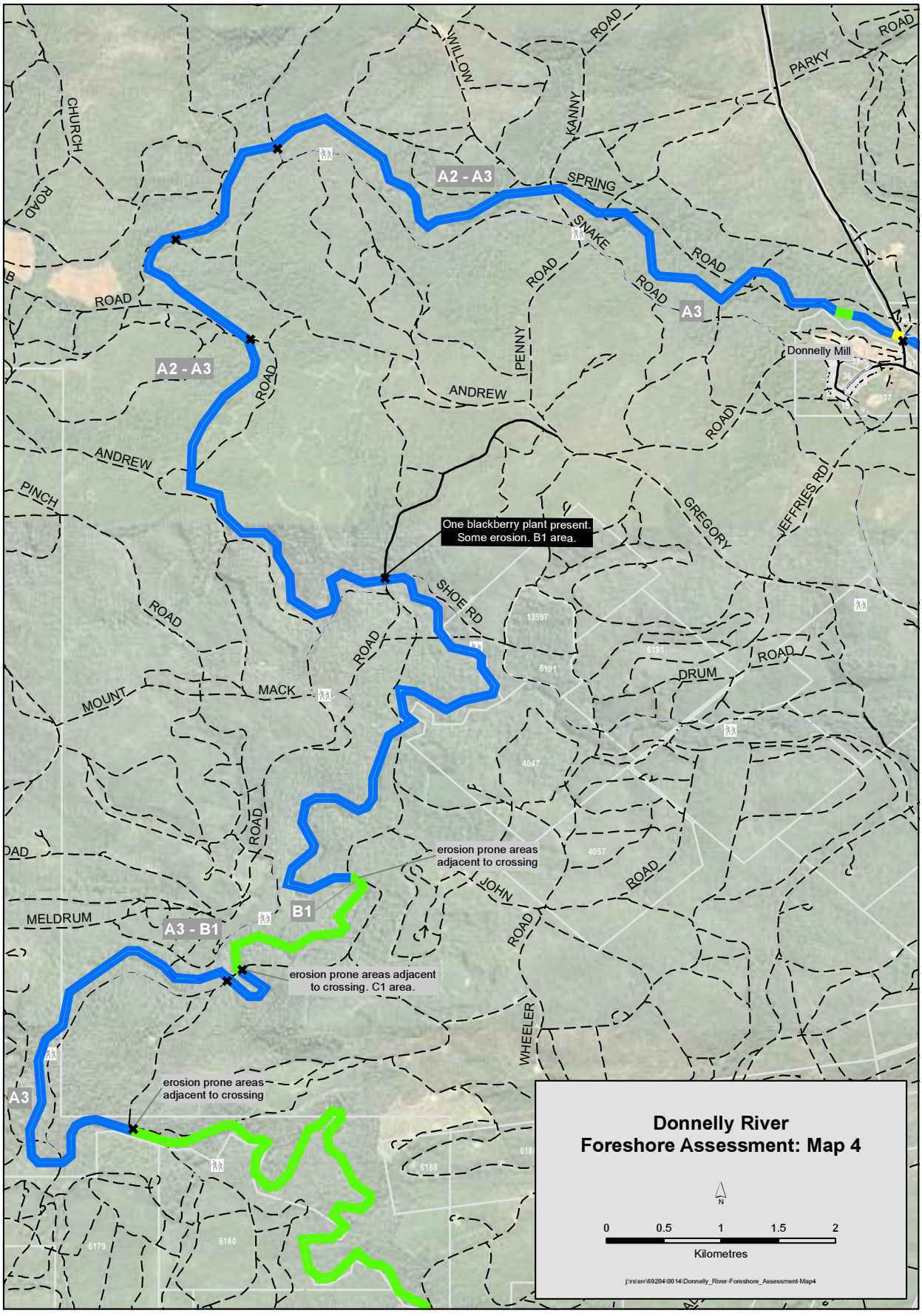
Map 4

This section of the Donnelly travels from Penny Rd to Panda Rd crossing, through the Mack and Wheatley State Forests. The entire section is State Forest. The section is densely vegetated with predominantly native species such as flooded gum *Eucalyptus rudis*, swamp willow (wonnich) *Callistachys lanceolata* and grey honey myrtle *Melaleuca incana*. Fringing species include native *Lepidosperma* sp. sword sedges and *Juncus* sp. rushes. A minor growth of common blackberry was noted at the Tom Rd/Shoe Rd crossing; however its appearance would suggest that it had been sprayed recently. Some disturbance is observable at access points; however the quality of intervening areas is high, with minimal if any disturbance. Access along the foreshore area is restricted due to dense vegetation growth and lack of vehicle entry roads. The section is unfenced; however grazing by stock is unlikely due to location. Map 4 covers approximately 23 km.

Summary Information	
Location/lot numbers of adjacent properties	Mack and Wheatley State Forests
Foreshore condition rating (as at Dec 2005)	A 45% B1 55%
Vegetation cover & health	Dense, healthy vegetation exists both fringing and surrounding the river. A diverse, predominantly weed-free assemblage exists, free from grazing stock. Active natural regeneration is occurring.
Land use	State Forest conservation areas, silviculture

Issues	Comments
General foreshore conditions	Flow through this area maintains an increased velocity. A healthy, predominately native assemblage of fringing and in-stream vegetation exists. Flow remains ephemeral. Good foreshore condition overall.
Fencing	The section is unfenced; however the chances of stock accessing river foreshore are remote. Access to the foreshore is restricted due to dense vegetation growth. 0 km fenced.
Erosion/bank stability	No serious erosion present, minor points of subsidence and bank de-stabilisation present. Erosion present is dynamic and naturally occurring. Erosion points predominantly found adjacent to road crossings.
Weeds	Minor common blackberry growth noted with prior control evident.
Other comments	Situated in State Forest, the Donnelly as covered by Map 4 is not easily accessible and shows little evidence of human disturbance, apart from access points. The river is in good condition and needs little if any work to maintain its condition.

Prioritised management actions recommended
1. Monitor regrowth of common blackberry plants in section as well as new growths becoming established.
Long term management actions recommended
1. Follow up monitoring and spraying of isolated common blackberry plants to prevent establishment.
2. Continue to monitor section for weed presence to avoid establishment. Initial mapping completed.



Donnelly River Map 4

Map 5

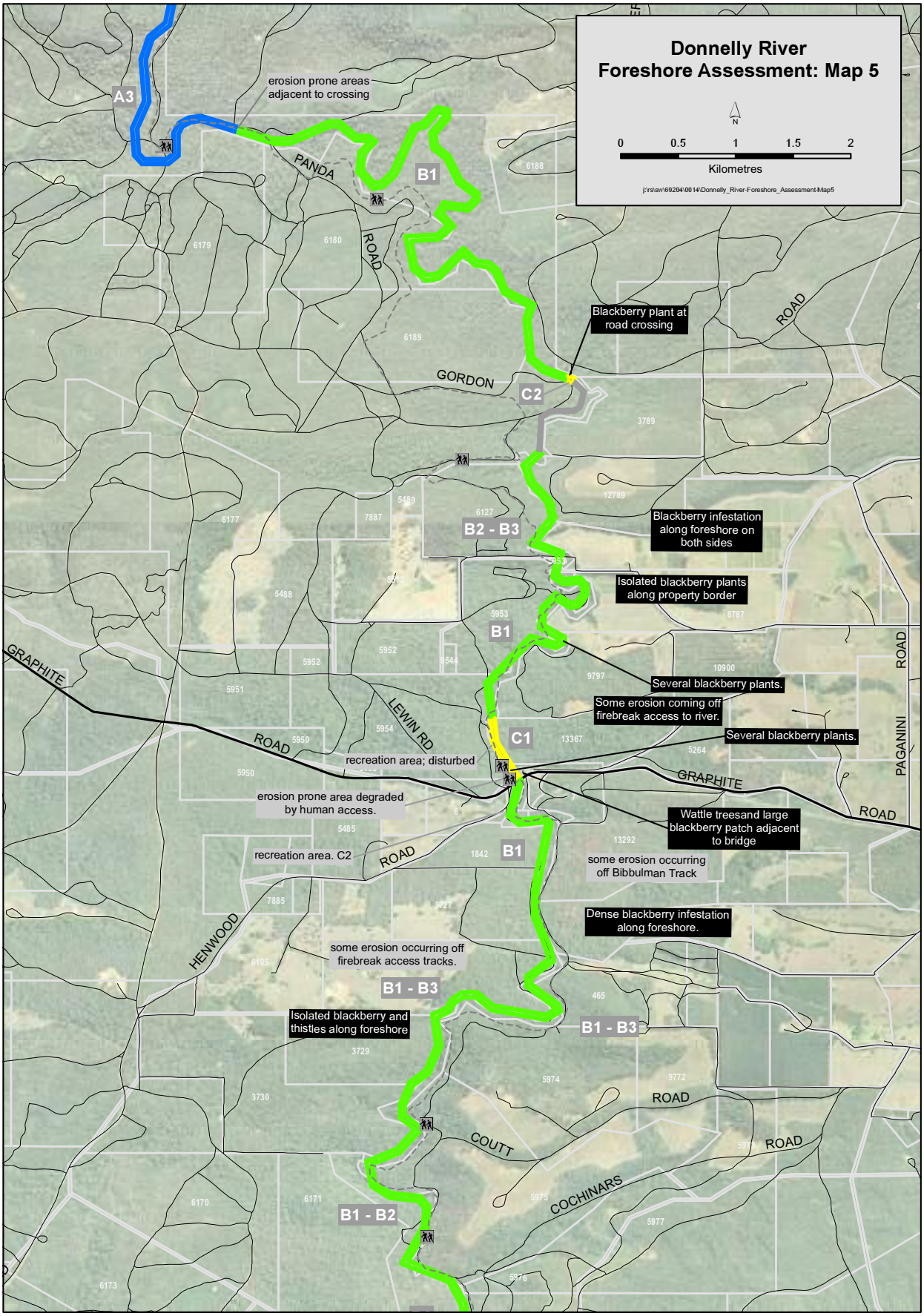
The Donnelly River stretches from the Panda Rd crossing through Gordon State Forest to the Graphite Rd intersection. From here, Map 5 extends to just south of Graphite Rd, which represents the end of agricultural properties for a significant distance. Both landholder properties and State Forest areas are covered within this section. The initial State Forest areas are densely vegetated with predominantly native species such as flooded gum *Eucalyptus rudis*, karri *Eucalyptus diversicolor*, karri hazel *Trymalium floribundum* and fringing species such as *Lepidosperma* sp. sword sedges and *Juncus* sp. rushes. In these State Forest areas, some disturbance is observable at access points; however the quality of intervening areas is high, with minimal if any disturbance. State Forest areas are unfenced.

The lower portion of Map 5 moves into agricultural and rural residential sections. All landholder properties but one are fenced to restrict stock access to the foreshore, and the unfenced property has no stock. The Bibbulmun Track follows the river on the opposite bank from the landholder properties for a portion of this section. A popular local picnic site, Greens Island, occurs within this area. River access is possible and common blackberry infestations were recorded. The river channel narrows, and landholders reported issues with blackberries and native (but invasive) bracken. The foreshore area on both sides of the river in this lower section of Map 5 is degraded and erosion prone. Landholder foreshore areas are on steep slopes, predominantly cleared and dominated by annual grasses apart from a narrow riparian strip. The opposite side of the river (Bibbulmun Track side) is degraded by the presence of the well-used walking track and recreation area that allows free access to the foreshore. Map 5 covers approximately 16 km.

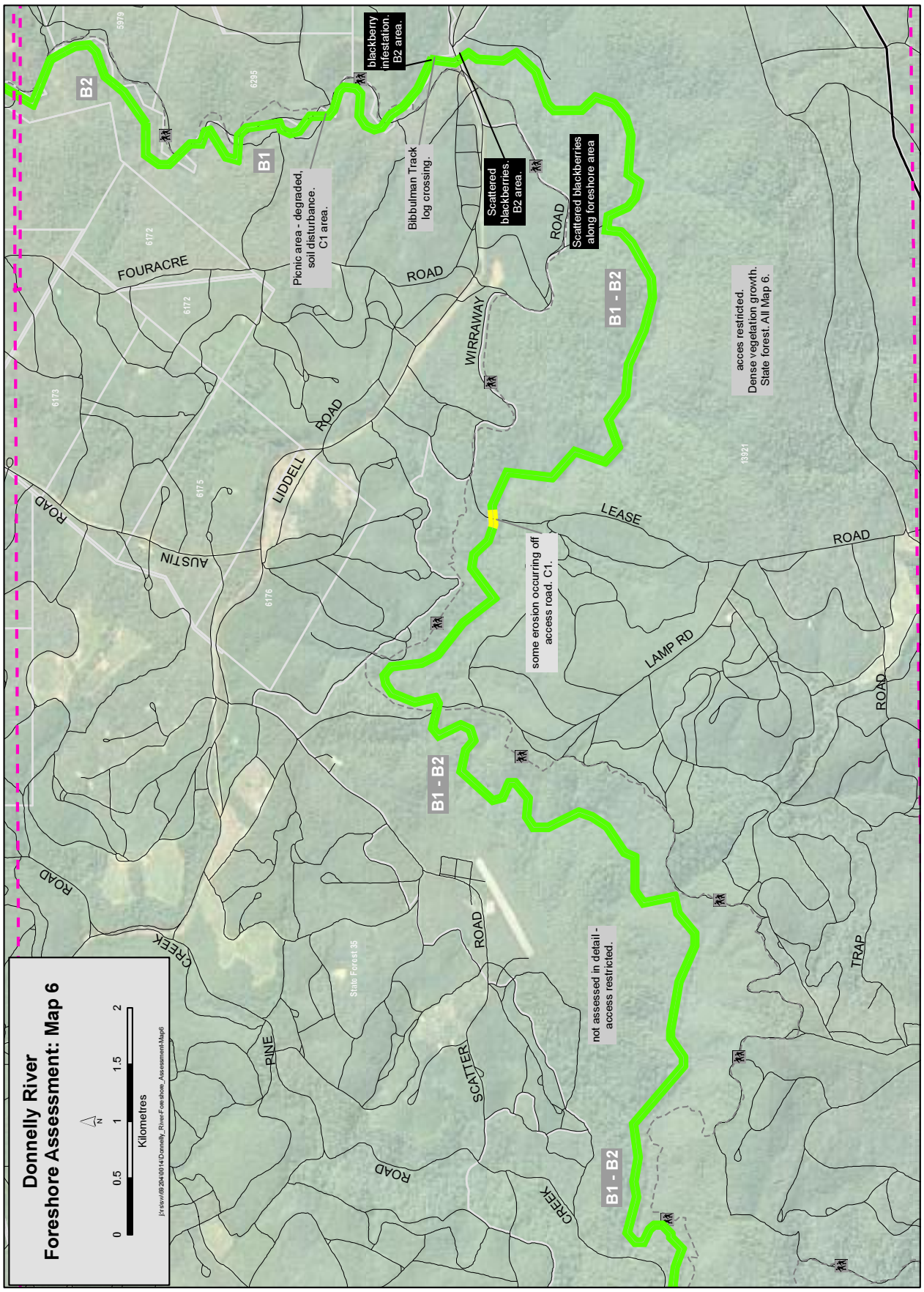
Summary Information	
Location/lot numbers of adjacent properties	Gordon State Forest; 3789; 8787; 9797; Reserve 20810; 81; Reserve 2351; Reserve 159; 3727; 3728; 3729; 3730
Foreshore condition rating (as at Dec 2005)	B1-B3 100% (discrete, small parts C1/C2 grade)
Vegetation cover & health	The upper part of Map 5 contains relatively healthy native vegetation, although not in as good condition as earlier sections. The lower sections start to experience greater problems with weeds, notably blackberry, and overall bank condition degrades due to improved human access.
Land use	State Forest conservation areas, silviculture, agriculture, tourism, recreation (Bibbulmun Track), remnant bush.

Issues	Comments
General foreshore conditions	Foreshore condition running through Map 5 is more degraded than the 2 preceding sections, with a high degree of accessibility and general public use along much of its length. However fringing and in-stream vegetation appears healthy and natural regeneration is freely occurring along the majority of the section. Flow remains ephemeral.
Fencing	The upper part of Map 5 is unfenced, and stock access is not an issue. The majority of private properties are fenced on one side (landholder properties) and unfenced on the other (Bibbulmun Track/Forest reserve land). ~7.9 km fenced.
Erosion/bank	No serious erosion present, points of natural and dynamic subsidence and bank de-stabilisation present. Erosion points predominantly found adjacent to road crossings and track access points.
Weeds	Common blackberry noted as a problem towards the end of the section. Plants growing at Gordon Rd crossing. Serious infestation problems occurring south of the Graphite Rd crossing and near Greens Island. Evidence of previous and more recent chemical control of blackberry along this southern stretch
Other comments	The Donnelly River reaches passing through State forest are not easily accessible and show little evidence of human disturbance, apart from access points. The river is in good condition and needs little work aside from weed monitoring to maintain current condition. Condition deteriorates somewhat when passing by landholder properties and blackberry infestations become a serious problem. Consider area for release of blackberry biocontrol rust.

Prioritised management actions recommended
1. Address isolated blackberry plants and infestations by spraying on private property.
2. Address blackberry infestations on non-private land with responsible agencies.
3. Implement release of blackberry biocontrol rust at selected sites throughout infestation.
Long term management actions recommended
1. Continue follow up monitoring and spraying of isolated blackberry plant to prevent spread and establishment.
2. Continue to monitor section for weed presence to avoid establishment. Initial mapping completed.



Donnelly River Map 5



Donnelly River Map 6

Map 6

This section of the Donnelly passes through Graphite and Beavis State Forests. The area begins from the southern border of landholder property south of Glenoran Pool and runs through to the Strickland Rd intersection. The section is densely vegetated with predominantly native species such as swamp peppermint *Taxandria linearfolia*, water bush *Bossiaea aquifolium* and grey honey myrtle *Melaleuca incana*. Fringing species include native *Lepidosperma* sp. sword sedges and *Juncus* sp. rushes. Some disturbance is observable at access points; however the quality of intervening areas is high, with minimal if any disturbance. Common blackberry growth is evident throughout this section, with some thick infestations.

The upper half of Map 6 (to Palings Rd crossing) is within the area known locally as 'Eleven Bridges', referring to the existence of eleven now-defunct bridges along the river. Access along one side of the river in this upper half is facilitated by the Bibbulmun Track, which parallels much of the area. The lower half of Map 6 continues to run through State Forest, however the Bibbulmun Track deviates from following the Donnelly and hence access is restricted to logging roads. Dense vegetation growth exists along the length of this section. The area covered by Map 6 is unfenced; however grazing by stock is unlikely due to location and difficulty of accessing the foreshore area. Map 6 covers approximately 24 km.

Summary Information	
Location/lot numbers of adjacent properties	Graphite and Beavis State Forests
Foreshore condition rating (as at Dec 2005)	B1-B2 100%
Vegetation cover & health	Dense, healthy vegetation exists both fringing and surrounding the river. A diverse, predominantly weed-free assemblage exists, no stock grazing. Active natural regeneration is occurring.
Land use	State Forest conservation areas, silviculture, recreation (Bibbulmun Track)

Issues	Comments
General foreshore conditions	Flow through this area maintains an increased velocity. A healthy, predominately native assemblage of fringing and in-stream vegetation exists. Flow remains ephemeral. Good foreshore condition overall- access to foreshore area restricted.
Fencing	The section is unfenced; however the chances of stock accessing river foreshore are remote. Access to the foreshore is restricted due to dense vegetation growth and lack of access roads. 0 km fenced.
Erosion/bank stability	Points of naturally occurring subsidence and bank de-stabilisation present, exacerbated at access points. Erosion points predominantly found adjacent to road crossings.
Weeds	Isolated common blackberry plants, some thickets noted along the length of the area. Occurrence is more widespread in the upper half of Map 6 (to Palings Rd bridge).
Other comments	The upper half of Map 6 is easily accessible to the general public via the Bibbulmun Track. Erosion and weed occurrences are more prominent in this area. The lower half of the Donnelly River on Map 6 is accessible only from limited access roads. Consider area for release of blackberry biocontrol rust.

Prioritised management actions recommended

1. Monitor and where appropriate control localised blackberry and other weed occurrences.
2. Implement release of blackberry biocontrol rust at selected sites throughout infestation.

Long term management actions recommended

1. Maintain vigilance with blackberry and other weed occurrences, visiting for a succession of years to ensure eradication. Initial weed mapping completed.
2. Continue to monitor section for weed presence to avoid establishment.

Map 7

Map 7 covers the Donnelly River as it flows from the Strickland Rd campsite through to the last landholder property on Storry Rd. Encompassing approximately 14 km, Map 7 covers predominantly Beavis and Cleave State Forest reaches, although the river also passes through seven landholder properties. In this section the river leaves the Darling Plateau and drops onto the Coastal Plain. This point is known as Peerabeelup by the Nyungar people. The section is densely vegetated with predominantly native species such as swamp peppermint *Taxandria linearfolia*, water bush *Bossiaea aquifolium* and blackbutt trees *Eucalyptus patens*. Dominant fringing species include native *Lepidosperma* sp. sword sedges and *Juncus* sp. rushes. In the State Forest reaches, some disturbance is observable at access points; however the quality of intervening areas is high, with minimal if any disturbance. The State Forest reaches are unfenced and stock access is unlikely due to inaccessibility and location.

In the parts of the Donnelly River bordered by landholder properties, the environmental quality of the river foreshore decreases, and the first occurrences of several potentially serious weed species were noted. The first sightings of arum lily *Zantedeschia aethiopica*, apple of Sodom *Solanum linnaenum* and feral olive trees *Olea europaea* were recorded along this stretch. Common blackberry plants were also noted. Landholder properties were all unfenced with the exception of one property which was partially fenced; however the fenced area did not have any stock. Some stock was present on two landholder properties and access point disturbance issues were noted. Serious bank erosion problems were noted on several landholder properties, and channel cutting and subsidence was common. Many fringing trees were undermined by bank cutting, contributing to the significant amount of large woody debris in the river.

Summary Information	
Location/lot numbers of adjacent properties	Beavis and Cleave State Forests, 1915, 159, 2940, 1179, 3/63351, 6984, 4497, 6982
Foreshore condition rating (as at Dec 2005)	B1-B3 57 % C1-C3 43%
Vegetation cover & health	Vegetation density and health varies from the State Forest to landholder areas. State Forest areas generally healthy with active regeneration; landholder areas weed/annual grasses significant. Evidence of past stock access reflected in degraded bank condition. Some regeneration is occurring.
Land use	State Forest conservation areas, viticulture, agriculture, grazing, residential, tourism (farm stay cottages)

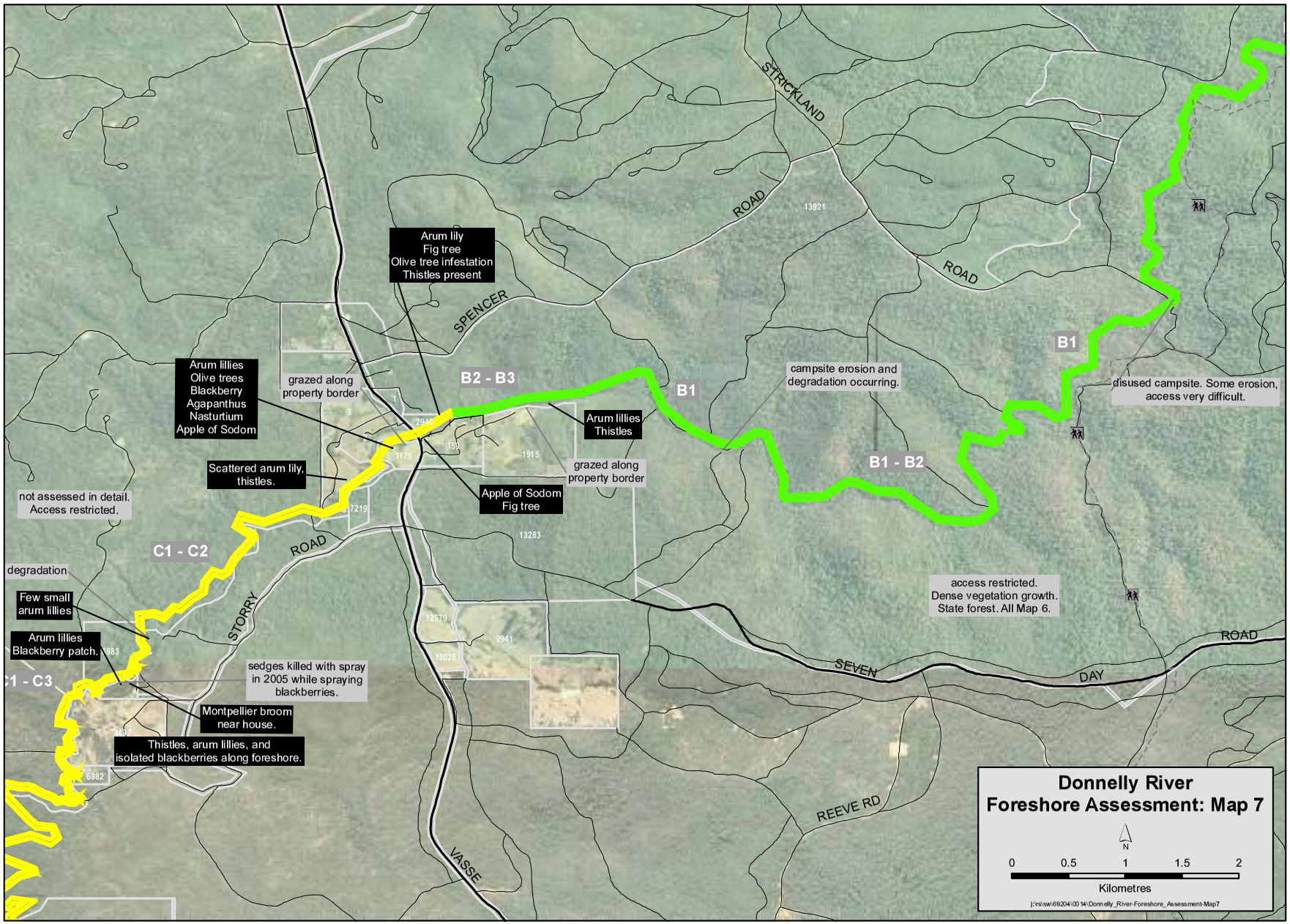
Issues	Comments
General foreshore condition	In the initial State Forest area, healthy, predominately native assemblage of fringing and in-stream vegetation exists. The riverbed sometimes dries up over summer. Good foreshore condition overall; access to foreshore area restricted. In landholder properties, foreshore condition decreases, with bank erosion, cutting and subsidence. The same situation occurs throughout the lower State Forest reaches of this section.
Fencing	The section is almost entirely unfenced however very little stock is present along the stretch. In State Forest areas, access to the foreshore is restricted due to dense vegetation growth and lack of access roads. ~0.3 km fenced.
Erosion/bank stability	In the past, stock has had free access to the foreshore, which has resulted in eroding banks. Both natural and stock exacerbated bank erosion and cutting is significant for the majority of this section of the Donnelly River. Current stock access exacerbates bank instability and erosion.
Weeds	First noted occurrences of arum lily, apple of Sodom, fig trees and feral olive trees noted in landholder properties. Pennyroyal and thistles occurring in adjoining (non-riparian) landholder property. Isolated common blackberry plants.
Other comments	Weed prevalence increases in and downstream of landholder properties of this area. Significant amounts of large woody debris are located in-stream. Channel cutting is common, as are undermined banks and trees, both natural and stock exacerbated. Blackberry biocontrol rust release site within the section

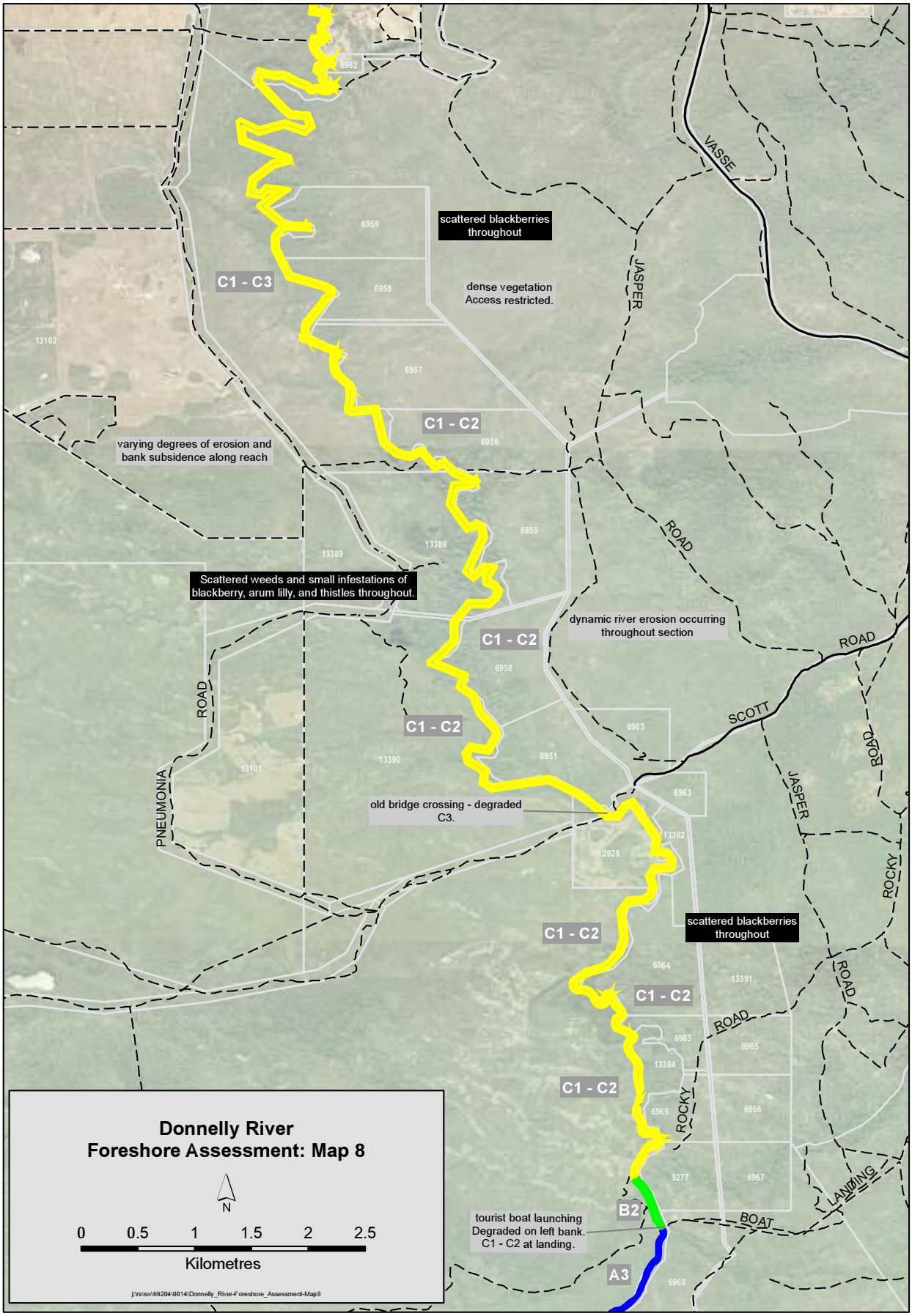
Prioritised management actions recommended

1. Control arum lily, olive trees and apple of Sodom on landholder property when seasonally appropriate.
2. Implement an area-wide weed control program, to target arum lily, olive trees, apple of Sodom and common blackberry. Initial mapping of weed species completed.

Long term management actions recommended

1. Monitor to detect and control regrowth of arum lily, olive trees and Apple of Sodom, visiting for a succession of years to ensure eradication.
2. Continue to monitor section for weed presence to avoid establishment.
3. Erect fencing along properties with stock to assist in lessening foreshore disturbance.
4. Investigate options for re-alignment of large woody debris in some areas to aid in water flow and erosion control.


Arum lily
Fig tree
Olive tree infestation
Thistles present
Arum lillies
Olive trees
Blackberry
Agapanthus
Nasturtium
Apple of Sodom
grazed along property border
Scattered arum lily, thistles.
not assessed in detail. Access restricted.
Arum lillies
Thistles
Apple of Sodom
Fig tree
grazed along property border
B2 - B3
B1
B1 - B2
campsite erosion and degradation occurring.
disused campsite. Some erosion, access very difficult.
access restricted. Dense vegetation growth. State forest. All Map 6.
C1 - C2
C1 - C3
degradation
Few small arum lillies
Arum lillies
Blackberry patch.
sedges killed with spray in 2005 while spraying blackberries.
Montpellier broom near house.
Thistles, arum lillies, and isolated blackberries along foreshore.
STRICKLAND
ROAD
SPENCER
STORRY
SEVEN
DAY
REEVE RD
VASSE
Donnelly River
Foreshore Assessment: Map 7
N
0
0.5
1
1.5
2
Kilometres



Donnelly River Map 8

Map 8

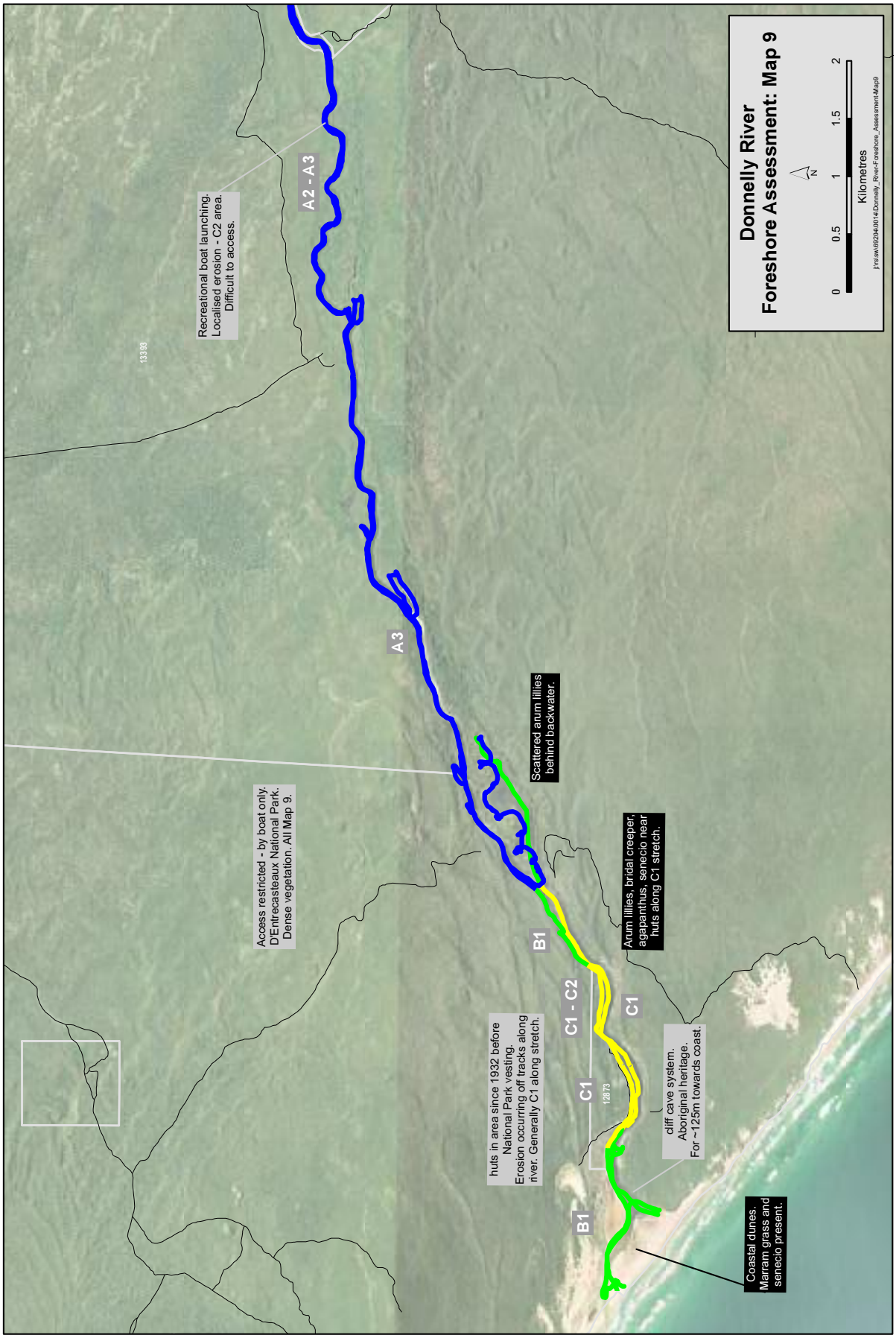
Map 8 covers an area of Cleave and Jasper State Forest (including part of D'Entrecasteaux National Park) stretching from the last landholder property on Storry Road to Boat Landing Road. Encompassing 18km, the section is densely vegetated with predominantly native species such as swamp peppermint *Taxandria linearfolia*, water bush *Bossiaea aquifolium* and swamp willow (wonnich) *Callistachys lanceolata*. Smaller fringing species include native *Lepidosperma* sp. sword sedges and *Juncus* sp. rushes. The section flows solely through State Forest/National Park, with some human disturbance observable at access points such as the Boat Landing area which is the embarkation point for boats travelling to the mouth of the Donnelly River. The quality of vegetation in intervening areas is high, with minimal if any human disturbance evident. Naturally occurring bank cutting and subsidence is present along much of the section, in all probability partly attributable to previous (historical) stock access as well as river velocity. As a result, much of the fringing vegetation is being undermined by water flows and significant amounts of large woody debris are present in-stream. The section is unfenced.

Access was restricted throughout the section by dense vegetation and a dearth of vehicle entry roads. Weed species recorded include arum lily, although of lesser density than upstream, common blackberry and thistle.

Summary Information	
Location/lot numbers of adjacent properties	Cleave and Jasper State Forest, D'Entrecasteaux National Park
Foreshore condition rating (as at Dec 2005)	C1-C3 100 %
Vegetation cover & health	Generally healthy with active regeneration occurring, however fringing vegetation affected by undercutting and bank subsidence.
Land use	State Forest/ National Park conservation areas.

Issues	Comments
General foreshore condition	A generally healthy, predominately native assemblage of fringing and in-stream vegetation exists. Access to foreshore area restricted
Fencing	The section is unfenced; however the chances of stock accessing river foreshore are remote as there are no landholder properties along this stretch. Access to the foreshore is restricted due to dense vegetation growth and lack of entry roads. 0 km fenced..
Erosion/bank stability	Natural, dynamic bank undercutting and subsidence are occurring along the section. Probably exacerbated by historical stock access in places and water flows instability and erosion.
Weeds	Isolated occurrences of arum lily, common blackberry and thistles
Other comments	Significant amounts of large woody debris are located in-stream. Channel cutting is common, as are undermined banks and trees.

Prioritised management actions recommended
1. Control arum lily, common blackberry and other weed species identified along stretch.
2. Map occurrence of other weeds present along the section. Initial mapping completed.
Long term management actions recommended
1. Monitor weed regrowth and new establishment for control.



Donnelly River Map 9

Map 9

Map 9 represents the lower Donnelly River, stretching from the Boat Landing area to the river mouth at Donnelly Beach. The Donnelly along this stretch is contained within the D'Entrecasteaux National Park, which roughly contains 180,000 ha of forest from Augusta to Walpole. The approximately 11 km section is accessible only by boat. A commercial tourist operation conducts boat tours along the stretch; foreshore observations were recorded from the middle of the river channel. Otherwise, access is restricted to small private boats and canoes which travel towards the mouth, where clusters of huts have existed since 1932. As the area has since been gazetted as a national park, no further construction of huts is allowed and the future of the huts will be determined by the latest *Shannon and D'Entrecasteaux National Park Draft Management Plan* (2005). The section is densely vegetated with predominantly native species such as swamp peppermint *Taxandria linearfolia*, Warren River cedar *Taxandria juniperina*, swamp willow (wonnich) *Callistachys lanceolata*, karri hazel *Trymalium floribundum* and swamp paperbark *Melaleuca raphiophylla*. *Lepidosperma* sp. sword sedges and *Juncus* sp. rushes are in abundance along the entire length. Fauna observed in the area include purple swamp hens, pacific black ducks, swans and at times wood and shell ducks. In the year of the river foreshore survey, white breasted sea eagles were observed nesting in the cliffs at the river mouth.

Some human-exacerbated erosion problems were noted at three specific points along the stretch; the Boat Landing entry point, an isolated recreational fishing entry point, and near the hut area, where erosion is occurring off existing tracks. Power boats travelling the river contribute to erosion in that they produce a wake, creating a wave action that disturbs riverbanks. Water quality in the area is of potential concern, being affected by boat fuels and fumes (predominately 2 stroke motors).The huts also have the potential to pollute water quality due to the lack of controlled sewage and sewerage systems in the area. The quality of other areas is high, with minimal if any disturbance and thick fringing vegetation. Large in-stream woody debris is less prominent than further upstream, however this distinction could have been a function of vegetation type and seasonal water levels. Vegetation at the river mouth comprises typical low coastal associations. Around the hut area, isolated arum lilies *Zantedeschia aethiopica* were noted, as were several agapanthus *Agapanthus praecox* plants and purple groundsel *Senecio elegans*. The purple groundsel also occurs at the river mouth, along with marram grass *Ammophila arenaria*. Isolated bridal creeper *Asparagus asparagoides* was also recorded around the hut area. Wavy gladioli *Gladiolus undulates* and arum lily infestations were located off the river foreshore. One willow tree (*Salix* sp.) was growing in-stream downstream from the Boat Landing point. At the time of the survey, the river mouth was closed over, elevating water levels to approximately 9 m at their highest. Average water depths vary between 3-5m when the river mouth is not closed over.

Summary Information	
Location/lot numbers of adjacent properties	D'Entrecasteaux National Park
Foreshore condition rating (as at Dec 2005)	A2-A3 55% B1 25% C1-C2 20%
Vegetation cover & health	Majority of foreshore very healthy, dense native vegetation assemblage, active regeneration.
Land use	D'Entrecasteaux National Park: conservation and ecotourism. Area of holiday huts, infrequently occupied.

Issues	Comments
General foreshore condition	A dense, healthy native assemblage of fringing and in-stream vegetation exists. Overall, excellent foreshore and river condition marred by weeds occurring near hut area and erosion occurrences.
Fencing	Unfenced, no stock. 0 km fenced.
Erosion/bank stability	Banks well vegetated and stabilised, points of natural, dynamic erosion and bank cutting occurring. Human-induced erosion in hut area and recreational boat launching area (restricted access).
Weeds	Overall a very healthy stretch of river, with isolated weed infestations.
Other comments	Significant amounts of large woody debris are located in-stream. Channel cutting is common, as are undermined banks and trees.

Prioritised management actions recommended

1. Remove willow tree.
2. Map extent of and implement a weed control program to target arum lily, bridal creeper and agapanthus plants along the stretch in conjunction with DEC and community groups. Initial mapping completed, significant populations of arum lily controlled.

Long term management actions recommended

1. Maintain vigilance to detect and control regrowth of arum lily, bridal creeper, agapanthus and other weeds. Management plans underway with relevant agencies.

8. Summary of findings

The foreshore assessment surveys produced the following information for overall foreshore condition ratings along the Donnelly River. Foreshore condition ratings have been averaged from both banks of the river.

As evident from Table 6 (below), the majority of the Donnelly River foreshore is classed as B grade (representing 55.1% of the entire river foreshore). The B foreshore rating implies that although the bushland is of a generally good quality, some degradation, weed invasion or soil disturbance is occurring along the river. Most of the foreshore classed as B grade fell into the B1-B2 category, meaning that weeds have not yet become dominant in the vegetation understorey. Having a significant proportion of the Donnelly classed as B grade is a positive, as B grade foreshores with weed issues are easier to manage than foreshore areas with serious erosion problems. Decisive action by both landholders and responsible government agencies to control weed occurrences and spread will be instrumental in protecting B grade stretches of foreshore. Keeping these B grade foreshore areas in a B grade condition, or enhancing their condition, will require ongoing weed control measures and monitoring for any erosion issues that may emerge. The main management issue for areas classed as 'B' grade was common blackberry infestations. Prioritised actions for these areas are to control the blackberry present and prevent re-establishment, allowing for natural regeneration.

The next most common foreshore condition rating for the Donnelly River was C grade, with 25.7% of the river classified as erosion prone or eroding. The foreshore in these C grade areas has in some cases experienced significant fringing vegetation loss, resulting in exposed soil and bank undercutting. Much of the C grade foreshore erosion recorded along the Donnelly can be attributed to historical or current stock access to the river. In the upper catchment, stock has free access to the river and no natural regeneration was observed. Virtually no fringing vegetation remains other than a few remnant trees over pasture or weeds. Erosion occurring in the upper headwaters is on a smaller scale than in the lower Donnelly, with the low velocity river flows generally contained within a narrow, erosion-prone channel. However it is still extremely important to address the erosion issues in the upper catchment areas. The main management issue of sections classed as 'C' grade relate to clearing of fringing vegetation from the river foreshore, which results in increased sedimentation, impacting on downstream areas. Restricting stock access and replacing native fringing vegetation along the channel would help to improve the ecological condition of C grade foreshore in the upper catchment. The prioritised actions for these sections are to minimise the negative effects of cleared riparian areas, in conjunction with active promotion of revegetation options, including commercial riparian agroforestry.

In the lower catchment, stock access was predominantly historical (no stock on properties for at least the last 5 years), with damage sustained from previous stock access resulting in erosion problems for current landholders. There is a limited amount of stock access along the lower reaches. In some areas, serious bank erosion and undercutting are present. These processes are also occurring in State Forest reaches, which may have experienced historical stock access. The erosion occurring appears to be predominantly natural and of a dynamic nature, exacerbated by high velocity flows and by landholder properties with more recent stock access issues. Foreshore stabilisation in these eroding and erosion-prone areas would help to improve the condition of these C grade foreshores.

Table 6: Overall foreshore condition ratings for the Donnelly River (as at December 2005)

Foreshore Condition	Description of Grade	Total length (km)	Total as a percentage of the entire Donnelly River
A	Pristine to slightly disturbed	25.85	17.1
B	Moderately degraded, soil disturbance, weeds present	83.24	55.1
C	Eroded, soil exposed, little foreshore vegetation	38.93	25.7
D	Ditch/drain	2.98	2

A grade foreshore with healthy, native vegetation was recorded for 17.1% of the Donnelly. Those areas recorded as A grade were either A2 or A3 condition, meaning that there were either some weeds present, but no soil disturbance (A2), or very localised weed infestations in areas with soil disturbance (A3). All areas classed as A grade were located within State Forest conservation reserves or within D'Entrecasteaux National Park. Most of the A2 foreshore was recorded in the upper Donnelly area, where blackberry infestations generally are not yet established as dense infestations. A3 grade foreshores occur further down the river, in conservation areas with some human access or blackberry infestations. Prioritised management actions for 'A' grade sections of the river are to encourage and assist land managers to control isolated weed incidences, thereby maintaining or improving further the condition of their river reach.

Finally, a small proportion (2%) of the Donnelly was classified as D grade, indicating the presence of an eroding ditch or weed-infested drain. The D grade foreshore recorded refers to specific sites which had either been artificially widened with a backhoe or were points along a C grade foreshore that were actively eroding and gouging out larger pools. D grade foreshore was recorded for the upper headwaters of the Donnelly River only. In these degraded areas, management priorities centre on determining barriers to adoption of revegetation schemes, with emphasis being placed on working collaboratively with landholders to provide incentives to revegetate and possibly fence, helping to improve the condition of their river foreshore.

The foreshore condition ratings recorded for each Map section of the Donnelly River are summarised in Table 7.

An overview of the management works plan recommended by Southern Forests Landcare for each map section of the river is given below (Table 8). In addition to future works outlined below, Southern Forests Landcare will be assessing associated wetlands and tributaries in 2006/2007.

Table 7: Section foreshore condition ratings for the Donnelly River

Map Section	A Grade %	B Grade %	C Grade %	D Grade %
Map1	0	21	64	15
Map 2	0	0	81	19
Map 3 (includes Maps 3a and 3b)	35	65	0	0
Map 4	45	55	0	0
Map 5	0	100	0	0
Map 6	0	100	0	0
Map 7	0	57	43	0
Map 8	0	0	100	0
Map 9	55	25	20	0
TOTAL %	**15**	**47**	**34**	**4**
TOTAL km	**25.85**	**83.24**	**38.93**	**2.98**

Table 8: Works plan for each river section surveyed

Map Section	Works completed 2005	Works completed 2006	Future works
Map1	• Initial weed mapping	• Control of common blackberry growth (small)	• Follow up blackberry control to ensure effectiveness • Promote revegetation and other farming systems to reduce erosion • Monitor for other weed incursion
Map 2	• Watsonia infestation controlled • Initial weed mapping	• Watsonia control (follow up) • Tagasaste control • Investigation into options for • Re-establish demonstration site • Survey of associated wetlands	• Continue watsonia control and monitor for regrowth • Continue tagasaste control and monitor for regrowth • Monitor for other weed incursion control of Typha • Promote revegetation and other farming systems to reduce erosion
Maps 3a and 3b	• Initial weed mapping	-	• Monitor for weed incursion
Map 4	• Initial weed mapping	• Follow up prior blackberry control	• Monitor and if necessary follow up blackberry control • Monitor for other weed incursion
Map 5	• Initial weed mapping	• Release of blackberry biocontrol rust fungi into infestations	• Monitor progress of biocontrol rust fungi • Control of isolated blackberry plants • Monitor for other weed incursion
Map 6	• Initial weed mapping	• Release of blackberry biocontrol rust fungi into infestations	• Monitor progress of biocontrol rust fungi • Monitor for weed incursion
Map 7	• Initial weed mapping	• Arum lily, olive tree, apple of Sodom eradication	• Follow up of arum lily, apple of Sodom and olive tree control to ensure eradication • Monitor progress of blackberry biocontrol site • Monitor for other weed incursion
Map 8	• Initial weed mapping	• Arum lily eradication	• Monitor arum lily control and follow up if necessary • Monitor for other weed incursion
Map 9	• Initial weed mapping	• Willow tree removed • Arum lily infestation controlled	• Monitor effectiveness of arum lily control works to eradicate • Work with DEC to monitor and map existing and new weeds

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Appendix 1: Suggested list of appropriate revegetation species

This information was sourced from a variety of reference material, including the online resource *Florabase*, a joint initiative of the Western Australian Herbarium and DEC, Wheeler *et al*. (2002) and WRC (1997) as well as from local 'in-house knowledge. Further information regarding the species given below as well as other species can be found in these and other sources.

TREES			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Agonis flexuosa	Western Australian peppermint	Tree or shrub, to 10m high	Flowers white, Jul-Dec. Sands and gravels (white or grey sand, sandy soils, laterite, limestone) with shallow fresh water table. Coastal sand dunes, granite outcrops, limestone areas. Direct seed/planting autumn or spring.
Taxandria juniperina	Warren River cedar/wattie	Small- medium to 25 m	Flowers white, much of year. Fringing plant for creeks, lakes & swamps. Can form dense thickets. Seed, brushing, cuttings.
Allocasuarina decussata	Karri sheoak	Monoecious tree shrub, to 15m high	Loam soils within karri forest. Craft timber.
Allocasuarina fraseriana	Sheoak	Dioecious, erect. tree, 5-15 m high, bark fibrous, reddish-brown	Flowers brown, May-Oct. Lateritic soils, white, grey or yellow sand. Valuable furniture timber.
Allocasuarina humilis	Dwarf sheoak	Dioecious or monoecious, erect or spreading shrub, 0.2-2 m high.	Flowers red, orange, brown, May-Nov. Sand, often over laterite, sandy clay, gravel.
Banksia attenuata	Slender banksia	Lignotuberous tree or shrub, 0.4-10 m high, with epicormic buds.	Flowers yellow, Oct-Feb. White, yellow, brown or pale red sand, sometimes over laterite. Sand dunes, sandplains.
Banksia ilicifolia	Holly-leaved banksia	Tree or shrub, 0.7-10m high, with epicormic buds.	Flowers white, cream, pink, yellow, red, Mar-Jan. Dry to damp white or grey sand soils. Consolidated dunes or low-lying flats.
Banksia littoralis	Swamp banksia	Tree to 12 m high, with epicormic buds	Flowers yellow, orange, Mar-Aug. Grey or black peaty sand. Low-lying, seasonally damp areas, along watercourses. Fire tolerant. Grown from seed in autumn, late winter. Good craft timber.
Banksia seminuda	River banksia	Tree to 20 m high	Flowers yellow, brown,(sub species = red) Feb-Jun. Slightly acidic or neutral soils. Fire sensitive. Grow from seed.
Corymbia callophylla	Marri	Tree to 40 m, bark rough, tesselated	Flowers white, pink, Dec-May. Wetlands, besides drainage lines, fringing salt marshes, flats, hills, breakaways. Grow from seed/direct seed.

TREES (continued)			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Eucalyptus decipiens	Moit; marlock, red heart	Tree (often mallee form), 1.5–15 m high, bark rough, flaky or ribbony.	Flowers white, Aug-Jan. White. yellow or grey sand, sandy clay, gravelly loam, laterite. Sandplains, hills, swamp margins, winter-moist sites. Fresh damp areas often perched amid saline soils, 500- 800 mm rainfall. Red timber; poor form.
Eucalyptus marginata	Jarrah	Large tree to 50 m	Flowers white, Sept-Dec. Grow from seed/direct seed.
Eucalyptus megacarpa	Bullich, bastard karri	Tree (mallee), 2–35m high, bark smooth	Flowers white, Apr-Nov. Sand, sandy loam, limestone. Hills, near swamps & streams. Clay subsoils.
Eucalyptus patens	Yarri/ WA blackbutt	Large tree to 50 m, bark rough, longitudinally furrowed.	Flowers white, cream, Nov-Feb. Gravelly soils, sandy clay, loam. Depressions, stream banks, valleys. Lower slopes, well drained soil, good timber tree, needs dense planting, heavy culling and form pruning to produce timber. Grow from seed/ direct seed.
Eucalyptus rudis	Flooded gum	Tree to 25 m, bark rough.	Flowers white, Jul-Sept. Sandy or loam soils. Wetter parts of south western WA, flats, hillsides. Seasonally waterlogged clays on floodplains, leaf miners attack it. Grow from seed/ direct seed, seedlings. Plant in spring.
Melaleucas priessiana	Moonah/ *paperbark*	Tree to 10 m.	Flower yellow, cream, white, Nov-Feb. Sandy soils, swamps. Less tolerant of prolonged inundation than *M. raphiophylla*. Direct seed.
Melaleuca raphiophylla	Swamp paperbark	Small to medium tree, to 10 m.	Flower white, cream, Aug-Mar. White or grey sand, clay soils, limestone. Saltmarshes, swamps, along watercourses. Withstands seasonal inundation. Direct seed, cuttings.
Paraserianthes lophantha	Albizia, Cape wattle	Tree or shrub, to 10 m.	Flowers cream, greenish yellow, Jun-Sept. Fringing watercourses and swamps. Grown from seed.

SHRUBS			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Acacia saligna	Coojong/ orange wattle/ golden –wreath wattle Smooth dark grey bark.	Dense. often weeping shrub or tree to 6 m.	Flowers yellow, orange, Jul-Nov. Variety of habitats. Fringes watercourses. Colonises disturbed habitats. Scarified seed, brushing.
Taxandria linearfolia	Swamp peppermint/rosa or coarse tea tree	Shrub to 5 m, spread to ~3 m,	Flowers white, most of year. Cut flower trade. Fringes swamps & watercourses-stream stabiliser. Direct seed, brushing, cutting in autumn.
Agonis parviceps	White/ fine leaf tea tree	Medium shrub	Cut flowers, commercial, stream stabiliser.
Astartea fascicurlaris	Astartea	Erect shrub to 3 m high, weeping branches.	Flowers white, pink, Jan-May/Oct-Dec. Sandy alkaline soils along watercourses, winter-wet depressions, granite outcrops. Direct seed, brushing, cuttings in autumn.
Beaufortia decussata	Gravel bottlebrush	Shrub, 1–3 m high.	Flowers red, Aug-Apr. Lateritic soils.
Beaufortia sparsa	Swamp bottlebrush	Shrub, 1–3 m high.	Flowers red, orange, Jan-Apr/Sept-Nov. Sand. Swampy areas (likes winter wet peaty sands), riverbanks. Cut flowers.
Boronia molloyae	Tall boronia	Slender shrub,	Flowers pink, red, Sept-Dec. Sandy soils. Winter-wet 1-5 m high depressions & the edges of swampy areas. Unknown, try seed with smoke.
Bossiaea aquifolium	Water bush, netic	Shrub or tree, 0.6-8 m high. Legume.	Understorey to karri- marri Flowers orange, yellow, red, brown, Jul-Nov. Clay loam, laterite, granite.
Brachysema celsianum	Dark pea	Low spreading shrub/ground cover	Flowers pea shaped, red. Stock like it. Various habitats, fringing watercourses.
Callistachys lanceolata	Wonnich/ swamp willow/ greenbush	Erect shrub/ small open tree to 8 m	Flowers pea shaped, yellow-orange, Sept-Dec. Fringes watercourses, winter wet depressions. Thick middle storey shrub fringing watercourses. Grows from seed.
Hakea oleifolia	Dungyn/olive-leafed hakea	Erect shrub or tree, 2-10 m high.	Flowers white, Aug-Oct. Grey or red/brown sand, peaty sand, sandy loam, clay, laterite, granite, lime-stone. Coastal sites. Ornamental, windbreak species.
Hakea varia	Variable–leaved hakea	Erect or spreading shrub to 4m, to 3m wide.	Flowers white, cream, yellow, Jul-Nov. White, grey red loamy sand, clay loam, laterite. Grows in seasonally wet flats. Seed.
Homalospermum Firmum	Common tea-tree	Shrub to 4 m	Forms thickets in permanently wet areas along watercourses.
Hovea elliptica	Tree hovea	Slender, erect shrub or tree to 3 m.	Flowers blue, purple, white, pea shape, Aug-Dec. Laterite, gravel, clay loam, sandy loam, sandy soils. Rocky slopes, granite outcrops, stabilised sand dunes, slopes, ridges.

SHRUBS (continued)			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Leucopogon propinquus	-	Erect shrub to 15 m.	Flowers white, Jan-July. Sandy, gravelly soils. Coastal heath, forest.
Leucopogon verticullaris	Tassel flower, native bamboo	Bamboo-like shrub to 4 m.	Flowers pink, red, Aug-Nov.Gravelly lateritic, granitic soils. Often in wet areas.
Macrozamia reidlei	Zamia palm	Palm like plant to 2 m.	Flowers cones, Mar-June. Widespread. Forests, woodland, heathland.
Melaleuca diosmifolia	Bottlebrush	Erect, open shrub to 3 m.	Flowers green, Sept-Oct. Shallow sandy soils, sandy - clay. Granite outcrops.
Melaleuca incana	Grey honey myrtle	Shrub or tree, 0.4-5 m high.	Flowers white, cream, yellow, May-Nov. Red-grey-brown sand, sandy clay over ironstone. Seasonally wet flats & depressions, swamps. Seed, brushing, cuttings.
Melaleuca lateritia	Robin redbreast bush	Shrub to 2.5 m, spread 1m, coarse, fibrous bark.	Flowers red, Sept-May. Fringing watercourses, seasonally wet depressions. Grow from seed or semi-hardwood cuttings.
Melaleuca microphylla	-	Shrub or small tree, often weeping, 1.5-5 m high.	Flowers yellow, cream, Sept-Nov. Sand, sandy clay, often over granite. Fringing plant for creeks, lakes & swamps. Seed, brushing.
Melaleuca nesophila	Mindiyed	Shrub, 0.6–5 m high.	Flowers pink, purple, Sept-Jan. Sandy soils. Honey, cut flowers.
Melaleuca uncinata	Honey myrtle/ broom bush	Shrub or tree, 0.5-5 m high. Forms thickets.	Flowers white, cream, yellow, Feb-Mar/Jul-Dec. Sandy or clayey soils, laterite. Near creeks or wet depressions, along watercourses, rocky coastal areas, flats. Commercial brushwood.
Melaleuca Viminea	Mohan/ tea tree	Shrub or tree, 0.6-5 m high. Forms thickets.	Forms thickets. Flowers white, cream, Jul-Nov. Sandy or clayey soils. Near creeks or wet depressions, along watercourses, rocky coastal areas, flats. Commercial brushwood.
Persoonia longifolia	Snottygobble	Erect lignotuberous tall shrub or tree, to 5 m.	Flowers yellow, Nov-Mar. Grey/yellow sand, sandy loam or laterite. Difficult to propagate.
Persoonia elliptica	Spreading snottygobble	Shrub or small tree to 8 m.	Flowers yellow, green Oct- Feb. grey/ yellow sands, sandy loam, laterite.
Podocarpus drouynianus	Emu bush/ wild plum	Shrub to 3 m. (conifer)	Flowers cones, Aug–Jan. White or grey sand, sandy loam or gravelly loam. Lower slopes or lowlands, near creeks. Edible fruit with external seed.
Trymalium florabundum	Karri hazel	Shrub to 9 m.	Flowers white, pale yellow, green July-Dec. Clay, sandy clay, gravelly soils, laterite, granites. Near watercourses and swamps.
Vimineria juncea	Swish bush	Shrub to 5 m, spread 2m.	Flowers pea shaped, yellow, orange, red-brown, Sept-Feb. Winter-wet depressions, near lakes. Grow from seed.

SHRUBS (continued)			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Xanthorrhoea gracilis	Graceful grass tree	Tufted tree-like monocot, to 2 m. No trunk.	Flowers white, cream, Oct-Jan. Lateritic loam, gravel, sand.
Xanthorrhoea preissii	Grass tree, balga	Tree-like monocot to 5 m. Trunk to over 3 m.	Flowers cream, white, Jan-Nov. grey sand, laterite. Grow from seed, transplant. Extract seeds from capsules with tweezers.
Mirbelia dilatata	Holly-leaved mirbelia	Erect prickly shrub to 3 m.	Flowers pea shaped, pink, purple, yellow centre. Gravelly, laterite, sandy soils.
Chorileana quercifolia	Karri oak	Shrub to 9m.	Flowers yellow, white, green, drooping heads, Apr-Jan. Sandy & loamy soils. Rocky coast & hillsides, granite & limestone rocks

RUSHES, SEDGES, GROUND COVER			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Baumea arthrophylla	Sparse twig rush	Sedge, spasely spreading to 1 m.	Flowers brown, Sept-Dec. Seasonally wet depressions, lakes. Tolerates partially sumberged conditions. Grow from seed or rhizome division.
Baumea articulata	Jointed twig rush	Sedge to 2.5 m, spreading. Often forms extensive colonies.	Flowers spike-like, greyish brown, Sept-Dec. Lake margins and watercourses. Fresh and brackish water, tolerates prolonged inundation (>1 m), wide tolerance Grow from seed/rhizome division in winter.
Baumea juncea	Bare twig rush	Sedge to 2 m, creeping under-ground stems. Often forms extensive colonies. Smooth cylindrical blue-green stems. Good colonising plant.	Flowers spike-like, brown, grey, Oct-Mar. Dark grey sand, waterlogged soils along rivers and winter- wet depressions. Tolerates seasonal water fluctuations up to 0.5 m, fresh-brackish- seasonally saline water. Rhizome transplantation, in-vitro culture of seed embryos.
Baumea preissii	Sedge	Sedge to 2 m. Rhizomatous, robust, colonising perennial.	Flowers purple, brown, grey, Jul-Dec. Silty sand, waterlogged soils. Waterlogged soils bordering lakes & watercourses. Rhizomatous division.
Baumea riparia	River twig rush	Sedge to 1.5 m.	Flower brown, Aug-Oct. Black peaty sand. Seasonal swamps, often brackish. Seasonally inundated areas. Rhizome division.
Baumea rubiginosa	Sedge	Sedge to 4 m, spread 2 m.	Flowers brown, Aug-Mar. Waterlogged soils bordering lakes & watercourses. Grow from seed, rhizome division.
Baumea vaginalis	Sheath twig rush	Sedge to 2.5 m, grows in large clumps. Circular stems 2-6 mm wide.	Flowers spike-like, brown, Sept-Dec. Fresh to semi-saline water, seasonally wet to permanaently inundated. Grows from rhizome division or tissue culture.
Bolboschoenus	Marsh club rush	Sedge to 1.2 m, forms large colonies. Stems bright green, triangular in cross-section. Grass-like tufted plant.	Flowers spikelets, golden brown, Aug-Mar. White or grey sand, mud, saline silt, sandy clay. Seasonally damp to seasonally inundated habitat. Tolerates seasonal water fluctuation. Direct seed; seed germinates readily when fresh. Also in-vitro culture.
Carex appressa	Tall sedge	Sedge to 2 m, spread 0.5 m. Tufted, often forms large clump	Flowers spikelets, greenish brown, Sept-Dec. Seasonally inundated or shallow permanent water habitat, fresh or brackish conditions. Grow from rhizomes in early spring.

RUSHES, SEDGES, GROUND COVER (continued)			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Carex fascicularis	Tassel sedge	Sedge to 1.5 m, spread 1m.	Flowers spikelets, green, Sept-Nov. Black peaty sand. Freshwater to brackish conditions along seasonally inundated and partially waterlogged watercourses. Rhizomatous division.
Carex tereticaulis	Sedge	Sedge to 0.7 m. Tufted.	Flowers brown, Sep-Oct. Black peaty sand.
Chorizema cordatum	Flame pea	Climber/ground cover to 1.5 m.	Flowers yellow, orange, July-Dec. Sandy gravelly soils, clay loam. Rocky hillsides, lateritic ridges, undulating places.
Chorizema ilicifolium	Holly-flame pea	Climber/ ground cover to 0.5 m.	Flowers yellow, orange with pink wings, July-Dec. Coastal limestone. Sand, sand over limestone.
Eleocharis acuta	Common spike rush	Creeping sedge to 0.7 m, tuffs arising along a slender rhizome.	Flowers spikelet, brown, Sept- Jan. Forms dense mass in seasonally waterlogged depressions, often partially submerged. Also fringes freshwater watercourses. Grow by division, in-vitro culture. Plant in clumps for increased stability.
Gahnia trifida	Coast saw-sedge	Sedge to 1.5 m, spread 1 m.	Flowers yellow, brown, Aug-Oct. Grey or white sand, clay, sometimes saline. Swamps, creeks.
Hardenbergia comptoniana	Native wisteria	Twining shrub or climber.	Flowers blue, purple, white, Jul-Oct. Sandy soils. Coastal limestone, sandplains, dunes.
Isolepsis nodosa	Knotted club rush	Tufted rush to 1 m. radiating rhizomes.	Flowers spikelets, brown, Sept-Mar. Sandy soils. Coastal dunes, winter-wet depressions and fringing watercourses. Direct seed.
Juncus kraussii	Shore rush/ sea rush	Rush. Tussock-forming, to 1.5 m. Dark green stems. Forms extensive compact clumps. Good colonising plant.	Flowers brown, red, Oct-Jan. White or grey sand, clay, alluvium. Swamps, brackish estuaries, saline flats, seashores. Grow from rhizome division or direct seed. Transplant while dormant (May-June).
Juncus pallidus	Pale rush	Rush. Tufted plant to 2 m. Good colonising plant.	Flowers green, Sept-Dec. Clay. Wet or seasonally damp soils around fresh to brackish watercourses and lakes. Seed viable around Jan, or rhizome division. Plant in clumps.
Juncus pauciflorus	Loose flower rush	Rush. Tufted plant to 1 m.	Flowers greenish brown, Sept-Dec. Permanently damp or seasonally wet soil. Fringes fresh watercourses. Direct seed.
Juncus subsecundus	Finger rush	Tufted sedge to 1 m.	Flowers straw-coloured, Sept-Dec. Moist or seasonally wet soils. Direct seed.
Kennedia coccinea	Coral vine	Twining or trailing shrub or climber. Climber/ground cover.	Flowers orange, pink, red, purple, Aug-Dec. Often on sandy soils. Grow from seed.

RUSHES, SEDGES, GROUND COVER (continued)			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Lepidosperma effusum	Spreading sword-sedge	Tufted sedge to 3 m, spread 1 m.	Flowers spikelets, brown, dull grey, Sept-Dec. Sands and clay in seasonally moist or wet watercourses (occasionally tidal). Grow from rhizome division, tissue culture.
Lepidosperma gladiatum	Coastal sword-sedge	Sedge to 1.5 m, forms broad clumps.	Flowers spikelets, brown, Oct-Feb. Seasonally moist or wet sands, dry dunes. Grow from seed, transplant.
Lepidosperma longitudinale	Pithy sword-sedge	Creeping sedge to 2 m. Forms large colonies.	Flowers spikelets, brown, May-Aug. Sands/ peaty sands in winter-wet depressions and along watercourses. Rhizome transplantation, seed propagation difficult.
Lepidosperma tetraquetrum	Angle sword-sedge	Sedge to 3 m, spread to 2.5 m. Forms large colonies.	Flowers spikelets, brown, Aug-Mar. Black peaty sand. Seasonally moist or wet sands along watercourses and winter-wet depressions. Rhizome division, tissue culture.
Leptocarpus aristatus	Bearded twine-rush	Densely tufted sedge to 0.8 m.	Flowers spikelets, May-Nov. Sand or clay soils in seasonally wet depressions. Grow from tissue culture.
Leptocarpus diffusus	Velvet rush	Tufted plant to 2 m.	Flowers spikelets, Sept-Apr. Swamps and winter-wet heath.
Meeboldina kraussii		Rhizomatous, perennial, herb (rush-like) to 1 m high. Forms clumps.	Sandy & clayey soils. Fringing plant along swamps, creeks, granite outcrops, seasonally wet sites. Rhizomatous division.
Microlaena stipoides	Weeping grass	Clumping grass.	Flowers Sept-Jan. Widespread.
Reedia spathacea	Sedge	Robust, tufted perennial, grass like or herb (sedge), 2-3 m high, clumps 1.5-2 m wide.	Flowers brown, Nov–Jan. Peaty sand. Swamps, river edges. Propagation unknown, possibly rhizome division.
Schoenoplectus pungens	Sharpleaf rush	Erect sedge to 1 m.	Flowers spikelets, Sept-Dec. Fresh, brackish or semi-saline water in swampy conditions and standing water. Transplant rhizomes in winter, in-vitro culture.
Schoenoplectus Validus	Lake club rush	Erect sedge to 3 m. Forms clumps and at times extensive colonies.	Flowers spikelets, brown, Nov-Mar. Fresh, brackish or semi-saline water in winter-wet depressions and margins of watercourses. Transplant rhizomes in winter, in-vitro culture.
Schoenus subfascicularis	Bog rush Several other suitable varieties exist.	Rush to 1 m.	Flowers spikelets, brown, July-Dec. Seasonally wet depressions, fringing swamps and estuaries. Produces very little viable seed. Grow from rhizome division.

Appendix 2: Useful contracts

Contact	Location	Contact details
Southern Forests Landcare	Manjimup	Ph. (08) 97 718 180 Fax. (08) 97 718 108 E-mail: nrm-warren@southernforestslandcare.org.au
Ribbons of Blue- Andy Russell	Warren region	Ph. (08) 97 761 559/ 97 718 180 E-mail: andy@westnet.com.au
Manjimup LCDC/ Warren Catchments Council	Manjimup	As above for Southern Forests Landcare
Blackwood Valley Landcare	Bridgetown	Ph. (08) 97 614 277 E-mail: bvlandcare@westnet.com.au
DAFWA (inc. Biosecurity)	Manjimup	Ph. (08) 97 770 000 Fax. (08) 97 770 001 Web: www.agric.wa.gov.au
Department of Environment (now integrated with CALM)	Bunbury	Ph. (08) 97 264 111 Fax. (08) 97 264 100 Web: www.dec.wa.gov.au
Department of Environment and Conservation (DEC)	Donnelly District	Ph. (08) 97 717 988 Fax. (08) 97 712 677 Web: www.dec.wa.gov.au
Department of Fisheries		Ph. (08) 97 212 688 Fax. (08) 97 911 862 Web: www.fish.wa.gov.au
Department of Water	Manjimup	Ph. (08) 97 711 878 Fax. (08) 97 718 108 Web: www.water.wa.gov.au
Forest Products Commission	Manjimup	Ph. (08) 97 770 988 Fax. (08) 97 772 233 Web: www.fpc.wa.gov.au
Land for Wildlife	Nannup	Ph. (08) 97 561 465 Fax. (08) 97 561 242 Web: www.dec.wa.gov.au/landforwildlife.com
Manjimup Weed Action Group	Manjimup	Ph. (08) 97 717 988 Fax. (08) 97 712 677
Shire of Bridgetown-Greenbushes	Bridgetown	Ph. (08) 97 611 555 Fax. (08) 97 612 023 Web: www.bridgetown.wa.gov.au
Shire of Manjimup	Manjimup	Ph. (08) 97 717 777 Fax. (08) 97 717 771 Web: www.manjimup.wa.gov.au
Shire of Nannup	Nannup	Ph. (08) 97 561 018 Fax. (08) 97 561 275 Web: www.nannup.wa.gov.au
SWCC	Bunbury	Ph. (08) 97 806 193 Fax. (08) 97 806 198 Web: www.swcatchmentscouncil.com.au

Appendix 3: Fish fauna of the Donnelly Rover, Western Australia

Acknowledgements

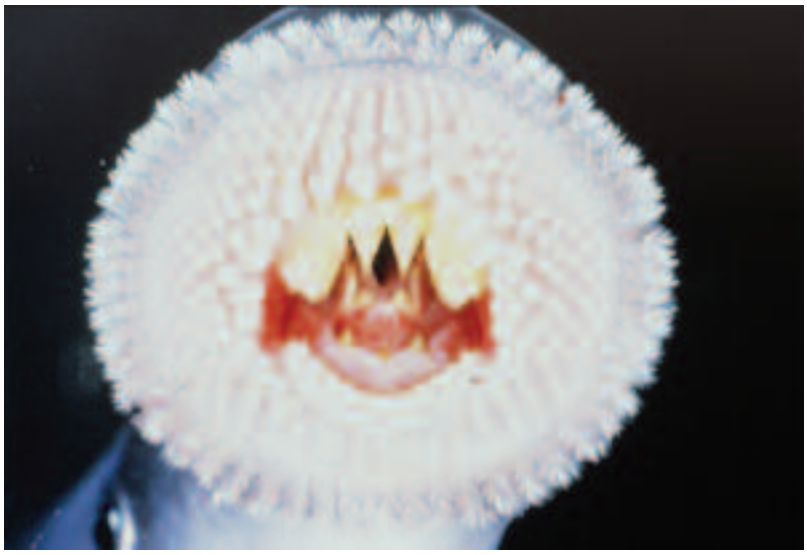
We would like to thank Jenni Munro (Southern Forests Landcare) and Cassandra Jury (Cape to Cape Catchments Group) for initiating the study and coordinating sample sites. We would also like to thank the South West Catchment Council for funding the project. Thank you to Professor Ian Potter and Dr Howard Gill (Murdoch University) for providing further information relating to lampreys. We would also like to thank John Evans for providing accommodation while at the Donnelly River mouth.

Report should be cited as:

Morgan, D. & Beatty, S. (2006). Fish fauna of the Donnelly River, Western Australia. Freshwater Fish Research, Murdoch University report to the Southern Forests Landcare.

Summary

This report provides an overview of the fishes of the Donnelly River that is based on collections made during June 2006 and from historical data. The Donnelly River, including Lake Jasper, Lake Wilson and Lake Smith, is one of the few catchments in south-western Australia that is inhabited by all of the region's endemic freshwater fishes. The relative high diversity of freshwater fishes is likely to have been fostered by the diversity of aquatic habitats offered within the catchment. For example, species such as the Salamanderfish and Black-stripe Minnow are restricted to ephemeral pools and floodplain environments and within the Donnelly catchment are confined to the wetlands and pools on Scott Rd and around Lake Smith. Lake Smith is also the only known location within the catchment of the rare Balston's Pygmy Perch and, together with Lake Wilson is the only known habitat in the catchment with the large Freshwater Cobbler. The Western Minnow, Western Pygmy Perch and Nightfish are relatively common and widespread through the catchment, occurring in most habitat types including the lakes. The rare Mud Minnow is restricted to headwater streams and is very uncommon in the system, possibly as a consequence of predation by exotic species. Three introduced fishes are known from the Donnelly River, the Eastern Mosquitofish, Redfin Perch and Rainbow Trout, the latter being the most widespread, presumably as a consequence of the long term stocking of the species into the catchment. For example, over 500,000 Rainbow Trout were stocked into the system between 1999 and 2004, however there is limited information on the impacts of the species on the ecology of the river. There have been only limited surveys of the estuary of the Donnelly River, and only a small number of species have been recorded there. It is recommended that further seasonal surveys are conducted within the estuary to determine the species composition. The Donnelly River also supports extremely important breeding and nursery grounds for the primitive Pouched Lamprey. Good water quality and habitats (uncleared, high organic content and shade) in some of the major tributaries provide the ammocoetes (larvae) with important nursery areas. The Donnelly River and its catchment is an important refuge for a number of fishes that are unique to Western Australia, while it is also important to many people for recreational purposes and possesses many sites that are of cultural and archaeological importance.



Contents

Background

The catchment of the Donnelly River is comparatively small; covering an area of approximately 1600 km2, with the headwaters arising between Bridgetown and Manjimup some 60 km inland before flowing south-west where they meet the Southern Ocean (Hodgkin and Clarke 1989). Situated in the high rainfall belt in the south-western corner of Western Australia, the catchment is largely uncleared (80-90%) and dominated by impressive Karri (*Eucalyptus diversicolor*) and Jarrah (*Eucalyptus marginata*) forests (Hodgkin and Clarke 1989, Pen 1999). Although in south-western Australia there are some 20 river systems that are larger than the Donnelly River, it is sixth in terms of mean annual flow (310000 ML). Within the Donnelly River catchment are the near pristine wetlands of Lake Jasper, Lake Wilson and Lake Smith. Parts of the lower Donnelly River, Barlee Brook and much of Lake Jasper are of important cultural and archaeological significance and many of these sites are Registered Aboriginal Heritage Sites (Dortch & Godfrey 1990, Goode 2003, Goode & Irvine 2006).

There have been several studies relating to the fish fauna of the Donnelly River. The distributions of freshwater fishes inhabiting the Donnelly River and the adjacent lakes were documented by Morgan *et al*. (1998), and include data from the collections in the Western Australian Museum and from those made by Christensen (1982) and from Jaensch (1992) in Lakes Jasper, Wilson and Smith. Hodgkin and Clarke (1989) provide a list of the fish species found within the Donnelly River Estuary and also provide information on the catchment characteristics and physical features. Hoddell (2003) examined the phylogeny (i.e. evolutionary relationships) of the Western Hardyhead (Leptatherina wallacei) and the Swan River Goby (Pseudogobius olorum) in the lower estuary and Lake Jasper and compared these to populations elsewhere in south-western Australia. Since the mid 1970s Professor Ian Potter and his staff and students in the Centre for Fish and Fisheries Research at Murdoch University have been extremely active in the study of the Pouched Lamprey (*Geotria australis*), with much of the work (almost 100 scientific publications) involving lampreys from the Donnelly River, many of which have been collected by the senior author with site captures of adults and ammocoetes (larvae) presented in Morgan et al. (1998). The Donnelly River is also regularly stocked with trout and information regarding such stockings was obtained from the Department of Fisheries Western Australia while there is some information on the diets of trout from the Donnelly River in Morgan et al. (2004). By collating relevant information in the above studies and through additional sampling in the lower Donnelly River, this report provides an overview of the fishes in the Donnelly River.

Adult Pouched Lamprey (Geotria australis)

Methodology

Collections of fish in the Donnelly River

As mentioned in the Background, a number of studies provide information regarding specific aspects of the fishes of the Donnelly River. Utilising GPS co-ordinates and species occurrences in Christensen (1982) (11 sites), Jaensch (1992) (3 sites), Morgan *et al.* (1998) (24 sites) and Hoddell (2003) (3 sites), together with five sites sampled during June 2006, we have generated a series of species maps using *MapInfo* (MapInfo Corporation 1998) (see Figure 1). Information regarding species in the estuary was collated from Hodgkin and Clarke (1989), Hoddell (2003), Brearley (2005) and from samples obtained during June 2006 (this study).

Sampling during June 2006 included four sites within the estuary (tidal influence) and one site on Carey Brook (Figure 1). Sampling methods included monofilament gill nets, fine mesh (3 mm) seine nets, and both boat deployed (240v) and backpack (12v) electrofishers. At the time of sampling the river mouth was open and the river was tidally influenced to at least Boat Landing Road.

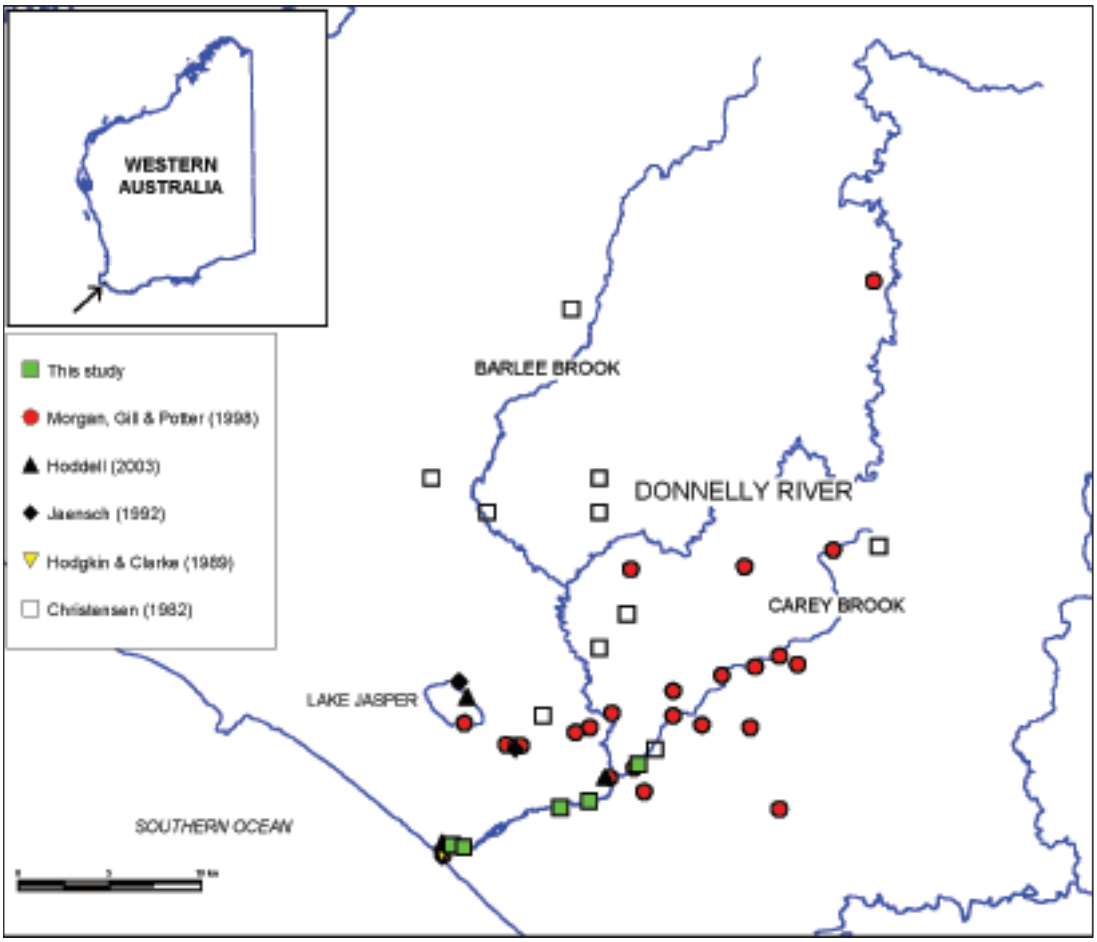


Figure 1: Sites sampled for fish in June 2006 and during relevant past studies; each of which was used to provide species distributions throughout the catchment.

Fish fauna of the Donnelly River

In the following synopsis of the fish fauna of the Donnelly River we have grouped species into a number of conventionally used life history categories, i.e. species have been conveniently grouped if they are strictly **freshwater species**, are estuarine teleosts or whether they are **introduced fishes**. A further category has been included to account for the anadromous **Pouched Lamprey**, which belongs to a primitive group of fishes known as the Agnatha

Native Freshwater Fishes of the Donnelly River

The south-west of Western Australia (otherwise known as the Southwest Coast Drainage Division) has the highest proportion (80%) of endemic fishes in the country. Of the 10 native freshwater fishes that are naturally found within the south-west, eight are found nowhere else. The Donnelly River catchment (including Lakes Jasper, Wilson and Smith) is one of the few systems in the south-west that provides refuge for all of the south-west's endemic fishes. As such, it is extremely important to the State's biodiversity and houses the enigmatic Salamanderfish (*Lepidogalaxias salamandroides*), the Freshwater Cobbler (*Tandanus bostocki*), the Western Minnow (*Galaxias occidentalis*), the Black-stripe Minnow (*Galaxiella nigrostriata*), the Mud Minnow (*Galaxiella munda*), the Western Pygmy Perch (*Edelia vittata*), Balston's Pygmy Perch (*Nannatherina balstoni*) and the Nightfish (*Bostockia porosa)*. A synopsis of each of these species follows:

Salamanderfish *(Lepidogalaxias salamandroides)*.
Photo D. Morgan

Distribution in the Donnelly River catchment: The Salamanderfish has a very restricted distribution, occurring in pools from Augusta to just east of Walpole (Morgan *et al*. 1998). The Salamanderfish is seldom found in the main channel, or even a major tributary, of any river system and the Donnelly is no exception. Within the Donnelly catchment the Salamanderfish has been captured from: the swamps surrounding Lake Smith, in pools along Scott Rd and on a large flat on Pneumonia Rd (Figure 2). The species is characteristically found in tannin stained, acidic, ephemeral pools in heath land associated with the peat flats (Christensen 1982, Morgan *et al*. 1998).

Life history and general remarks: Although the Salamanderfish is of small size (generally <80 mm total length (TL)) and very restricted in distribution, it has created much interest amongst biologists not only because it is the sole member of the Lepidogalaxiidae, but because it possesses a number of unusual characteristics. For example, not only does it aestivate when the pools in which it inhabits dry up (Pusey 1989) but it can bend its head at right angles to the body (Berra and Allen 1989); has an anal fin which, in the adult male, becomes greatly modified to facilitate sperm transfer to the female (Pusey and Stewart 1989); has an unusual sequence of fin development (Gill and Morgan 1999); and an atypical sperm morphology (Leung 1988). This species survives aestivation by inter alia secreting a mucous sheath over its entire body, which thereby protects it from desiccation, and by possessing mechanisms that enable it to minimise the accumulation of urea (Pusey 1989). The ability to burrow is facilitated by a robust wedge-shaped skull, a flexible vertebral column and reduced ribs (Berra and Allen 1989). Salamanderfish are multiple spawners that breed between winter and early spring and although some may attain maturity in their first year of life, most mature in their second (Morgan *et al*. 2000). Salamanderfish live for a maximum of only four to five years (Morgan *et al*. 2000).

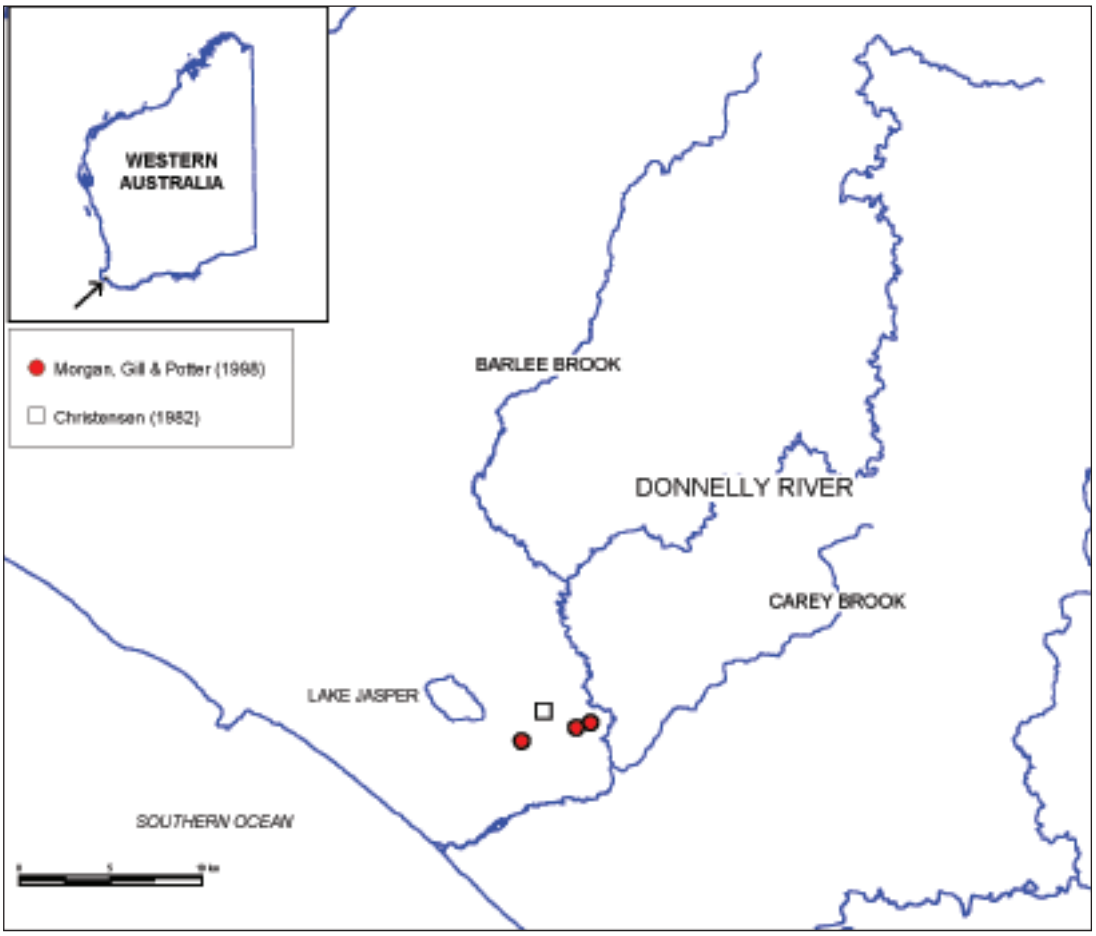


Figure 2: Distribution of Salamanderfish within the Donnelly River catchment.

Freshwater Cobbler *(Tandanus bostocki). Photo: M. Allen*

Distribution in the Donnelly River catchment: The Freshwater Cobbler has a relatively sporadic and unusual distribution within south-western Australia and the same may be said within the Donnelly catchment, where it is only known from Lake Smith and Lake Wilson (Figure 3) (Jaensch 1992, Morgan et al. 1998). The species is characteristically found in large waterbodies such as the main channel of rivers and/or dams.

Life history and general remarks: Attaining almost 500 mm TL, this is the largest of the region's freshwater fishes. Breeding occurs in late spring and early summer and the diet is dominated by freshwater crayfish, mussels and small teleosts.

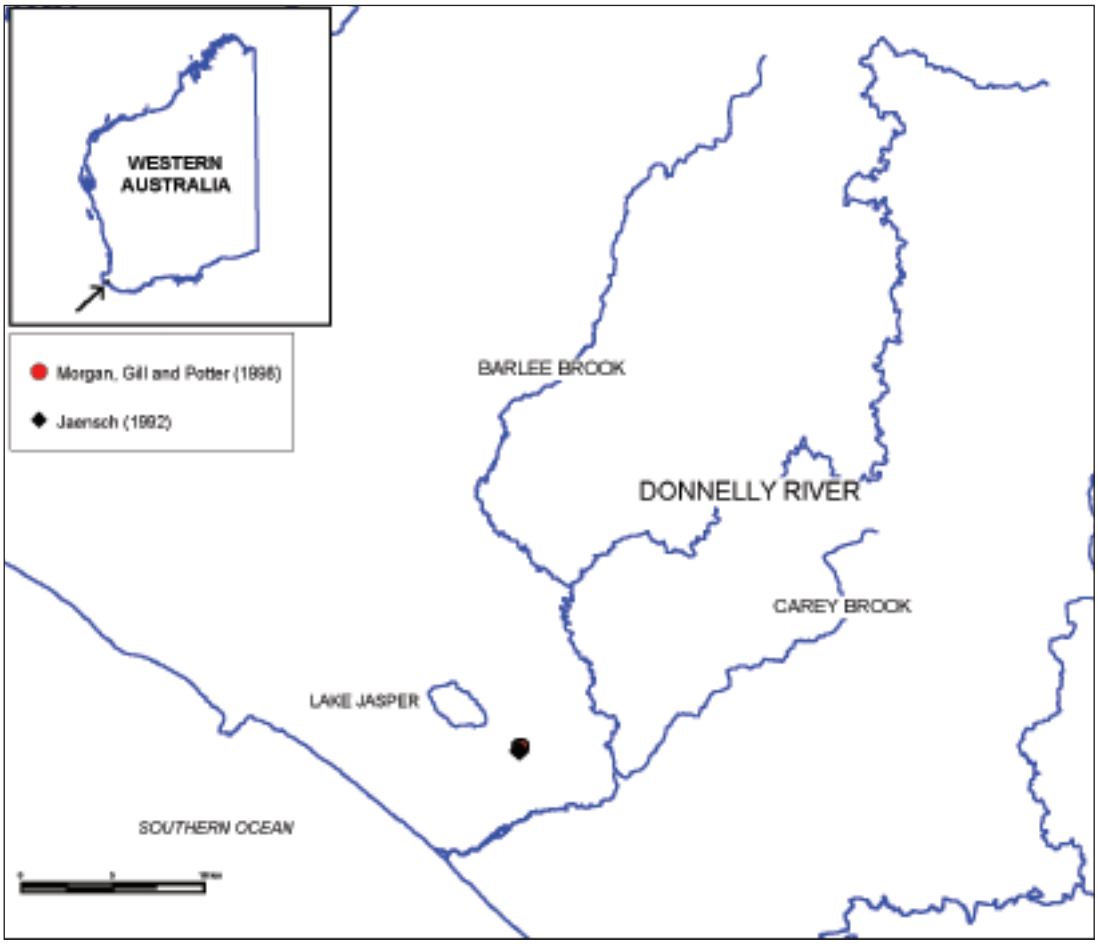


Figure 3: Distribution of Freshwater Cobbler within the Donnelly River catchment.

Western Minnow *(Galaxias occidentalis).*
Photo: D. Morgan

Distribution in the Donnelly River catchment: The Western Minnow is the most widespread and abundant of south-western Australia's endemic freshwater fishes and is known from the Arrowsmith River in the north to the Waychinnicup River in the south-east. They are found in larger rivers, small streams, lakes and floodwaters and have a diet that consists largely of terrestrial insects. The Western Minnow is widespread throughout the Donnelly River and is very abundant in Lakes Jasper, Wilson and Smith where they often form large schools (Figure 4).

Life history and general remarks: Major migratory periods include late winter and spring to spawn and late spring for new recruits. Rarely exceeding 150 mm TL, the species is considerably tolerant of salt and is still found in the upper reaches of salt-affected systems, such as the Blackwood River. Considerable coloration differences exist between populations in Lake Jasper compared to Lake Wilson and Smith; presumably as a response to the tannin coloured waters of the latter lakes. The Lake Jasper population is infected with an introduced cestode (tapeworm), *Ligula intestinalis*.

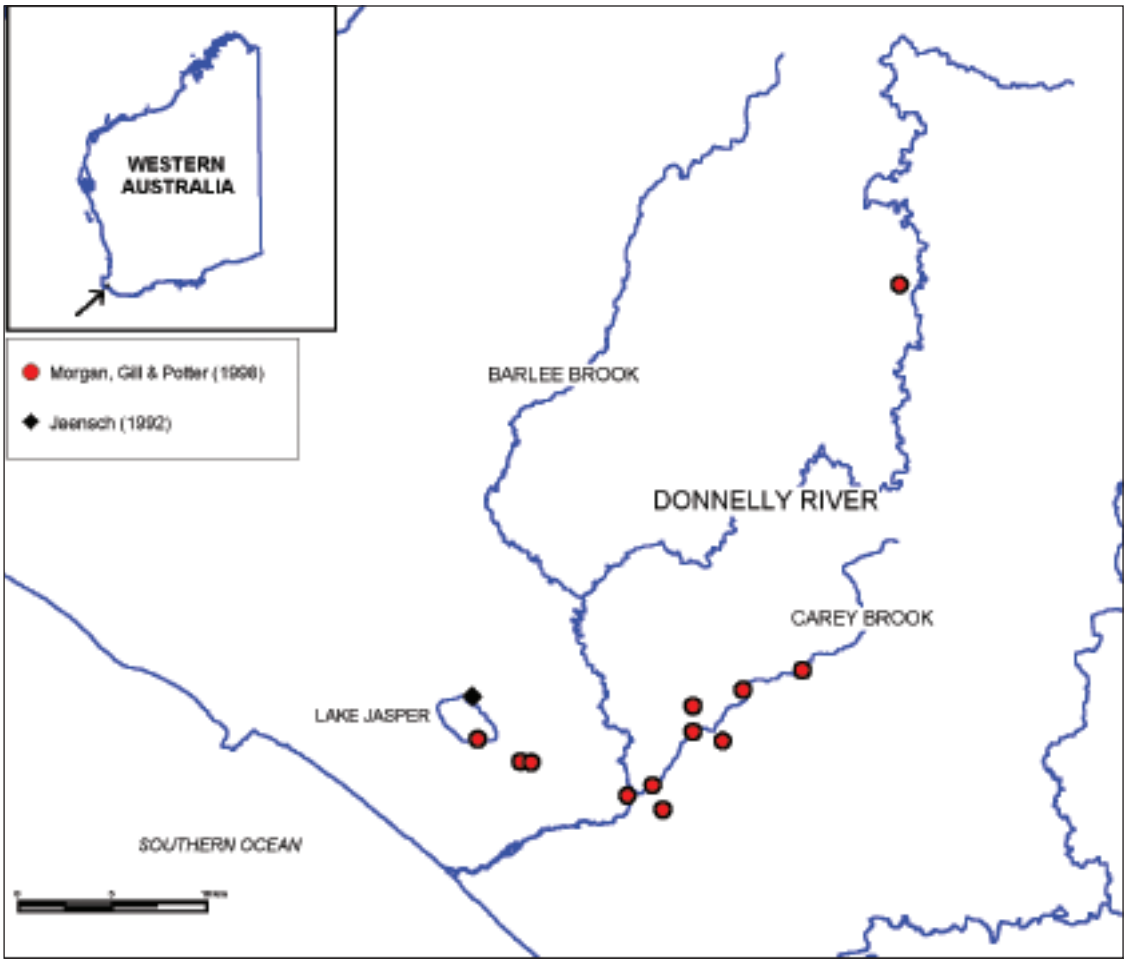


Figure 4: Distribution of the Western Minnow within the Donnelly River catchment.

Mud Minnow (*Galaxiella munda*). *Photo: D. Morgan*

Distribution in the Donnelly River catchment: The Mud Minnow is one if the rarest of the south-west's endemic fishes and it has only been reported in the Donnelly River catchment in three localities by Christensen (1982) (Figure 5). An isolated population of the species is found in the Moore River catchment near Gingin, the next nearest population being in the upper headwaters of Margaret River (Morgan *et al*. 1998).

Life history and general remarks: Mud Minnows have an extended breeding period (July-October), are multiple spawners and die in the next few months after spawning, i.e. they only live for just over a year, and rarely exceed 60 mm TL (Pen et al. 1991). The small size, surface feeding and preference for headwater streams has seen it disappear from a number of systems, presumably as a result of predation by introduced fishes such as Redfin Perch, trout and Eastern Mosquitofish (Morgan *et al*. 1998, 2002).

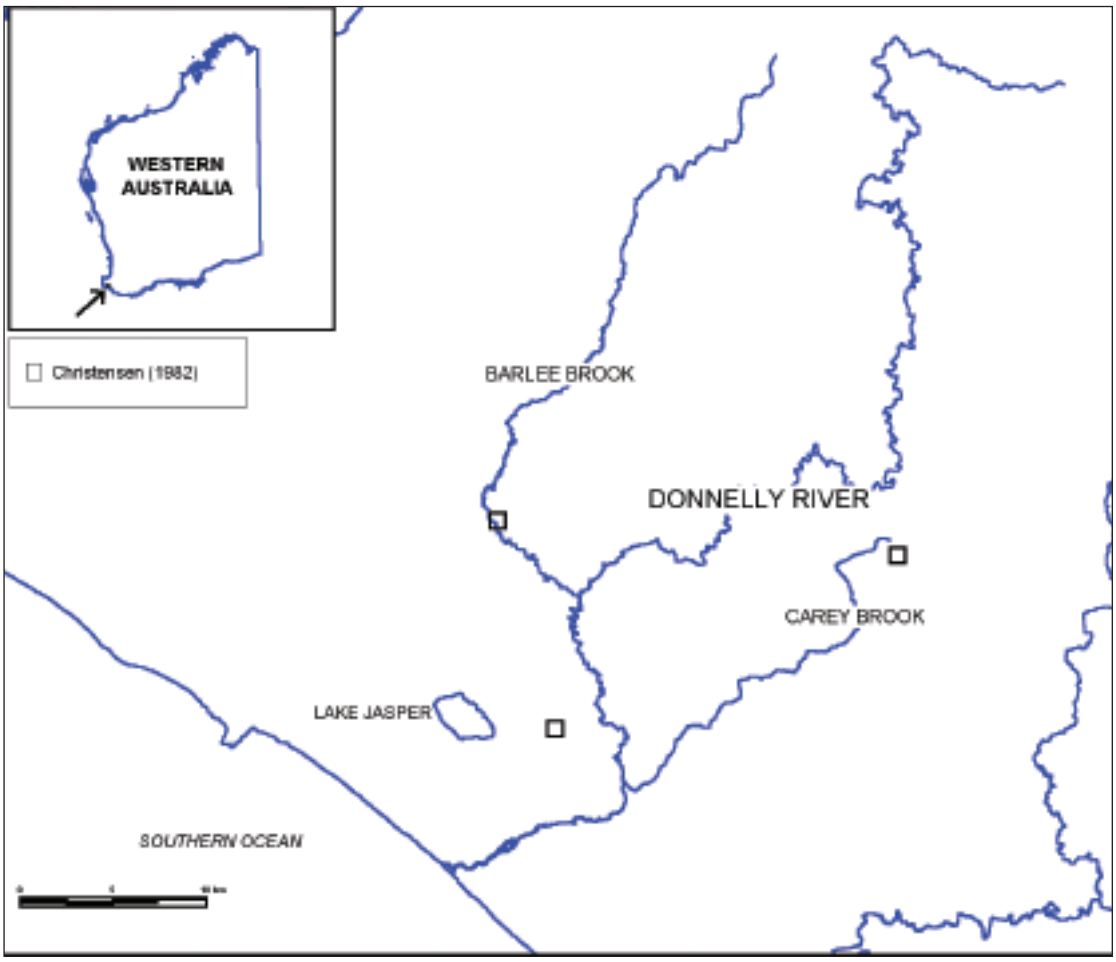
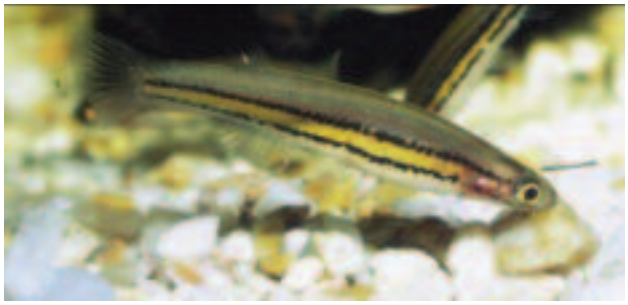


Figure 5: Distribution of the Mud Minnow within the Donnelly River catchment.



Black-stripe Minnow (*Galaxiella nigrostriata*). *Photo: G. Allen*

Distribution in the Donnelly River catchment: The Black-stripe Minnow is very restricted in geographical distribution and also in the habitat types that it occupies. Along with the Salamanderfish, it is generally restricted to ephemeral pools along the south coast between Augusta and Walpole although disjunct populations have been recorded (Morgan et al. 1998, Morgan & Gill 2000). Within the Donnelly River catchment it is restricted to a number of pools/floodwaters along Scott Road (Figure 6).

Life history and general remarks: The waters in which it lives are generally tannin stained and acidic (pH 3-6). Their appearance in pools that were artificially filled with water suggests that they are capable of aestivation (Morgan et al. 1998). The Black-stripe Minnow has a diet that consists largely of terrestrial insects as adults and aquatic invertebrates as larvae (Gill & Morgan 2003) and it generally only lives for just over a year (Pen et al. 1993).

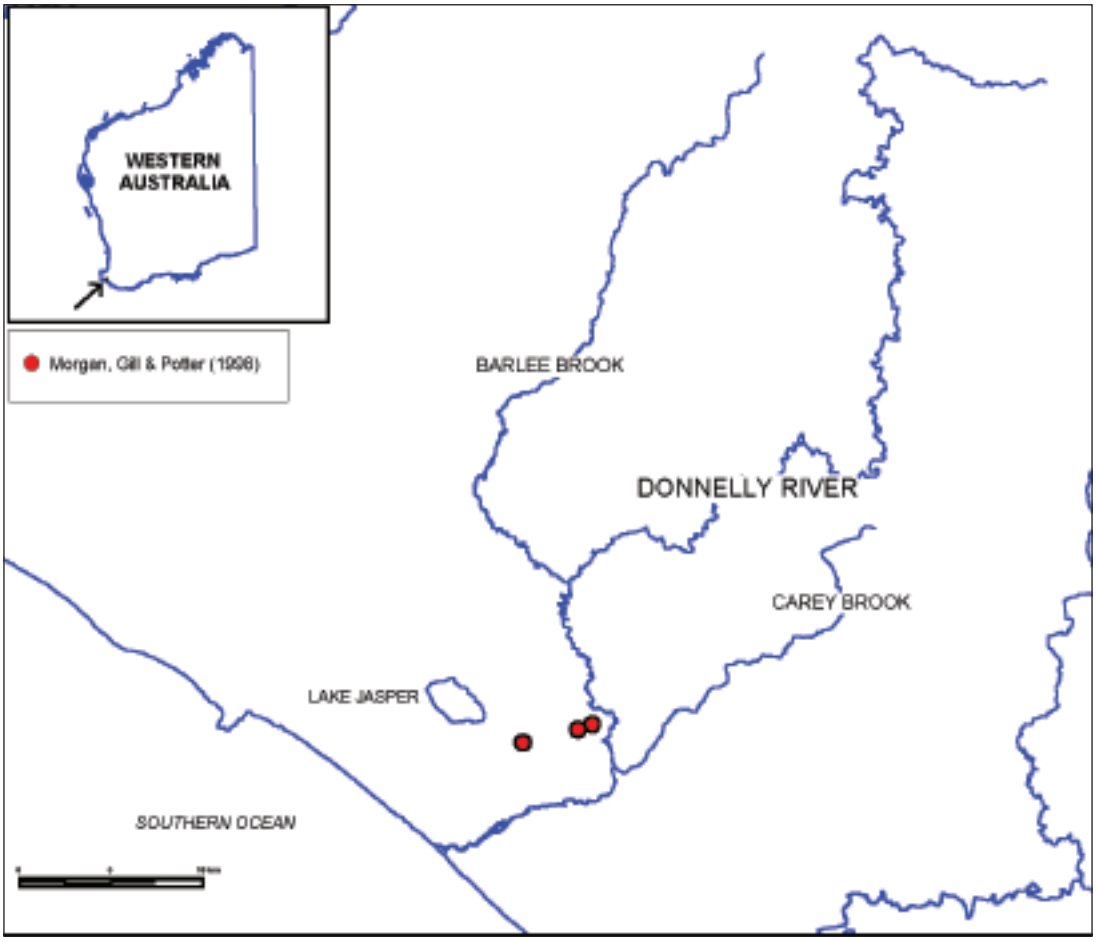


Figure 6: Distribution of the Black-stripe Minnow within the Donnelly River catchment.

Western Pygmy Perch *(Edelia vittata). Photo: D. Morgan*

Distribution in the Donnelly River catchment: The Western Pygmy Perch is widespread and relatively common in a number of habitats throughout the Donnelly River catchment (Figure 7). It is particularly abundant in Lake Smith and Lake Wilson. The species is widespread throughout south-western Australia, from the Arrowsmith River in the north to the Angove River in the south-east.

Life history and general remarks: Its absence from the main channel of some of the region's larger salt-affected rivers suggests a relatively low tolerance to dissolved salts. They are also susceptible to Gambusia attack. They are multiple spawners during spring and live for up to five years (Pen & Potter 1991).

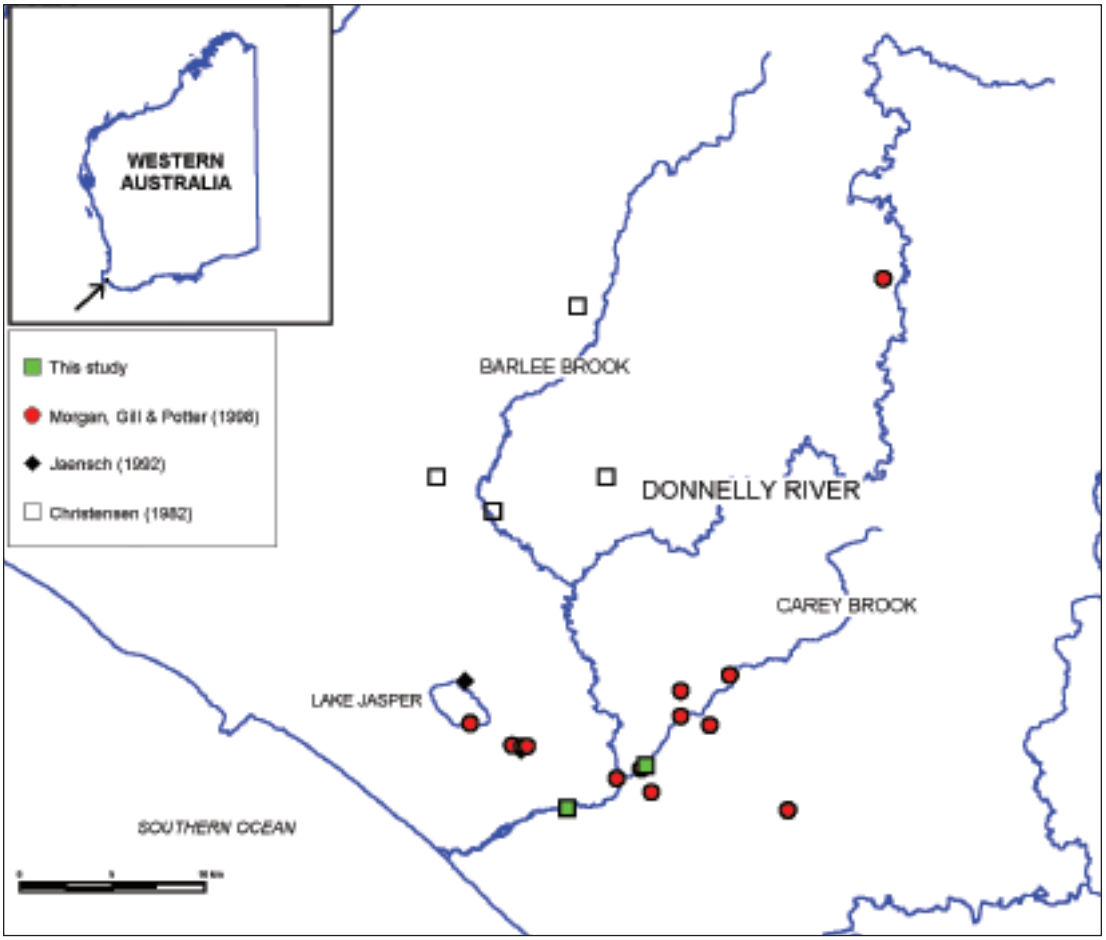


Figure 7: Distribution of the Western Pygmy Perch within the Donnelly River catchment.

Balston's Pygmy Perch *(Nannatherina balstoni). Photo: D. Morgan*

Distribution in the Donnelly River catchment: Balston's Pygmy Perch is extremely rare, and within the Donnelly River catchment is only known from Lake Smith, with one individual found in Fly Brook (Figure 7) (Morgan et al. 1998). Specimens of the species from Moore River are housed in the Western Australian Museum and Pen (1999) reports one individual from the Collie River. Their range has been severely fragmented by development and they are now found from the upper reaches of Margaret River east to the Angove River.

Life history and general remarks: Balston's Pygmy Perch breed in their first year of life and the diet is dominated by terrestrial insects. They are not long lived and are rarely found in large numbers (Morgan *et al.* 1995).

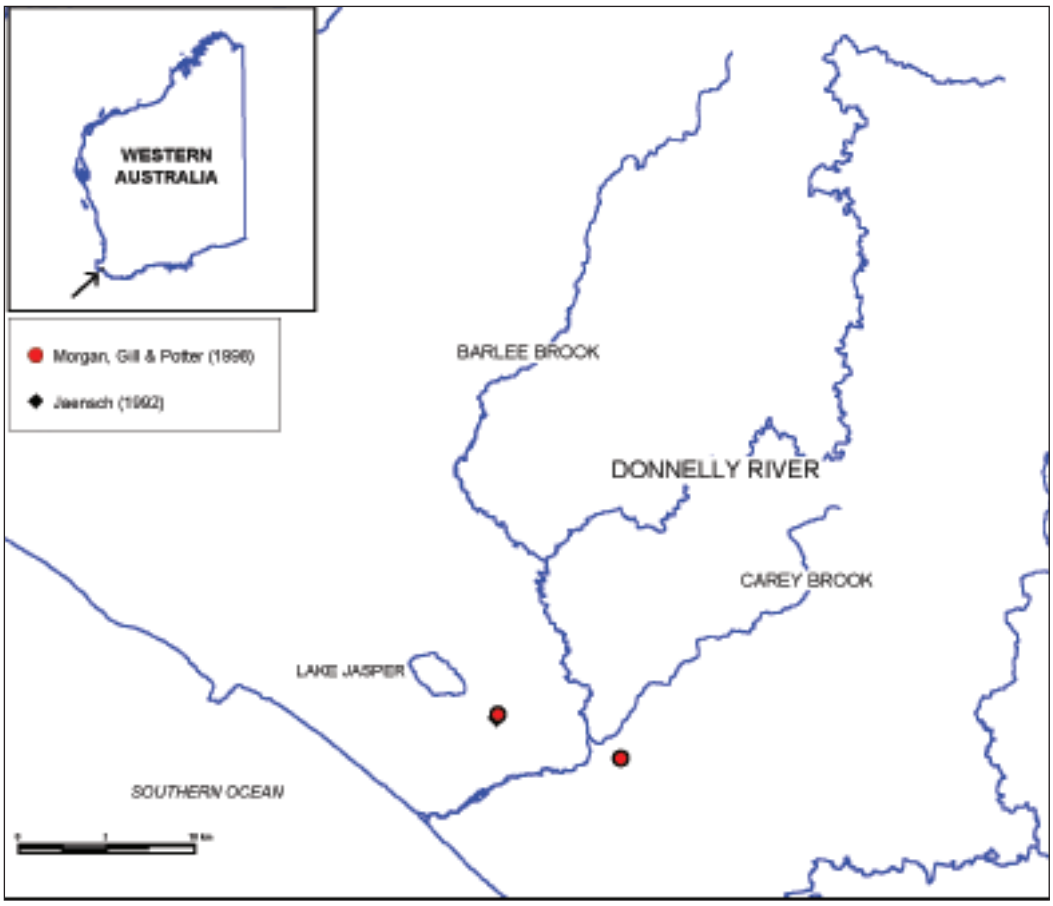


Figure 8: Distribution of the Balston's Pygmy Perch within the Donnelly River catchment.

Nightfish *(Bostockia porosa). Photo: D. Morgan*

Distribution in the Donnelly River catchment: The Nightfish is found throughout the catchment including in the Lakes Jasper, Wilson and Smith (Figure 9). It is comparatively widespread throughout south-western Australia from the Hill River to the Kalgan River.

Life history and general remarks: A nocturnal species, the Nightfish requires complex habitat and is thus rarely found in areas devoid of instream structure. Nightfish attain a maximum of 150 mm TL, with most males reaching maturity in their first year and females delaying maturation until their second year (Pen & Potter 1990). Nightfish live for up to six years.

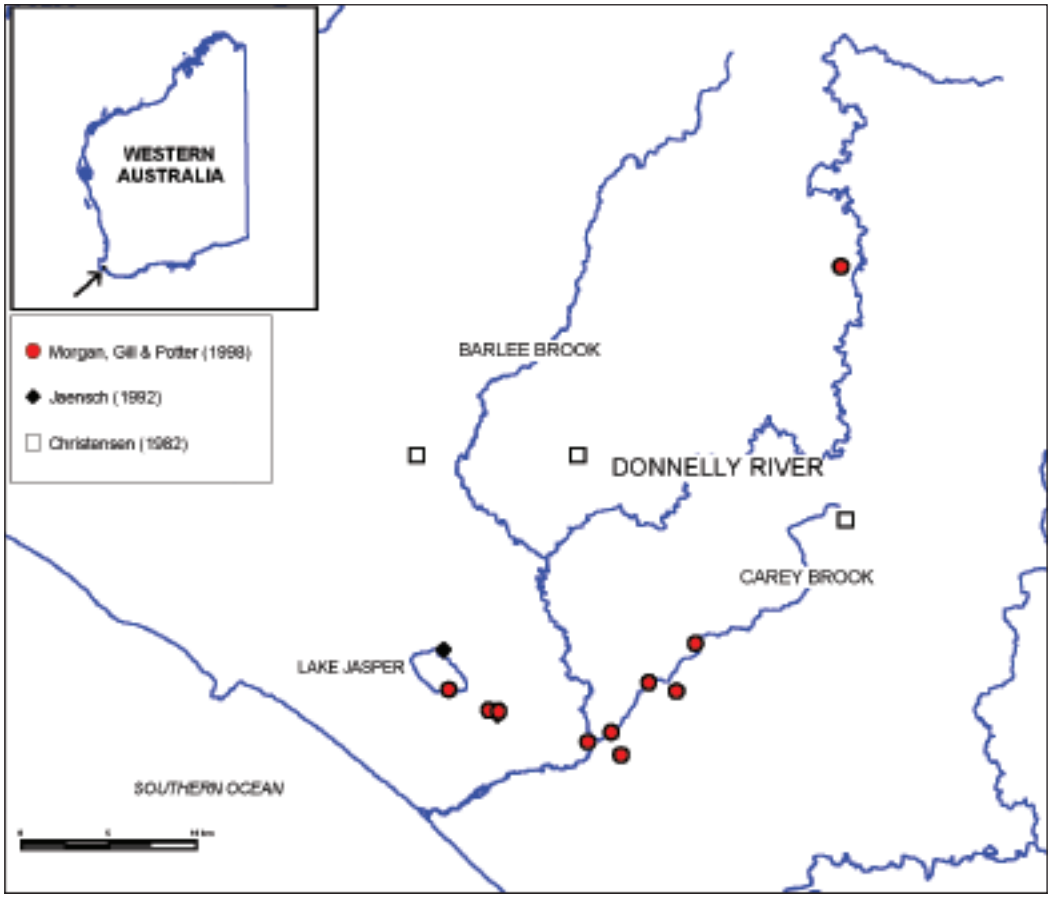


Figure 9: Distribution of the Nightfish within the Donnelly River catchment.

Estuarine Fishes in the Donnelly River

Hodgkin and Clarke (1989) report a number of marine/estuarine fishes from the Donnelly River estuary including: Black Bream (*Acanthopagrus butcheri*), Yelloweye Mullet (*Aldrichetta forsteri*), Sea Mullet (*Mugil cephalus*), Silverfish (*Atherinosoma presbyteroides*), Hardyhead (listed as Atherinid sp. but is presumably the Western Hardyhead (*Leptatherina wallacei*)), South West Goby (*Afurcagobius suppositus*) and Blue Spot or Swan River Goby (*Pseudogobius olorum*). Brearley (2005) adds that other species, including Tarwhine (*Rhabdosargus sarba*), Cobbler (presumably *Cnidoglanis macrocephalus*), Australian Herring (*Arripis georgianus*) and flathead sp. are also caught by recreational anglers in the river. Our sampling in June 2006 in the estuary captured the majority of these species including Black Bream, Tarwhine, Australian Herring, Sea Mullet, Yelloweye Mullet, Western Hardyhead, Swan River Goby and South West Goby. At the time of sampling the mouth of the river was open, and the salinity of the bottom (at Hut 20) was 21.1 ppt while the surface salinity was 1.0 ppt. The salinity at Boat Landing Rd boat ramp was still ~18 ppt on the bottom but was fresh on the surface. While the majority of the above species are not found beyond the lower estuary or limit of tidal influence, the Western Hardyhead, Swan River Goby and South West Goby are recorded upstream into freshwaters in many of the south-west's river and within the Donnelly catchment they are each very abundant within Lake Jasper (Morgan *et al*. 1998). During recent sampling we also captured the South West Goby in Carey Brook and the Swan River Goby was previously captured a considerable distance up the main channel of the Donnelly River (see Morgan *et al*. 1998).

Introduced Fishes

Prior to 2005 a total of 10 species of introduced freshwater fish were recorded from Western Australia (Morgan *et al*. 2004), with a further two introduced fish species being captured in south-western Australia in the last two years. The Donnelly River catchment has records of Eastern Mosquitofish (*Gambusia holbrooki*) and Redfin Perch (*Perca fluviatilis*) from a few locations (see Morgan *et al*. 1998) while Rainbow Trout (*Oncorhynchus mykiss*) are fairly prolific within the catchment, presumably as a result of a long term stocking programme in the system (Figure 11). For example, approximately 500,000 Rainbow Trout fry were stocked by the Department of Fisheries Western Australia into the Donnelly River between 1999 and 2004, and this figure includes approximately 70,000 fry into both Carey Brook and Barlee Brook. This represents about 20% of all of the Rainbow Trout fry stocked into Western Australian waters. A further 20,500 yearling Rainbow Trout were also stocked during this period, representing ~13% of all yearling Rainbow Trout stocked. Although they are stocked into the freshwaters of the main channel and main tributaries of the system, Rainbow Trout are apparently commonly captured at the mouth of the river system at certain times of the year and were reported from the mouth of the river by Hodgkin & Clarke (1989). The impact of stocking a large predatory fish such as Rainbow Trout within the Donnelly River has not been assessed. An examination of the stomachs of 20 small Rainbow Trout (<310 mm TL, mean TL = 152 mm) in Carey Brook captured in May 1996 revealed that they preyed on a variety of fauna, but the stomachs were dominated by terrestrial fauna (insects) (35% by volume), freshwater crayfish (13%), dipteran larvae (11%), dipteran pupae (12%) and fish/larval lampreys (4%). The proportion of different prey eaten will no doubt change when considering larger trout (see Tay 2005). The impact of trout stocking in this system needs to be assessed in both the freshwaters and the estuary. The impacts of the other feral species that are found in the system are summarised in Morgan *et al*. (2004), while information on Redfin Perch and Eastern Mosquitofish in WA can also be found in Morgan *et al*. (2002) and Gill *et al*. (1999), respectively.

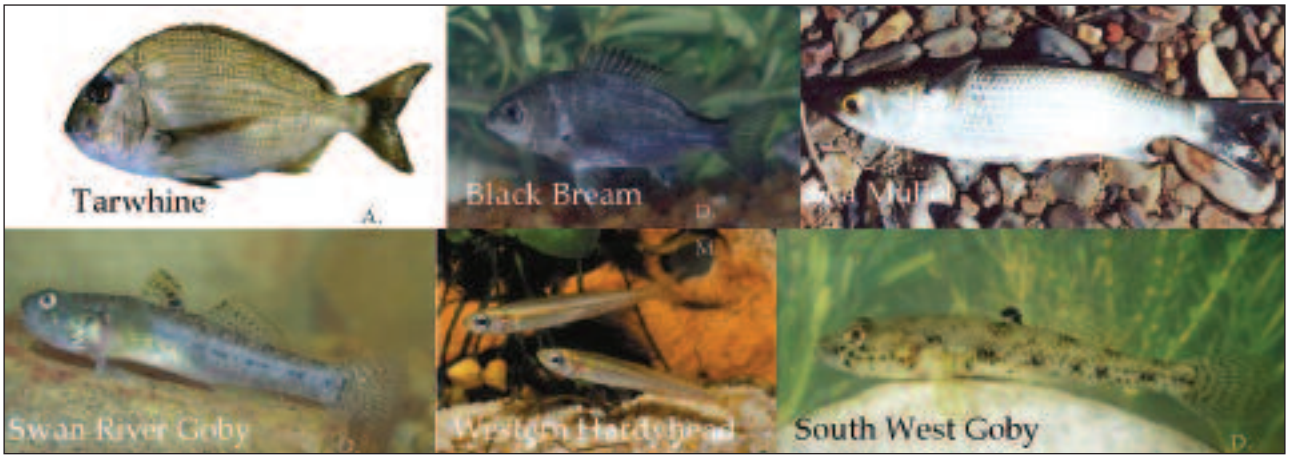


Figure 10: Some of the fish species found within the Donnelly River estuary.

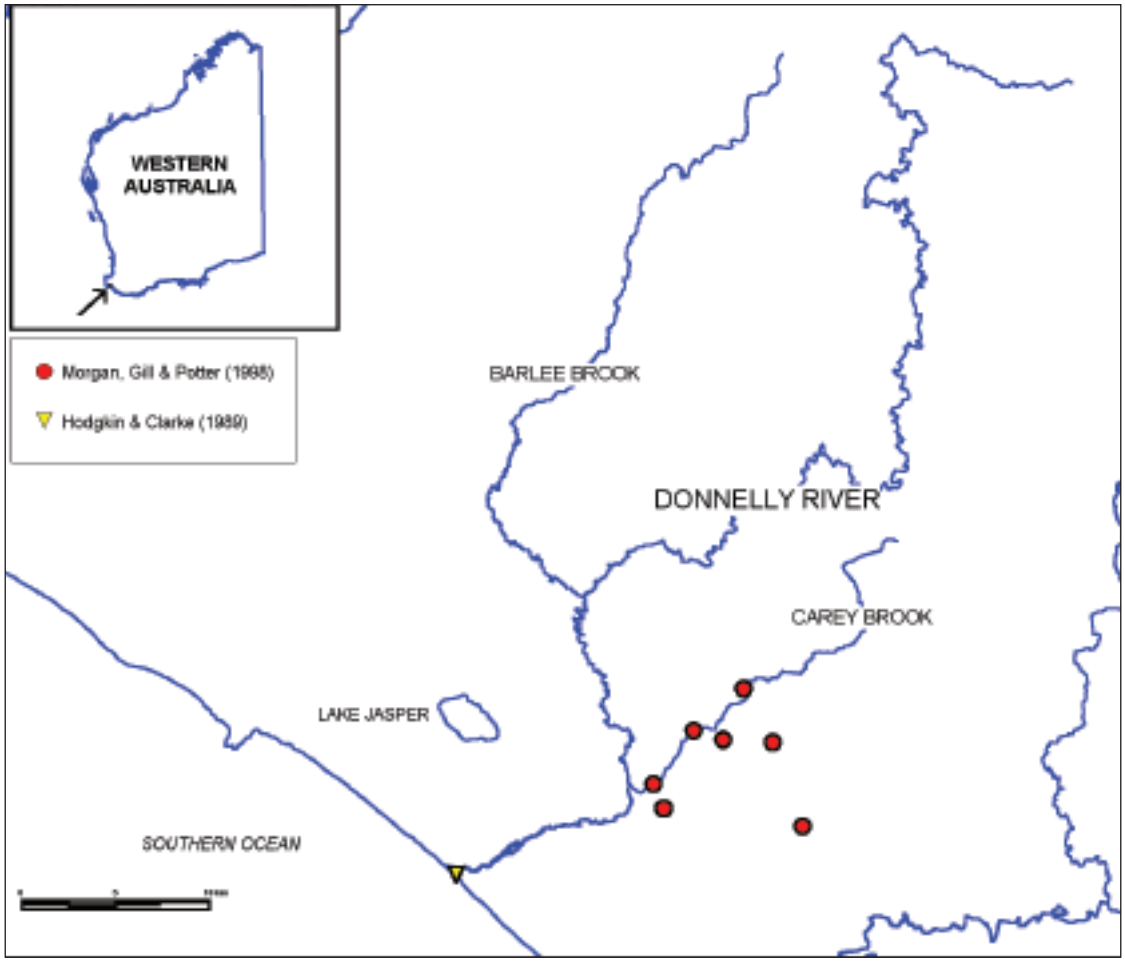


Figure 11: The published records of Rainbow Trout within the Donnelly River catchment.

Lampreys in the Donnelly River

The Pouched Lamprey (*Geotria australis*) belongs to the Petromyzontiformes, which are one of the only two surviving groups of the jawless (agnathan) stage in vertebrate evolution (Hardisty 1982). The absence of jaws and paired fins separates the agnathans from the cartilaginous (sharks and rays) and bony (teleosts) fishes. While there are 38 species of extant lampreys, the Pouched Lamprey is the sole member of the Geotriidae and one of only four species of Southern Hemisphere lampreys (Potter 1980). The species is known from south-western and south-eastern Australia, Tasmania, New Zealand and south-western and south-eastern South America (Potter 1996) and in WA it is found in most of the river systems from the Murray River south to approximately the Waychinnicup River east of Albany (Morgan *et al.* 1998). After four or so years, the microphagous larva (ammocoete) undergoes a radical metamorphosis into an adult, which possesses eyes, one or two prominent dorsal fins and a tooth-bearing suctorial disc (Potter et al. 1980, Potter & Hilliard 1986). The adult of the species is parasitic and is thought to feed on the flesh of teleost fishes (Gill *et al.* 2003).

Much of the work on the species in south-western Australia has been undertaken by Professor Ian Potter and his colleagues at Murdoch University who have worked on the species since 1976, with almost 100 scientific articles published on various aspects of the species including, for example: biology, habitats, development, morphology, relationship to other lampreys and physiology. The life-cycle is complex, with the worm–like larval stage (ammocoete) living in 'burrows' below the substrate where they feed on diatoms, detritus and micro-organisms. In south-western Australia at approximately four years of age (and at approximately 90 mm TL) the ammocoete undergoes metamorphosis (Figure 12) with the

resultant downstream migrant leaving the river during winter. It is thought that there is a one to two year marine trophic phase, where it presumably feeds on fish and their length increases to approximately 500-700 mm TL. The adult then ceases feeding, re-enters rivers and embarks on an upstream migration (moving predominantly at night) during winter and spring. After spending approximately 15-16 months in the river, when they survive off accumulated fat reserves, the adults spawn and die. During this 15-16 month period in the river the adults mature and the males develop a large gular pouch (hence the name pouched lamprey) (Figure 12). An enlargement of the oral disc also occurs during this maturation period.

The sites that ammocoetes were found buried in within the Donnelly River (Figure 13) were characterised by a high degree of shade and a high abundance of organic material on the substrate, factors that are known to influence larval densities (Potter *et al*. 1986). The metamorphosed juveniles (downstream migrants) however are most often associated with (buried in) sandy substrates that occur in well-oxygenated waters. At the site sampled on Carey Brook during this study, a total of 92 downstream migrants were captured, at an approximate density of 0.31 m-2, while only 11 ammocoetes were captured.

The strength of the upstream migration is variable from year to year, and due to their nocturnal migration being in winter they are seldom seen. The larvae are particularly vulnerable to habitat modification and rely on well oxygenated non-saline waters that are characterised by shade and organic matter. There is substantial evidence that lampreys are declining in numbers, particularly as a result of loss off suitable habitat for the larvae, and this is evident within south-western Australian rivers such as the Blackwood where salinisation and land clearing are causing loss of larval beds.

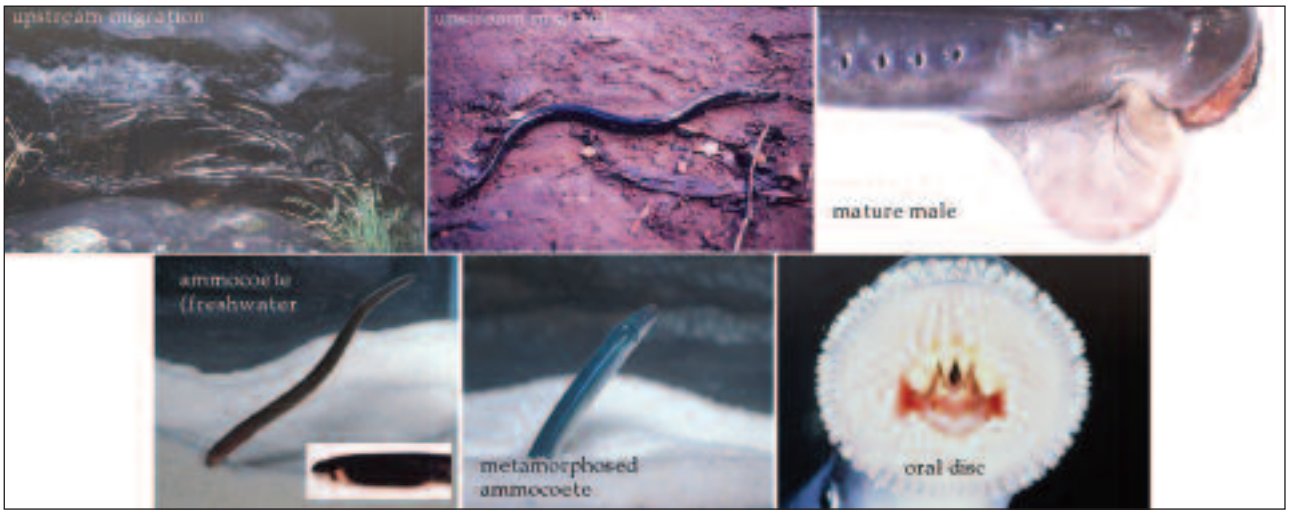


Figure 12: The life-cycle of the Pouched Lamprey includes an upstream migration phase from the sea to a river, the adults mature over the next year with males developing a gular pouch and enlarged oral disc; larvae (ammocoetes) remain buried in freshwater tributaries for over four years then metamorphose into a small juvenile and head back to sea during winter. Photographs: D. Morgan, I. Potter & L. Brooker

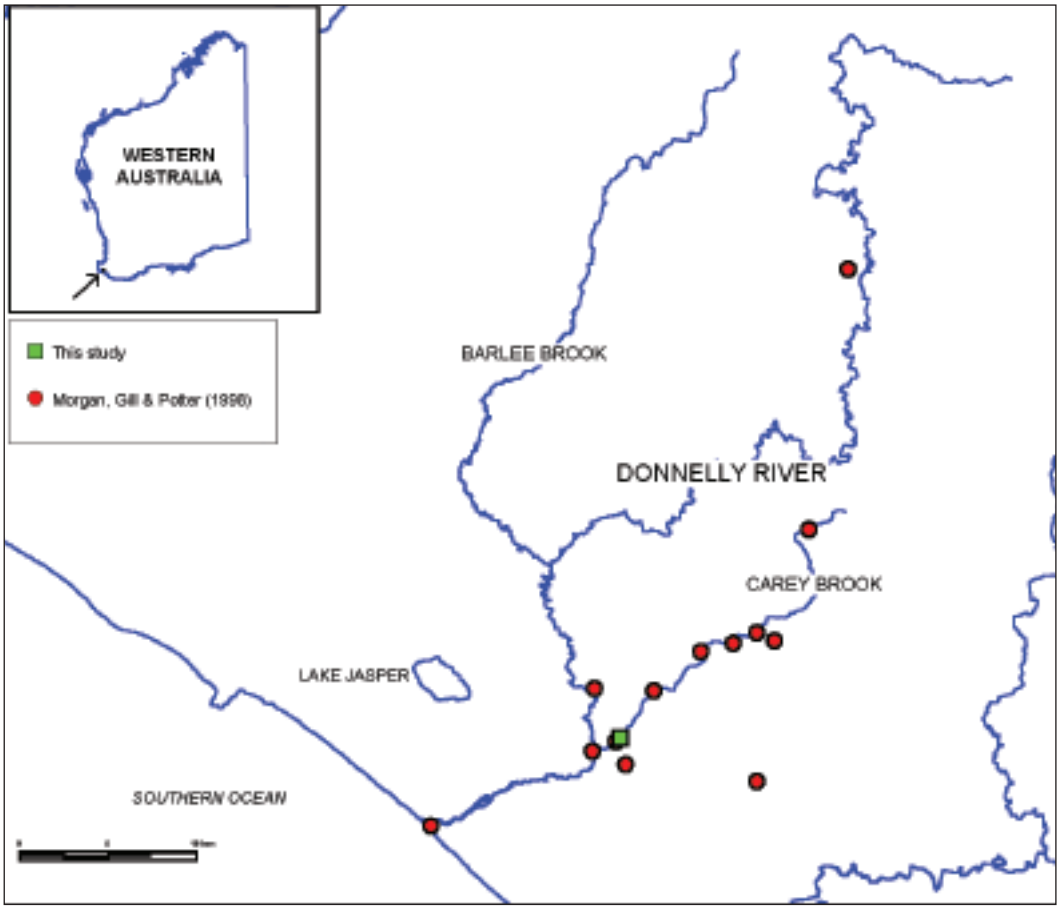


Figure 13: The locations of the Pouched Lamprey within the Donnelly River catchment. The site at the mouth and the upper river represents adults caught by colleagues at Murdoch University. Most other sites indicate ammocoete (larval) beds.

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