Tasmania's Native Riparian Vegetation

Elizabeth A. Daley B.Sc., Dip. Ed., B.Sc. (Hons)

Submitted in fulfilment of the requirements for the degree of
Doctor of Philosophy

School of Geography and Environmental Studies
University of Tasmania
Hobart

September 2003

Cent
Thesis
DALEY
Ph.D.
2003

THE
UNIVERSITY
OF TASMANIA
LIBRARY

Science is the systematic study of living and non-living things based on reproducible observations, measurements and experiments, and the knowledge, skills and proficiencies so gained. It is both a process and a resource developed by people in order to gain an understanding of the natural, chaotic processes that impose limitations to their survival and existence.

The acquisition of scientific knowledge, skills and proficiencies is limited by human nature, the ethics, values and intellectual capacity of the scientist, and the economic, social and political context in which the knowledge is acquired. The interpretation of scientific knowledge is limited by the methods used to acquire knowledge about complex, dynamic and interrelated processes and the tools used to compute and simplify complex, dynamic and interrelated processes.

Communication and use of science and scientific knowledge, skills and proficiencies for the improvement or degradation of the lives of all living things is ultimately determined by the powers, processes and political affiliations of people who find themselves in positions of authority at any given time.

DECLARATION

This is to certify that this thesis contains no material which has been accepted for a degree or diploma, not any material which has been previously published or written by another person except where due reference has been made.

AUTHORITY OF ACCESS FOR THESIS

This thesis may be made available for loan. All rights are reserved in accordance with the *Copright Act 1968*. No part of this thesis may be reproduced, stored in any retrieval system or transmitted in any form or by any means electronic, mechanical, photocopying, recording or otherwise without the prior written permission of the author.

AUTHORITY OF ACCESS FOR DATA

All data generated from this research project remain the property of the author in accordance with the *Copyright Act 1968*. All access, copying or use of any part of the data set is prohibited for five years from the date this statement was signed. Access by examiners to the copy of the data set which exists within the School of Geography and Environmental Studies for the purpose of verification of analysis is subject to a confidentially agreement. All enquiries regarding the data for this project should be directed to the author.

Elizabeth Daley

7.4.2003

ABSTRACT

Riparian vegetation has significant environmental, social and economic values that are intimately linked to its roles and functions in the terrestrial and aquatic environments. Yet, riparian vegetation research is in its infancy relative to studies of other terrestrial vegetation. Riparian plant communities have not been included in national or statewide vegetation mapping projects and there is a general lack of knowledge about individual native species and floristic assemblages that inhabit the riparian zone.

In order to address some of the knowledge gaps associated with riparian vegetation, a rapid survey methodology was developed and used to document the native species composition of approximately 50,000 km^2 of mainland Tasmania. No native riparian vegetation could be found in 6 000 km^2 of the survey area. Structural attributes of the riparian vegetation, and key environmental factors associated with riparian soil, substrate, landform, channel and bank characteristics, were also measured or described during the field survey. Climatic data, altitude, aspect, adjoining land use, visible disturbances and the vegetation structure of riparian vegetation and adjoining vegetation were also recorded.

The number of native vascular plant species recorded in the riparian zone of 460 sites was 860. Of these species, only 8 were recorded in at least 50% of sites; the majority of native vascular species in the riparian zone of Tasmania occur in less than 10% of sites. Only 2 native vascular species are considered to be possibly obligate riparian species. At least 46 species listed under the Tasmanian *Threatened Species Protection Act 1995* were located in the riparian zone. In addition, populations of at least 4 undescribed species were found during the survey.

From the statewide reference data set, 21 riparian floristic communities were described and their distributions mapped. Altitude, rainfall and temperature, hydrologic and geomorphologic factors, and the composition of the vegetation itself, all contributed significantly to an explanation of floristic variation in riparian vegetation.

At present, assessments of river condition at the state and regional scales are predominantly made using the AUSRIVAS modelling approach. An AUSRIVAS-style model was developed and used to assess the condition of native riparian vegetation in Tasmania. As well as providing an interpretation of riparian vegetation condition based on species composition relative to a reference data set, the model is able to generate a predictive list of species for any site in the survey area. While the model was considered to be suitable for assessing the condition of riparian vegetation at the statewide scale, the large discrepancies between observed and predicted species lists from the preliminary trial raised considerable

doubts as to its suitability for use for revegetation purposes or for ecological classification of sites into communities at this stage.

There is a strong case to support the view that all remaining native riparian vegetation should be conserved or protected because of its natural significance, its significant functions and roles as part of freshwater ecosystems and its high economic, cultural and social values. However, the reality is that only a part of the landscape can be managed primarily for conservation, and this is usually a relatively small part. In order to provide decision-makers and natural resource managers with an objective scientific process to facilitate the conservation of riparian floristic communities that are poorly-reserved or unreserved, a 5-stage planning process was developed to illustrate how priority riparian reaches could be selected from an extensive reference dataset.

If riparian vegetation is to retain high environmental, social and economic values, considerable strategic planning for long-term management of all components of freshwater ecosystems needs to be undertaken at the local, catchment and state levels. The riparian zone is an area where the preservation of what remains that is native is by far the most cost-effective strategy for management.

ACKNOWLEDGEMENTS

I offer my sincerest gratitude to Professor Jamie Kirkpatrick for assistance in the field, plant identification, academic support, funding for the project, and faith that it could be achieved. I also wish to acknowledge the support provided by the University of Tasmania through the provision of a Research Higher Degrees Scholarship.

I am also grateful for the many hours of consultation and practical assistance generously provided by Dr Peter Davies from Freshwater Ecosystems. Peter's exceptional modelling skills facilitated the development of the Tasmanian AUSRIVAS riparian vegetation predictive model.

A good sherpa is hard to find! I would like to thank my husband, Alan, for time, energy and service beyond the call of duty. He excelled as a field assistant and was my greatest supporter and mentor.

Thanks also goes to the other field assistants and companion explorers who braved the wild rivers of Tasmania with me - Juliette Chapman, Kate Daley, Jane Andrew, Deb Pulton, Melanie Kelly, Helen Dunn, Ronlyn Duncan and Bonnie Wintle.

I would also like to acknowledge assistance with access, permits and information provided by Penny Wells and other staff of Forestry Tasmania, Parks and Wildlife Service, Department of Primary Industries, Water and Environment, Huon Valley Council, Australian Bulk Minerals and Glenorchy Council. Thanks also to Hydro Tasmania who generously provided training, helicopter access and transport within the World Heritage Area.

Staff at the Tasmanian Herbarium have been incredibly patient and helpful during the two years that I visited them frequently with mysterious samples. In particular I would like to thank Alec Buchanan, Dr Andrew Rozefelds, Dennis Morris and Alan Gray for assistance with plant identification and Dr Gintras Kantilavis for his cheerful support. The many interesting chats and lovely cakes shared at morning teas were very much appreciated.

My thanks also goes to the many landholders, farm managers and community members around Tasmania who invited me onto their properties to document their riparian vegetation or who provided information, directions and local history. A special thanks goes to Arthur of Rossarden, who towed the Hilux out of a deep, muddy hole on a rainy afternoon.

Countless hours were spent developing an efficient database to manage the voluminous mass of detail generated from the field surveys. Without Darren Turner's assistance with macros, computer support and spreadsheet problem-solving genius, the results could not have been so efficiently achieved.

Thanks also goes to other staff and colleagues at the School of Geography and Environmental Studies for their cheerful assistance - David Sommerville, Dennis Charlesworth, Kate Charlesworth, Pep Turner, Sapphire McMullan-Fisher, Anita Wild, Johnny Tasirin, Frances Mowling, Mick Russell, Greg Phillips and Kate Harris.

Phil Long, my long time friend and cameraman, gave his time freely to provide assistance and advise with photographic techniques. I am grateful for his input and saw a distinct improvement in my photographic ability after his tuition – most of the time.

I am also grateful for the support and assistance provided by Col and Sue Dyke and continue to be motivated and inspired by their dedication to sustainable development.

Many thanks also go to Tony Daley for the many hours spent scanning over 1000 site photos and referencing them for easy access.

Finally, my sincere appreciation goes to my children, Kate, Ben, Bob, Tony and Mark, and my mum, Lydia Oliver, for their cheerful and encouraging support and assistance with data entry, data checking, cups of tea, cooking and housework!

TABLE OF CONTENTS

CHAPTER 3 – TASMANIA'S NATIVE RIPARIAN VEGETATION

CHAPTER 5 - CONSERVATION OF NATIVE RIPARIAN VEGETATION

CHAPTER 6 - GENERAL DISCUSSION

APPENDICES

List of Figures

List of Tables

List of Plates

Glossary

Active floodplain – area immediately adjacent to the active channel that is flooded periodically.

Algorithm – an effective procedure for solving a particular mathematical problem in a finite number of steps (Macquarie Dictionary, 3rd edition).

Alluvium - stream-deposited debris.

ANOVA - analysis of variance.

ANZECC - Australian and New Zealand Environment and Conservation Council.

ARMCANZ - Agriculture and Resource Management Council of Australia and New Zealand.

AUSRIVAS - Australian River Assessment System.

Baseline study - a study of existing environmental conditions, which are designed to establish the baseline conditions against which any future changes can be measured or predicted.

Biodiversity - a term that refers to the variety of life on earth and can be described in terms of genes, species and ecosystems. Biodiversity includes diversity within and between species and the diversity of ecosystems.

Biological diversity - the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species and of ecosystems.

Riparian buffer - a protective margin of vegetation adjoining a watercourse that protects it from potentially detrimental disturbances. The width of a riparian buffer usually refers to the horizontal distance from one bank.

CAR Reserve – Comprehensive Adequate and Representative reserve which is usually an old growth forest reserve on private land established as part of the CAR process of the Tasmanian Regional Forest Agreement 1997.

Catchment condition – is determined by integrated characteristics that include vegetation cover, hydrologic factors associated with flow, runoff and water storage, sediment and nutrient output and site productivity. Riparian vegetation communities tend to reflect both biotic and abiotic conditions of the catchments in which they reside.

Centres of endemism - areas where populations have been isolated for sufficiently long to evolve distinctive new species-specific characteristics that prevent outbreeding with other species populations.

Community - an assemblage of species that inhabits a particular area in nature (Commonwealth of Australia, 2002). The essential characteristic of a community is that it consists of spatially and temporally repeating combinations of biological attributes.

Conservation - the official care, protection, or management of natural resources for the purpose of restoring, maintaining or improving biological diversity and ecological functions. More simply, conservation means all the processes and actions of looking after a place so as to retain its natural significance and always includes protection, maintenance and monitoring (Commonwealth of Australia, 2002).

Conservation agreement - a legally binding agreement between a landholder and a third party, usually government, to manage an area of native vegetation for conservation. Such agreements often take the form of a statutory covenant, but at a local level could also be established by zoning the area in a conservation zone within local land use plans.

Cover – proportion of the ground occupied by a perpendicular projection of the aerial parts of individuals of the species under consideration and is usually expressed as a percentage. Because of the over-layering of different species, the total cover for an area may exceed 100% and in the case of highly stratified forests may reach several hundred percent.

Cumulative impacts – the sum of impacts (positive and negative, direct and indirect, long-term and short-term impacts) arising from a range of activities throughout an area or region.

Cv – annual co-efficient of variance. This value provides a measure of variability allowing for comparisons between rivers. Cv is calculated by dividing the standard deviation of annual flows by the mean annual flow.

CV – co-efficient of variance.

DECODA - Database for Ecological Community Data.

Degradation – any significant decline in the quality of natural resources or natural integrity of a place or the viability of an ecosystem, caused directly or indirectly by human activity (Commonwealth of Australia, 2002).

Density – the number of individuals of a particular species per unit area. Counts are usually made in a number of quadrats, multiplied by the area under study and divided by the area sampled to give the density in the study area.

Disturbance - any relatively discrete event in time that disrupts ecosystem, community or population structure and changes resources, and the physical environment.

Diversity – a measure of the biological complexity of an area or a system. Diversity refers to the variety of species in a place rather than the number of different species present in a place (see species richness).

Dominant species - species with either the greatest cover or the most biomass, usually in the tallest stratum of the vegetation. For this study, dominant species were also recorded in the second and third strata of riparian vegetation. Dominance is not necessarily related to the importance of a species for ecosystem functioning.

DPIWE – Department of Primary Industry Water and Environment.

Ecological processes – all those processes that occur between organisms, and within and between communities, including interactions with the non-living environment, that result in existing ecosystems and bring about changes in ecosystems over time (Commonwealth of Australia, 2002).

Ecosystem - A functional unit that includes a dynamic complex of plant, animal and micro-organism communities together with their non-living environment.

Environmental Management Plan - An action plan or system that addresses the 'how, when, who, where and what' of integrating environmental mitigation and monitoring measures throughout an existing or proposed operation or activity. It encompasses all the elements that are sometimes addressed separately in mitigation, monitoring and action plans.

Ephemeral streams – watercourses that flow only during and immediately after rain. They have channels that are above the water table at all times.

Exotic species - a plant that is not native or naturalised to Tasmania.

Facultative riparian species - vascular plant species that occur in a variety of other habitats and are not exclusive to a river environment.

Fragmented - the spatial dissection of habitat into smaller parts.

GPS - Global Positioning System.

ha – hectare. A hectare is equal to 10 000 m^2.

Habitat – structural environment where an organism lives for all or part of its life, including environments once occupied (continuously, periodically or occasionally) by an organism or group of organisms, and into which organisms of that kind have the potential to be reinstated (Commonwealth of Australia, 2002).

IBRA - Australia, Interim Biogeographic Regionalisation for Australia.

Inactive floodplain – area above the lowest terrace level that is flooded only during extraordinary flow events.

Intermittent streams – watercourses that flow for certain times of the year, when they receive water from springs or runoff. During dry years they may cease to flow entirely or they may be reduced to a series of separate pools.

Inundation – submergence of leaves of riparian plants in water.

Iv – index of variability. This is the standard deviation of the logarithms of peak annual flows.

km – kilometre. A kilometre is equal to 1000 metres.

km^2 – square kilometre. A square kilometre is equal to 100 hectares.

Lentic wetlands – areas unconnected to the sea that are covered by still water less than four metres deep for all or a substantial part of the year (Kirkpatrick & Harris 1999).

Lotic wetlands – wetlands associated with rivers and streams.

Marsupial lawn – a lawn-like area comprising diverse mixtures of grasses, graminoids and herbs. Marsupial lawn resembles a manicured lawn as a result of constant grazing.

MCB - multiple comparison with the best.

MDS - Global non-metric multi-dimensional scaling.

Natural Resource Management - management of all activities that use, develop and/or conserve our air, water, land, plants, animals and microorganisms, and the systems they form.(Tasmanian Natural Resource Management Framework 2001).

NLWRA – National Land and Water Resources Audit.

Obligate riverine species - vascular plant species that are exclusive to a river environment.

O/E - observed over expected.

PA - presence, absence.

Perennial streams – flow year round. Perennial streams are sustained by baseflow during dry periods.

Permeability – determines how fast the water can flow through a substrate.

Physiognomy – the forms of the plants that constitute vegetation, e.g. trees, shrubs, tussock grasses, ferns, graminoids.

Plant community - an assemblage of plant species that repeatedly cohabitate (Kirkpatrick 1999: 17).

Porosity – measure of how much water a substrate contains.

Precautionary approach – a decision to take action based on the possibility of significant environmental damage, even before there is conclusive, scientific evidence that the damage will occur.

PCA – Principle Components Analysis.

Protection – taking care of a place by managing impacts to ensure that natural significance is retained (Commonwealth of Australia, 2002).

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

Reserve – an area of land formally or informally set aside for a specified purpose or purposes.

Restoration – returning existing habitats to a known past state or to an approximation of the natural condition by repairing degradation, by removing introduced species or by reinstatement (Commonwealth of Australia, 2002).

Riparian - bank or land alongside of a watercourse. See p. 1 for a broader definition.

RIVPACS - River Invertebrate Prediction and Classification System.

Selection criteria - attributes or standards that provide the basis for a value judgement of a resource's worth (Lockwood *et al.* 1997: 396)

Species richness - the number of different species present in an area.

Specific mean low annual discharge – the mean low annual discharge divided by catchment area (Q low $m^3/s/km^2$).

Specific mean peak discharge – is the mean peak annual discharge divided by catchment area. This is an index of flood response.

State of the environment report - a report that provides information on the environmental quality of countries and region covering issues such as water quality, waste management and biodiversity.

Structure – the geometry of vegetation. The most commonly used classification of Australian vegetation is that of Specht (1981). It divides vegetation on the basis of height (using boundaries of 2 m, 8 m and 30 m) and projective foliage cover (using boundaries of 10%, 30% and 70%).

Sustainable development - development such that the needs of the present are met, without compromising the ability of future generations to meet their own needs.

Sustainable use - the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.

TWINSPAN - Two-way Indicator Species Analysis.

Watercourse – a natural depression carrying perennial or intermittent flows of surface water for part or all of the year in most years, consisting of a defined channel, with banks and a bed along which water may flow (Forest Practices Code 2000).

Water-dependent ecosystems – those parts of the environment, the species composition and natural ecological processes which are dependent on the permanent or temporary presence of standing or flowing water. The in-stream areas of rivers, riparian vegetation, springs, wetlands, floodplains and estuaries are all water-dependent ecosystems (National Principles for The Provision of Water for Ecosystems).

Wetlands - areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres. Wetlands may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands (RAMSAR Convention articles 1.1 and 2.1).

CHAPTER 1

Introduction

"GENERAL ORDER

The Lieutenant Governor having at length been enabled to fix the Settlement advantageously, and in a situation that appears to be blessed with that great comfort of life, a permanent supply of running water, cautions the people against polluting the stream by any means whatsoever; a proper place for them to water at shall be pointed out, and he positively forbids their going into, or destroying the underwood adjacent to the water, under pain of being severely punished." Lt Governor David Collins, 1804.

1.0 Background

Lieutenant Governor David Collins saw the wisdom of preserving the "underwood adjacent to the water" very soon after settlement at Risdon Cove. Yet his wisdom has not prevailed in Tasmania.

What is this "underwood" adjacent to the water? "Riparian" vegetation, derives its meaning from the Latin, "*ripa*", meaning bank or land along side of a watercourse. The term, 'riparian', was in common usage from 1849 (Oxford University Press 1973).

According to the RAMSAR Convention, riparian zones are classified as 'wetlands': "Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres. Wetlands may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands" (RAMSAR Convention articles 1.1 and 2.1, Ramsar Convention Bureau 1996). While riparian lands could be broadly classified as wetlands, the focus of research for this project will be the vegetation that occurs in terrestrial habitats that adjoin, or are directly influenced by a natural watercourse that may be permanent, intermittent or ephemeral.

Riparian vegetation can be found adjacent to and in:

- gullies and dips which sometimes run with surface water (Tubman & Price 1999);
- small creeks and rivers including the riverbank;
- wetlands on river floodplains that interact with the watercourse in times of flood;

- land above the high water mark where vegetation may be influenced by elevated water tables or extreme flooding and by the ability of soils to hold water (Naiman *et al.* 1993); and
- estuaries (Kirkpatrick & Glasby 1981).

Riparian vegetation is associated with lotic wetlands but may also be found around lentic wetlands where they occur on floodplains. Riparian vegetation is distinguished from other wetland and lotic aquatic vegetation in that it is usually not covered by water unless there have been periods of sustained or intensive rainfall resulting in high flow or flood conditions. The nature and extent of riparian vegetation are defined by flowing fresh water and the geology and geomorphology of the watercourse.

There have been some difficulties associated with categorizing riparian vegetation because it exists at the interface between aquatic and terrestrial vegetation. In some areas, for example rainforest, native riparian vegetation so closely appears to resemble its terrestrial neighbour that it is not considered as a separate entity (Jarman *et al.* 1984). In some regions, riparian vegetation is difficult to discern amongst vegetation bordering the many bogs and channels of buttongrass moorlands (Jarman *et al.* 1988). River floodplains are sometimes categorized as "back swamps" or wetlands, and so the vegetation within these lands is categorized as wetland, riverine vegetation (Kirkpatrick & Tyler 1988) or "swamp" riparian (North *et al.* 1998). Yet, in many areas, riparian vegetation is distinctly different from neighbouring terrestrial and aquatic vegetation (Wintle 2002).

Knowledge of native riparian plant species, assemblages and their environmental needs and interactions is sparse; yet this knowledge is important in order to make informed and appropriate decisions for appropriate and successful conservation, restoration and rehabilitation of riparian lands and ecosystems.

1.1 Values of riparian vegetation

Riparian vegetation has significant environmental, social and economic values that are intimately linked to roles and functions in the terrestrial and aquatic environments. As part of its terrestrial role (Tubman & Price 1999; Fischenich & Copeland 2001), riparian vegetation:

- is an important source of food, shelter and habitat;
- provides travel and migratory corridors for animals, birds and insects within and between catchments;
- generally has a higher diversity of plants and animals than neighbouring terrestrial plant communities and therefore has a role in conserving genetic resources;

- buffers streams against nutrient, pollutant and sediment runoff;
- performs a valuable role in rainfall interception, hydraulic energy dissipation, flood attenuation and groundwater regulation;
- has deep and varied root mass which reinforces the bank and floodplain thereby reducing bank erosion and maintaining channel morphology and stability. Deep rooted vegetation also assists in maintaining water table levels and preventing salinity;
- limits and suppresses the growth and invasion of exotic plant species; and
- withstands a large measure of natural disturbance before it loses its integrity and therefore its ability to perform its critical functions.

As well as its terrestrial functions, riparian vegetation also performs valuable aquatic ecosystem roles. Riparian vegetation is important:

- as an energy source through litterfall;
- in habitat diversity from the inputs of woody debris;
- for providing shade, regulating water temperature and reducing algal growth; and
- as a source of food, shelter and habitat.

The social and economic values of riparian vegetation are inextricably linked with environmental values and include:

- visual and aesthetic beauty;
- role in tourism and recreation;
- research and education; and
- cultural identity.

1.2 Conservation of native riparian vegetation

Native riparian vegetation plays an essential ecological and structural role in a predominantly water-related environment that is intrinsically linked to the terrestrial landscape. Riparian vegetation is not only crucial habitat for avian, mammal and aquatic animal species but occupies a longitudinal footprint of land that is much sought after for farmlands, house sites, recreational facilities, industrial sites and water storage for irrigation and town water supply.

Riparian vegetation is increasingly endangered by pollution, loss of substrate, channel modification, flow regulation, hydrological modifications and commercial enterprises that compete for the components of the natural environment on which riparian vegetation depends for its survival (White 2000; Australian State of Environment Committee 2001).

The literature pertaining to riparian vegetation conservation and rehabilitation indicates that there are three main factors that play a part in determining the fate of riparian vegetation:

- knowledge and information about riparian vegetation;
- economics of the riparian zone; and
- competing interests in the riparian zone.

1.2.1 Riparian vegetation knowledge and information

Riparian vegetation research is in its infancy relative to other studies on terrestrial vegetation. Therefore, there are considerable gaps in knowledge about hydrologic, geomorphic, and ecosystem interactions at the reach and catchment scales. There is also scant knowledge about individual native species and their ability to survive and reproduce in the riverine ecosystem, and about riparian communities and their biological, hydrological and terrestrial interactions.

In 1981, it was estimated that over 70% of riparian communities had been altered and less than 2% of the land area in the USA consisted of intact natural riparian communities (Brinson *et al.* 1981). Major losses occurred as a result of logging, drainage for agriculture, channelization, debris removal and grazing. The biological integrity of riparian zones was dramatically reduced before intensive research on riparian vegetation began. Since the general order handed down by Lt Governor David Collins in 1804 (p.1) a considerable amount of Tasmania's native riparian vegetation has been fragmented, permanently cleared or degraded. In 1993, there was an estimated 1 500 km^2 of significantly degraded riparian zones in agricultural areas of Tasmania (Geraghty & Ratcliffe 1993). It is estimated from analysis of The LIST hydrological data that Tasmania has approximately 39 000 km of major watercourses. In 1998, data on river disturbance in Tasmania related to human intervention was collected as part of the assessment for the Regional Forest Agreement. The unpublished data from the project shows that moderate to substantial disturbance was evident along approximately 20,855 km of major streams and watercourses (River Disturbance Index, Wild Rivers Project 1998; data obtained from RPDC, Hobart, 2002).

In Tasmania, the detailed statewide classification of vascular plant communities commenced in the early 1970s (Specht *et al.* 1974) revealing considerable gaps in knowledge. By 1995, considerable fieldwork had been undertaken to address this knowledge gap and results of the fieldwork were summarised in a compendium of Tasmanian vascular plant communities compiled from all major studies undertaken in the State (Kirkpatrick *et al.* 1995). Some riparian vegetation communities are included in the compendium but these are limited to sites along 10 rivers in the midlands and Ben Lomond and southeast regions (Askey-Doran 1993), and to the rainforest and swamp regions predominantly in the west and northwest of the State (Pannell 1992; Jarman *et al.* 1991). Other smaller-scale vegetation surveys which include riparian vegetation but which are not included in the compendium have also been undertaken around Tasmania (e.g. Brown & Bayley-Stark 1979; Duncan 1983; Ziegeler & Harris 1994; Wintle 2002). Vegetation surveys are also included in local studies associated with site assessments (e.g. Woolley 1999), catchment management planning (e.g. Green 1999) and hydroelectric power generation (e.g. Davidson & Gibbons 2001). There are also numerous unpublished reports from local surveys that exist within Local Councils and the DPIWE which contain information relating to riparian vegetation (pers. comm. Mike Askey-Doran, DPIWE 2002).

Since 1995, rapid flora surveys have been conducted in State forests, conservation areas and reserves around Tasmania associated with the Regional Forest Agreement (e.g. North *et al.* 1998). Catchment co-ordinators have been appointed around Tasmania funded under a Commonwealth-State partnership established as part of the Natural Heritage Trust and specialist riparian staff have been appointed to the Department of Primary Industry, Water and Environment (DPIWE) funded by the same partnership agreement. Together these appointments have raised awareness of catchment and riverine issues and many local catchment management plans have been developed which include general lists of native plants that grow in the riparian zone (e.g. Green 1999).

A nationally agreed system for assessing the condition of riparian vegetation does not exist in Australia nor has there been a national survey of riparian vegetation. State vegetation surveys often do not target riparian vegetation (e.g. DPIWE 2002a). This vegetation type is not easily detected in satellite images and therefore cannot be quantified using current remote sensing technology.

Current techniques for assessing river health in Australia depend mainly on the use of aquatic macroinvertebrates as biological indicators of river condition. While these animals are effective and reliable indicators of river condition, they do not, by themselves, provide an accurate indication of the condition of riparian vegetation, nor of the integrity of river and floodplain ecosystems. At the state-wide scale, river health or condition assessments, or "State of Rivers" reports, include riparian vegetation, but not necessarily at the species or communities levels (Victorian Department of Natural Resources and Environment 1997; Ladson *et al.* 1999; Water and Rivers Commission 1999; Bobbi *et al.* 1999; Rutherfurd *et al.* 1999).

There are several manuals that provide some general assistance with riparian revegetation (Munks 1996; Thorp 1999; Gaffney *et al.* 1999; Price & Lovett 1999). Other information that relates to riparian vegetation exists but is difficult to disentangle from text describing terrestrial vegetation. It is usually referred to as a terrestrial vegetation type found on river banks, river flats or river valleys (e.g. Pemberton 1989), "gallery rainforest" (Jarman *et al.* 1984), "gully " vegetation (e.g. Kirkpatrick *et al.* 1980) or "riverine shrubbery" (e.g. Corbett & Balmer 2001).

It is difficult to map riparian vegetation at the statewide scale using current technology. Nearly all mapped vegetation communities are derived from satellite images or aerial photographs. Most riparian vegetation communities are not distinguishable from neighbouring terrestrial vegetation in satellite images or from standard aerial photographs at the standard 1:42 000 scale. At best, surrogate indicators, e.g. trees within 100 m of the river bank (NLWRA 2002), are used for coarse estimates of extent and condition of riparian vegetation.

The International Hydrological Programme Phase VI 2002-2007 (UNESCO 2002) recognises that there are significant gaps in knowledge and information with respect to water-dependent ecosystems. The scientific thrust and priorities for proposed activities in Land Habitat Hydrology are:

- data management;
- improved understanding of hydrological processes (experimentation and modeling);
- development of the eco-hydrological approach;
- analytical techniques and technology (both for hydrology and water resources management); and
- predictions and scenario analysis (referring to climate changes but also to the assessment of consequences of socio-economic trends upon land, habitat and hydrology).

The cost of gaining knowledge and information is always at the forefront of consideration. Because of the variable nature of the riparian zone, its vegetation structure and species composition, and its proximity to the aquatic and terrestrial environments, the only accurate way by which the extent, condition and composition of riparian vegetation can be determined or assessed is by field survey. Who pays for surveys? What sorts of data do they want? What is the budgetary time frame? Who owns the intellectual property from the survey? These questions need to be addressed in order to prioritise the spending of governments, businesses or individuals. Most surveys are paid for and carried out by governments, although the proportion of expenditure dedicated to surveys or the acquisition of new knowledge is not known. The full cost of surveys in time, resources and quality of data are very difficult to determine. Burbridge (1991: 5) provides an indication of costs based on three surveys undertaken for nature conservation purposes in Western Australia. In 1988, a survey in the Nullabor Region covering an area of 20 000 000 ha, cost $967 590. A survey of 4000 ha close to Perth cost $79 800. The totals included fieldwork, laboratory work, data analysis and publication. While recurrent budget considerations may be high in the short-term, the values of the data in the longer term need to be considered.

Current knowledge and understanding of riparian vegetation is fragmentary. Accurate, yet cost-effective methods for describing vegetation extent and condition along riverine corridors are required to quantify riparian vegetation biodiversity, determine trends in riparian condition and set priorities for conservation and rehabilitation of riparian lands. The actual extent and condition of native riparian vegetation is not clearly known or understood as there has been no systematic analysis of riparian survey data already collected at the regional and State scales.

1.2.2 Economics of the riparian zone

Riparian vegetation values and functions in the riverine ecosystem are significant. But, in economic terms, environmental and social values and functions have not been easy to quantify in a way that is universally understood (Pearce *et al.* 1989) and therefore have had little monetary value attributed to them. Until recent times, there has been very little incentive to factor the cost of environmental degradation into costs associated with primary, secondary and tertiary production.

What has had financial value in Australia's cultural and economic paradigm is the land on which the vegetation exists and the water that is an integral part of the riparian ecosystem. Riparian lands are often: highly productive in agricultural terms; provide access to water; can be modified to incorporate large storages for water for irrigation and town water supply; and provide excellent ambience for house sites and recreational facilities. If property has "water views" or "river frontage" then the real estate value increases markedly compared with neighbouring properties that are not as well bestowed. In an agricultural context, "riparian rights" increase productivity potential.

Water a vital commodity in Australia, where 75% of the land is acutely arid; a further 10% is dry for much of each year and acutely arid in droughts; and only 15% is reasonably well-watered. Added to this is the El Nino-Southern Oscillation that makes Australia a land of drought and flooding rains (White 2000).

Fresh water, as a commodity in short supply, has monetary value. Water provides an economic return when sold for commercial, domestic, industrial and irrigation purposes. However, fresh water is also required for many environmental systems to function. Until recently, the value of water for maintaining environmental services and functions has not been considered. When a value per hectare per annum on freshwater based on the ecosystem services provided by various biomes dependent on fresh water is calculated (Costanza *et al.* 1997), riparian lands (swamps and floodplains) have the second highest values next to estuaries (Table 1.1).

Biome	Value ($ US)
Estuaries	22 832
Swamps and floodplains	19 580
Sead grasses and algae beds	19 004
Tidal marshes and mangroves	9 990
Lakes and rivers	8 400
Continental shelf	1 500
Temperate rainforest	302
Open ocean	252
Grasslands and range lands	232
Crop land	92

Table 1.1: Value of fresh water per hectare per annum for different biomes.
(Adapted from Costanza *et al.* 1997)

Because riparian lands, riparian vegetation and freshwater ecosystems are intrinsically linked, there are short and long-term problems associated with considering the riparian zone as a sum of its parts rather than a series of inter-related systems. There are significant social, economic and material costs at the local, catchment and regional scales associated with the destruction of native riparian vegetation and degradation of riparian lands. These costs are associated with:

- loss of native riparian flora and associated fauna;
- loss of aquatic and terrestrial gene pool, food, shelter and habitat;
- loss of estuarine productivity and health;
- dredging estuaries to maintain channels for shipping and boating;
- rehabilitation of degraded river banks, flood plains and channels;
- control of exotic species in the riparian vegetation;
- extra water treatment for town water supplies due to high sediment loads;
- pollution of waterways by toxic algal blooms;
- flood mitigation and repair;
- increasing soil salinity due to high water tables;
- loss of tourism; and
- loss of educational, scientific and recreation values.

The financial, human resource and material costs associated with river restoration and rehabilitation are enormous. Since 1996, Natural Heritage Trust has invested $1.4 billion for more than 11 900 projects around Australia, with an estimated 400 000 Australians involved in projects that involve repairing degraded natural environments and work directed towards the sustainable management of Australia's natural resources. In the May 2001 Budget, the

Commonwealth government extended the Natural Heritage Trust for a further five years, from 2002-03 to 2006-07 and allocated an additional $1 billion (Natural Heritage Trust, 2002a). It is unclear as to what proportion of the budget is directly related to national riparian revegetation and rehabilitation but, depending on the nature of the project, funding can come from Landcare, Bushcare, Rivercare or Coastcare program budgets.

Over $47 M has been spent on river rehabilitation projects across Tasmania since 1997/98 as part of the National Rivercare Program (pers. comm. Tony Watton, NHT Unit, 2002) (Table 1.2). The proportion of this funding directly related to riparian vegetation rehabilitation and management is again unclear. However, expenses related to riparian land and vegetation manipulation, repair, replacement or mitigation at individual sites. Total expenditure covers expert consultancy costs for planning, geomorphologic and hydrologic site assessments, engineering works, administrative costs, insurance, voluntary and professional employment and labour, operating costs associated with equipment use, hire and/or purchase, community skilling and publicity, fencing and vegetation-related expenditure (Natural Heritage Trust, 2002b). Restoration attempts have generally taken place without sufficient technical advice on the specific plant species and communities that originally inhabited rehabilitation sites.

NATURAL HERITAGE TRUST - NATIONAL RIVERCARE PROGRAM Funding from all Sources ($)			
	Commonwealth	**All Other Sources**	**Totals**
1997/98	732,948	886,562	1,619,510
1998/99	1,537,267	1,725,608	3,262,875
1999/00	3,948,189	13,769,839	17,718,028
2000/01	4,133,975	8,743,212	12,877,187
2001/02	3,752,734	8,014,733	11,767,467
Totals	**$14,105,113**	**$33,139,954**	**$47,245,067**

Table 1.2: Tasmanian Rivercare Funding 1997/1998 – 2001/02.
(Source: pers. comm. Tony Watton, NHT Unit 2002)

In Europe and the United States of America, individuals deemed responsible are incurring environmental liability for damage to biodiversity or natural resources (MacAlister Elliott and Partners Ltd *et al.* 2001). Riparian vegetation as part of riparian (wetland) ecosystems performs environmental services that can now be attributed monetary values (Table 1.3). It is suggested (ibid: 11) that tests for scale or 'significance' of damages include considerations of:

- the extent and magnitude of the impact;
- the duration of the impact, i.e. whether it is short term or long term;
- whether impacts are reversible or irreversible;
- the sensitivity and rarity of the resources impacted; and
- compatibility with environmental policies.

Ecological Services	Human Services
Geo-hydrological	**Commercial / public or private**
▪ Floodwater storage and conveyance ▪ groundwater recharge and discharge ▪ pollution assimilation ▪ sediment trapping and control ▪ nutrient cycling ▪ shoreline stabilisation	▪ drinking water ▪ waterway navigation ▪ hydropower generation ▪ irrigation / commercial process water ▪ property protection ▪ agriculture, timber ▪ fishing, trapping, fur-bearers
Recreational	**Ecosystem Integrity**
▪ beach use / swimming ▪ fishing, boating ▪ wildlife viewing ▪ hunting	▪ natural open space ▪ climate regulation ▪ biodiversity storehouse ▪ carbon cycling ▪ resistance and resilience
Production/Habitat	**Cultural / historical**
▪ fish and shellfish habitats ▪ habitat for fur-bearers, waterfowl & other wildlife ▪ food production ▪ oxygen production ▪ organic material ▪ timber production ▪ pollination ▪ maintenance of gene pools ▪ maintenance of plant populations	▪ religious / spiritual uses ▪ cultural uses ▪ historical
	Scientific
	▪ pharmaceutical (health) ▪ increase productivity
	Health
	▪ morbidity / mortality reductions due to provision ▪ of clean air, water and food
	Non-use value
	▪ Species, habitats, ecosystems ▪ Genetic, species diversity and resilience ▪ Life support: carbon/nutrient cycles

Table 1.3: Wetland ecosystem services and sources of value.
(Adapted from MacAlister Elliott and Partners Ltd *et al.* 2001: 10)

It is difficult to ascertain how the economics of native riparian vegetation conservation compares with the economics of other uses of the riparian lands with associated reparation and rehabilitation of degraded riparian ecosystems. However, it is highly likely that, if the full costs associated with the loss of riparian ecological and human services (Table 1.3) were considered in the economics of alternative commercial uses of riparian lands and vegetation, conserving healthy native riparian vegetation may yield a far greater economic return for riparian lands than any of the alternate activities that currently occur.

However, economic issues associated with conservation of areas with high natural values are also contentious. Typically, existing reserve systems throughout the world contain a biased sample of biodiversity, usually that of remote places and other areas that are unsuitable for commercial activities (Margules & Pressey 2000: 243). In recent years, this issue has been somewhat addressed in Tasmania by the inclusion of some economically valuable communities in the reserve system because of changes in motivation for reserve establishment, and the availability of gap analyses for many plant communities and plant species (Mendel & Kirkpatrick 2002). However, in Tasmania, reserves are not evenly spread across the State and the greatest proportion of formal reserves is still found in the remote areas of the West, Central Highlands, and Southern Ranges bioregions. Reserves cover only a small part of the Northern Midlands, Northern Slopes and Southeast bioregions where most agricultural development has occurred.

If riparian vegetation is to retain high environmental, social and economic values, considerable strategic planning for its long-term management needs to be undertaken at the local, catchment and state levels. The riparian zone is an area where the preservation of remaining native vegetation is by far the most cost effective strategy for management, as the current costs of reactive rehabilitation are high and future costs are likely to be higher.

1.2.3 Competing interest in the riparian zone

The world has changed from one that was relatively empty of humans and their artifacts to one that is relatively full (Daly 1992). Similarly, the human economy has passed from an "empty-world" era, in which human-made capital was the limiting factor in economic development, to the current "full-world" era, in which remaining natural capital has become the limiting factor (Costanza *et al.* 1997; Costanza *et al.* 2000).

In our "full" world, conflicts concerning values, rights and responsibilities are having an impact on riparian vegetation. Differing social values, perspectives and politics cause conflicts between:

- development and conservation;
- exploitation of natural resources and maintaining environmental integrity;

- the rights of individuals or groups and the responsibilities of individuals or groups; and
- immediate benefits and future benefits.

The first North American riparian conference was held in 1985 (USDA Forest Service 1985). The Governor of Arizona, Bruce Babbitt, stated, "it is estimated that 45 million acres of an original total of 127 million acres of wetland (*riparian lands*) have been lost to commercial development, agriculture and other uses. Much of the remaining wetlands have been damaged by pollution, timber cutting, land drainage and other activities" (ibid: viii).

The *Wild and Scenic Rivers Act 1968* provides a measure of protection to the few riparian lands of "certain selected rivers which possessed outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values" in the United States of America (www.nps.gov/rivers/wsract.html). Similarly, World Heritage Areas, National Parks and state reserves provide a measure of protection and conservation for riparian lands in Australia. However, "once reserves are established the problem becomes to sustain biodiversity through appropriate management of species, ecosystems and people in a context in which there is increasing pressure for expanded recreational and tourism activities and infrastructure, and frequent conflict with the users of adjacent land." (Kirkpatrick 2000: 47).

Riparian lands, especially those associated with broad floodplains and estuaries, are fertile and productive parts of the landscape. Past and present land use practices have focused on the commercial productivity of the riparian zone rather than the values of environmental integrity provided by riparian vegetation (CSIRO 1998). As a consequence, long reaches of native riparian vegetation have been cleared to facilitate cropping, grazing and tree plantations. Related activities, such as damming and channelisation, have reduced rivers and estuaries to the status of drains and sediment traps.

Nearly 60% of Tasmania is: in private ownership (38.4%); under State forest (19.1%); and under the control of the Hydro-electric Commission (1.8%). The remainder is mostly in State reserves (37.4%) (ABS 2001: 144). While there are State and federal Acts that exist to protect biodiversity and conservation of sensitive or valuable ecosystems such as those associated with riparian vegetation (e.g. *National Parks and Reserves Management Act 2002*; *Environment Protection and Biodiversity Conservation Act 1999*), the implementation of other Acts, policies and plans accelerates the destruction and degradation of valuable ecosystems (e.g. *Water Management Act 1999*; Tasmanian Water Development Plan 2001 - DPIWE 2002b).

For example, in Tasmania, in the absence of statutory water management plans, water rights, usually in conjunction with dam approvals, are currently allocated on a first-come, first-serve basis. By March 2003, there were 5 795 dams listed on the register as current and existing, and 1 437 listed as proposed (http://wims.dpiwe.tas.gov.au; accessed 12 March 2003). Of all the listed dams, only 202 are off-stream. The official list of dams does not include in-stream or catchment storages less than 1 ML. The number of these small storages across the state is not known, but in one small catchment alone (Little Swanport River), over 1 100 in-stream minor storages were counted from the 1:25 000 map series maps for the catchment (pers. comm. Colin Dyke 2002). Since the *Water Management Act 1999* was enacted, 455 dams have been approved and 217 new dam proposals are awaiting consideration by the Assessment Committee for Dam Construction. It is of note that the total capacity of the 455 dams approved after 1 January, 2000 was 31 000 ML and 12 of these were off-stream. The total capacity of the 217 new dam proposals is 88 672 ML and none of these are off-stream. At the time of writing, considerations of the number of in-stream dams, environmental flow or estuarine needs were not a necessary part of the dam approvals process.

There has been a significant loss of riparian vegetation associated with clearing watercourses for in-stream dam construction, especially in the north, northwest and southeast areas of Tasmania. It is reported that the area of vegetation lost to water inundation in Tasmania between 1802 and 1995 is 91 600 ha (Kirkpatrick *et al.* 1995: 10). It is not known what the total area lost since 1995 is as the data associated with storage area is incomplete (http://wims.dpiwe.tas.gov.au; accessed 12 March 2003). However, based on the official register of dams, it is conservatively estimated that, from 1996 to the end of 2003, a further 50 000 ha will be lost to in-stream water storages.

Responsibilities for downstream environmental impacts on riparian vegetation related to point source and diffuse chemical, nutrient and sediment pollution, loss of habitat and social impacts related to loss of recreation, education and aesthetic values have not been considered as part of primary production activities. Immediate financial benefits to many landholders are excluding future benefits for others.

One of the objectives of the Natural Resource Management and Planning System of Tasmania is 'to promote the sustainable development of natural and physical resources and the maintenance of ecological processes and genetic diversity' where

> **"sustainable development"** means managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural well-being and for their health and safety while –

(a) sustaining the potential of natural and physical resources to meet the reasonably foreseeable needs of future generations; and

(b) safeguarding the life-supporting capacity of air, water, soil and ecosystems; and

(c) avoiding, remedying or mitigating any adverse effects of activities on the environment (www.thelaw.tas.gov.au, Schedule 3, accessed October 2002).

There is a strong argument that the balance of competing values in the riparian zone has been tipped in favour of development, exploitation of natural resources, the rights of individuals and immediate benefits for too long. Native riparian vegetation has significant environmental values and plays a vital role in the maintenance of aquatic and terrestrial ecological processes and genetic diversity. There is a need to review legislation relating to riparian vegetation in order to comply with the objectives of the Natural Resource Management and Planning System of Tasmania.

1.3 What are the aims of this investigation?

Despite its significant environmental, social and economic values, there is insufficient detail within the current literature to develop a comprehensive appraisal of riparian vegetation and its environmental needs across Tasmania. The actual extent and condition of native riparian vegetation is not clearly known or understood as there has been no systematic analysis of data or information that exists at the regional or state scales. To date, there is no agreed geomorphic definition of the riparian zone and therefore, it is difficult to define the vegetation that grows in this zone to a level that is commonly understood. There is also no agreement on the data required at the state or national scales to describe riparian vegetation, and no agreed protocols for data collection or hierarchical classification of riparian communities for vegetation conservation or mapping purposes. There is also no firm agreement as to whether all listed riparian communities should comprise native species exclusively, or include exotic species. Lastly, as riparian floristic communities have not been documented at the state or national scales, there is no common understanding about which key environmental factors contribute to the health or survival of riparian vegetation.

It is difficult to promote the sustainable development of natural and physical resources and the maintenance of ecological processes and genetic diversity in the absence of sufficient knowledge and information about the resource being managed. The present project is designed to fill a large gap in the knowledge and information related to native riparian vegetation in Tasmania.

The main aims of this project are:

- to develop a rapid assessment field methodology to facilitate a statewide survey of riparian vegetation and the environment in which it occurs;

- to provide a broad, baseline survey of native riparian vegetation species and assemblages for mainland Tasmania;
- to identify significant environmental influences on variation in native riparian vegetation at the state-wide scale;
- to identify gaps in the conservation of the vegetation component of riparian ecosystems in mainland Tasmania;
- to develop a conservation planning process that will facilitate the reservation of significant reaches of riparian vegetation;
- to determine if it is possible to use riparian vegetation as a measure of river health using a RIVPACS/AUSRIVAS-style model; and
- to determine if it is possible to predict the species composition of native riparian vegetation within Tasmania using a RIVPACS/AUSRIVAS predictive model.

The benefits of the project are anticipated to be:

- a rapid assessment field methodology for riparian vegetation that can be easily used for regional riparian vegetation surveys;
- a comprehensive database of plants found in the riparian zone and the significant environmental conditions that influence their occurrence in the riparian zone;
- a historic record of native riparian species and communities;
- the identification of unreserved or poorly-reserved native riparian floristic communities;
- the ability to predict river health based on the presence or absence of riparian vascular plant species;
- information for revegetation of riparian areas so that scarce economical and social resources can be used more effectively; and
- the ability to set priorities for further riparian vegetation research in Tasmania.

1.4 How is this thesis arranged?

This chapter provides an insight into the values of riparian vegetation and some of the difficulties that have inhibited riparian vegetation research, conservation and rehabilitation. A literature review focusing on global, national and local issues concerning conservation and rehabilitation of riparian vegetation was followed by the aims and anticipated benefits of this project.

In Chapter 2, an account is given of the methodologies used to create the statewide database of riparian vegetation and associated environmental parameters. A descriptive and analytical record of Tasmania's riparian species, floristic assemblages and structures, and their significant environmental relationships is provided in Chapter 3.

Chapter 4 provides a detailed account of the development of a riparian-vegetation AUSRIVAS predictive model using the riparian vegetation data as well as an assessment of the model's capability to assess the condition of riparian vegetation. A preliminary assessment of the model's ability to predict the species composition of riparian vegetation at eight sites within the survey area is also provided.

In Chapter 5, issues and processes associated with the conservation of native riparian vegetation are explored and a planning process is developed to facilitate the adequate reservation of native riparian vegetation communities that are poorly reserved or unreserved in Tasmania.

A general discussion of the research findings relative to the aims of this project is provided in the final chapter along with recommendations for management of riparian vegetation and areas for further research.

Plate 1 Native riparian vegetation has many values, roles and functions – Arve River.

CHAPTER 2

General Methods

2.0 Introduction

The aim of this chapter is to provide an overview of the study area and the principles and practices developed for documenting and describing vascular plant species and floristic assemblages. Following the introduction, the methods used to sample or estimate key environmental factors that may contribute to the survival of riparian vegetation in Tasmania will be detailed, as well as the protocols used to document and describe the vascular plant species and communities in the field.

Mainland Tasmania is an island of approximately 64,000 km^2 lying between 40°S and 44°S and 144°E and 149°E. The main island can be subdivided into two distinct regions by what is often known as 'Tyler's Line' (Sustainable Development Advisory Council 1996). The rugged west coast with complex topographic and geological detail, high rainfall and dense forests differs markedly from the tabular mountains and structural basins of the east that support mostly sclerophyll forests and extensive woodlands and grasslands. Tasmania has a high density of watercourses, many still fringed by native riparian vegetation.

It is not possible to know precisely the nature of Tasmania's riparian vegetation in pre-Aboriginal or pre-European times as the extent and effects of past climates and land use practices are not known. Land use practices associated with burning, clearing, damming, mining, and the introduction of exotic plant and animal species may have altered conditions for reproduction or survival of native species. What is known is that stands of predominantly native riparian vegetation that may closely resemble pre-settlement riparian vegetation remain, and these survive, and sometimes thrive, in the climatic and altered environmental conditions of today.

A vascular plant species has very few requirements for life: it requires carbon dioxide and water in the presence of sunlight and appropriate temperatures; nutrients for effective construction and functioning of its cellular and metabolic components; and anchorage at a site that provides these essential life requirements. Vascular plants have a variety of reproductive strategies and adaptive structural modifications that influence their continued survival in particular habitats. Reproductive strategies and adaptive modifications are often developed in response to climatic factors and biotic and abiotic environmental factors. For example, Kirkpatrick *et al.* (1995: 2) state that

> Each species has its own distinctive distribution in the landscape and can be shown to vary in abundance along the primary ecological gradients that directly determine water availability, soil nutrients, radiation incidence and temperature, as well as along secondary gradients, such as altitude, aspect, drainage and pH, all of which are closely related to a number of basic plant requirements. Plants also respond to each other, as in epiphytic ferns on a tree fern, and to other components of the biotic environment such as insect pollinators, fungal symbionts and browsing mammals.

If a vascular plant species is able to germinate and grow in a particular habitat, then the continued existence of that plant in that habitat is determined by its ability to compete for its essential life requirements with other vascular plant species and to withstand other disturbances. In the riparian zone, carbon dioxide and water are usually abundant, as are nutrients and vectors for pollination. If a vascular plant species is successfully adapted to its climatic influences, then the main challenges that confront it in the riparian zone are the availability of sunlight, competition for anchorage sites and the frequency, intensity and timing of hydrological and other disturbances.

Cowling & Pressey (2001) suggest that the principal reasons for the definition of ecological communities are for retention and persistence of the communities to maximise biodiversity outcomes and targets. The essential characteristic of a plant community is that it consists of spatially and temporally repeating combinations of biological attributes. However, there are differing views about how vegetation should be classified.

The prevailing view of botanists and environmental ecologists is that vegetation should be characterised by its own features, such as dominant species or structural attributes, not by its environment (Richards *et al.* 1940; Müller 1997). Those who uphold this view consider that vegetation is the best integrator of environmental parameters. Therefore environmental descriptors such as altitude or rainfall are only used to improve the descriptive power of classifications of vegetation (e.g. Montane myrtle/tea-tree forest; *Eucalyptus ovata-Acacia dealbata-Pomaderris apetala* wet sclerophyll forest) but not as a basis for defining boundaries between classification units.

Early botanists who opposed the floristic approach to vegetation classification considered that the physiognomy or appearance of a plant community was all that was needed to classify a community because structure and life-forms could be measured exactly and defined mathematically (Salisbury 1931; Beard 1944). Thus, many studies focus on a single structural type, e.g. rainforest or heath. The physiognomic approach is favoured by stream hydrologists, geomorphologists and other non-botanical scientists involved in research associated with freshwater ecosystems. Aquatic research is well developed and the expedience of rapidly measuring and assessing riparian vegetation by its structural attributes has some significant statistical advantages.

Despite the differing approaches, the most useful method of classification is one that adequately fulfils the purpose for which it was designed. Generally, characteristics used to define plant communities include combinations of structure, physiognomy, dominance, floristics and environment. The Braun-Blanquet systematic classification of plant communities based on floristics and the Warming & Drude classification by environment and habitat (Mueller-Dombois & Ellenberg 1974) are the two most commonly used vegetation classification systems.

A variety of methodologies has been used for data collection and vegetation classification in Tasmanian riparian studies. The different approaches have been justified on the basis of scale, purpose, time and cost constraints of the projects. Riparian research conducted overseas follows the same trend (Curry & Slater 1986; Tabacchi 1995; Johnson 2002). The majority of methodologies used for riparian vegetation data collection are based on plots of varying sizes. Plotless releves in the riparian zone are not common but have been previously used by Curry & Slater (1986) and Wintle (2002). Classifications that included riparian communities are based on the dominance of species in the tallest stratum and vegetation structure (Jarman *et al.* 1991; Pannell 1992), or on floristics (Hughes 1987; Askey-Doran 1993; Wintle 2002).

A spatially explicit theory explaining the occurrence and abundance of riparian vegetation remains elusive and is one of the great challenges for sustaining the integrity of stream ecosystems worldwide (Meyer & Swank 1996). However, there is a general understanding that the major physical factors of river catchments that influence the development of riparian corridors are the bedrock geology, geomorphic features (e.g. surface landforms such as erosional features, and deposits created by fluvial, landslide and wind storm events), soil character, climate, and hydrological regimes (Tabacchi *et al.* 1998). The relationship of the physical factors to the floristic composition and structure of riparian vegetation is poorly understood.

There is a growing body of research that deals with environmental and climatic influences on riparian plant species and communities at the reach and catchment scales. Most common are studies investigating the effects of flooding (e.g. Hupp 1990; Wintle 2002), erosion (e.g. Sala & Calvo 1990) and fluvial-geomorphic processes (e.g. Hupp & Osterkamp 1996).

Generally, the climatic and environmental influences that have been found to be significant at the reach and catchment scales include factors associated with rainfall and/or temperature, geology, soil, substrate, geomorphic aspects of the bank, channel and surrounding landform, and flow. The significance of any one of these influences on riparian vegetation appears to vary in response to the scale of the investigation, the range of the environmental factors that are present in the study area, the types of plant species in the riparian zone and the extent and condition of the riparian buffer being investigated.

In Tasmanian riparian vegetation research, the significant environmental variables that have been shown to influence the distribution of riparian floristic communities have been associated with catchment hydrology and geomorphology (Hughes 1987; Askey-Doran 1993; Wintle 2002). There is general agreement, however, that the riparian environment is complex and dynamic as are riparian vascular plant species with their differential tolerances and adaptations to a broad range of hydrological, terrestrial and climatic disturbances.

2.1 Data collection

A rapid assessment methodology was developed that would enable a lone researcher to undertake a comprehensive field survey of the species and communities that comprise Tasmania's riparian vegetation and the environmental factors that may contribute to their survival in the riparian zone. In the development of the field survey methodology, issues relating to cost, the reliability, accuracy, robustness and portability of equipment, time constraints, the credibility of results and safety were considered.

Riparian vegetation was surveyed and measurements and estimates of environmental conditions were made and recorded on separate field data sheets (Appendix 1). A cross-sectional sketch of the watercourse and riparian structure was made at each site and a photograph upstream and downstream was taken at the time of survey in most cases, weather and light permitting. The assessment methods and protocols that define the factors listed in the field data sheet, are provided below.

2.1.1 Site selection

The initial aim was that at least one accessible, reference site would be documented in each of the 10 x 10 km National Mapping grid squares on mainland Tasmania. Usually, the native riparian vegetation recorded was representative of the majority of observed reaches within each grid. Where the native riparian vegetation in the grid square was highly variable and, where time and weather permitted, a second site was documented.

Reference sites, or 'least disturbed' riparian reaches, were sampled. The following criteria were used for site selection. Sites were:

- predominantly vegetated by native vascular species;
- well above or below major impoundments, extractions or diversions;
- upstream or away from roads, bridges, tracks or service corridors;
- free of channel modifications;
- subject to no or as little human related disturbance as possible;
- accessible by 4WD vehicle; and
- safe during sampling operations.

Because of the limitations of access, time and cost, many grids in the south, southwest and central highlands areas of Tasmania were not documented. Many grids within the northern and southern midlands regions and scattered grids in the southeast, northeast, north and northwest of Tasmania are also not represented either because of a lack of suitable native riparian vegetation or difficulties with access to private property where remnants may still be found.

2.1.2 Altitude and Location

Tasmania's highest peak, located in the Central Highlands, is Mt Ossa at 1667 m. The water from this peak and the mountain range in which it occurs contains the headwaters of the Pieman, Forth, Mersey and Derwent Rivers. These extensive river systems flow through gorges, peatlands, vales and plains to the points at which they meet the sea at the west, north and southeast coasts respectively. High altitudes can also be found in the mountains of Ben Lomond in the northeast of Tasmania where Legges Tor reaches an altitude of 1557 m, in the Southern Ranges where Mt Anne ascends to 1425 m and in the West where Frenchmans Cap stands as a distinctive feature in the landscape at 1443 m.

Where riparian sampling studies have been undertaken across a range of altitudes, this feature appears as a factor affecting the distribution of vascular species and communities in the riparian zone (Curry & Slater 1986; Hughes 1987; Askey-Doran 1993; Wintle 2002). This may be due to relative resistance to frost (Kirkpatrick & Gibson 1999) or a need for warmth (Hughes & Davis 1989).

A Garmon 12 GPS, set at AMG 66, was used to record altitude in conjunction with the 1:25 000 and 1:100 000 TASMAP series. The GPS was also used to establish location, which was recorded as easting and northing. Altitude and geocoordinates were approximated to the nearest 10 m.

2.1.3 Aspect

Aspect can influence shade and moisture availability. Shade, or the limitation of light to riparian plants, can reduce photosynthesis and thus affect the growth and reproduction of species. After altitude, gradient and geology, Curry and Slater (1986) suggested that the most important influence governing river corridor vegetation along four catchments in Wales was intensity of shade. Shade in the riparian zone is influenced by the height and density of neighbouring vegetation and landscape, and the width of channel. Aspect has also been found to relate to moisture availability in a terrestrial environment (Kirkpatrick & Nunez 1980). In Tasmania, northwest slopes are the driest and southeast slopes the wettest.

In the field, aspect at a site was determined by using a compass and the appropriate map. The Kirkpatrick & Nunez ordered multistate variables for aspect (ibid) were recorded for all sites using the left bank facing downstream as the standard. The variables recorded were: [1] NW [2] N & W [3] NE & SW [4] S & E [5] SE. During the field survey, as well as indicating which category of variable was representative of aspect at a site, the specific aspect of a site was also circled. However, as both banks of a stream were surveyed for the presence of riparian species, four classes of aspect were developed that more accurately represented the aspect of the survey site: [1] N/S [2] NE/SW [3] E/W and [4] SE/NW. The 5-factor field data for aspect was transformed to a 4-factor data set by reallocating the recorded aspect to the appropriate new category. For example, a site marked as [2] west in the field, was transformed to category [3]. The recorded aspects of all 460 sites were checked using a map prior to transformation. Both sets of aspect data for the reference sites were statistically analysed.

2.1.4 Stream class

Stream class was found to be a significant factor in determining riparian community distribution in two east coast rivers of Tasmania and related strongly to flood disturbance and altitude (Wintle 2002: 57). Stream class is a system developed for use in the forestry industry. Determination of class is based on size of the watercourse, permanence of flow and the area of catchment above the survey site (Table 2.1).

Stream class was used in preference to stream order (Strahler 1964) as a factor for investigation as this classification system is well-defined and simpler to use in the field. Stream class does not vary despite variability in mapping standards or map scale and has a direct relationship with riparian vegetation width.

However, because there are a considerable number of artificial, large, water impoundments around Tasmania, the stream class classification of some reaches is distorted because of the disproportionate area of the artificial catchment above the survey site: e.g. the catchment area above the headwaters of the Huon River. The large number of inter-basin and intra-basin transfers of flow for the purpose of power generation or water supply, also pose anomalies for stream class classification.

Class	Watercourse Type
1	Rivers and tidal waters - generally, reaches of watercourses named as 'rivers' on the 1:100000 topographical series maps which occur in lowland and estuarine areas whose catchment area exceeds 100 km^2
2	Creeks, streams and other named watercourses from the point where their catchment exceeds 100 ha – confirmed on a 1:25 000 map
3	Watercourses carrying running water most of the year between the points where their catchment is from 50 to 100 ha.
4	All other watercourses carrying water for part or all of the year for most years.

Table 2.1: Stream class based on Forest Practice Code 2000.
(Forest Practices Board 2000:56)

2.1.5 Geomorphology

Tasmania's geologic history and regional and local climatic influences have sculpted an island with high drainage density and varied topography. The principal agents in the construction of the contemporary Tasmanian landscape are river erosion and mass movement. In previous times, glacial processes during the Pleistocene period significantly contributed to landforms of the west-central and south-central regions. Periglacial activity during the same period was important at moderate altitudes. Landforms attributable to wind action are found in the east.

Riparian ecosystems undergo frequent erosion and/or deposition. Riparian vegetation cover can limit the fluvial system and check erosion and river meandering. Tolerance of submergence, alluvial deposition and erosion plays a major role in determining each species' position on the bank (Merry *et al.* 1981).

(a) Surrounding landform

Surface landforms such as erosional features, deposits created by fluvial, landslide and wind storm events are among the major physical factors that are thought to influence the development of riparian corridors (Sullivan *et al.* 1987). Surrounding landform has a bearing on the rate at which surface runoff and subsurface flow reach the riparian zone, the width of the floodplain, and, in some areas, the amount of sunlight that reaches riparian vegetation. This factor has been found to be of significance in relation to the distribution of floristic communities in eastern Tasmania (Wintle 2002: 61).

Average slope of surrounding landform was estimated visually but is generally related to slope categories according to McDonald *et al.* (1998: 12) where gentle slopes are less than 5°, moderate slopes are less than 18°, and steep slopes are greater than 18°. Qualitative, subjective cues were used in the field to assist with the standardisation of classification of slope (Table 2.2). Some watercourses have distinctly different landforms on both banks: eg. adjacent to a steep hill and a broad floodplain. In such cases, the surrounding landform was noted as composite on the field survey sheet, but for statistical purposes, recorded as the average of the differing gradients: e.g. a site with a steep and gentle gradient, was recorded as moderate.

Gradient description	**Slope Estimate (Degrees)**	**Qualitative descriptor**
Very steep	30+	Slope ascent slow and some climbing may be required.
Steep	18-30	Considerable effort required to ascend slope and difficult to stand upright on a hill.
Moderately inclined	5-18	Ascending slope requires some effort. 8° is about the maximum slope permitted on a main road.
Gently inclined	3-5	Can ascend slope easily at a walking pace.
Very gently inclined	1-2	Slope just perceivable
Level	0-1	No perceivable slope

Table 2.2: Landform slope descriptors.

(b) Stream Slope

The slope of the stream is intimately related to the velocity of flow because of gravitational forces. A stream with a steeper longitudinal profile will show a more rapid response and will produce higher peak discharges than one that is not as steep (Gordon *et al.* 1992: 114). The rate of discharge varies between seasons, with frequency and intensity of rainfall and is dependent on the shape of the catchment, the permeability and moisture content of the soil, subsurface geology and vegetation cover. Any assessment of the impact of discharge on riparian vegetation needs to be conducted over a number of seasons. During this rapid site survey, stream slope was used as a surrogate for peak discharge.

Stream slope affects the rate of delivery of sediments, nutrients and pollutants suspended, carried or dissolved in the water to the riparian zone. Stream slope also has a bearing on the force and extent of flood waters and the intensity of scouring which has an influence on the ability of some riparian species to become established and survive to maturity in the riparian zone (Wintle, 2002).

Ideally, if a field assistant were present, a clinometer and two-metre ruler would have been used to determine stream slope (Gordon *et al.* 1992: 134). However, for the majority of this riparian survey, only one person was present. Stream slope was estimated using the same slope categories as above but with qualitative descriptors that relate to typical in-stream features (Table 2.3).

Gradient description	**Slope Estimate (Degrees)**	**Qualitative descriptor**
Very steep	30+	Moderate to tall falls
Steep	18-30	Small falls and riffles
Moderately inclined	5-18	White-capped riffles and small terraces
Gently inclined	2-5	Riffles and pools
Very gently inclined	1-2	Visible flow
Level	0-1	Smooth, glassy surface

Table 2.3: Stream slope descriptors.

If the stream was dry or there were only small isolated pools present in the channel, visual cues such as the presence and steepness of longitudinally terraced channels or channel slope relative to surrounding landform characteristics were used to estimate degree of slope.

The accuracy of this measurement is limited by the ability of the researcher to accurately distinguish between the gentler slopes, especially in dry watercourses. It is recognised that overestimation is common (Gordon *et al.* 1992: 135).

(c) Channel shape and Bank Shape

The shape of the channel and bank may have an influence on the floristic composition of riparian vegetation. For example, if a site has a rectangular channel with vertical slopes and steep banks, shallow-rooted plants may not be able to survive the hydrological conditions at low flows and the degree of scouring and undercutting during high flows or flood events. For the survey, channel shape was categorised according to the field criteria used in the State of the Streams Survey in Victoria (Gordon *et al.* 1992: 95) (Figure 2.1).

Because of the extent of the survey site, an additional category of "irregular" was added to the list of descriptive categories where channel and bank shape at the survey site were seen to be combinations of descriptive categories or outside of the descriptive range (e.g. braided or multiple channels).

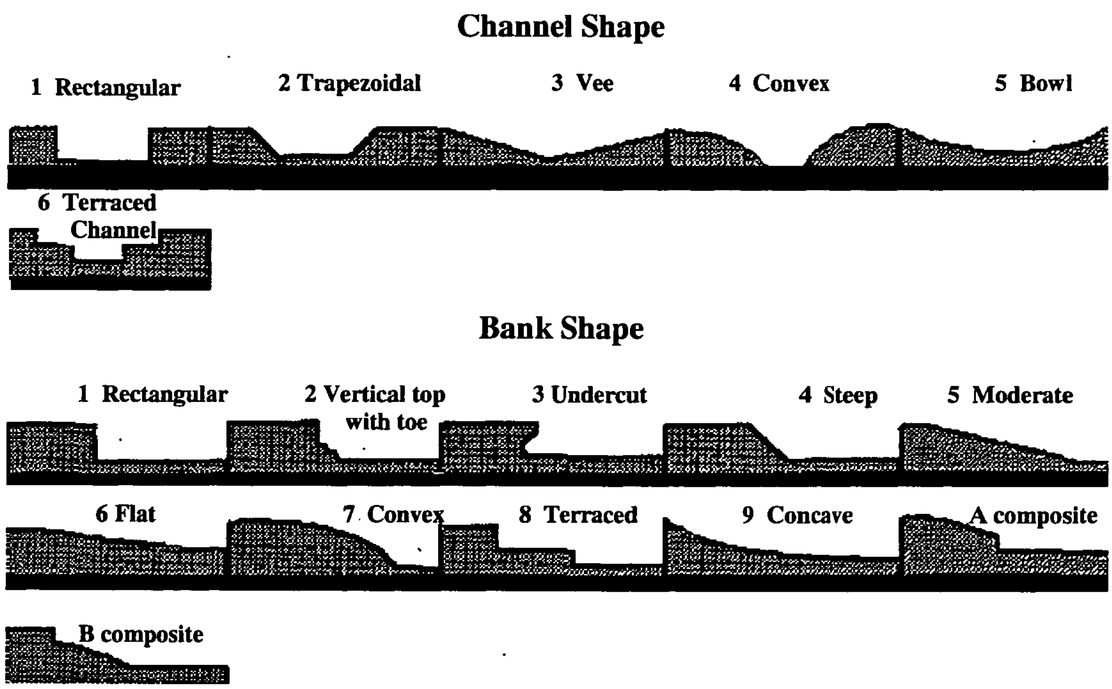


Figure 2.1: Channel shape and bank shape descriptors (Gordon *et al.* 1992: 95).

(d) Bank slope

It was evident very early in field surveys that bank slope was rarely consistent at any one site. Bank slope was estimated using similar criteria to those used for surrounding landform adapted to a smaller area and usually determined from the opposite bank or from the streambed. The categories of gentle and very gentle were incorporated because of difficulty in estimating small changes in slope at the lower angles. Where bank slopes at a site were variable, rather than providing an average bank slope, a classification of degree of variability of bank slope was developed and added to the primary slope classification as follows:

[1] vertical; [2] very steep; [3] steep; [4] moderate; [5] gentle;
[6] level; [7] gentle to vertical; [8] gentle to moderate; [9] gentle to very steep;
[10] moderate to steep; [11] moderate to very steep; [12] moderate to vertical;
[13] steep to very steep; [14] steep to vertical.

Degree of variability was categorised as:

[1] constant slope; [2] one gradient difference; [3] two gradient differences;
[4] three gradient differences; [5] four gradient differences.

2.1.6 Channel control

Streams can be separated into two major groupings, bedrock and alluvial, based on whether the form of the channel is predominantly controlled by geology or stream flow, respectively. In bedrock-controlled channels the flow is confined within rock outcrops and the channel morphology determined by the relative strength and weakness of the bed material. Alluvial channels are free to adjust their dimensions, shape and gradient and bed and bank materials are composed of materials transported by the river (Gordon *et al.* 1992: 88).

Channel control was initially recorded as either bedrock or alluvial. After a number of field surveys, it was noted that, in certain circumstances, riparian vegetation exerted an influence on channel control because of extensive and integrated root matting. Additional classifications (alluvial and vegetation; bedrock and vegetation) were added to the survey sheet.

2.1.7 Average width of channel

The width of the channel and slope of a river remain relatively constant whilst depth and velocity may vary from day to day. It was been found that aquatic plants occur in habitats that have a particular width-slope pattern, this being determined by topography and geology (Haslam 1978). The classification developed to investigate channel width was intended to reflect the range of Tasmania's watercourses from small to large and provide an indication of the range of watercourses at different altitudes. Average width of channel was visually estimated and recorded as one of the following classes: <5 m; 5-10 m; 10-50 m; or >50 m.

2.1.8 Floodplain

How wide is the riparian zone? The width of the riparian zone is very much related to the width of the floodplain. The width of the floodplain in a natural riverine system can be difficult to determine, especially if considering the "inactive" floodplain (Schumm 1977). In most cases though, the limits of the floodplain can be defined by geologic boundaries such as cliffs or steep slopes, distinctive changes in vegetation structure from riparian to terrestrial, by visual observation of terrace formations, and evidence of flood-borne debris.

For this rapid assessment survey, the extent of the floodplain was recorded as one of 7 classes: <10 m; 10-20 m; 20-30 m; 30-50 m; 50-75 m; 75 m – 100 m; or >100 m. The extent of the floodplain was taken as the distance between the extremities of the riparian zone of both banks.

In the site sketch, channel bed substrate was included but details were not recorded in the survey sheet. It is noted in Brussock *et al.* (1985), that channel beds can be a good method for extrapolating floodplain development and extent in an "ideal" river as follows:

- *Cobble and boulder-bed channel:* pools form behind large boulders or large accumulations of debris; valley is generally V-shaped; streams flow across bedrock, with little floodplain development.
- *Gravel-bed streams:* pools and riffles are more distinct and related to sinuosity. Streams flow through alluvium, with moderate to extensive floodplain development.
- *Sand-bed channels:* channel beds are mobile at discharges less than bankfull, with the formation of ripples, dunes, etc. The stream channel is easily modified by flood events and floodplains are extensive.

2.1.9 Stream zone

Sediments will be eroded, transported and stored within all sections of the river. The boundaries between aggradation and degradation are not always clear-cut. However, one process will predominate within each zone (Gordon *et al.* 1992: 419). The purpose of classifying a stream zone is to gain an understanding of the supply and variability of water and sediment to the riparian vegetation and an idea of dynamic interaction between aggradation and degradation processes at a site. Schumm's (1977) zone descriptions were modified to classify stream zones as areas of sediment production, transfer and deposition. Stream zone was determined from site characteristics and recorded as one of 7 categories (Table 2.4).

Stream zone	Stream zone classification	Visible Characteristics
1	Sediment production	Bank erosion; channel erosion
2	Transfer	Watercourse bounded by bedrock or densely matted vegetation – no other evidence of deposition or sediment production
3	Deposition	Sand bars, gravel bars, silty or sandy deposits in riparian zone
4	Transfer and deposition	Combination of 2 and 3 above
5	Sediment production and transfer	Combination of 1 and 2 above
6	Sediment production and deposition	Combination of 1 and 3 above
7	Sediment production, transfer and deposition	All processes as above visible within the riparian survey site.

Table 2.4: Stream zone classification characteristics.

2.1.10 Location in catchment

The general downstream trends of energy input, water quality and physical conditions lead to a longitudinal succession of plants, fish, benthic invertebrates and other organisms. These general changes can be divided into three zones: headwater, middle-order and lowland. (Davis 1899; Gordon *et al.* 1992: 88). Riparian vegetation also extends to the estuary where tidal variations have an influence on riparian characteristics. Therefore, a fourth zone was added for this survey – estuarine. Classifications of different zones of a watercourse tend to be qualitative rather than prescriptive, taking into account general characteristics such as stream slope, water temperature and streambed materials (Gordon *et al.* 1992: 89-90).

In the field, the position of the survey site within the catchment was determined from maps. The presence of salt-tolerant herbs and graminoids in the riparian understorey was also used to classify estuarine zones. The characteristics used to classify the position of the survey site within the context of the catchment are defined in Table 2.5.

In most cases, where the watercourses were long and had large catchment areas the classification of the survey site within the catchment was easily made. However, Tasmania has many short watercourses that drain into lakes, tarns or to the coast and these watercourses do not resemble the "model" watercourse structure. For short, atypically-structured watercourses, determination of the location was estimated using the above characteristics relative to the structure of the watercourse.

Site Location	Characteristic
Headwater	The source of a watercourse and its full length until the first tributary junction.
Middle order	From first tributary junction to the contour line where the watercourse leaves the steeper slopes of mountain ranges or hills and enters the gentler gradients of the lowlands. Stream may have short meanders and many tributary junctions.
Lowland	From the junction of the contour line used to demark middle-order streams to the terminus of the watercourse at a lake or the estuary. Gradient through which the stream passes is lower than middle order reaches; watercourse has longer meanders than in the middle-order. Stream is usually wider and deeper than middle-order section and water is more turbid.
Estuarine	The mouth of a watercourse entering the sea or a section of watercourse that is close to the mouth and influenced by tidal flow as evidenced by the presence of salt-tolerant species and/or high water conductivity values.

Table 2.5: Classification of position in catchment.

2.1.11 Hydrology

The influence of fluvial processes on the structure and distribution of riparian plant communities adds a dimension not found in other terrestrial plant communities. Plant species and assemblages within riparian zones have a tolerance range for inundation and waterlogging (Davidson & Gibbons 2001: 4). Outside this range, they may be:

- suddenly lost (e.g. through direct effects on leaves and roots);
- lost over an intermediate time frame through depletion of carbohydrate reserves and/or lack of light for photosynthesis (these are plants with some tolerance of inundation);
- lost over a long time-frame through inability to reproduce, set seed and recruit new individuals to the stand (extant plants with high tolerance of inundation); and
- increased in importance due to high tolerance and short reproductive cycle (or clonal propagation).

The rate of discharge, intensity of flow and frequency of flow also have an influence on riparian plant cover, species richness, species turnover and species diversity and evenness (Jarman & Crowden 1978; Hughes 1987: 175; Andersson *et al.* 2000a).

Of the inhabited continents, Australia has the lowest average annual rainfall and the highest proportional loss of rainfall by evaporation and transpiration resulting in the lowest mean annual runoff - only 1% of the world's total. Consequently, Australian rivers and streams are characterised by low discharges and many of them flow intermittently. However, perennial streams are also hydrologically distinctive (Lake *et al.* 1985).

Tasmania has four distinctive and spatially significant categories of hydrology with distinctive, monthly and annual flow patterns as well as peak and low flow events (Hughes 1987: 22-39) (Figure 2.2). Significant differences between the groups based on 12 hydrological variables are summaries in Table 2.6. In general, based on the coefficient of variation of mean annual flow, watercourses in eastern Tasmania have high flow variability and low mean annual runoff, while watercourses west of Tylers Line have relatively low flow variability and high mean annual runoff.

Hughes (1987: 34) found no significant relationship between drainage area and Cv for the two east coast rivers she studied. However, Hughes did find that catchments with low mean annual rainfall tend to have low specific mean low annual flows and that an increase in catchment area produced a higher mean low annual flow (ibid: 39). Hughes also found that rivers with low specific mean annual flows have high variability of low flows.

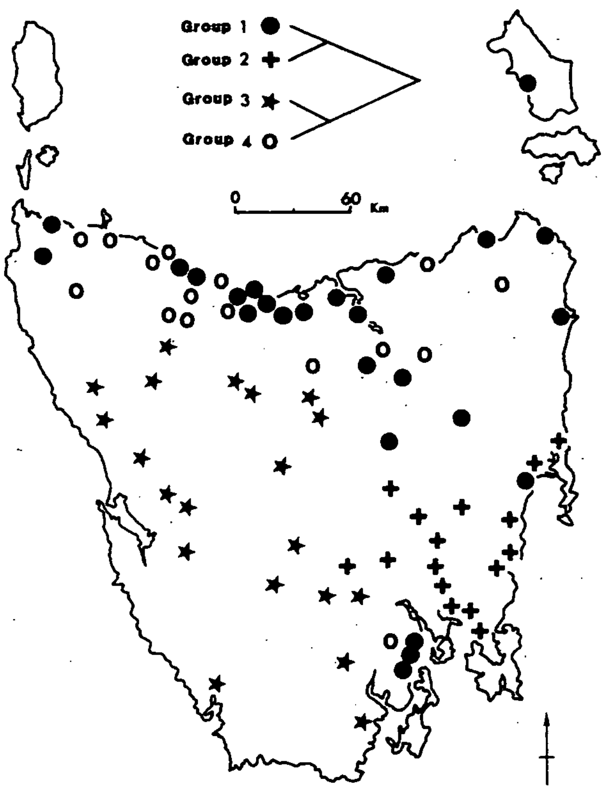


Figure 2.2: Tasmanian hydrologically distinctive river groups. (Source: Hughes 1987: 29)

Davies (1989: 353-354), in a study which included the investigation of 28 gauged watercourses around Tasmania, found a number of significant relationships between riverine geomorphological characteristics and flow C_v values. Streams with high C_v (mean annual flow) were narrower and had lower mean velocities and total discharge. They also contained more gravel and silt/sand and fewer medium boulders as well as having more eroding banks. Streams with high monthly flow C_v were characterised by being shallower and having more silt/sand and higher conductivities. Streams with high variability between monthly low and peak flows, had lower depth variance. Streams with high monthly flow C_v (low peak flows) had lower discharge, were narrower and had higher conductivities and more eroding banks (Davies 1989).

Davies (1989) also found that bank erosion was generally associated with variables that reflect bank stability. Streams with high C_v (mean annual rainfall), little overhanging vegetation and more undercut bank had more eroding bank. Bank erosion was high in narrow sites further from the sea and was associated with more silt/sand substrate. Low-order streams had more undercut banks.

Group	Region	Hydrological characteristics
1	North-central coast, midlands, northeast and 3 stations south of Hobart	Mean annual runoff between 225– 684 mm (similar to other temperate regions in the world); greatest variability for monthly flows along with Group 2 – Cv = 0.39 – 1.02; second highest index of variability of low flows – Iv = 0.34 – 2.28 ;
2	South east	lowest mean annual runoff – 142 mm (similar to semi-arid regions); highest co-efficient of variance (Cv) for annual flows – 0.87; greatest variability for monthly flows along with Group 1 – Cv = 0.39 – 1.01; lowest variability of monthly flow peaks; highest specific floods – g = -1.08 (Australian arid zones have a mean of -0.89 within a range of –2.3 to 1.2); lowest specific mean low annual discharge; highest average mean monthly low flows – Q low = 0.36; annual levels of disturbance are proportionally higher than elsewhere in Tasmania, (ibid, p.92)
3	South and west	highest mean annual runoff – 1347 mm; lowest Cv annual flow – Cv = 0.14 – 0.33; most consistent Cv monthly flows – Cv = 0.35 – 0.65; highest average specific mean peak discharges or catchment flood response – Q max average = 0.74 $m^3/s/km^2$; highest specific mean low annual discharge – Q low mean = 29.06 ($m^3/s/km^2$) $x10^{-4}$
4	Arc of stations from northwest to northeast	Mean annual runoff between 200-1203 mm; most normal distribution of annual flows; lowest variability of annual flows – Cv = 0.27-0.51; and lowest variability of monthly flows – Cv = 0.30 – 0.76

Table 2.6: Differences in hydrological characteristics of Tasmanian rivers.

As well as many small to large in-stream dams constructed for rural supply and town water and extensive water extraction for irrigation purposes, there has been significant alteration to the hydrology of Tasmania's rivers as a consequence of electricity production. Since 1914, significant intra-basin and inter-basin transfers of water occurred around Tasmania to facilitate hydro-electricity production. All Tasmania's major river systems have been affected by changes in environmental flow, water quality and quantity (Hydro Tasmania 2002).

In the absence of extensive, long-term hydrological data for most of Tasmania's watercourses, flow permanence and area of catchment above the survey site were determined.

(a) Flow permanence

Watercourses were categorised as:

- perennial - flow year round. Perennial streams are supplied by baseflow during dry periods;

- intermittent - flow for certain times of the year, when they receive water from springs or runoff. During dry years they may cease to flow entirely or they may be reduced to a series of separate pools; or
- ephemeral - flow only during and immediately after rain; they have channels which are above the water table at all times.

Because of the large number of catchments in Tasmania modified by the construction of in-stream dams, water extraction and water abstraction, additional categories were added to indicate whether the flow at the survey site was artificially perennial, artificially intermittent or artificially ephemeral. Categorisation of 'artificial' flow patterns were made if:

- a large dam (>3000 ML), in-stream dams or waterholes were observed upstream of the site or appeared on the map;
- the watercourse had been altered by channelisation, interbasin or intrabasin transfers (e.g. water is channeled from St Patricks River to Distillery Creek to facilitate a town water supply for Launceston); or
- many pumps were observed along the watercourse that altered flow as a result of excessive water abstraction.

The riparian survey was conducted over a period of 18 months. During this time, there were long periods of dry weather. The accuracy of this factor is limited by the assessment of the watercourse at the time of survey, the age and information provided on the maps used and the accuracy of information volunteered by local residents.

(b) Catchment area above survey site.

Hughes (1987: 36) found that there was a strong positive relationship between catchment area and mean peak flows for Tasmanian rivers. Therefore, catchment area is a reliable surrogate for mean peak discharge for Tasmanian rivers except where the river arises from a lake.

Catchment area above the survey site was estimated using the 1:25 000 and 1:100 000 map series and noted as class data. An exponential scale for catchment area was used: < 1 km^2; 1- 10 km^2; 11 - 100 km^2; 101 - 1000 km^2; 1001 – 10 000 km^2; and > 10 000 km^2. This parameter was estimated in order to determine whether there was a significant relationship between the relative size of the catchment area above the survey site and riparian vegetation at the site. As with stream class, there are anomalies with this factor due to the large number of artificial water impoundments and inter-basin and intra-basin transfers that exist within the survey area.

2.1.12 Geology and soils

Among the major physical factors of river catchments that influence the development of riparian corridors are the bedrock geology, geomorphic features (e.g. surface landforms such as erosional features, and deposits created by fluvial, landslide and wind storm events), soil character, climate, and hydrological regimes. These physical factors operate in three large geomorphic provinces of a river catchment: the erosional, transitional and depositional provinces (Sullivan *et al.* 1987).

Bedrock structure and composition has implications for drainage and plant establishment, growth and the provision of nutrients in the riparian zone. Increasing superficial rock cover reduces space available for plant establishment. Riparian soils are generally a mixture of alluvial deposits, deposits from terrestrial runoff, products of *in situ* rock decomposition and land and vegetation-derived decomposing organic matter. The ultimate composition of riparian soil at any time is determined by climatic, soil forming factors and frequency and intensity of flooding events.

The structure and composition of rocks and soils determines porosity and permeability of catchment and riparian substrates and thus has a bearing on water availability to riparian vegetation through surface, sub-surface and groundwater flow and flow permanence.

Geology, riparian substrate composition, and soil texture, acidity and salinity were recorded at each site as detailed below.

(a) Riparian substrate

The substrate in which riparian vegetation grows can be a determinant of health, vigour and survival. Substrates with high proportions of fine silts and clays may be waterlogged for much of the year. Substrates with high proportions of cobble and boulders may influence the ability of seeds to germinate and seedlings to survive to maturity. The composition of the top 10 cm of riparian substrate within the survey area was estimated in 5 categories (Table 2.7) using the Braun-Blanquet cover scale.

Riparian substrate	Description
Organic matter	organic or humus content of soil
Sand/Silt/Clay	particles less than 0.2 cm in diameter
Gravels	Stones 0.2 - 6 cm in diameter
Cobble	Rocks 6 – 20 cm in diameter
Boulder/bedrock	Large rocks > 20 cm in diameter

Table 2.7: Riparian substrate categories.

(b) Geology

The geology of a region is important in riverine classification because it gives an indication of the erodibility of bedrock materials, potential for groundwater movement, surface and groundwater chemistry, landform, stream form, drainage pattern and stream bed composition (Gordon *et al.* 1992: 415). At the reach and catchment scales, geology has been found to be an important factor in the longitudinal and latitudinal variation of riparian communities within catchments (Merry *et al.* 1981; Curry and Slater 1986; Nilsson 1986; Hughes 1987).

Tasmania's geological history and its drainage patterns, are varied and complex. Precambrian geology comprising predominantly siliceous metasediments dominates the west to a boundary that extends from the Forth River area in the north to Port Davey in the south. Jurassic dolerites dominate the central portion of the State and extend towards the east coast. In the northeast, Devonian granite batholiths intrude the mainly Palaeozoic Mathinna beds which are composed primarily of sandstone and coarse siltstone. Along the northwest coast, Tertiary basalts are widespread and locally extend into the eastern region. The deep volcanic soils in this region have a high water storage capacity and contribute to the persistent base-flow of northwest rivers (Hughes 1987: p.39).

Geological classification was based on the Tasmanian Geological Map series 1:100000 and 1:250 000. A specimen of any geological substrate that was not familiar to the researcher was taken to the Geology Department at the University of Tasmania for identification. The large range of geological classifications on mainland Tasmania does not easily facilitate statistical analysis. This is especially true for the category of alluvial deposits. Alluvial deposits at any site may be derived from the in-situ geology, land-based run-off deposits, and sediments from non-related geology much further upstream.

Riparian geology was classified in the field according to the rock type and/or dominant composition of the alluvial deposits. Thirty-two classes of geology were recorded from the field survey. The geology data was further grouped based on potential to provide nutrients to riparian vegetation (Table 2.8).

Code	Geology	Description
1	Sandstone	Predominantly quartz sandstone but includes Carboniferous pebbly mudstone and sandstone; Permian late sandstone, mudstone and limestone
2	Siltstone and Mudstone	Includes Carboniferous pebbly mudstone and sandstone, mudstone, minor limestone and Tasmanite oil shale
3	Dolerite	
4	Basalt	
5	Limestone	
6	Quartzite	Includes conglomerate and slate/ orthoquartzite combination
7	Granite	
8	Cambrian volcanics	
9	Mathinna formation	Early Ordovician to early Devonian micaceous quartzwacke turbiditic sequences
10	Dolerite and orthoquartzite	
11	Alluvial deposits	Includes Holocene sand gravel and mud of alluvial, lacustrine and littoral origin; Pleistocene fluvioglacial, periglacial and associated deposits; shale and lower glacio-marine sequences of mudstone, pebbly sandstone, minor limestone and basalt
12	Alluvial deposits on dolerite	
13	Alluvial deposits on Mathinna beds	
14	Alluvial deposits on limestone	
15	Alluvial deposits on conglomerate	
16	Alluvial deposits on quartzite	Includes Precambrian orthoquartzite
17	Alluvial deposits on basalt	
18	Alluvial deposits on Cambrian volcanics	

Table 2.8: Riparian geology classification.

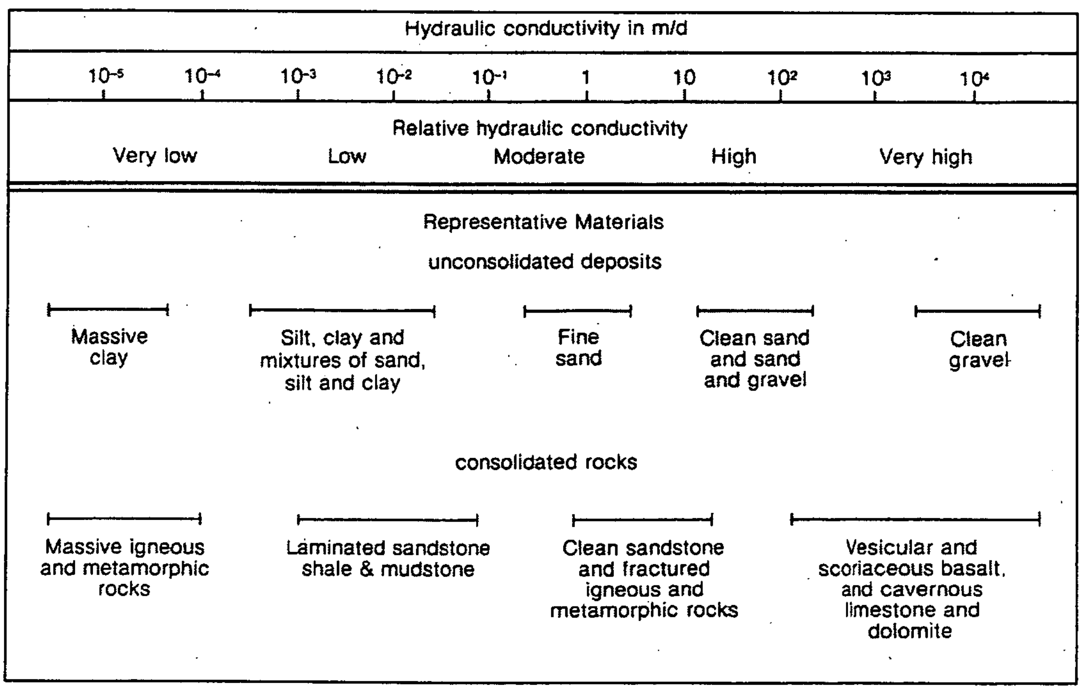


Figure 2.3: Hydraulic conductivities for various rock types. (Source: Gordon *et al.* 1992)

The hydraulic conductivity of geological substrates in catchment aquifers that drain into the riparian zone before reaching the watercourse will determine the impact of flow and duration of water availability for riparian vegetation (Figure 2.3). Water will easily permeate medium and coarse sands and fine gravels but not glacial clays and Carboniferous mudstone. Regional flow through a sandstone aquifer to the riparian zone will be much faster than the same volume of flow through granite. The researcher regrets that the classification of geological attributes in the field was not more thoroughly investigated before field work began. In hindsight, it would have been more appropriate to group the geology (and soil texture) according to hydraulic conductivity using the four broad categories defined in Figure 2.3 above: very low; low; moderate-high; very high. Unfortunately, there were insufficient geology descriptors recorded on the field data sheets to reclassify the dataset according to hydraulic conductivity.

(c) Soil Texture

Soil properties such as depth, texture and stoniness affect soil moisture storage, drainage, erodibility and root mass development. Soil texture is an important characteristic because it gives a good indication of other soil properties such as water storage, drainage and nutrient supply. It is also a stable property (McLaren & Cameron 1996: 60).

The classification of soil texture is usually undertaken after an analysis of the soil structure and composition of soils above the bedrock layer. It is impractical to do a full soil profile in a riparian situation because of the difficulties associated with penetrating riparian substrates with high rock and root mat densities. Therefore, soil texture in the riparian zone only refers to the texture of the top-soil.

Soil texture in a 500 m reach of the riparian zone can be extremely variable depending on weathering, erosion, transfer and depositional factors. It was noted during the field survey that, at many riparian reaches, soil texture varied across several texture classes, e.g. heavy clay to clay loam. Recently deposited sands and gravels further complicated soil texture classes.

In the field, soil texture was assessed from the top 10 cm of riparian substrate using the 'field texturing' technique developed by Northcote (1979). Descriptions of riparian soil texture were based on the definitions detailed in McDonald *et al.* (1998: 118-120) and summarized in Gordon *et al.* (1992: 198) (Table 2.9). These classes were simplified into more general categories developed by McKnight (1990) (Figure 2.4). In the field, the soil texture was sampled at different places within the survey site and described according to the types and variations that were observed: 59 classes of riparian soil textures were observed (Table 2.10).

Code	Description	Behaviour of moist bolus of soil
1	Clay	Handles like plasticine, plastic and sticky; will form a long ribbon of 5 cm or more
2	Silty Clay	Plastic bolus; smooth and silky to manipulate; will form long ribbon
3	Silty Clay Loam	Coherent smooth bolus; plastic and silky to the touch; will form longer ribbon than loam
4	Silt	Pure silt will have a smooth, floury or silky feel; bolus can be manipulated without breaking
5	Sandy Clay	Plastic bolus; fine to medium sands can be seen, felt or heard in clayey matrix; will form a thin, long ribbon which breaks easily
6	Sandy Clay Loam	Strongly coherent bolus, sandy to touch, medium size sand grains visible in finer matrix; will form a longer ribbon than sandy loam
7	Sandy Loam	Bolus just coherent but very sandy to touch; will form a short ribbon; dominant sand grains can be seen, felt or heard
8	Loamy sand	Slight coherence; can be sheared between thumb and forefinger to give minimal ribbon of about 6 mm; discolours fingers with dark organic stain
9	Sand	Crumbles readily; cannot be moulded; single sand grains adhere to fingers
10	Clay Loam	Coherent plastic bolus; smooth to manipulate; will form ribbon similar to silty clay loam
11	Silt Loam	Coherent bolus, very smooth to silky when manipulated; may form short ribbon
12	Loam	Coherent and rather spongy bolus; smooth feel when manipulated but with no obvious sandiness or silkiness; may be somewhat greasy to the touch if much organic matter present; will form a short ribbon

Table 2.9: Riparian soil texture categories. (Source: Gordon *et al.* 1992: 198)

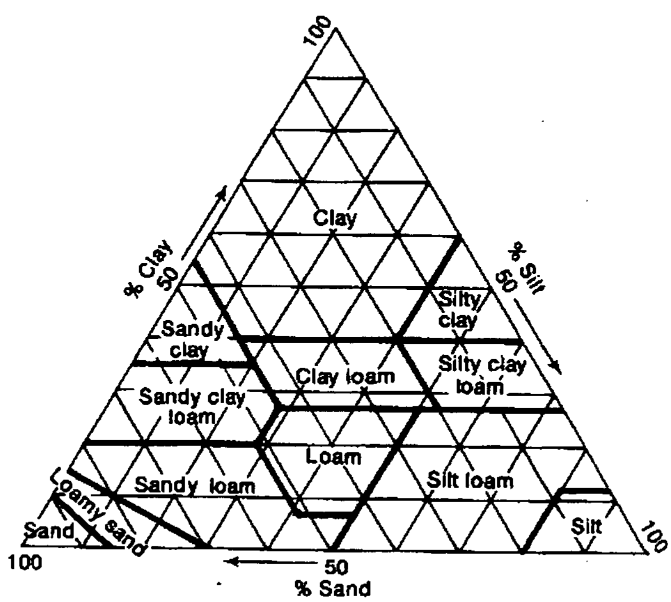


Figure 2.4: Soil texture triangle. (Source: McKnight 1990: 329)

Riparian Soil Texture	Code	Riparian Soil Texture	Code
Sand	S	Sandy Clay	SC
Loamy Sand	LS	Sandy Loamy Clay	SLC
Clayey Sand	CS	Sandy Medium Heavy Clay	SMHC
Sandy Loam	SL	Loamy Sand to Sand	LS/S
Loam	LS	Sandy Loamy Medium Clay	S/LMC
Silty Loam	ZL	Loamy, Silty Medium Clay	LZMC
Sandy Clay Loam	SCL	Varies from Sandy Loam to Sandy Clay Loam	SL/SCL
Clay Loam	CL	Loamy Gravelly Sand	LGS
Clay loam, sandy	CLS	Loamy Silty Clay	LZC
Silty Clay loam	ZCL	Varies from Gravelly Sand to Sandy Loamy Clay	GS\SLC
LoamyClay	LC	Loam to Gravelly Sand	L\GS
Light Medium Clay	LMC	Loamy Gravelly Sandy Clay	LGSC
Medium Clay	MC	Loamy Gravelly Clayey Sand	LGCS
Medium heavy clay	MHC	Varies from Sand to Sandy Heavy Clay	S\SHC
Heavy Clay	HC	Varies from Loam to Sandy Clay Loam	L\SCL
Gravelly Sand	GS	Gravelly Silty Clay Loam	GZCL
Gravelly Sandy Clay Loam	GSCL	Varies from Sandy Light Medium Clay to Sandy Clay Loam	SLMC\ SCL
Gravelly Sandy Loam	GSL	Varies from Sandy Clay Loam to Gravelly Clay	SCL\GC
Gravelly Loamy Sand	GLS	Varies from Loam to Sandy Loamy Clay	L\SLC
Gravelly Medium Clay	GMC	Loamy Clayey Sand to Clayey Sand	LCS\CS
Gravelly Clayey Sand	GCS	Varies from Sandy Clay to Gravelly Sand	SC\GS
Varies from Gravelly Medium Clay to Sandy Clay Loam	GMS/SCL	Varies from Sandy Loam to Sandy Loamy Clay	SL\SLC
Gravelly Sandy Clay	GSC	Varies from Gravelly Sandy Loam to Sandy Clay	GSL\SC
Gravelly Loamy Medium Clay	GLMC	Gravelly Sandy Loamy Clay	GSLC
Sandy/Loamy Heavy Clay	S/LHC	Clayey Loamy Sand	CLS
Loamy Sand to Loam	LS/L	Gravelly peaty Loam	GPL
Sand to Sandy Loam	S/SL	Varies from Loamy Sand to Gravelly Clay	LS\GC
Varies from Loamy Sand to Clayey Sandy Loam	LS/CSL	Varies from Gravelly Sandy Clay to Sandy Loamy Clay	GSC\SLC
Gravelly Clayey Loamy Sand	GCLS	Gravelly silty Clay	GZC
Sandy Light Medium Clay	SLMC	Peat	P

Table 2:10: Observed riparian texture descriptors.

There was considerable variation in the observed riparian soil texture. McLaren & Cameron's assertion that soil texture is a stable property, is possibly not an accurate assessment of soil texture in the riparian zone.

Observed Riparian Structure Code	12-Texture Transformation	3-Texture Transformation	Observed Riparian Structure Code	12-Texture Transformation	3-Texture Transformation
S	9	2	SC	5	1
LS	8	2	SLC	6	1
CS	5	2	SMHC	5	1
SL	7	3	LS/S	8	2
LS	12	3	S/LMC	6	1
ZL	11	3	LZMC	3	1
SCL	6	3	SL/SCL	6	3
CL	10	3	LGS	8	2
CLS	6	3	LZC	3	1
ZCL	3	3	GS\SLC	6	2
LC	10	1	L\GS	8	3
LMC	1	1	LGSC	6	1
MC	1	1	LGCS	6	2
MHC	1	1	S\SHC	5	2
HC	9	1	L\SCL	6	3
GS	9	2	GZCL	3	3
GSCL	6	3	SLMC\SCL	6	3
GSL	7	3	SCL\GC	6	3
GLS	7	2	L\SLC	6	3
GMC	1	1	LCS\CS	6	2
GCS	5	2	SC\GS	5	2
GMS/SCL	6	2	SL\SLC	6	3
GSC	5	1	GSL\SC	6	3
GLMC	10	1	GSLC	6	1
S/LHC	6	1	CLS	8	2
LS/L	8	3	GPL	12	3
S/SL	7	3	LS\GC	6	2
LS/CSL	6	2	GSC\SLC	6	1
GCLS	8	2	GZC	2	1
SLMC	5	1	P	12	3

Code descriptions provided in Table 2.10; 12-texture key: 1= Clay; 2=Silty Clay; 3= Silty Clay Loam; 4= Silt; 5=Sandy Clay; 6=Sandy Clay Loam; 7-Sandy Loam; 8=Loamy sand; 9=Sand; 10=Clay Loam; 11= Silt Loam; 12=Loam

Table 2.11: Observed riparian soil textures and simplified soil texture classifications used

For the purpose of statistical analysis, the observed riparian soil texture was simplified into the 12 classes of the soil texture triangle. There were some difficulties associated with deciding into which texture class to place the descriptors where there was variation across texture classes observed at a site (e.g. varies from Sand to sandy Heavy Clay). The transformations that were made appear in Table 2.11.

The general principles used for transforming 59 categories to 12 categories were: all descriptions that matched the 12 texture classes (McKnight 1990) were classified accordingly; all combinations of sandy clay loam (eg. loamy sandy clay, clay sandy loam, sandy loam clay) were transformed to sandy clay loam; where soil texture descriptions spanned more than 1 texture class, consideration was given to the range of all textures present at the reach and a class that most closely matched the range of descriptors was allocated (e.g. varies from Gravelly Medium Clay to Sandy Clay Loam was transformed to sandy clay loam); peat was transformed to loam - there were very few reaches were peat was recorded as the soil texture descriptor. A macro was developed in Excel to facilitate the transformation of observed data.

(d) Soil Acidity

The acidity of the soil can affect the establishment, growth and health of plants in a terrestrial environment and is also known to have an affect on aquatic fauna and flora (Cassidy 1998: 286). This factor was measured to determine if there was a relationship between the pH of riparian soils and riparian plant species and communities. Where soils were not homogenous, the pH of the dominant riparian substrate was measured.

A CSIRO soil testing kit was used instead of an electronic meter because the degree of accuracy of the measure was sufficient for the purpose of the survey. Results of pH tests using this method are limited in accuracy to 0.5 of a pH unit.

(e) Soil salinity

Soil salinity is a growing problem in Tasmania as well as in other parts of Australia. While some agricultural and native species are known to be salt tolerant and are used as potential indicators of soil salinity in Tasmania (Finnigan 1992), little is known about the relative ranges of soil salinity in which most Tasmanian plants grow naturally: lentic vascular species are the exception (Kirkpatrick & Harwood 1983b). Inorganic solids (e.g. salts derived from sodium, magnesium, calcium, iron and aluminium), dissolved in water produce ions that conduct an electric current. Electrical conductivity is used as a surrogate measure of soil salinity.

The Simple Field Test procedure recommended by the Department of Primary Industry and Fisheries was used to determine soil conductivity (DPIF 1998). In brief the procedure involved the following steps.

- Place 10 mL of soil from the top 20 cm layer or riparian substrate into a jar marked at 10 mL, removing any stones, gravels or debris.
- Measure 50 mL of distilled water and test this water with the conductivity meter. Readings greater than zero should be noted and subtracted from the final test reading.
- Transfer distilled water into the jar with soil, shake vigorously for two minutes.
- Measure conductivity of the soil-water solution.

A TD Scan 20 conductivity metre (Eutech Instruments, Singapore) was used for measuring conductivity as it has a range of 0 – 20 000 microsiemens per centimetre (μS/cm) which is suitable for testing fresh and estuarine waters. The conductivity metre was calibrated weekly as per the manufacturers instructions and is accurate to ±2%.

2.1.13 Climate

Tasmania has a temperate maritime climate with mild winters and cool summers. Rainfall and temperature vary unevenly across the State (Figures 2.5 and 2.6). There is no well-defined seasonality in rainfall across the State except that winter rainfall is generally heaviest in west and northwest regions and summer rainfall, as a proportion of total rainfall, is higher in the south and east corresponding with season movements of the Subtropical High Pressure Belt (Bureau of Meteorology 2002; www.bom.gov.au/climate). Snow may fall in any season but is usually confined to winter and is significant only at altitudes in excess of 600 m. An intermittent covering of snow, frost and ice is common in west, southwest and northeast highlands during the winter months. Frosts can occur in any season.

Extreme seasonal and annual events may cause changes in the floristic structure of riparian vegetation (White 1979). The impact of climate on riparian vegetation varies locally depending on topography and is intimately linked with catchment hydrology. The contribution that regional climatic factors make to local riparian conditions is not known and data collected from the weather stations gives only a broad indication of climatic variability.

Broad-scale climatic data was used for this project (Busby 1995). BIOCLIM is a climate analysis and prediction system that can be used to stratify an area on a climatic basis prior to survey and also to predict distributions of individual entities such as species or vegetation types. BIOCLIM is based on continuous mathematical surfaces fitted to measured meteorological data, and can be used to generate estimates of monthly mean minimum and maximum temperatures and precipitation for any point on or near mainland Australia and Tasmania from inputs of latitude, longitude and elevation. (Busby 1991: 64). It has been determined that predictive error is of about the same magnitude as normal instrumental and observer error. Therefore, BIOCLIM estimates of primary climatic attributes are generally robust and the least likely cause of anomalous values in the analysis (Busby 1991: 65). The climate variables used in data analysis appear in Table 2.12.

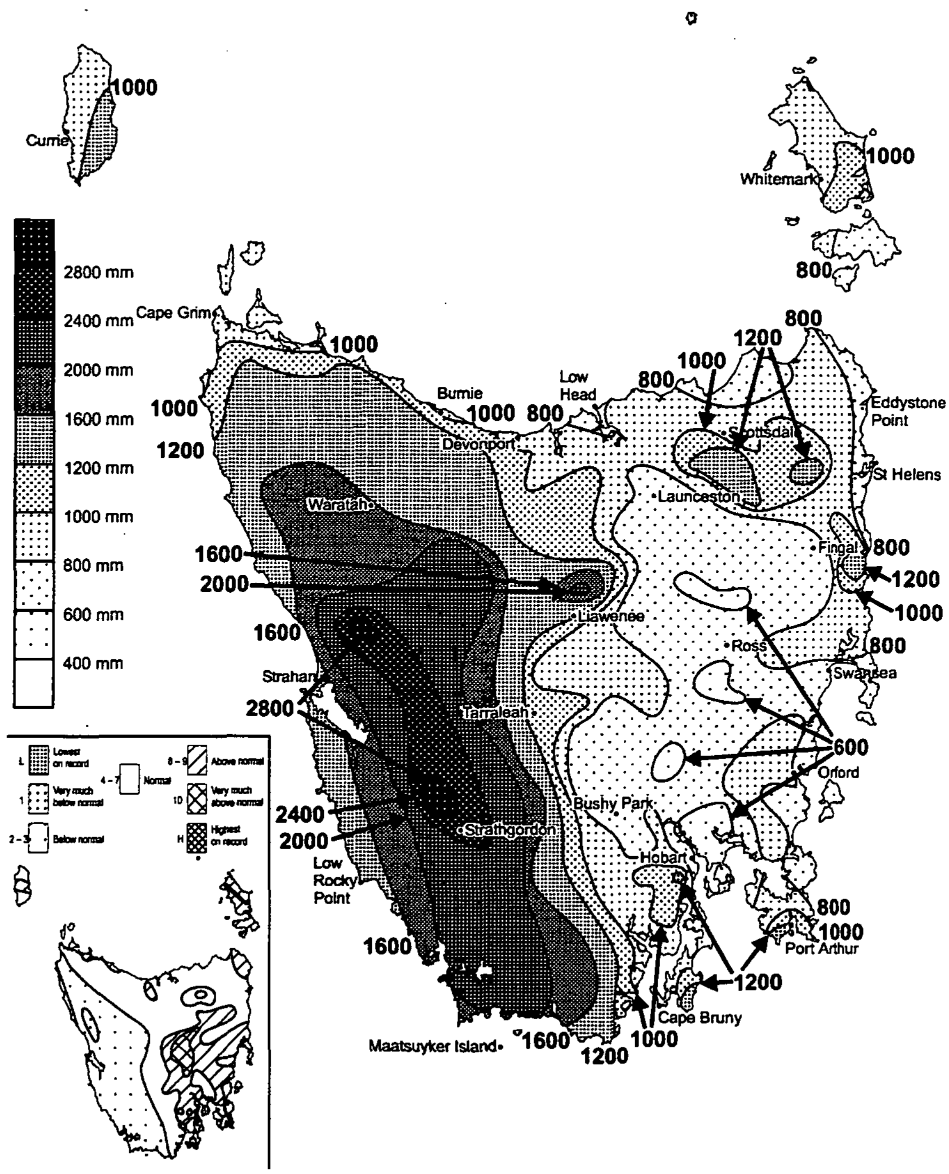


Figure 2.5: Rainfall totals 2001. (Prepared by the Bureau of Meteorology, Hobart 18.9.02)

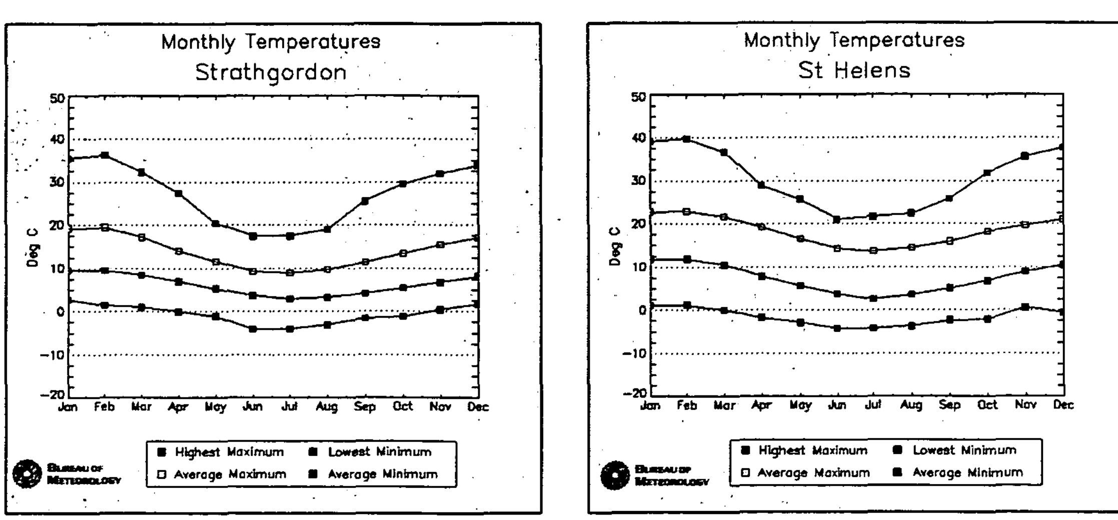


Figure 2.6: Average monthly temperature variations at Strathgordon on the west coast and St Helens on the northeast coast. (Source: Bureau of Meteorology 2002)

No.	Parameter	Unit
1	Annual mean temperature	°C
2	Minimum temperature of coolest month	°C
3	Maximum temperature of warmest month	°C
4	Annual temperature range	°C
5	Mean temperature of coolest quarter	°C
6	Mean temperature of warmest quarter	°C
7	Mean temperature of wettest quarter	°C
8	Mean temperature of driest quarter	°C
9	Annual mean precipitation	°C
10	Precipitation of wettest month	mm
11	Precipitation of driest month	mm
12	Coefficient of variation of monthly precipitation	
13	Precipitation of wettest quarter	mm
14	Precipitation of driest quarter	mm
15	Precipitation of coolest quarter	mm
16	Precipitation of warmest quarter	mm
17	Mean precipitation of driest month	mm
18	Mean precipitation of driest quarter	mm

Table 2:12: Climate profile parameters.

2.1.14 Vegetation

There have been relatively few studies of riparian vegetation in Tasmania. Askey-Doran (1993), Hughes (1987) and Davidson & Gibbons (2001) used varying quadrat-based methodologies to determine specific riparian vegetation characteristics such as zonation, species richness and diversity, or relationship between species composition and physiographic features at a particular site, or in a particular region. Curry & Slater (1986) and Wintle (2002) used a plotless releve methodology (Mueller-Dombois & Ellenberg 1974) to record riparian species and environmental conditions.

In the present study, a releve was used in preference to quadrat sampling because of time-saving advantages resulting from not having to delimit and mark a sample plot. It was also not possible to establish quadrats at some survey sites without causing damage due to the density of the vegetation. Vegetation on both banks of the watercourse was recorded regardless of cross-sectional variation. Sampling of riparian species was considered to be complete when, after 45 minutes, there were no new species recorded in the area being sampled.

Species dominance and structure, following the projective foliage cover and height classes of Specht (1974) was recorded for each releve. A visual estimate of the cover of each stratum, and life-form cover, at each site was made using the Braun-Blanquet cover scale. Vouchers for nearly all plant species observed during the field survey were pressed and are held as a collection by the researcher. A species was recorded as dominant or co-dominant in a stratum according to the rules in Table 2.13.

Classification	Rule
Dominant	Species with more than 50% or greater of total plant cover.
Co-dominant	Where a dominant species is present, a species with between 30% - 50% plant cover.
No clear dominant	No species has a cover of >30 % of the cover of the stratum

Table 2.13: Riparian species dominance classification.

(a) Riparian species and vegetation structure

At present, there are 2,502 vascular plant species that are known to be, or have been, native to or naturalized in Tasmania (Table 2.14). Ten of the total vascular plant species are now considered extinct. The majority of Tasmania's vascular plant species are native (71%). Of the native species, about 25% are endemic to Tasmania.

Vascular plant type	Native	Endemic	Introduced	Total
Dicotyledonae	1050 (4 ex)	305 (1 ex)	512 (2 ex)	1562 (6 ex)
Monocotyledonae	611 (2 ex)	136	215 (1 ex)	826 (3 ex)
Gymnospermae	11	9	1	12
Pteridophta	101 (1 ex)	6	1	102 (1 ex)
TOTAL	1773 (7 ex)	456 (1 ex)	729 (3 ex)	2502 (10 ex)

Table 2.14: Summary of Tasmania's vascular species as at 13 January 2003.
(pers. comm. Alex Buchanan, Tasmanian Herbarium 2003). (ex = extinct)

It is not known how many of these species occur in the riparian zone and there are conflicting accounts about which species are obligate riparian species (i.e. exclusive to a river environment) and which are facultative (i.e. not exclusive to the river environment). There may also be facultative species that occur predominantly in the riparian zone, but this issue has not previously been explored.

Nomenclature for plant species follows Buchanan (1999). Vouchers of specimens that were unnamed, listed as threatened species or unusual in form were lodged with the Tasmanian Herbarium. Exotic vascular species were noted but not included in data analysis. The presence of moss, lichen and marsupial lawn was also recorded. "Native" species refers to native vascular species and moss, lichen and marsupial lawn found in the riparian zone. Moss, lichen and marsupial lawn are each given a unit value where totals are provided in descriptions of riparian species unless otherwise stated. Marsupial lawn is defined as lawn-like area comprising diverse mixtures of grasses, graminoids and herbs. Marsupial lawns are good indicators of habitats frequented by grazing marsupials.

Every effort was made to identify all vascular plant species present at a survey site, to species level. However, where plants could not be identified to species level because they were uncommon and not in flower at the time of survey and/or diseased, and therefore structurally aberrant, such plants were identified to the first level (genera or family) of certainty. It is possible that the number of species at some sites may have been underestimated because their flowering periods did not coincide with the time of survey. Grazing factors and the density of vegetation at some sites may also have contributed to an underestimation of some life-forms, especially grasses, grass-like graminoids and herbs. In addition, the identification of some vascular plant species may be limited by human error.

A vascular plant is classified as "rare", "vulnerable" or " endangered" based on its status within the "Complete Listing of Threatened Vascular Plants" (obtained from the Department of Primary Industry, Water and Environment website – www.dpiwe.tas.gov.au accessed 27 March 2002).

There were 4 vascular plant species collected during the field survey that are not yet described and while they are known to staff at the Tasmanian Herbarium, their full extent and range is not known. Flowering samples were lodged at the Tasmanian Herbarium. The four plants are recorded as:

- *Acacia* sp. (HO: 512458; HO: 512459) (found at 3 survey sites in the riparian zone of the Derwent River);
- *Hakea* aff. *epiglottis* (HO: 520626) (found at 3 survey sites on the West Coast);
- *Tetratheca* aff. *pilosa* (no Herbarium voucher number has been allocated to date) (found at 2 survey site in the Eastern Tiers); and
- *Hibbertia* aff. *riparia* (no Herbarium voucher number has been allocated to date) (found in at least 1 survey site in the northeast).

While the general rule for categorising a species into a life-form is to place it into the category which best describes its mature form, this general rule was difficult to apply uniformly for all vascular species found in the riparian zone. For example, in the western regions of Tasmania, *Leptospermum lanigerum* frequently occurs as a single-stemmed tree up to approximately 25 m in height. However, in many of the eastern regions of Tasmania, *L. lanigerum* was not observed to reach a height above 2 m tall and was nearly always multi-stemmed. Thus some species are labeled by two life-form categories.

Each stratum in adjoining vegetation and riparian plant communities was classified according to Specht (1974) (Table 2.15) and the dominant species. It is noted that the Specht system of community classification is largely designed for dry-land vegetation communities where the tallest stratum, usually trees, defines the overall structure of the community. This is not necessarily the case in riparian vegetation. Thus the structural labeling used in the present study provides information on all strata.

In most cases, there were 3 distinct strata. Sometimes there were 4 clearly distinct strata: e.g. tall forest, woodland, scrub and a ground cover layer of grasses or sedges; or woodland, scrub, grassland and herbland. In such cases, the additional stratum was noted in the field sheet but transformed into a 3-stratum classification system for statistical purposes by using the ground stratum as a descriptor of the second stratum: e.g. woodland, scrub, grassland and herbland would be transformed to woodland, scrub and herby grassland.

Where more than one species was equally or approximately-equally dominant or co-dominant within a stratum, '/' was used in the naming of the assemblage (e.g. *E. viminalis/A. melanoxylon* open-forest over *L. lanigerum* shrubby closed-scrub).

The vegetation category at the end of the classification denotes the structure of the stratum with the greatest cover (e.g. *E. obliqua\E. globulus* woodland over *L. lanigerum\Acacia dealbata* ferny closed-forest indicates that, while there was moderate tree cover (woodland) in the tallest stratum and a covering of ferns in the understorey, the second stratum was closed-forest and had the greatest cover).

For the purpose of statistical analysis, riparian vegetation structure was classified into forest and non-forest. All sites where a forest descriptor was present in the description of riparian structure were classified as forest. All other sites were classified as non-forest. Riparian vegetation was also classified into 9 structural types according to the stratum with the greatest cover: closed-forest; open-forest; closed-scrub; open-scrub; shrubland; heath; fernland; sedgeland; and grassland.

2.1.15 Adjoining Land use

Major land use adjoining the survey site was recorded as one of the following categories: [1] reserve [2] cropland/pasture [3] forestry [4] recreational [5] rural residential [6] urban [7] forest & recreation [8] bush block [9] rough grazing - sheep [10] rough grazing - cattle [11] wilderness (native vegetation with no land use evident) and [12] mining.

Life form and height of tallest stratum	**Projective foliage cover of tallest stratum**			
	Dense (70-100%)	**Mid-dense (30-70%)**	**Sparse (10-30%)**	**Very sparse (<10%)**
Trees > 30 m* Trees 10-30 m Trees 5-10 m	Tall closed-forest Closed-forest Low closed-forest	Tall open-forest Open forest Low open-forest	Tall woodland Woodland Low woodland	Tall open-woodland Open-woodland Low open-woodland
Shrubs 2-8 m* Shrubs 0-2 m	Closed-scrub Closed-heath	Open-scrub Open-heath	Tall shrubland Low shrubland	Tall open-shrubland Low open-shrubland
Hummock grasses 0-2 m			Hummock grassland	Open-hummock grassland
Herbs	Closed-herbland (1) Closed-tussock grassland (2) Closed-grassland (3) Closed-herbfield (4) Closed-sedgeland (5) Closed-fernland (6) Closed-mossland	Herbland (1) Tussock grassland (2) Grassland (3) Herbfield (4) Sedgeland (5) Fernland (6) Mossland	Open-herbland (1) Open-tussock grassland (2) Open-grassland (3) Open-herbfield (4) Open-sedgeland (5) Open-fernland (6) Open-mossland	Ephemeral herbland

*A tree is defined as a woody plant more than 5 m tall, usually with a single stem.
A shrub is a woody plant less than 8 m tall, frequently with many stems arising at or near the base.

Table 2.15: Vegetation structural formations. (Adapted from Specht 1974)

2.1.16 Disturbances

From a landscape ecology perspective, a disturbance is considered to be an event that causes a significant change or disruption to ecosystems, community or population structure, and changes resources or the physical environment (Forman & Gordon 1986; Resh *et al.* 1988; Wissmar & Swanson 1990). Disturbances can be natural (e.g. flood, fire, wind, glacial activity and volcanic events), or can result from human actions (e.g. land clearing, channel modification, agricultural and urban development). The impact of disturbances on riparian vegetation is related to: frequency and intensity of the event; the source and extent of the disturbance (i.e. localized or widespread); the nature of the disturbance (i.e. acute or chronic) and the recovery potential of riparian vascular plant species in the altered biological, geomorphic and hydrologic conditions.

Wissmar & Beschta (1998) contend that extensive historical and ongoing modifications of riparian corridors and floodplains for flood management, water diversion, land reclamation, commerce and other development purposes are leading to losses in the natural physical and biological integrity in river catchments. These modifications often fragment riparian corridors and lead to losses in complexity and connectivity between the riparian, channel and floodplain habitats. The widespread fragmentation of river landscapes and cumulative degradation of channel structures and riparian habitats are major components affecting the continuing loss of riparian species biodiversity.

Disturbances, whether natural or resulting from human actions, were noted during the riparian survey to provide an indication of tolerance of riparian species and communities to disturbances. There were two classes of disturbances recorded - stock usage of riparian area, and visible disturbances.

(a) Stock usage of riparian zone

Livestock and native animals are attracted to riparian areas by availability of water, shade, thermal cover and quality and quantity of forage (Platts & Nelson 1989; Askey-Doran & Pettit 1999). Excessive grazing of the riparian zone cause: compaction of soils which increases runoff and decreases water availability to plants; removal of leaves and stems, which lowers plant vigour and changes competitive interactions among species; physical damage to vegetation by rubbing, trampling and browsing; and changes to fluvial processes that may lower water tables and/or cause a decline in invasion sites for woody species.

In order to determine if stock usage of native riparian lands had an effect on the distribution of vascular plant species, stock usage was assessed and categorised as: none; occasional/seasonal; and frequently based on visual evidence such as trampling, droppings and the presence of stock at time of survey, and local enquiry.

(b) Visible disturbances

Human influences can uncouple riparian and stream ecosystem interactions. As well as extensive unmanaged livestock grazing, impacts associated with wildfires, mining and past forest clearing coupled with numerous small linear perturbations such as walking tracks and low standard roads affect riparian vegetation. Vegetation removal and soil compaction substantially increases surface runoff producing sediment-laden flows and increased erosive power to the channel system.

In order to gain an understanding of the full range of visible disturbances that exist in native riparian areas, natural and human-based disturbances were noted and recorded according to the nature of the disturbance. The range of disturbance factors visible during the survey were: animal (stock and native); flood; landslip; rubbish; weeds; fire; tracks; road; bridge; treefall; dam upstream; weir; tidal; waterhole; water extraction upstream; recent timber harvesting within riparian zone; water diversion via canals upstream; railway; pine plantation in riparian zone; gully erosion; forest plantation in riparian zone; jet boating; recreational fishing and gully erosion. The majority of sites had multiple disturbance factors that were evident at the time of survey and these were recorded. The 96 disturbance categories derived from the field survey were categorised as: natural; artificial; or natural and artificial.

2.2 Summary

A summary table of geographic, environmental, disturbance and climatic variables statistically interrogated to determine their influence on the distribution of native riparian vegetation in Tasmania is provided in Table 2.16.

Category of variable	Variable	Type
Geographic	Easting Northing Altitude (m) Aspect	Quantitative Quantitative Quantitative Disordered m-s
Hydrological	Surrounding Landform Stream Slope Flow Permanence Average Width of Channel Floodplain Position in Catchment Catchment area above site	Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s
Local geomorphic influences	Channel Shape Bank Shape Bank Slope Channel Control Bank slope variability Stream zone	Disordered m-s Disordered m-s Ordered m-s Disordered m-s Ordered m-s Disordered m-s
Geology, substrate and soils	Geology Organic Sand/Silt/Clay Gravel Cobble Bedrock/Boulders Soil texture Soil pH Soil EC (uS)	Disordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Disordered m-s Quantitative Quantitative
Biotic	Riparian Structure (forest/non-forest) Riparian Structure 2 (9 classes) Stratum 1 height Stratum 1 cover Stratum 2 height Stratum 2 cover Stratum 3 height Stratum 3 cover Trees Shrubs Prostrate Shrubs Herbs Graminoids Grasses Pteridophytes	Ordered m-s Disordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s Ordered m-s
Other Disturbance Factors	Stock usage of riparian zone Source of disturbance factor (natural; artificial; natural & artificial)	Ordered m-s Disordered m-s
Climate	18 temperature and rainfall parameters listed in Table 2.11.	Quantitative

(m-s = multi-state)

Table 2.16: Geographic, environmental and disturbance variables investigated to determine their contribution to the presence of native riparian species and floristic assemblages.

CHAPTER 3

Tasmania's Native Riparian Vegetation

> The earth's atmosphere; its plant, animal, and human inhabitants; its oceans, plains, and forests; its ecological stability; and its promise for mankind can only be grasped by observing the dynamic interrelationships that constitute its being. Isolate any part, and neither what you have taken nor what you have left behind remains what it was when all was one. (Savory 1988: 26*)

3.0 Introduction

The aims of this chapter are to describe the Tasmanian riparian vascular flora, the floristic assemblages that comprise Tasmanian riparian vegetation, and the environmental factors that are related to floristic variation in the riparian zone in Tasmania.

3.1 Survey Data

The field survey extended over approximately 50 000 km^2 of mainland Tasmania. As a result of the investigation, 460 reference riparian reaches were surveyed (Figure 3.1). The names of the watercourses whose riparian reaches were surveyed and the geographic coordinates that facilitate their ready location can be found in Appendix 2.

No stands of native riparian vegetation that met the selection criteria (Chapter 2) could be found in 44 of the grids surveyed (4 400 km^2). In 16 other grids surveyed (1 600 km^2), it was possible that some isolated stands of riparian vegetation may be present but access to potential sites was not possible. A summary table of areas surveyed where native riparian vegetation stands could not be located is provided in Appendix 3.

Of the 460 sites surveyed, 452 were used for data analysis in this chapter together with the 845 native vascular plant taxa found at these sites. Eight sites were excluded from analysis because of uncertainty relating to 'reference' status based on information that came to hand during or after the field survey. For example, at one site, the vegetation was just over 10 years old due to total clearing and rechannelisation of the watercourse. At another site, the vegetation was so heavily grazed that there was some doubt as to whether the suite of species recorded was adequately representative.

* Permission was obtained to use this excerpt on 25 March 2003.

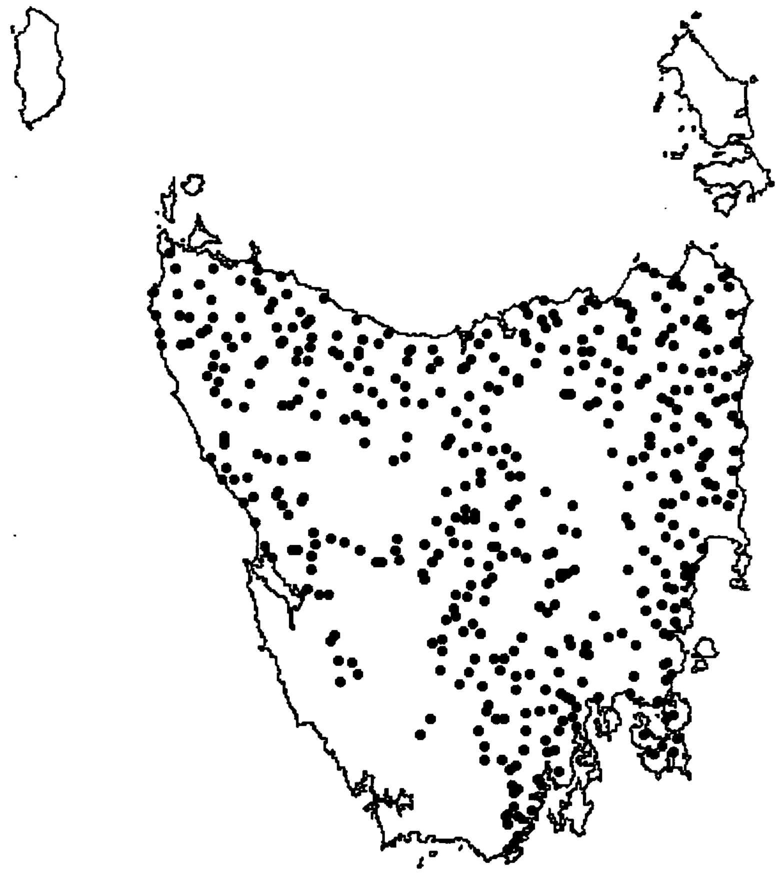


Figure 3.1: Riparian vegetation survey sites.

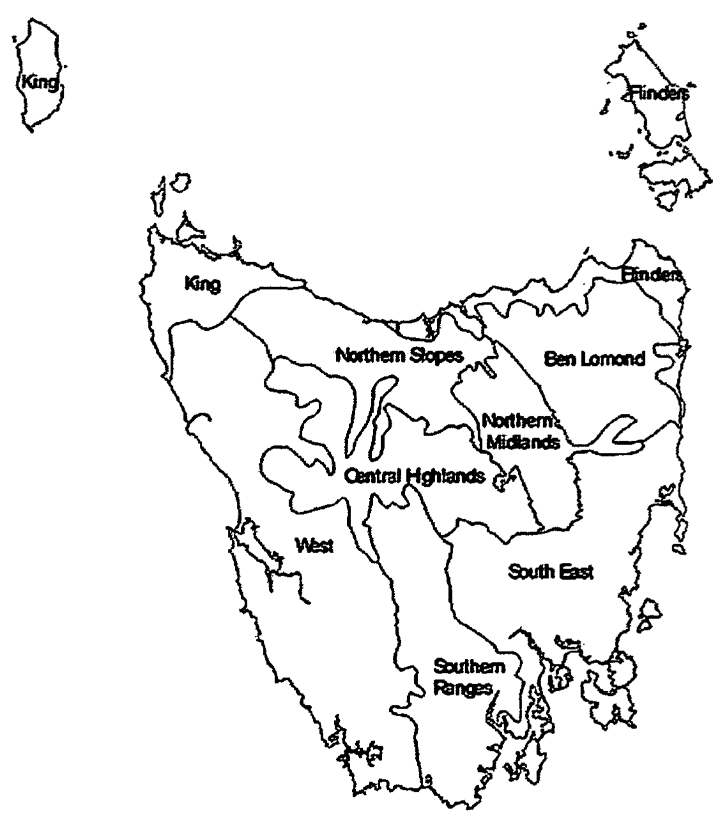


Figure 3.2: Tasmanian IBRA Bioregions. (Map supplied by Tony Davidson 2002)

3.2 Data analysis

In order to further understand associations and interactions between and amongst species in the riparian zone, and any significant environmental interactions, proven statistical tools developed for the analysis of ecological data were used to interrogate the reference data set. The statistical tools used for the present investigation were selected on the basis of repeated use by other plant ecologists, availability, ease of use, and access to experienced users and program support.

Data from each site were recorded in an Excel spreadsheet and transferred to DECODA (Database for Ecological Community Data) (Minchin 1990) where TWINSPAN (Two-way Indicator Species Analysis) (Hill 1979) was used to produce a polythetic, divisive classification of the sites into floristic groups based on species presence and absence data. Although TWINSPAN has been criticised for problems related to the repeatability of the classification process (Westfall *et al.* 1997: 137), TWINSPAN reveals the major floristic assemblages in ordered tables. These ordered tables can be visually scrutinized and allow judgments to be made concerning the major species composition of a floristic assemblage and the classification of sites into groups. Thus, classification of sites into floristic groups is based on detailed inspections of the sorted table, clarity of definition of different sections of the table, and the ecological knowledge of the researcher. Other methodologies could have been used to group floristic assemblages and classify survey sites into community groupings: e.g. cluster analysis (McCune & Mefford 1999). An attempt was made to use UGMPA cluster analysis. However there was considerable chaining in the resultant dendrogram. "Dendrograms that are highly chained are usually undesirable as they are generally not helpful in defining subgroups" (McCune & Mefford, 1999: 182).

The species which characterise a riparian floristic community were selected using a two-stage process: firstly, the species which were listed by TWINSPAN as the indicator species at each binomial splitting of the data; and secondly, unique assemblages of species which were generally faithful to only one community. A key to floristic communities was then developed.

A number of attributes were used to describe the riparian floristic communities: percentage frequency of species that occur in 30% or more of samples within the community; structural attributes; and affinity with previously listed communities. Bioregional location/s of the communities are noted in the descriptions. The structural description of each community was derived from the structural descriptions of all sites within a community. The vegetation structure that was common to the largest number of sites in a community was selected as the descriptor of the community. Affinity with previously described communities (those listed in Kirkpatrick *et al.* 1995, and Wintle 2002) was calculated as the percentage of the number of frequently occurring species in common, divided by the mean number of species in the two lists (Bray-Curtis similarities). An affinity score of 50% or greater was taken to indicate close similarity between the newly described community and a previously listed community.

The most widely-used bioregional system for the assessment and management of natural resources at the national and state levels has become the IBRA system (Australia, Interim Biogeographic Regionalisation for Australia system) (Environment Australia, 2000). IBRA bioregions have been used as the major subunit within the State from which to assess the reservation status of floristic communities and as a tool to facilitate any planning and management decisions or strategies that may arise from the results of riparian vegetation data analysis and any subsequent recommendations (Figure 3.2). Bioregions are defined by biological and environmental attributes and are frequently used as units for decision-making where there is uncertainty or a lack of knowledge about the status and function of ecosystem attributes (Thackway & Creswell, 1992; Brunckhorst, 1994).

Floristic similarities amongst groups were calculated using the Bray-Curtis distance measure on percentage frequency of species in groups (Appendix 4). A minimum spanning tree was used to display the floristic similarities (defined as the lowest value and second lowest Bray-Curtis values) amongst the groups. Global non-metric multi-dimensional scaling (MDS) of the floristic data using the Bray-Curtis co-efficient of dissimilarity was undertaken using the default options in DECODA (Minchin 1987a; Minchin 1987b; Minchin 1990). "Non-metric multidimensional scaling is an ordination method that is well suited to data that are nonnormal or are on arbitrary, discontinuous, or otherwise questionable scales" (McCune & Mefford, 1999:111). Amongst other uses, MDS is a method used to display community patterns through clustering and ordination of samples and the linking of community differences to patterns in the physical and chemical environment (Clarke, 1993). As some of the riparian data were discontinuous (e.g. aspect, geology and flow permanence) and the scales used were variable (e.g. annual rainfall; altitude – nearest 10 m interval), ordination was used in addition to classification to ensure that non-linear as well as linear relationships or patterns could be detected.

After examination of the stress values of the ordination, three dimensions were accepted with a minimum stress value of 0.172. Mean and standard deviations of MDS scores obtained from the ordination illustrates the floristic variation amongst riparian floristic communities (Appendix 7). The mean MDS scores for each community were plotted to illustrate the general distribution of communities in ordination space.

Vector-fitting analysis was performed within DECODA using continuous, qualitative and ordered multi-state variables, in the space defined by the three ordination axes. The technique determines the strength and direction of linear relationships within ordination space.

In MINITAB (Release 13.20, 2000) one-way analysis of variance (ANOVA) with Tukey's method and Hsu's MCB (multiple comparison with the best) using the largest "best", was used to test the strength of relationships between continuous and multi-state variables. Where only 1 community is differentiated by Hsu's MCB, only one indicator of difference will be provided in the results. Where more than one community was differentiated by Hsu's MCB, all differentiated communities were identified with an indicator of difference in the results.

Cross-tabulation of community with multi-state variables was undertaken. Chi-squared was used to test the significance of the variation from the expected random distribution. In all tests, the 95% confidence interval was used to test the null hypothesis.

In MINITAB, Principal Components Analysis (PCA) was used to identify the factors which explained the greatest variability within the environmental dataset. PCA facilitates the identification of principal variables from a large number of variables by reducing redundancy.

3.3 The vascular flora

This section presents the results of statistical analysis of the reference riparian data set with a specific focus on the vascular plant species. The major questions that were addressed were:

- How does species richness vary between sites?
- Which are the most commonly occurring life-forms in Tasmania's riparian lands?
- Which are the most frequently occurring vascular species in the riparian zone? and
- Are there any obligate riparian vascular species in Tasmania?

In addition, a brief account will be given of the exotic species observed in the riparian zone during the field survey but not included as part of the reference data set.

3.3.1 Observed vascular plant taxa

A total of 857 native taxa (Appendix 5) and 89 exotic taxa were recorded from the survey sites. The number of native species ranged between 10 at Falls Rivulet (a site within a Special Management Zone in the state forest within the Southern Ranges bioregion) to 85 along the middle reaches of the Little Swanport River in the South East bioregion. The riparian vegetation at Falls Rivulet is predominantly mature Horizontal (*Anodopetalum biglandulosum*) closed-scrub with a canopy of Sassafras (*Atherosperma moschatum*) and an understorey dominated by moss and a few sparsely distributed ferns. The riparian reach along the Little Swanport River is predominantly closed-scrub with a dense understorey of sedges, grasses, herbs and ferns. A variety of tree species occurs at this site but cover is usually less than 10%.

3.3.2 Observed vascular plant life-forms

Shrubs make up the majority of species in the riparian zone (Table 3.1). Herbs are the second most species-rich life-form, followed by graminoids. The species richness of ferns, trees and grasses in the riparian zone is relatively low, though the representation of Tasmanian native life-forms in the riparian zone is relatively high for trees and ferns.

Life-form	Count	Percentage of Total (%)	Percentage of Tasmanian native life-forms (%)
Trees	62	7.24	58.49
Shrubs	265	30.92	50.77
Graminoids	126	19.83	37.61
Herbs	231	26.95	35.65
Grasses	61	7.12	37.20
Ferns	68	7.94	53.54

Table 3.1: Life-form richness in the riparian zone, and relative to Tasmanian native life-forms.

3.3.3 Frequently occurring species in the riparian zone

No vascular plant species are ubiquitous in the riparian zone. The most commonly occurring were *Pomaderris apetala* and *Leptospermum lanigerum*. Only 8 species were found in more than half the sites and only 84 species in at least 10% of sites (Table 3.2). Therefore, most of the vascular species found in the riparian zone occur infrequently.

Common Riparian Species	%	Lifeform	Common Riparian Species	%	Lifeform
Pomaderris apetala	69	tree/shrub	*Bursaria spinosa*	22	shrub
Leptospermum lanigerum	65	tree/shrub	*Histiopteris incisa*	22	fern
Acaena novae-zelandiae	62	herb	*Monotoca glauca*	21	shrub
Acacia dealbata	61	tree	*Beyeria viscosa*	21	shrub
Blechnum nudum	60	fern	*Blechnum minus*	21	fern
Pteridium esculentum	58	fern	*Nematolepis squamea*	20	shrub
Acacia melanoxylon	58	tree	*Exocarpos cupressiformis*	20	shrub
Coprosma quadrifida	54	shrub	*Melaleuca squarrosa*	20	shrub
Carex appressa	46	sedge	*Juncus pauciflorus*	20	rush
Gahnia grandis	44	sedge	*Eucalyptus ovata*	19	tree
Polystichum proliferum	42	fern	*Lomatia tinctoria*	19	shrub
Dicksonia antarctica	41	fern	*Poa* spp.	19	grass
Cassinia aculeata	40	shrub	*Eucryphia lucida*	18	shrub
Blechnum wattsii	38	fern	*Epacris impressa*	18	shrub
Eucalyptus viminalis	38	tree	*Gleichenia microphylla*	17	fern
Lomandra longifolia	38	sagg	*Notelaea ligustrina*	16	tree
Acacia verticillata	37	tree/shrub	*Microsorum pustulatum*	16	fern
Oxalis perennans	34	herb	*Hypericum japonicum*	16	herb
Viola hederacea	34	herb	*Lepidosperma laterale*	15	sedge
Pimelea drupacea	34	shrub	*Euchiton* spp.	15	herb
Nothofagus cunninghamii	33	tree	*Sticherus tener*	15	fern
Agrostis spp.	33	grass	*Anopterus glandulosus*	15	shrub
Hydrocotyle hirta	33	herb	*Eucalyptus delegatensis*	15	tree
Eucalyptus obliqua	32	tree	*Schoenus* spp.	15	sedge
Poa labillardierei	32	grass	*Eucalyptus regnans*	15	tree
Leptospermum scoparium	31	tree/shrub	*Isolepis* spp.	15	sedge
Acacia mucronata	30	shrub	*Olearia argophylla*	14	shrub
Eucalyptus amygdalina	30	tree	*Hypolepis rugosula*	14	fern
Poaceae spp.	29	grass	*Juncus astreptus*	14	rush
Clematis aristata	27	climber	*Ozothamnus ferrugineus*	14	shrub
Olearia lirata	25	shrub	*Zieria arborescens*	14	shrub
Tasmannia lanceolata	25	shrub	*Allocasuarina littoralis*	13	shrub
Juncus spp.	25	rush	*Schoenus maschalinus*	13	sedge
Pultenaea juniperina	25	shrub	*Melaleuca ericifolia*	12	tree/shrub
Gonocarpus teucrioides	24	herb	*Aristotelia peduncularis*	12	shrub
Dianella tasmanica	24	lily	*Baloskion tetraphyllum*	12	rush
Banksia marginata	24	tree/shrub	*Eucalyptus globulus*	12	tree
Geranium potentilloides	23	herb	*Cyathodes juniperina*	11	shrub
Lepidosperma ensiforme	23	sedge	*Senecio hispidulus*	11	herb
Prostanthera lasianthos	23	shrub	*Billardiera longiflora*	10	climber
Pittosporum bicolor	23	shrub	*Juncus australis*	10	rush
Atherosperma moschatum	23	tree	*Lepidosperma elatius*	10	sedge

Table 3.2: Vascular plant taxa found at 10% or more riparian sites.

Riparian Species	Common Name	Life Form	Endemic (e) Rare (r) Vulnerable (v) Endangered (en)
Acacia axillaris	Midlands mimosa	shrub	e; v
Acacia sp. *	Derwent acacia	shrub	e
Acradenia frankliniae	Whitey wood	shrub	e
Alternanthera denticulata	Lesser joy weed	shrub	en
Amphibromus neesi	Swamp wallaby grass	grass	
Amphibromus spp.	Swamp wallaby grass	grass	
Asperula charophyton	Strap-leaf asperula	herb	en
Asterotrichion discolor	Currajong	shrub	e
Barbarea australis	Native wintercress	herb	e; en
Bertya rosmarinifolia	Bertya	shrub	v
Blechnum cartilagineum	Gristle-fern	fern	
Blechnum chambersii	Lance water fern	fern	
Callistemon viridiflorus	Prickly bottlebrush	shrub	e
Callitris oblonga	South Esk Pine	tree	e; v
Carex appressa	Tall sedge	sedge	
Carex gaudichaudiana	Sedge	sedge	
Carex polyantha	Sedge	sedge	
Centipeda cunninghamii	Common sneezeweed	herb	r
Discaria pubescens	Thorn bush; Anchor plant	shrub	
Eleocharis acuta	Common spike-rush	sedge	
Eleocharis gracilis	Slender spike-rush	sedge	
Eleocharis pusilla	Small spike-rush	sedge	
Epacris apsleyensis	Apsley heath	shrub	e; en
Epacris exserta	South Esk heath	shrub	e; v
Epacris grandis	Great heath	shrub	e; v
Epacris mucronulata	Franklin's heath	shrub	e
Eucalyptus ovata	Black or Marrawah gum	tree	
Gleichenia dicarpa	Pouched coral fern	fern	
Gleichenia microphylla	Scrambling coral fern	fern	
Gratiola nana	Matted brooklime	herb	
Gratiola peruviana	Austral brooklime	herb	
Gratiola pubescens	Hairy brooklime	herb	
Grevillea australis var. *australis*	Southern grevillea	shrub	
Grevillea australis var. *brevifolia*	Southern grevillea	shrub	e
Grevillea australis var. *erecta*	Southern grevillea	shrub	e
Grevillea australis var. *linearifolia*	Southern grevillea	shrub	e; r
Grevillea australis var. *planifolia*	Southern grevillea	shrub	e; r
Grevillea australis var. *subulata*	Southern grevillea	shrub	e
Grevillea australis var. *tenuifolia*	Southern grevillea	shrub	e
Gunnera cordifolia	Gunnera	herb	e
Gynatrix pulchella	Common hemp bush	shrub	obligate; r
Hydrocotyle comocarpa	Mueller's pennywort	herb	r
Hydrocotyle pterocarpa	Wing pennywort	herb	
Isolepis fluitans	Floating club-rush	sedge	
Isolepis inundata	Swamp club-rush	sedge	
Isolepis producta	Club-rush	sedge	
Isotoma fluviatilis	Swamp isotome	sedge	
Juncus procerus	Great rush	sedge	
Lagarostrobos franklinii	Huon pine	tree	e
Leptospermum riparium	Riverine tea-tree	shrub	e
Lycopus australis	Native gypsywort	herb	en
Lythrum salicaria	Purple loosestrife	herb	
Mazus pumilio	Swamp mazus	herb	
Micrantheum hexandrum	Box Micrantheum	shrub	
Milligania longifolia	Pendant milligania	sedge	e; r

* Description of this new species is in progress.

Table 3.3: Vascular plant taxa that show a strong preference for the riparian zone.

Riparian Species (continued)	**Common Name**	**Life Form**	**Endemic (e) Rare (r) Vulnerable (v) Endangered (en)**
Mimulus repens	Creeping monkey flower	herb	
Olearia obcordata	Heartleaf daisy bush	shrub	e
Oreomyrrhis gunnii	Gunns caraway	herb	e
Ourisia integrifolia	Creeping ourisia	herb	e
Persicaria decipiens	Slender knotweed	herb	v
Phebalium daviesii	Davies wax-flower	shrub	e; obligate; en
Plantago daltonii	Tasmanian alpine plantain	herb	e
Pomaderris elachophylla	Small-leaf pomaderris	shrub	v
Pomaderris phylicifolia	River dogwood	shrub	r
Pultenaea selaginoides	Clubmoss bush pea	shrub	e; v
Ranunculus amphitrichus	Water buttercup	herb	r
Richea gunnii	Gunn's richea	shrub	e
Rorippa dictyosperma	Lobed rorippa	herb	
Rumex bidens	Dock	herb	r
Rumex brownii	Swamp or slender dock	herb	
Scaevola aemula	Fairy fan-flower	herb	
Scaevola hookeri	Creeping fan-flower	herb	
Schoenus fluitans	Floating bog-rush	sedge	
Spyridium gunnii	Gunn's spyridium	shrub	e
Spyridium lawrencei	Small-leaf spyridium	shrub	e; v
Typha domingensis	Cumbungi; Bulrush	sedge	
Uncinia riparia	River hook-sedge	sedge	

Table 3.3 (contd): Vascular plant taxa that show a strong preference for the riparian zone.

3.3.4 Facultative, obligate and riparian species

There has been some mention in previous studies of particular plants being obligate or exclusive to the river environment as distinct from facultative riparian species or those that occur in a variety of other habitats (Hughes 1987; Askey-Doran 1993; Harris & Kirkpatrick 1991). Based on the observations and results of the present study and after discussions with staff at the Tasmanian Herbarium, it was agreed that there were many Tasmanian plants that were found predominantly in the riparian zone but these species were, nevertheless, mostly facultative riparian species. Of all native vascular plant species that are known to exist in Tasmania to date, only two species are considered to be obligate riparian species – *Gynatrix pulchella* and *Phebalium daviesii,* both rare in Tasmania. There are, however, 77 vascular plant taxa that are found predominantly in the riparian zone and therefore could be categorized as "riparian" plants (Table 3.3). *Prostanthera cuneata* was also found predominantly in the riparian zone, but it is now listed as extinct. It is of note that nearly 30% of the riparian species listed in Table 3.3 are threatened species.

Species	**Status under the *Threatened Species Protection Act 1995*** Rare (r) Vulnerable (v) Endangered (en)
Acacia axillaris	v
Callitris oblonga	v
Epacris apsleyensis	en
Epacris exserta	v
Grevillea australis var. *linearifolia*	r
Gynatrix pulchella	r
Milligania longifolia	r
Pomaderris phylicifolia ssp. *phylicifolia*	r
Ranunculus amphitrichus	r
Spyridium lawrencei	v
Acacia siculiformis	r
Asplenium hoorerianum	v
Asperula subsimplex	r
Baumea gunnii	r
Blechnum cartilagineum	v
Carex longebrachiata	r
Cypanthera tasmanica	r
Discaria pubescens	en
Ehrharta juncea	r
Eucalyptus radiata ssp. *robertsonii*	r
Eucalyptus gunnii	en
Epilobium pallidiflorum	r
Gratiola pubescens	v
Hypolepis muelleri	r
Juncus amabilis	r
Juncus prismatocarpus	r
Juncus vaginatus	r
Lepidosperma forsythii	r
Melaleuca pustulata	r
Muehlenbeckia axillaris	r
Olearia hookeri	r
Persicaria decipiens	v
Pimelea curviflora var. *gracilis*	r
Pimelea filiformis	r
Pimelea flava ssp. *flava*	r
Pimelea pauciflora	r
Poa mollis	r
Pomaderris oraria	r
Prostanthera rotundifolia	v
Ranunculus sessiliflorus	r
Sagina diemensis	en
Spyridium obcordatum	v
Teucrium corymbosum	r
Uncinia elegans	r
Westringia angustifolia	r
Xanthorhoea spp.	v

Table 3.4: Species found in the riparian zone that are listed under the *Threatened Species Protection Act 1995.*

Hughes (1987) found that in Tasmania, there appears to be a strong representation of woody species along watercourses. Although there is an absence of many obligate riverine species (as is the case elsewhere in Australia), the actual assemblage of species is very much confined to a riverine environment. Thus facultative riverine species are unlikely to be found growing in the same community in other environments.

3.3.5 Threatened species

At least 46 species listed under the *Threatened Species Protection Act* 1995 were found in the riparian zone during the survey (Table 3.4). *Xanthorrhoea* sp. is included in the list as there were two distinctively different taxa collected during the survey. As there are only three *Xanthorrhoea* species in Tasmania (Buchanan 1999), and two of them are listed as rare, one of the species found in the riparian zone must be rare.

3.3.6 Exotic species in the riparian zone

Ulex europaeus (Gorse), *Rubus fruticosus* (Blackberry), *Salix fragilis* (Crack willow) and *Crataegus monogyna* (Hawthorn) thrive in the riparian zone in Tasmania. While these prominent shrubs are prolific and form extensive stands across much of the developed riparian landscape, they are only four of 89 exotic species that were noted during the survey (Table 3.5). The large number of exotic species observed to be invading native stands of riparian vegetation is of concern.

Exotic Species	Common Name	Life Form
Acetosella vulgaris	Sheep sorrel	herb
Agrostis capillaris	Brown-top bent	grass
Agrostis stolonifera	Creeping bent	grass
Aira praecox	Early hairgrass	grass
Aira spp.		grass
Amaranthus deflexus	Spreading amaranth	herb
Anagallis arvensis	Scarlet pimpernel	herb
Anthoxanthum odoratum	Sweet vernal	grass
Aphanes arvensis	Parsley piert	herb
Atriplex prostrata	Hastate orache	herb
Bellis perennis	English daisy	herb
Brassica napus	Rape	herb
Brassica nigra	Black mustard	herb
Brassica rapa	Turnip	herb
Briza spp.	Quaking grass	grass
Bromus spp.		grass
Cakile edentula	American sea rocket	herb
Carduus pycnocephalus	Shore slender thistle	herb
Centaurea solstitialis	St. Barnaby's thistle	herb
Centaurium erythraea	Common centuary	herb
Cerastium glomeratum	Sticky mouse-ear chickweed	herb
Chrysanthemoides monilifera ssp. monilifera	Boneseed	herb
Cirsium vulgare	Spear thistle	herb
Convolvulus arvensis	Blushing bindweed	herb
Cotoneaster glaucophyllus	Greu-leaved cotoneaster	tree
Crataegus monogyna	Hawthorn	shrub
Cynosurus echinatus	Rough dogs-tail	herb
Cyperus eragrostis	American galingale	sedge
Dactylis glomerata	Cock's foot	grass
Digitalis purpurea	Foxglove	herb
Echium plantagineum		herb
Echium vulgare		herb
Erica lusitanica	Spanish heath	shrub
Erodium cicutarium	Common storksbill	herb
Erophila verna	Vernal whitlow grass	herb
Euphorbia lathyrus	Spurge	herb
Festuca spp.	Fescue species	grass
Geranium maderense		herb
Geranium molle	Mountain geranium	herb
Holcus lanatus	Yorkshire fog-grass	grass
Hypericum androsaemum		herb
Hypochoeris radicata	Cat's ear	herb
Juncus articulatus	Jointed rush	rush
Juncus bufonius	Toad rush	rush
Juncus bulbosus		rush
Juncus capitatus	Dwarf rush	rush
Juncus squarrosus		rush
Leontodon taraxacoides	Hawkbit	herb
Leycesteria formosa	Himilayan honeysuckle	shrub
Linum catharticum	flax	herb
Lolium spp.	Rye grass	grass
Lotus corniculatus	Bird's-foot trefoil	herb
Mimulus moschatus		herb
Myosotis arvensis	Forget-me-not	herb
Myosotis discolor	Forget-me-not	herb
Oxalis corniculata	Yellow wood sorrel	herb
Parentucellia latifolia	Bartsia	herb

Table 3.5: Exotic species in the riparian zone.

Exotic Species (continued)	Common Name	Life Form
Passiflora mollissima	Banana passionfruit	shrub\climber
Petrorhagia nanteuilii	Proliferous pink	herb
Phalaris spp.	Canary grass	grass
Pinus radiata	Monterey pine	tree
Pittosporum undulatum	Sweet pittosporum	tree
Plantago lanceolata	Narrow leaf plantain	herb
Poa annua	Annual grass	grass
Polycarpon tetraphyllum	Four-leaved allseed	herb
Polygala vulgaris		herb
Polypogon monspeliensis	Annual beard grass	grass
Prunella vulgaris	Self heal	herb
Psoralea pinnata	Blue butterfly bush	shrub
Ranunculus repens	Creeping buttercup	herb
Reseda alba		herb
Rubus fruticosus	Blackberry	shrub\climber
Rumex crispus	Curled dock	herb
Sagina procumbens	Procumbent pearlwort	herb
Salix fragilis	Crack willow	tree
Sambucus nigra	Elberberry tree	shrub
Senecio jacobaea	Ragwort	herb
Silybum marianum	Variegated thistle	herb
Sollya heretophylla		herb
Sonchus asper	Prickly sow thistle	herb
Spergularia media		herb
Spergularia rubra	Sand spurry	herb
Taraxacum officinale	Dandelion	herb
Trifolium spp.	Clover	herb
Ulex europaeus	Gorse	shrub
Vicia spp.	Vetch	herb\climber
Vinca major	Blue periwinkle	herb

Table 3.5 (contd): Exotic species in the riparian zone.

3.4 Riparian floristic communities

From the 460 stands of native riparian vegetation documented, there were 454 different descriptions of the vegetation based on the structural attributes, dominant species and life-forms that characterised each strata. The polythetic, divisive classification of the sites into floristic groups based on species presence and absence data resulted in the definition of 21 riparian floristic assemblages.

This section presents the results of statistical analysis of the reference riparian data set with a specific focus on the 21 riparian floristic communities. The major questions that were addressed were:

- Which species characterise Tasmania's riparian communities?
- Are there any similarities amongst the communities?
- Is there a process that can be followed to facilitate the consistent classification of riparian vegetation at sites into riparian communities?

- How are the communities distributed across Tasmania and what are their key structural and floristic attributes?
- How does species richness vary between riparian communities?

3.4.1 Species that characterise Tasmania's native riparian communities

The groups of indicator species used to classify the TWINSPAN sorting of sites into floristic groups are shown in Figures 3.3 and 3.4. These groups form the basis of the 21 riparian communities. The species in Groups 1-3 are characteristic of alpine and sub-alpine vegetation in Tasmania (Figure 3.3). The species in Group 4 are characteristic of estuarine habitats. Species in Groups 5-12 are generally associated with different types of vegetation found in the drier regions of Tasmania (Figure 3.3).

The species in Groups 13-19 are frequently found in wet forests or rainforests in higher rainfall areas of Tasmania (Figure 3.4). The species in Groups 20 and 21, are commonly found in heaths associated with low nutrient soils mainly in western Tasmania (Figure 3.4).

As a general principle, the species that are listed towards the top of the tree could be considered common to all groups that branch below. The indicator species that characterise a group, are not necessarily found at all of the sites belonging to that group. In two cases, it was the absence of indicator species that characterised the group (Groups 8 and 18).

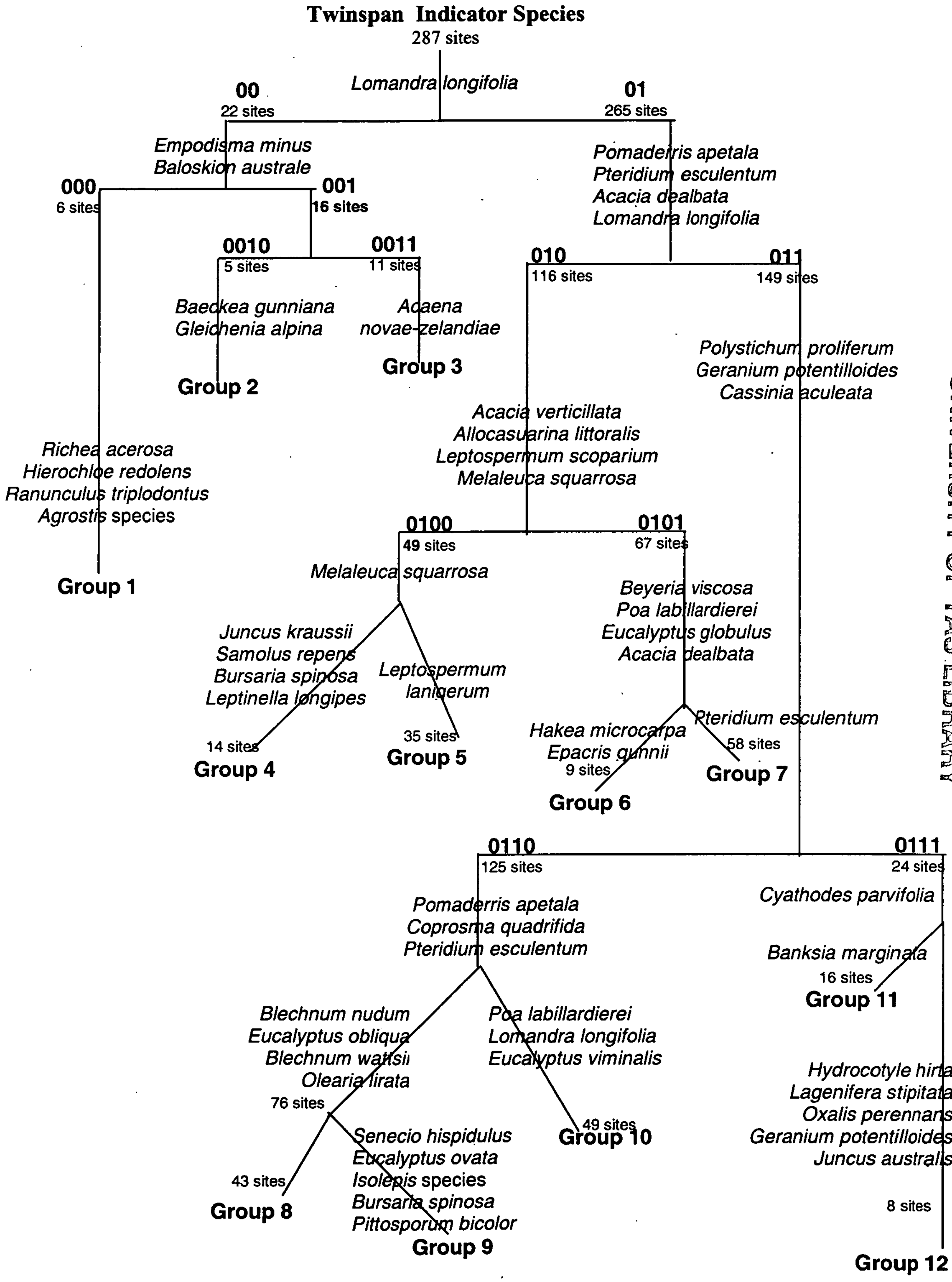


Figure 3.3: Indicator species for groups 1-12

UNIVERSITY OF TAS LIBRARY

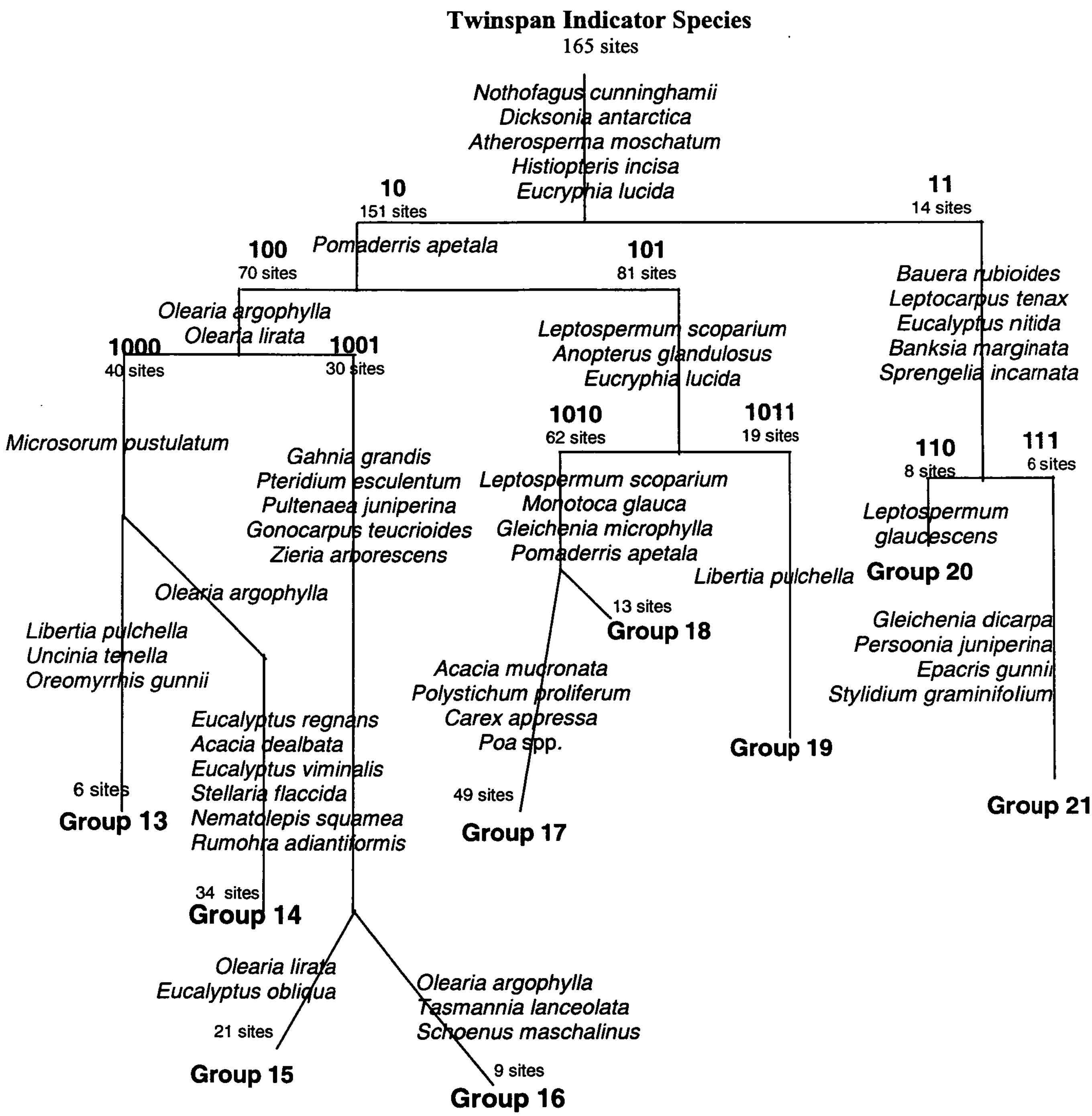


Figure 3.4: Indicator species for Groups 13-21.

3.4.2 Similarities between riparian floristic communities

Some of the more widespread communities (e.g. Communities 7, 8, 15 and 17) have links with several other communities (Figure 3.6; see Appendix 4 for values). Other communities are quite distinctive in their floristic composition, with very few close links with other communities (e.g. Groups 1, 4, 6, 14 and 18).

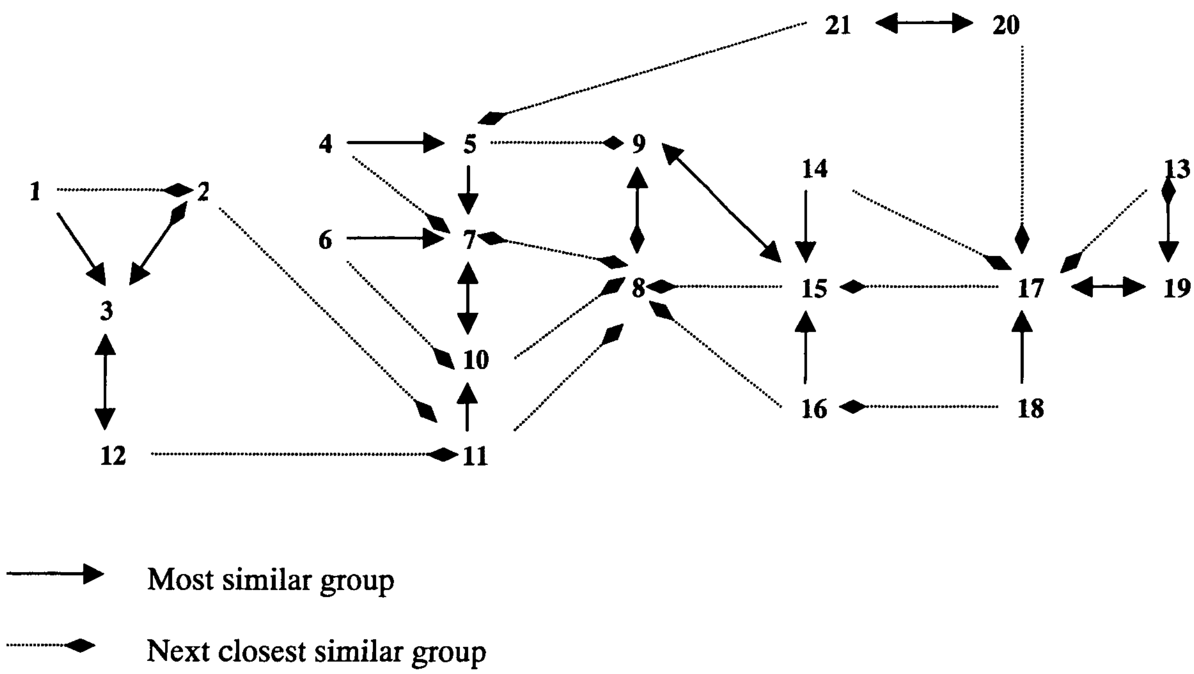


Figure 3.5: Minimum spanning tree depicting floristic similarities between groups calculated using the Bray-Curtis distance measure based on percentage frequency of species in groups.

In ordination space, many of the floristic communities are not clearly differentiated from each other. The floristic similarities amongst groups are not dissimilar from the groupings revealed by the minimum spanning tree (Figure 3.5). However, there are some notable differences. Community 3 is more closely related to Communities 20 and 21 than to Communities 1 and 2, and Community 11 is more closely related to Community 5 than to Community 12. Using ANOVA, communities were significantly different on Axis 1 ($p = 0.000$) and Axis 2 ($p = 0.004$) but not on Axis 3 (0.0.089).

The MDS scores for each community were plotted to illustrate the general distribution of communities in ordination space (Figure 3.6).

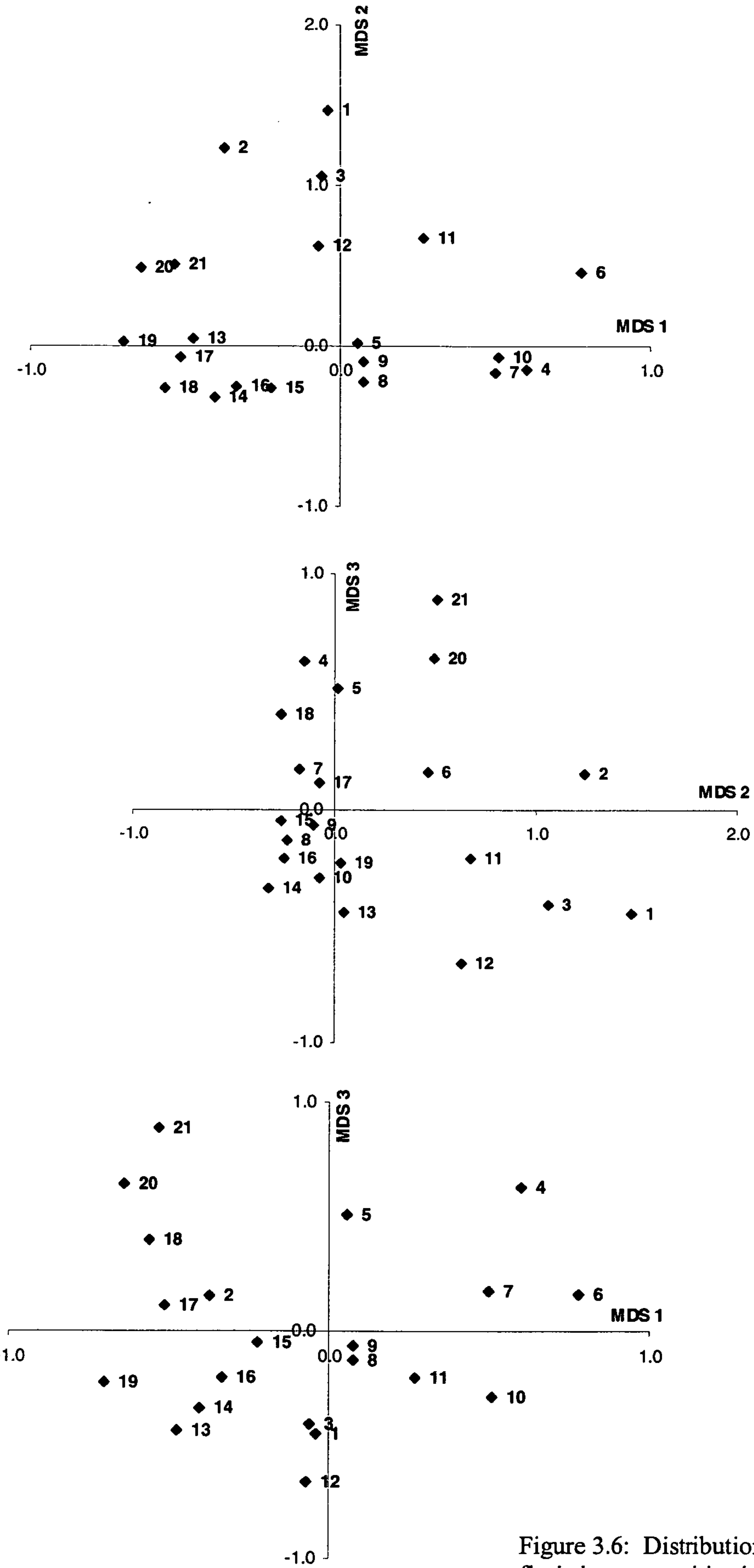


Figure 3.6: Distribution of riparian floristic communities in ordination space (each pair of axes in the three dimensions is represented).

3.4.3 Classification of sites into riparian floristic communities – a key

In order to develop some consistency in the classification of sites into floristic communities and to facilitate rapid classification of sites in the field, a key to the riparian floristic communities was developed. This key is based on the presence of species within a group and facilitates the identification of major riparian floristic communities. It should be used in conjunction with the indicator species dendrograms (Figures 3.4 and 3.5) and the physical and structural descriptions of the communities provided in section 3.3.4. The key should be used sequentially (i.e. if a group of species is not found in the first community, move to the next community). If a reach of riparian vegetation does not key out satisfactorily or suitably match a described community, it may represent an undescribed community.

In most cases, the key lists the most abundant species in a group. However, where groups are similar, based on the presence of species, only the species that best differentiate between the groups are used in the key.

1 *Baeckea gunniana, Richea acerosa, Hierochloe redolens* and *Agrostis* species and one from *Ranunculus triplodontus* and *Epacris serpyllifolia*...**Community 1**

2 *Baeckea gunniana* and *Gleichenia alpina* and one from *Oxylobium ellipticum* or *B. gunniana* and *Rubus gunnianus* and two from *Gymnoschoenus sphaerocephalus, Lomatia polymorpha, Allocasuarina zephyra*.. **Community 2**

3 *Leptospermum lanigerum* and at least three from *Eucalyptus gunnii, Acaena novae-zelandiae, Cyathodes parvifolia,* and *Carex gaudichaudiana* ....**Community 3**

4 *Juncus kraussii* and at least one from *Acacia sophorae, Samolus repens, Gahnia filum, Selliera radicans* and *Schoenus nitens* or three from *Bursaria spinosa, Exocarpos cupressiformis, Leucopogon parviflorus, Rhagodia candolleana* ....**Community 4**

5 Two from *Pteridium esculentum, Melaleuca squarrosa, Leptospermum lanigerum* and *Gahnia grandis* and at least three from *Dicksonia antarctica, Blechnum nudum, Blechnum minus, Blechnum wattsii, Polystichum proliferum, Gleichenia microphylla, Gleichenia dicarpa* and *Hydrocotyle hirta* ....**Community 5**

6 *Hakea microcarpa* and *Epacris gunnii* or *Lepidosperma inops* or three from *Hibbertia prostrata, Hibbertia riparia, Lagenifera stipitata, Epacris apsleyensis, Grevillea australis, Baumea juncea, Baeckea ramosissima* and *Astroloma humifusum* .... **Community 6**

7 At least three from *Eucalyptus globulus, Acacia melanoxylon, Allocasuarina littoralis, Bedfordia salicina, Cassinia aculeata, Beyeria viscosa, Epacris impressa, Lepidosperma laterale* and *Pteridium esculentum* ....**Community 7**

8 At least two from *Acacia dealbata, A. mucronata, Eucalyptus obliqua, E. regnans, E. delegatensis,* and at least two from *P. apetala, Coprosma quadrifida, Cassinia aculeata, A. verniciflua, A. verticillata, Prostanthera lasianthos, Bedfordia salicina, Olearia lirata, O. viscosa, Notolaea ligustrina, Callistemon pallidus* and at least one from *Hypericum japonicum, Senecio species, Juncus species, Schoenus species, Isolepis species, Carex species, Gleichenia microphylla* and *Blechnum fluviatile*.........**Community 8**

9 At least two from *Eucalyptus ovata, E. delegatensis, Acacia melanoxylon, A. verticillata, A. dealbata and Melaleuca ericifolia* and at least two from *Pittosporum bicolor, Exocarpos cupressiformis, Bursaria spinosa, Micrantheum hexandrum, Correa lawrenceana, Ozothamnus ferrugineus, Tasmannia lanceolata, Senecio hispidulus, Blechnum minus* and *Rubus parvifolius* ....**Community 9**

10 At least three from *Eucalyptus viminalis, Pomaderris apetala, Cassinia aculeata, Poa labillardierei, Lomandra longifolia* and *Carex appressa* and at least two from *Bursaria spinosa, Acacia melanoxylon, Beyeria viscosa, Coprosma quadrifida, E. amygdalina, Olearia viscosa, Asterotrichion discolor, Lepidosperma laterale, Lepidosperma ensiforme, Polystichum proliferum* and *Leptinella longipes*......................................**Community 10**

11 At least two from *Eucalyptus coccifera, E. delegatensis, E. pauciflora, E. rodwayi, E. rubida, E. ovata, E. dalrympleana* and at least three from *Pultenaea juniperina, Hakea microcarpa, Notolaea ligustrina, Lomandra longifolia, Banksia marginata, Oxylobium ellipticum, Lomatia tinctoria, Cassinia aculeata, Coprosma hirtella* and *Almaleea subumbellata*..**Community 11**

12 At least 5 from *Geranium potentilloides, Hydrocotyle hirta, Blechnum penna-marina, Gonocarpus montanus, Gonocarpus micranthus, Euchiton involucratus, Oxalis perennans, Lagenifera stipitata* and *Carex gaudichaudiana*..**Community 12**

13 *Nothofagus cunninghamii* and *Atherosperma moschatum* and at least two from *Poa labillardierei, Libertia pulchella, Uncinia tenella* and *Aristotelia pedunculata*..**Community 13**

14 At least three from *Olearia argophylla, Monotoca glauca, Microsorum pustulatum, Rumorha adiantiformis, Juncus pauciflorus, Utrica incisa, Muehlenbeckia gunnii, Grammitis billardierei, Hypolepis rugosula* and *Hymenophyllum flabellatum*..**Community 14**

15 At least three from *Pomaderris apetala, Olearia lirata, Eucalyptus obliqua, Prostanthera lasianthos* and *Acacia mucronata* and two from *Gahnia grandis, Dianella tasmanica, Lepidosperma ensiforme, Pultenaea juniperina, Blechnum minus* and *Sticherus tener* ....**Community 15**

16 *Dicksonia antarctica, Acacia dealbata, Pomaderris apetala, Olearia argophylla* and one of *Eucalyptus regnans* or *E. delegatensis* and one of *Tasmannia lanceolata* or *Euchiton collinus* ....**Community 16**

17 *Nothofagus cunninghamii* and *Acacia mucronata* or *Nematolepis squamea* and *Eucalyptus nitida* or *E. obliqua* and at least two from *Leptospermum riparium, Gleichenia microphylla, Histiopteris incisa* and *Monotoca glauca* ....**Community 17**

18 *Acacia verticillata* and/or *Eucalyptus regnans* and two from *Acacia riceana, Acacia dealbata, Olearia stellulata, Melaleuca squamea, Gleichenia dicarpa, Drymophila cyanocarpa, Pimelea cinerea* and *Carex fascicularis*...**Community 18**

19 *Nothofagus cunninghamii* and at least three from *Libertia pulchella, Anopterus glandulosus, Trochocarpa cunninghamii, Trochocarpa gunnii, Archeria eriocarpa, Coprosma nitida, Cenarrhenes nitida, Hakea lissosperma, Richea pandanifolia, Blechnum fluviatile and Oxalis magellanica* ....**Community 19**

20 Two from *Eucalyptus nitida, Acacia mucronata* and *Baloskion tetraphyllum* and at least two from *Nothofagus cunninghamii, Gymnoschoenus sphaerocephalus, Diplarrena latifolia, Calorophus elongatus, Gaultheria hispida* and *Lepidosperma filiforme*.....................................**Community 20**

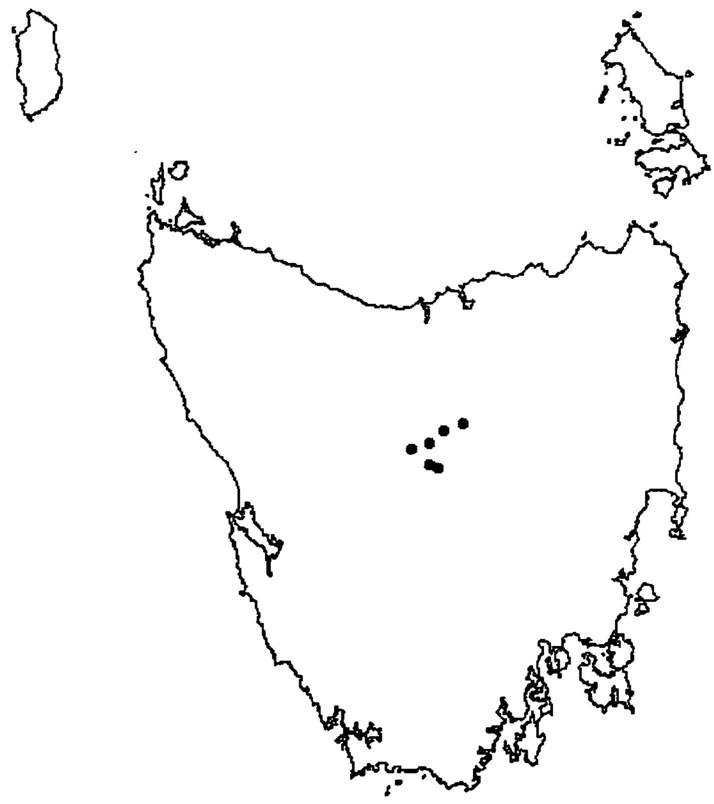
21 Gleichenia dicarpa and either Persoonia juniperina or Philotheca virgata..**Community 21**

An evaluation of the use of the key in conjunction with the indicator species dendogram and descriptions of the riparian floristic communities is provided in Chapter 5 where these tools were used to classify 8 test sites.

3.4.4 Description of riparian floristic communities

A map indicating the location of sites in each of the 21 communities together with the vascular plant species that occur at 30% or more of the sites that comprise a community, a brief description of the major characteristics of each community, and photographs depicting some of the sites representative of the riparian floristic community, follow. The name of the each community was derived after interrogating the data at all sites that comprise a community and then by combining: most frequently occurring species; characteristic and/or indicator species; and frequently occurring structural manifestations.

Community 1 *Orites acicularis-Baeckea gunniana-Richea acerosa-Hierochloe redolens-Poa costiniana* grassy heath



Common species

Almaleea subumbellata	shrub	*Hypericum japonicum*	herb
Baeckea gunniana	shrub	*Isotoma fluviatilis*	herb
Bauera rubioides	shrub	*Leptinella reptans*	herb
Bellendena montana	shrub	*Mimulus repens*	herb
Epacris gunnii	shrub	*Myriophyllum* species	herb
Grevillea australis var. *montana*	shrub	*Nymphoides exigua*	herb
Leptospermum lanigerum	shrub	*Plantago daltoni*	herb
Leptospermum rupestre	shrub	*Plantago paradoxa*	herb
Orites acicularis	shrub	*Pratia pedunculata*	herb
Orites revoluta	shrub	*Ranunculus* species	herb
Ozothamnus hookeri	shrub	*Ranunculus triplodontus*	herb
Richea gunniana	shrub	*Senecio gunnii*	herb
Carex gaudichaudiana	sedge	*Veronica gracilis*	herb
Carex species	sedge	*Viola cunninghamii*	herb
Baloskion australe	rush	*Agrostis* species	grass
Empodisma minus	rush	*Austrodanthonia species*	grass
Juncus sandwithii	rush	*Hierochloe redolens*	grass
Acaena montana	herb	*Poa costiniana*	grass
Acaena novae-zelandiae	herb	*Poa* species	grass
Geranium potentilloides	herb	Poaceae species	grass
Geranium sessiliflorum	herb	*Lycopodium fastigiatum*	fern
Gonocarpus serpyllifolius	herb	Marsupial lawn	grass/sedge/herb
Helichrysum rutidolepis	herb	Moss species	
Hydrocotyle hirta	herb	Lichen species	
Hydrocotyle muscosa	herb		

Community 1 *Orites acicularis-Baeckea gunniana-Richea acerosa-Hierochloe redolens -Poa costiniana* grassy heath

The species that best characterise this community are *Baeckea gunniana, Richea acerosa, Hierochloe redolens, Agrostis species, Ranunculus triplodontus* and *Epacris serpyllifolia.*

This floristic community occurs in the Central Highlands at altitudes of 1000 m or higher and was found in the catchments of the River Ouse, the upper River Derwent and along a watercourse that now drains into Great Lake.

There are two distinctive structural variants within this community – heath and open-heath over closed-grassland. In the tallest stratum of the heath communities, *Orites acicularis*, *Baeckea gunniana* and *Leptospermum rupestre* are dominant and form closed thickets over lower strata usually dominated by alpine grasses, sedges, rushes and a diverse array of herbs. There is one site allocated to this community whose tallest stratum is dominated by *Leptospermum nitidum* and *L. lanigerum* overlaying an understorey dominated by *Grevillea australis* var. *montana* and *Baeckea gunniana* over herbs and the pteridophyte, *Lycopodium fastigiatum.*

Open-heath grassland communities are much shorter, rarely exceeding 0.5 metres in height. *Richea acerosa* is the dominant woody shrub in the tallest stratum of this variant with a covering of less than 50%. There is a dense cover in the ground stratum of tussock grasses, mainly *Poa costiniana* and *Austrodanthonia* species in association with *Hierochloe* and other Poaceae species.

This riparian community adjoins grassy-sedgey heath dominated by *Ozothamnus*, *Leptospermum* or *Richea* species and *Eucalyptus coccifera* heathy open forest. It is closely related floristically to Community 3.

No affinity exists between this community and any other described vascular community.

Examples of the different structural variants of this floristic community can be seen in Plates 2 and 3.

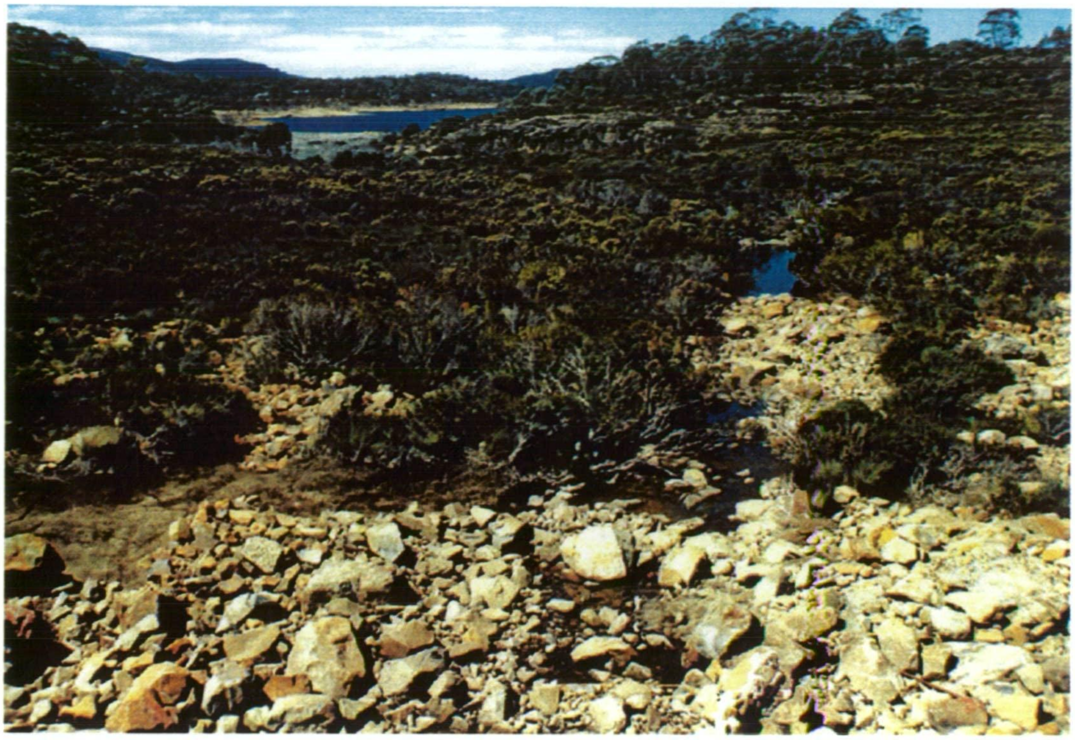
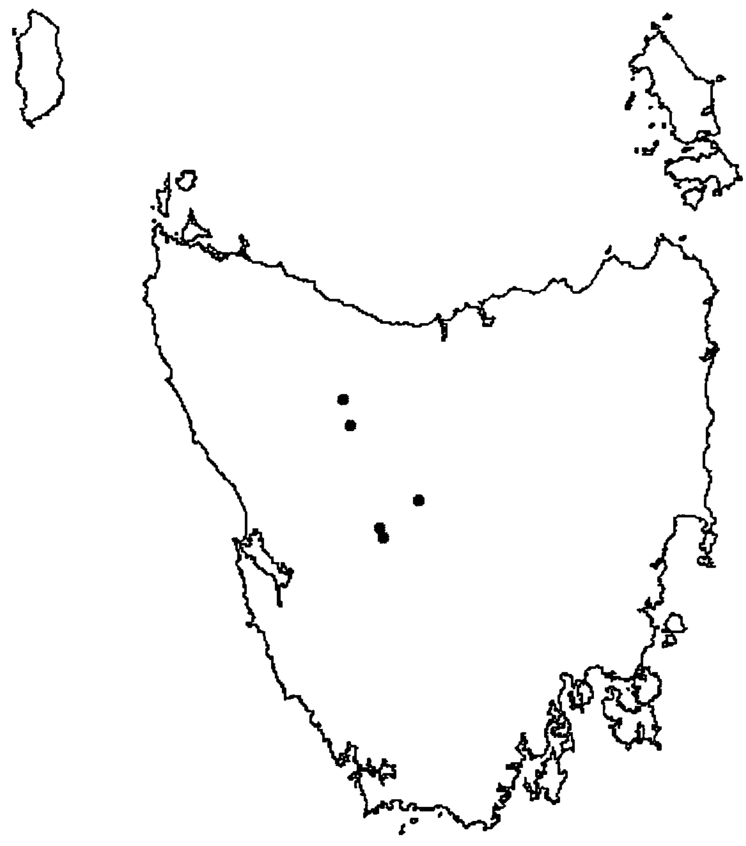


Plate 2 *Baeckea gunniana* heath at Site 208 – Pine Tree Rivulet.

Plate 3 *Baeckea gunniana* heath over closed-grassland at Site 230 - Little Pine Rivulet.

Community 2 *Eucalyptus* open-forest over *Baeckea gunniana-Gleichenia alpina-Rubus gunnianus* sedgey-ferny closed-heath



Common species

Eucalyptus pauciflora	tree	*Gahnia grandis*	sedge
Allocasuarina zephyrea	shrub	*Gymnoschoenus sphaerocephalus*	sedge
Almaleea subumbellata	shrub	*Lepidosperma filiforme*	sedge
Baeckea gunniana	shrub	*Baloskion australe*	rush
Bauera rubioides	shrub	*Calorophus elongatus*	rush
Callistemon viridiflorus	shrub	*Empodisma minus*	rush
Coprosma nitida	shrub	*Astelia alpina*	lily
Epacris gunnii	shrub	*Diplarrena latifolia*	iris
Epacris lanuginosa	shrub	*Diplarrena moraea*	iris
Hakea lissosperma	shrub	*Acaena montana*	herb
Hakea microcarpa	shrub	*Cotula alpina*	herb
Leptospermum lanigerum	shrub	*Nymphoides exigua*	herb
Lomatia polymorpha	shrub	*Pratia surrepens*	herb
Lomatia tinctoria	shrub	*Rubus gunnianus*	herb
Melaleuca squamea	shrub	*Austrostipa* species	grass
Oxylobium ellipticum	shrub	*Dichelachne* species	grass
Pultenaea juniperina	shrub	*Ehrharta tasmanica*	grass
Sprengelia incarnata	shrub	*Poa* species	grass
Tasmannia lanceolata	shrub	*Gleichenia alpina*	fern
Carex gaudichaudiana	sedge	Lichen species	

Community 2 *Eucalyptus* open-forest over *Baeckea gunniana-Gleichenia alpina-Rubus gunnianus* sedgey-ferny closed-heath

The floristic assemblage that characterises this community is *Baeckea gunniana, Gleichenia alpina, Oxylobium ellipticum, Rubus gunniana, Gymnoschoenus sphaerocephalus, Lomatia polymorpha* and *Allocasuarina zephyrea.*

This community occurs in the Central Highlands at altitudes between 700 m and 1000 m. It occurs in the headwaters and middle-order streams of the River Forth, upper River Derwent and Pieman River catchments. This community is distinguishable from the previous community mainly by the diversity of heathy species, the prominance of graminoids and/or ferns in the lower strata and the sparseness of herb cover.

There are two distinctive structural variants within this community – *Eucalyptus* open-forest with a heathy understorey and *Hakea-Leptospermum* ferny-sedgey-grassy heath. In the tallest stratum of the open-forest, *Eucalyptus delegatensis* or *Eucalyptus pauciflora* occur as dominants with *E. rodwayi, E. dalrympleana* and *E. gunnii* occasionally present. *Leptospermum lanigerum* and *Melaleuca squamea* are dominant in the second stratum amongst a variety of other shrubs. The ground layer in this variant of the community is also dominated by shrubs of which *Cyathodes parvifolia* and *Bauera rubioides* are the most common, interspersed with a sparse covering of herbs and a variety of graminoids, including rushes, cord rushes and sedges and/or a variety of ferns.

In the treeless heath community, *Baeckea gunniana, Leptospermum rupestre, L. nitidum, L. lanigerum* and *Hakea epiglottis* are the dominant shrubs in the tallest stratum, usually with a cover of between 10 and 25% and a height between 1.5 m and 2 m. The second stratum of this community is also characterised by a diverse range of heathy shrubs with a cover of between 76% and 100% and a height between 0.5 m and 1 m. The dominant species recorded in this stratum are *Nematolepis squamea* subsp. *retusa*, *Hakea lissosperma, Melaleuca squamea, Ozothamnus hookeri, L. lanigerum, Carex gaudichaudiana* and *Baeckea gunniana.* At several sites within this community, there were no species that could be distinguished as being dominant in this stratum. The ground stratum in this community has a cover of between 76% and 100%. Where dominant species are discernible in the ground stratum, these are usually *Bauera rubioides, Poa* species, *Gleichenia alpina* and *Cyathodes parvifolia.*

This riparian community is found adjacent to *Eucalyptus delegatensis, E. pauciflora, E. rodwayii* and *E. coccifera* heathy woodlands, buttongrass plains and, at one site, a *Poa* tussock grassland. It is closely related floristically to Community 3.

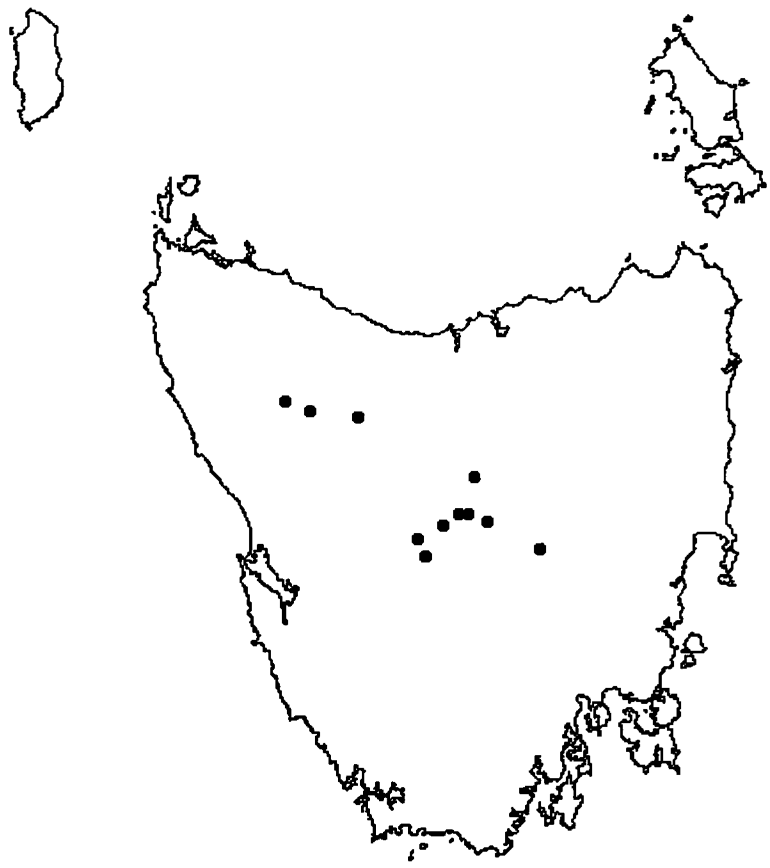
No affinity exists between this community and any other described vascular community.

Examples of the different structural variants of this floristic community can be seen in Plates 4 and 5.

Plate 4 *Eucalyptus* heathy open-forest at Site 228 – Navarre River.

Plate 5 Grassy heath at Site 459 – Lake Lea Creek.

Community 3 ***Eucalyptus gunnii*** **woodland or open-forest over** ***Leptospermum lanigerum*** **herby, grassy, sedgey heath and scrub**



Common species

Eucalyptus gunnii	tree	*Hydrocotyle hirta*	herb
Eucalyptus pauciflora	tree	*Hydrocotyle sibthorpioides*	herb
Leptospermum lanigerum	tree/shrub	*Hypericum japonicum*	herb
Bauera rubioides	shrub	*Oxalis perennans*	herb
Callistemon viridiflorus	shrub	*Plantago paradoxa*	herb
Coprosma nitida	shrub	*Agrostis* species	grass
Cyathodes parvifolia	shrub	*Austrodanthonia* species	grass
Epacris gunnii	shrub	*Poa labillardierei*	grass
Epacris lanuginosa	shrub	*Poa* species	grass
Grevillea australis var. *montana*	shrub	*Baloskion australe*	rush
Hakea microcarpa	shrub	*Empodisma minus*	rush
Ozothamnus hookeri	shrub	*Juncus australis*	rush
Pultenaea juniperina	shrub	*Carex gaudichaudiana*	sedge
Tasmannia lanceolata	shrub	*Blechnum penna-marina*	fern
Acaena novae-zelandiae	herb	*Blechnum nudum*	fern
Epilobium billardierianum	herb	Marsupial lawn	grass/sedge/herb
Geranium potentilloides	herb	Moss species	
Gonocarpus montanus	herb	Lichen species	
Gonocarpus serpyllifolius	herb		

Community 3 *Eucalyptus gunni* woodland or open-forest over herby, grassy, sedgey *Leptospermum lanigerum* open-heath and closed-scrub

The assemblage of species that characterises this community is *Leptospermum lanigerum, Eucalyptus gunnii, Acaena novae-zelandiae, Cyathodes parvifolia* and *Carex gaudichaudiana.*

This floristic community occurs in the Central Highlands and the Southern Ranges bioregions at altitudes between 650 m and 1050 m. This community was recorded mostly in the upper reaches of the Arthur River, River Clyde, River Ouse, Pieman River and upper River Derwent catchments and along watercourses that drain to the north coast and to Great Lake. It is distinguishable from the previous community by the dominance of *Eucalyptus* species in the tallest stratum and the dominance of *Leptospermum lanigerum* in the second stratum.

In the tallest stratum, *Eucalyptus* species are generally between 8 m and 30 m tall and have a cover of less than 25%. *E. gunnii* is most common but *E. pauciflora*, *E. rodwayi*, *E. coccifera*, and *E. dalrympleana* may also be present or dominant.

In the second stratum, *L. lanigerum* may range in height from less than 2m to 8 m and varies in cover from 25% to over 76%. *Banksia marginata, Callistemon viridiflorus* and *Hakea epiglottis* may also be present as co-dominants in the second stratum. *Tasmannia lanceolata, Hakea microcarpa, Coprosma nitida, Bedfordia linearis*, *Grevillea australis* and *Almaleea subumbulata* are frequently found in the second stratum.

The ground stratum of this community displays the greatest variation in species composition and cover. The dominant species include *Carex gaudichaudiana, Poa labillardierei, Bauera rubioides, Cyathodes parvifolia, L. lanigerum* and *Baloskion australe*, although there is sometimes no clear dominant because of the diverse combination of herbs, *Poa* and Cyperaceae species found in this community. This is one of the communities most often frequented by native animals, as marsupial lawns occur in over half the sites.

There is one site within this community, Hatfield Creek, which has no tree cover and is structured as *L. lanigerum* closed scrub over herby *Carex gaudichaudiana* closed- sedgeland. There is also one site where *L. rupestre* is the dominant shrub in the second stratum in the absence of *L. lanigerum.*

This riparian community is found adjacent to buttongrass plains and heathy and scrubby *Eucalyptus* woodland and open-forest. It is closely related to Community 12.

No affinity exists between this community and any other described vascular community.

Examples of two of the structural variants of this floristic community can be seen in Plates 5 and 6.

Plate 6 *Eucalyptus* woodland over *Leptospermum lanigerum* sedgey heath at Site 139 – Shannon River.

Plate 7 *Leptospermum lanigerum* closed-scrub and *Carex gaudichaudiana* herby closed-sedgeland at Site 457 – Hatfield Creek.

Community 4 ***Melaleuca ericifolia-Lomandra longifolia-Juncus kraussii*** **estuarine forest and scrub**

Common species

Acacia dealbata	tree	*Pultenaea daphnoides*	shrub
Eucalyptus amygdalina	tree	*Lepidosperma elatius*	sedge
Eucalyptus obliqua	tree	*Lepidosperma ensiforme*	sedge
Eucalyptus ovata	tree	*Schoenus nitens*	sedge
Eucalyptus viminalis	tree	*Gahnia filum*	sedge
Exocarpos cupressiformis	tree	*Lomandra longifolia*	sagg
Melaleuca ericifolia	tree/shrub	*Acaena novae-zelandiae*	herb
Pomaderris apetala	tree/shrub	*Gonocarpus teucrioides*	herb
Acacia sophorae	shrub	*Leptinella longipes*	herb
Acacia verticillata	shrub	*Oxalis perennans*	herb
Banksia marginata	shrub	*Phragmites australis*	grass
Bursaria spinosa	shrub	*Agrostis* species	grass
Coprosma quadrifida	shrub	*Poa labillardieri*	grass
Leptospermum scoparium	shrub	*Dianella tasmanica*	lily
Leucopogon australis	shrub	*Pteridium esculentum*	fern
Melaleuca squarrosa	shrub	Moss species	

Community 4 *Melaleuca ericifolia-Lomandra longifolia-Juncus kraussii* estuarine forest and scrub

The species that characterise this community are mostly salt tolerant. The floristic assemblage includes *Juncus kraussii, Samolus repens, Gahnia filum, Acacia sophorae, Selliera radicans, Schoenus nitens, Bursaria spinosa, Exocarpos cupressiformis, Leptinella longipes, Phragmites australis, Leucopogon parviflorus* and *Rhagodia candolleana.*

This floristic community occurs in the King, Northern Slopes, Flinders and Southern Ranges bioregions. It is found at the estuaries of the Arthur, Boobyalla, Catamaran, Mersey, Tomahawk, Brid, Little Forester, Curries, Detention, Black and Inglis Rivers, the River Leven and Gumbill and Tam O'Shanter Creeks.

Melaleuca ericifolia is present at nearly all sites and is dominant in one third of the sites. However, *Eucalyptus amygdalina, E. ovata, E. obliqua, E. pauciflora, E. pauciflora, Melaleuca squarrosa and Acacia sophorae* also occur as dominants in the tallest stratum. *Banksia marginata, Leptospermum scoparium* and *Pomaderris apetala* are frequently found as co-dominants within the tallest stratum. The tallest stratum ranges in cover from 25% to 100%.

Where *Eucalyptus* species are present in the tallest stratum, *M. ericifolia* is frequently dominant in the second stratum. *M. squarrosa, Leucopogon parviflorus, L. scoparium, Allocasuarina littoralis, Rhagodia candolleana* and *A. sophorae* are also amongst the shrubs that dominate in the second stratum. At some sites within this community, graminoids are dominant in the second stratum. *Lepidosperma elatius, L. ensiforme,* and *Gahnia filum* are the most common. The grass, *Phragmites australis* was also recorded as an infrequent dominant species in this stratum.

The ground stratum displays greatest variability in its composition frequently including a variety of grasses, sedges, rushes, ferns and herbs. Amongst the dominants in this stratum are *J. kraussii, Schoenus nitens, Lomandra longifolia, Poa labillardierei, Austrostipa stipoides, Distichlis distichophylla, Lepidosperma ensiforme, Leptocarpus tenax, Pteridium esculentum and Blechnum nudum.* Depending on the site, cover of the second and third strata varies from 6% to 100%.

The most common riparian structure within this community is *Eucalyptus* woodland or open-forest over a sedgey, grassy or ferny *Melaleuca* closed-scrub. However, *Melaleuca* sedgey-herby closed-forests and various sedgey, scrubby, ferny, herby or grassy open-scrub structures also occur.

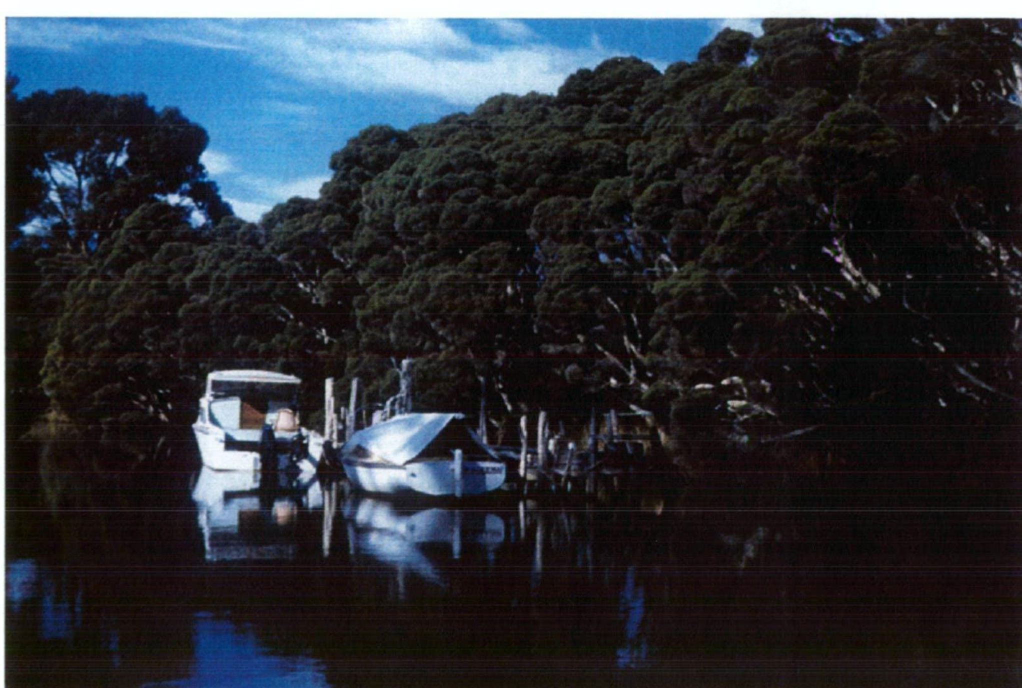
This riparian community is found adjacent to coastal scrub and scrubby, sedgey or ferny *Eucalyptus* woodland and open-forest. However, it also occurs adjacent to cleared agricultural land, rural residential and urban areas.

No affinity exists between this community and any other described vascular community.

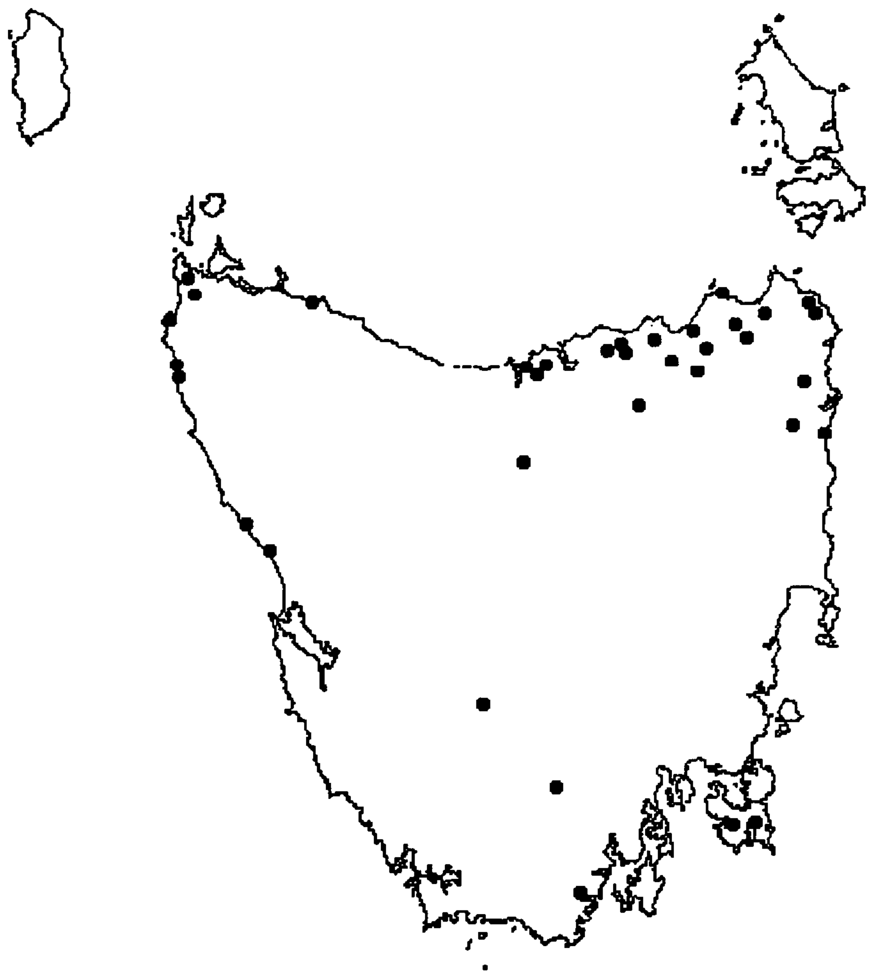
This floristic community is readily identifiable by virtue of its estuarine association but is closely related to Community 5. Examples of the structural variants of this floristic community can be seen in Plates 8 and 9.

Plate 8 *Eucalyptus* woodland over *Melaleuca* closed-scrub at Site 1 – Catamaran River.

Plate 9 *Melaleuca ericifolia* closed-forest at Site 284 – Brid River.



Community 5 ***Melaleuca squarrosa-Leptospermum lanigerum*** **heathy-ferny-sedgey closed-scrub**



Common species

Acacia dealbata	tree	*Carex appressa*	sedge
Acacia melanoxylon	tree	*Gahnia grandis*	sedge
Eucalyptus amygdalina	tree	*Lepidosperma ensiforme*	sedge
Eucalyptus obliqua	tree	*Dianella tasmanica*	lily
Eucalyptus ovata	tree	*Acaena novae-zelandiae*	herb
Leptospermum lanigerum	tree/shrub	*Gonocarpus teucrioides*	herb
Melaleuca ericifolia	tree/shrub	*Hydrocotyle hirta*	herb
Pomaderris apetala	tree/shrub	*Agrostis* species	grass
Acacia verticillata	shrub	*Poaceae* species	grass
Banksia marginata	shrub	*Blechnum minus*	fern
Coprosma quadrifida	shrub	*Blechnum nudum*	fern
Epacris impressa	shrub	*Gleichenia microphylla*	fern
Leptospermum scoparium	shrub	*Pteridium esculentum*	fern
Melaleuca squarrosa	shrub	Moss species	
Pimelea drupacea	shrub	Lichen species	
Lomandra longifolia	sagg		

Community 5 *Melaleuca squarrosa-Leptospermum lanigerum* heathy-ferny-sedgey closed-scrub

The species that characterise this community are *Pteridium esculentum, Melaleuca squarrosa, Leptospermum lanigerum, Gahnia grandis, Blechnum nudum, Dicksonia antarctica, Blechnum minus, Polystichum proliferum, Blechnum wattsii, Gleichenia microphylla, Gleichenia dicarpa and Hydrocotyle hirta.*

This floristic community is widespread and found from headwaters to estuaries of watercourses in the King, Flinders, West, Northern Slopes, Southern Ranges, and Ben Lomond bioregions. It is found in the catchments of the Boobyalla, Brid, George, Great Forester, Little Forester, Huon, Lune, Meander, Pipers, Ringarooma, Scamander, Little Denison, Tomahawk, Welcome and Nelson Bay Rivers and creeks and rivulets that drain into the east, southeast, north, northeast, northwest and west coasts and the Tamar estuary. It is found at altitudes up to 400 m.

There are three structural variants within this community:

- *Eucalyptus, Acacia, Melaleuca* or *Leptospermum* forest with an understorey of ferns and/or sedges;
- *Eucalyptus, Acacia, Melaleuca, Leptospermum* or *Banksia* woodland over ferny-sedgey-heathy closed-scrub; and
- *Eucalyptus, Acacia* or *Leptospermum* woodland over ferny-sedgey-grassy heath.

The second variant was the most common structural type for this community.

The tallest stratum in this floristic community may be dominated by *Eucalyptus, Acacia, Melaleuca, Leptospermum* or *Banksia* species with the most common dominant species being *E. obliqua, E. ovata, E. nitida, E. amygdalina, Acacia melanoxylon* and *Leptospermum lanigerum*. However, *E. globulus, E. sieberi, E. regnans, E. viminalis, A. dealbata, M. ericifolia, M. squarrosa* and *Banksia marginata* were occasionally dominant at sites within this community. *Acacia melanoxylon* and *Leptospermum lanigerum* feature strongly in the closed forest variants of this community such as those found at Boobyalla River, Three Mile Creek and Browns Creek in the north and north-east of Tasmania.

Depending on the riparian structure, dominant species in the second stratum were mostly shrubs, but graminoids, sedges and ferns also appeared as dominants in this stratum. Of the shrubs, *Melaleuca squarrosa, Pomaderris apetala, M. ericifolia* and *L. lanigerum* were the most common dominants. *Bauera rubioides, A. melanoxylon, L. glaucescens, B. marginata, Kunzea ambigua, L. scoparium* and *Zieria arborescens* were present as dominants at individual sites. Of the graminoids, *Gahnia grandis, Lepidosperma laterale* and *Xanthorrhoea* species were occasionally dominant in the second stratum. *Blechnum nudum* and *Gleichenia dicarpa* were dominants in the second stratum at two sites.

In the ground stratum, small shrubs, sedges and/or ferns all occur as dominants in this community depending on the structural variant and the particular site. Of the shrubs, *Bauera rubioides, Kunzea ambigua, L. lanigerum* and *L. scoparium, M. squarrosa* or *Bossiaea cordigera* were dominant. Of the sedges and graminoids, *Lepidosperma filiforme, L. laterale, L. longitudinale* and *L. ensiforme, Schoenus nitens, Carex appressa, Gahnia sieberi* and *Empodisma minus* were recorded as dominants. Of the ferns, *Gleichenia dicarpa, G. microphylla, Pteridium esculentum, B. nudum* and *Todea barbara* were dominant.

This riparian community is found adjacent to *Eucalyptus* and *Melaleuca* scrubby, heathy or sedgey woodland and open-forest, buttongrass and *Xanthorrhoea* sedgelands as well as cleared agricultural, rural residential, pine and *Eucalyptus* plantations and regrowth forests.

This community has an affinity (53%) with *Asterotrichion discolor-Pteridium esculentum-Blechnum nudum-Lepidosperma ensiforme* fernland (Wintle, 2002:53).

This floristic community is closely related to Community 4. Examples of the three structural variants of this floristic community can be seen in Plates 10, 11 and 12.

Plate 10 *Eucalyptus* woodland over closed-scrub at Site 137 – Clear Creek.

Plate 11 *Eucalyptus* ferny-sedgey-scrubby open-forest at Site 86 – Scamander River.

Plate 12 *Eucalyptus* woodland over closed-heath at Site 191 – Bosses Creek.

Community 6 *Eucalyptus* woodland over *Hakea microcarpa-Poa labillardierei-Lomandra longifolia* grassy-sedgey scrub

Common species

Acacia dealbata	tree	*Leptospermum scoparium*	shrub
Eucalyptus amygdalina	tree	*Micrantheum hexandrum*	shrub
Eucalyptus ovata	tree	*Ozothamnus ferrugineus*	shrub
Eucalyptus viminalis	tree	*Pomaderris apetala*	shrub
Acacia genistifolia	shrub	*Carex appressa*	sedge
Acacia mucronata	shrub	*Lepidosperma elatius*	sedge
Acacia verticillata	shrub	*Lepidosperma inops*	sedge
Allocasuarina littoralis	shrub	*Lepidosperma laterale*	sedge
Astroloma humifusum	shrub	*Lomandra longifolia*	sagg
Banksia marginata	shrub	*Baloskion australe*	rush
Bauera rubioides	shrub	*Baumea juncea*	rush
Bursaria spinosa	shrub	*Juncus australis*	rush
Callistemon viridiflorus	shrub	*Juncus* species	rush
Callitris oblonga	shrub	*Diplarrena moraea*	iris
Epacris apsleyensis	shrub	*Acaena novae-zelandiae*	herb
Epacris gunnii	shrub	*Hydrocotyle hirta*	herb
Exocarpos cupressiformis	shrub	*Hypericum japonicum*	herb
Grevillea australis var. *subulata*	shrub	*Lagenifera stipitata*	herb
Grevillea australis var. *tenuifolia*	shrub	*Oxalis perennans*	herb
Hakea microcarpa	shrub	*Wahlenbergia* species	herb
Hibbertia prostrata	shrub	*Poa labillardierei*	grass
Hibbertia riparia	shrub	*Poaceae* species	grass
Hibbertia serpyllifolia	shrub	*Themeda triandra*	grass
Leptospermum lanigerum	shrub	Moss species	

Community 6 *Eucalyptus* woodland over *Hakea microcarpa-Poa labillardierei-Lomandra longifolia* grassy-sedgey scrub

This community is characterised by the conjoint presence of *Hakea microcarpa, Epacris gunnii, Lepidosperma inops, Hibbertia prostrata, Lagenifera stipitata, Hibbertia riparia, Epacris apsleyensis, Grevillea australis, Baumea juncea, Baeckea ramosissima* and *Astroloma humifusum.*

This floristic community is found in the Southeast and Northern Midlands bioregions. It is found in the catchments of the Apsley, Little Swanport, St Pauls, Swan, Wye and Macquarie Rivers and along an unnamed minor watercourse at Dodges Ferry at altitudes above sea level to 320 m.

There are two main variants within this community – *Eucalyptus* woodland over sedgey and/or grassy scrub and *Eucalyptus* woodland over scrubby and/or grassy sedgeland. Ferns are rarely present in this community.

E. viminalis is by far the most common dominant species in the tallest stratum of this community but *E. amygdalina, E. ovata, E. rodwayi, E. pulchella* and *E. tenuiramis* are also present as dominants. *Eucalyptus* cover in this community is always less than 25%.

In the second stratum, *L. lanigerum* is the most common dominant species but *Melaleuca squamea, Acacia mucronata, A. verticillata, A. melanoxylon, L. scoparium, Callitris oblonga, Allocasuarina littoralis and A. monilifera* also occur infrequently as dominants. Also common in the second stratum are *Hakea microcarpa, Hibbertia riparia, Micrantheum hexandrum, Pomaderris apetala* and *Bursaria spinosa*. Cover of the second stratum varies from less than 5% to 100%.

The third stratum is dominated by a combination of *Poa* species, including *Poa labillardierei,* Cyperaceae species with *Lepidosperma inops, L. laterale* and *Baumea juncea* the most common, and shrubs with *L. lanigerum, A. mucronata* and *Baeckea ramosissima* the most common. Also common in this stratum are *Themeda triandra, Carex appressa, Epacris gunnii, Grevillea australis, Astroloma humifusum* and *Juncus* species. Cover in this stratum also varies from less than 5% to 100%.

This riparian community is found adjacent to grassy-heathy-sedgey-scrubby *Eucalyptus* woodland and open-forest and cleared agricultural land.

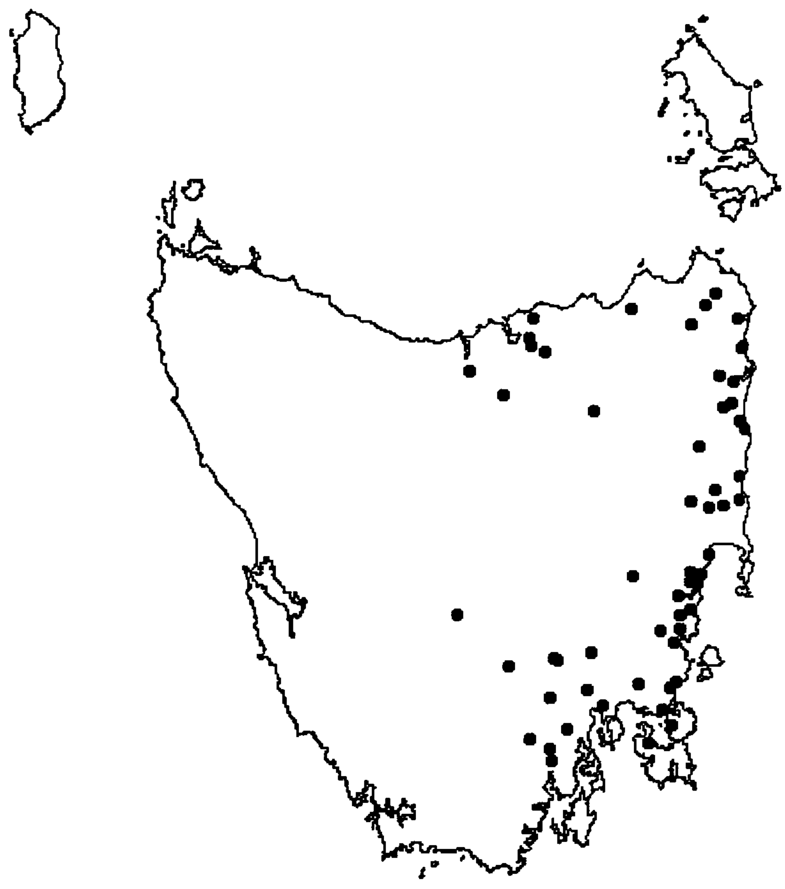
No affinity exists between this community and any other described vascular community.

This floristic community is closely related to Community 7. Examples of both structural variants of this floristic community can be seen in Plates 13 and 14.

Plate 13 *Eucalyptus* woodland over sedgey closed-scrub at Site 99 – Apsley River.

Plate 14 *Eucalyptus* woodland over scrubby sedgeland at Site 173 – St Pauls River.

Community 7 ***Eucalyptus viminalis-E. globulus-E. obliqua-E. amygdalina*** **woodland over** ***Beyeria viscosa-Exocarpos cupressiformis*** **sedgey, grassy, ferny or heathy closed-scrub**



Common species

Acacia dealbata	tree	*Leptospermum scoparium*	shrub
Acacia melanoxylon	tree	*Pomaderris apetala*	shrub
Eucalyptus amygdalina	tree	*Carex appressa*	sedge
Eucalyptus globulus	tree	*Gahnia grandis*	sedge
Eucalyptus obliqua	tree	*Lepidosperma ensiforme*	sedge
Eucalyptus viminalis	tree	*Lepidosperma laterale*	sedge
Exocarpos cupressiformis	tree	*Juncus species*	rush
Acacia mucronata	shrub	*Lomandra longifolia*	sagg
Acacia verticillata	shrub	*Acaena novae-zelandiae*	herb
Allocasuarina littoralis	shrub	*Oxalis perennans*	herb
Banksia marginata	shrub	*Viola hederacea*	herb
Beyeria viscosa	shrub	*Poa labillardierei*	grass
Bursaria spinosa	shrub	Poaceae species	grass
Cassinia aculeata	shrub	*Pteridium esculentum*	fern
Coprosma quadrifida	shrub	Moss species	
Leptospermum lanigerum	shrub		

Community 7 *Eucalyptus viminalis-E. globulus-E. obliqua-E. amygdalina* woodland over *Beyeria viscosa-Exocarpos cupressiformis* sedgey-grassy, ferny or heathy closed-scrub

This community has the largest number of sites. It is characterised by the presence of *Eucalyptus globulus, Acacia melanoxylon, Allocasuarina littoralis, Bedfordia salicina, Cassinia aculeata, Beyeria viscosa, Epacris impressa, Lepidosperma laterale* and *Pteridium esculentum.*

This floristic community is found mainly in eastern Tasmania in the South East, Ben Lomond and Flinders bioregions although there is also one site in the Southern Ranges and one in the Northern Slopes bioregions. The community occurs in the catchments of Ansons, Apsley, Buxton, Coal, Douglas, George, Great Musselroe, Great Forester, Huon, Jordan, Little Swanport, Macquarie, Meander, North Esk, Prosser, Ringarooma, Rubicon, Scamander, South Esk, and Swan Rivers, the upper, lower and estuarine reaches of the River Derwent, and along minor watercourses that drain to the east coast, D'Entrecasteaux Channel, north-east coast, north coast and the Tamar estuary. It is found at altitudes just above sea level to 380 m and includes rocky estuarine sites.

The most common structures in this community in order of frequency were:

- *Eucalyptus* woodland over sedgey-grassy open or closed-scrub;
- *Eucalyptus* woodland over sedgey open or closed-scrub;
- *Eucalyptus* woodland over sedgey-ferny open or closed-scrub; and
- *Eucalyptus* woodland over heathy closed-scrub.

Other structures that occurred infrequently were:

- *Eucalyptus* or *Acacia* woodland over scrubby-grassy sedgelands; and
- *Dodonea* open scrub over sedgey-grasslands;
- *Eucalyptus* woodland over scrubby heath; and
- Closed-scrub.

The height of the tallest stratum was generally between 8 m and 30 m and usually with a cover of less than 25%. The most common dominants species in this stratum were *E. viminalis, E. obliqua, E. globulus* and *E. amygdalina.* Also dominant in this stratum, but occurring less frequently, were *E. ovata, Acacia dealbata, A. melanoxylon, E. regnans* and *E. sieberi.* In the communities where no tall *Eucalyptus* or *Acacia* species were present, *Dodonaea viscosa, Acacia verticillata* and *Leptospermum lanigerum* were noted as dominant species in the tallest stratum with a height between 2 m and 8 m.

The most commonly occurring dominant species in the second stratum were shrubs, with the most prominent species being *Leptospermum lanigerum, Pomaderris apetala, Acacia* *mucronata, A. dealbata, A. melanoxylon, A. verticillata, Melaleuca ericifolia, Beyeria viscosa, Banksia marginata, Bursaria spinosa* and *Allocasuarina littoralis*. Also occurring infrequently as dominants were *Cassinia aculeata, Micrantheum hexandrum, Acacia mearnsii, Notelaea ligustrina, Callistemon pallidus, Melaleuca squarrosa, Coprosma quadrifida, Exocarpos cupressiformis* and *Dodonaea viscosa*. *Carex* species and *Cyperus* species were also noted as dominant species in this stratum where shrubs were sparse.

There were two main frequently occurring dominant lifeforms in the ground stratum: shrubs and graminoids. The most frequently occurring shrubs were *Leptospermum lanigerum, L. scoparium* and the prostrate shrub, *Baeckea ramosissima*. Also occurring as infrequent dominant shrubs were *Olearia lirata, Micrantheum hexandrum, Acacia mucronata, Kunzea ambigua, Melaleuca squarrosa* and the undescribed, *Acacia* sp. Graminoids were by far the most dominant lifeform in the ground stratum of this community with *Lomandra longifolia, Lepidosperma* species, especially *L. laterale* and *L. ensiforme*, and *Carex appressa* the most frequently occurring dominant species. Also occurring as infrequent dominants were *Gahnia filum* and *Juncus kraussii* at the estuarine sites and *J. astreptus* in combination with Cyperaceae species. *Poa labillardierei* was the most frequently occurring dominant at grassland sites often in combination with other Poaceae species. Of the ferns, *Gleichenia microphylla, Blechnum nudum* and *Pteridium esculentum* were the most frequently occurring dominant species.

This riparian community is most frequently found adjacent to *Eucalyptus* scrubby, sedgey, ferny, grassy or heathy woodland or open-forest but is also found adjacent to cleared agricultural land or rough pasture and pine plantations.

This community has affinity with *Eucalyptus viminalis-Pomaderris apetala-Leptospermum lanigerum-Wahlenbergia* spp. shrubby open-forest (59%), *Eucalyptus amygdalina-Lomandra longifolia-Juncus* spp.-*Geranium potentilloides* sedgey woodland (56%) and *Crataegus monogyna-Rosa rubiginosa-Poa labillardierei-Dactylis glomerata* agricultural grassy woodland (52%) (Wintle, 2002: 49-52).

It is closely related to Community 10. Examples of the four main structural variants of this floristic community can be seen in Plates 15, 16, 17 and 18.

Plate 15 *Eucalyptus* woodland over grassy-sedgey closed-scrub at Site 184 – Buxton River.

Plate 16 *Eucalyptus ovata* woodland over *Melaleuca ericifolia\Leptospermum lanigerum heath* at Site 417 – Gum Scrub Creek.

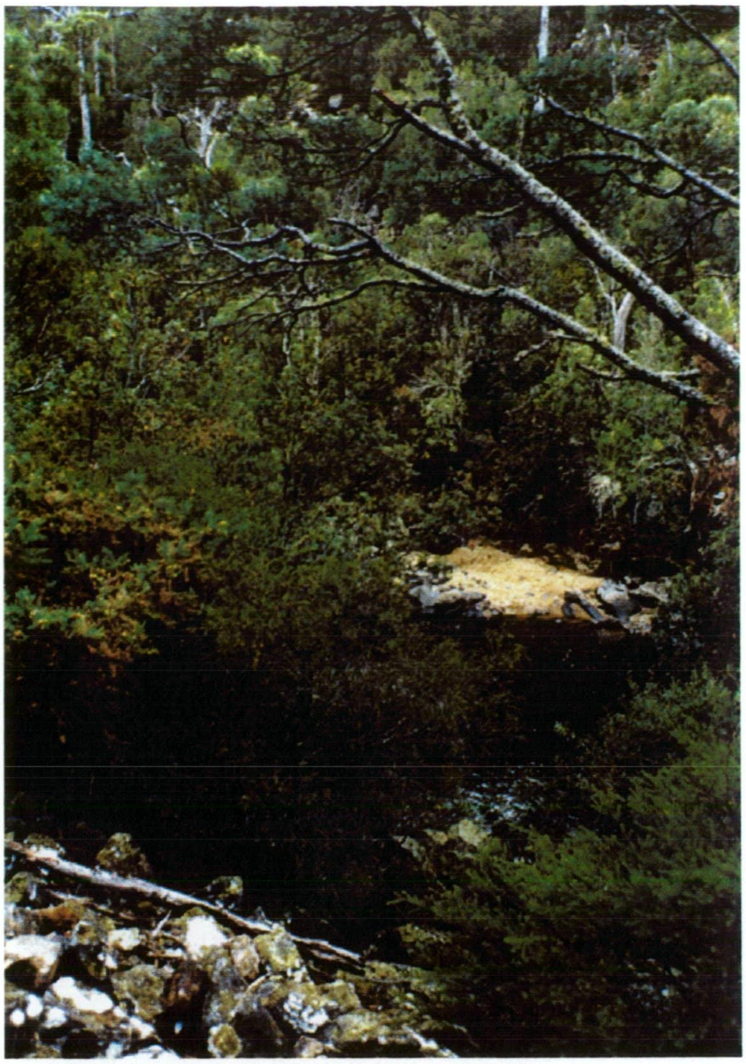
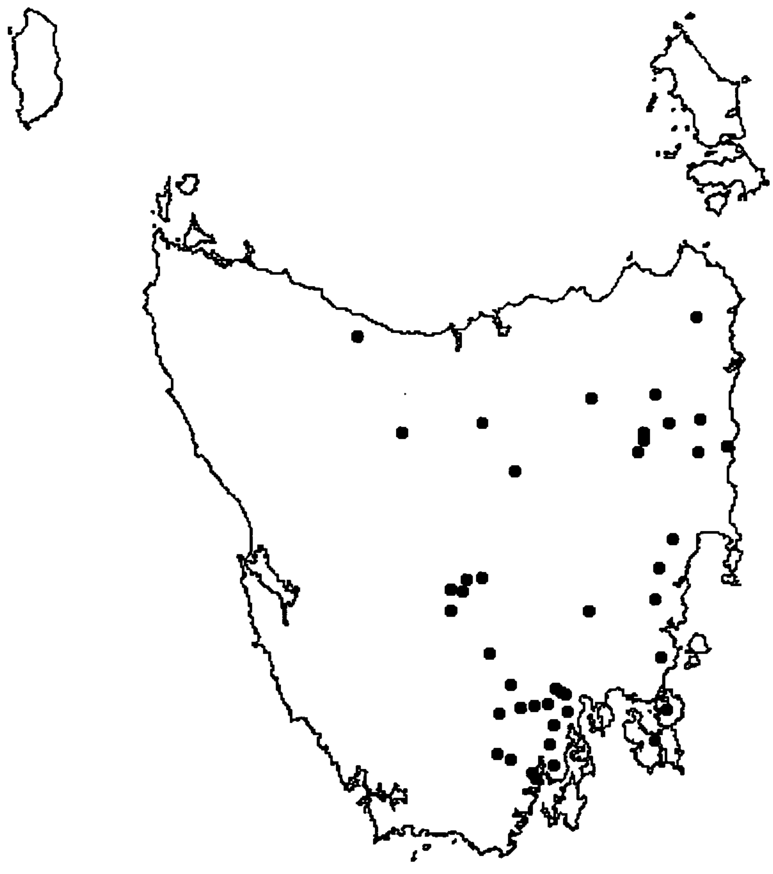


Plate 17 *Acacia dealbata\Pomaderris apetala* woodland over *Micrantheum hexandrum\Beyeria viscosa* heathy scrub at Site 203 – North Esk River.

Plate 18 *Eucalyptus sieberi\E. obliqua* woodland over *Acacia dealbata\Allocasuarina littoralis* ferny closed-scrub at Site 190 – Constable Creek.

Community 8 *Eucalyptus obliqua-E. regnans* woodland over *Acacia-Pomaderris* ferny-sedgey-grassy closed-scrub



Common species

Acacia dealbata	tree	*Senecio linearifolius*	shrub
Acacia melanoxylon	tree	*Carex appressa*	sedge
Eucalyptus amygdalina	tree	*Gahnia grandis*	sedge
Eucalyptus obliqua	tree	*Dianella tasmanica*	iris
Eucalyptus regnans	tree	*Juncus* species	rush
Eucalyptus viminalis	tree	*Clematis aristata*	climber
Acacia verticillata	tree/shrub	*Acaena novae-zelandiae*	herb
Leptospermum lanigerum	tree/shrub	*Gonocarpus teucrioides*	herb
Pomaderris apetala	tree/shrub	*Hydrocotyle hirta*	herb
Bedfordia salicina	shrub	*Hypericum japonicum*	herb
Beyeria viscosa	shrub	*Oxalis perennans*	herb
Cassinia aculeata	shrub	*Viola hederacea*	herb
Coprosma quadrifida	shrub	*Agrostis* species	grass
Lomatia tinctoria	shrub	*Blechnum nudum*	fern
Olearia argophylla	shrub	*Blechnum wattsii*	fern
Olearia lirata	shrub	*Dicksonia antarctica*	fern
Pimelea drupacea	shrub	*Polystichum proliferum*	fern
Prostanthera lasianthos	shrub	*Pteridium esculentum*	fern
Pultenaea juniperina	shrub	Moss species	

Community 8 *Eucalyptus obliqua-E. regnans* woodland over *Acacia-Pomaderris* ferny-sedgey-grassy closed-scrub

This large community is characterised by the presence of *Acacia dealbata, A. mucronata, Eucalyptus obliqua, E. regnans, E. delegatensis, P. apetala, Coprosma quadrifida, Cassinia aculeata, A. verniciflua, A. verticillata, Prostanthera lasianthos, Bedfordia salicina, Olearia lirata, O. viscosa, Notelaea ligustrina, Callistemon pallidus, Hypericum japonicum, Senecio* species, *Lomatia tinctoria, Lepidosperma ensiforme, Hypolepis rugosula, Histiopteris incisa, Blechnum fluviatale, Juncus australe* and *Ehrharta stipoides.*

This floristic community is found mainly in the Southern Ranges and Ben Lomond bioregions but it also occurs in the South East, Flinders, and Northern Slopes bioregions. It occurs in the catchments of the Coal, Great Musselroe, Huon, Little Swanport, Meander, Mersey, North Esk, South Esk and Macquarie Rivers, the River Ouse, and along minor watercourses that drain into the east, southeast and northeast coasts, the D'Entrecasteaux Channel and the upper, lower and estuary of the River Derwent. It is found at altitudes from 20 m to 740 m.

There are two frequently occurring structural forms in this community:

- *Eucalyptus* woodland over sedgey, ferny, grassy or heathy closed-scrub (24 sites); and
- *Acacia* or *Pomaderris* woodland over ferny, sedgey and/or heathy closed-scrub (8 sites).

Other riparian structural types represented in this community are:

- *Acacia* closed scrub over sedgey *Poa* grasslands
- *Acacia* woodland over scrubby fernland
- *Eucalyptus* woodland over shrubby fernland
- *Eucalyptus* woodland over sedgey *Poa* grasslands
- *Eucalyptus* woodland over heathy-ferny sedgeland
- *Eucalyptus/Acacia* open forest over open scrub
- *Eucalyptus* woodland over *Acacia* ferny open and closed forest

The tallest stratum is generally between 8 m and 30 m tall with a cover of less than 25%, although at 4 sites, cover was greater than 50%. The most frequently dominant *Eucalyptus* species in this community are *E. delegatensis, E. viminalis* and *E. regnans*, although *E. dalrympleana, E. amygdalina, E. ovata, E. globulus* and *E. sieberi* also occur as infrequent dominants. *Acacia dealbata* and *Pomaderris apetala* are the most frequently occurring dominant species in communities where *Eucalyptus* species are either not present or very sparse. Also featuring strongly in the tallest stratum are *Beyeria viscosa, Acacia verticillata* and *Leptospermum lanigerum.*

The second stratum has a variety of shrubs that occur as dominant species at various sites although *Pomaderris apetala, Leptospermum lanigerum* and *Acacia dealbata* are the most common dominant species. Also occurring as infrequent dominants are *Bedfordia salicina, Ozothamnus thyrsoideus, Olearia argophylla, O. lirata, Allocasuarina littoralis, Beyeria viscosa, Acacia melanoxylon, A. mucronata, A. verniciflua, A. verticillata, L. riparium, L. scoparium, Pomaderris elliptica, Coprosma quadrifida, Zieria arborescens, Prostanthera lasianthos, Asterotrichion discolor, Micrantheum hexandrum* and *Melaleuca squarrosa*. In the sedgeland, grassland and fernland sites, *Carex appressa, Gahnia grandis, Blechnum nudum* and Poaceae species occur as dominant species in this stratum.

In the ground stratum where a clear dominant species is discernable, shrubs, ferns, sedges and grasses are dominant depending on the site. The dominant shrub species in the ground stratum are *Leptospermum lanigerum, Beyeria viscosa, Bauera rubioides* and *Prostanthera lasianthos*. The dominant sedges or graminoids are *Carex appressa, Lepidosperma elatius, L. laterale, L. ensiforme* and *Lomandra longifolia*. At most sites, however, ferns are dominant in this stratum. *Blechnum nudum* is the most frequently occuring dominant species but *B. wattsii, B. minus, Dicksonia antarctica, Gleichenia microphylla, Hypolepis muelleri* and *Polystichum proliferum* also occur as infrequent dominants. At grassland sites, *Poa labillardierei* is the dominant species although *Ehrharta* and *Agrostis* species are often present. Herbs rarely exceed 10% cover in this stratum but, where present may be significant as indicator species for this community.

This community occurs adjacent to *Eucalyptus* open-forest and woodland that may be scrubby, shrubby, sedgey, ferny, grassy or heathy. It also occurs adjacent to regrowth forest, pine plantations, cleared agricultural land and rural residential areas.

This community has affinity with *Eucalyptus obliqua-Olearia lirata-Pultenaea juniperina* wet sclerophyll forest (52%), *Eucalyptus regnans-E. obliqua-Pomaderris apetala-Olearia lirata* wet sclerophyll forest (60%), *Eucalyptus delegatensis-E. viminalis-Acacia melanoxylon* wet sclerophyll forest (55%); *Eucalyptus globulus-Acacia dealbata-Cassinia aculeata-Acacia melanoxylon* wet sclerophyll forest (52%), *Eucalyptus ovata-Acacia delabata-Pomaderris apetala* wet sclerophyll forest (52%), *Eucalyptus regnans-Acacia dealbata-Pomaderris apetala* wet sclerophyll forest (52%), and *Eucalyptus sieberi-Olearia argophylla-Coprosma quadrifida* wet sclerophyll forest (50%) (Kirkpatrick *et al.*, 1995: 128, 132, 134, 138, 140) and *Pomaderris apetala-Olearia argophylla-Coprosma quadrifida-Hymenophyllum* spp. open-forest (Wintle, 2002: 47). Structural variants in this community with no dominant *Eucalyptus* species in the tallest stratum have no affinity with any described communities.

It is closely related floristically to Community 9. Examples of the two most frequently occurring structural variants can be seen in Plates 19 and 20.

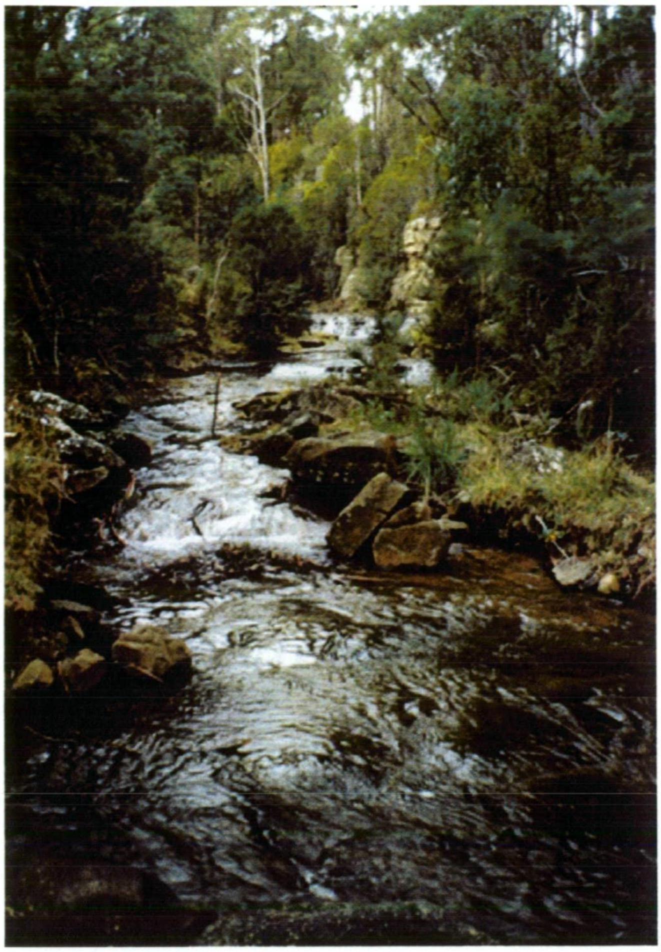
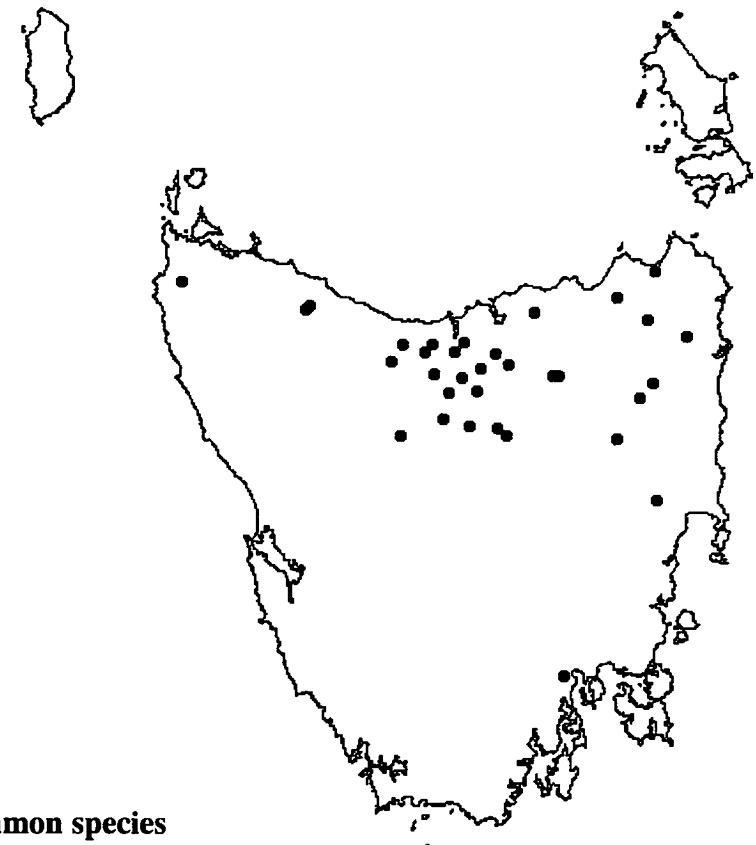


Plate 19 *Eucalyptus obliqua*\ *E. regnans* woodland over *Leptospermum lanigerum* grassy open-scrub at Site 38 – Crabtree Rivulet.

Plate 20 *Eucalyptus amygdalina* woodland over *Acacia mucronata*\ *Micrantheum hexandrum* heathy open to closed-scrub at Site 172 – St Pauls River.

Community 9 *Eucalyptus viminalis-E. ovata-E. obliqua-Acacia dealbata-A. melanoxylon* woodland over sedgey-ferny scrub



Common species

Acacia dealbata	tree	*Gahnia grandis*	sedge
Acacia melanoxylon	tree	*Isolepis* species	sedge
Eucalyptus amygdalina	tree	*Lepidosperma ensiforme*	sedge
Eucalyptus obliqua	tree	*Lepidosperma laterale*	sedge
Eucalyptus ovata	tree	*Schoenus* species	sedge
Eucalyptus viminalis	tree	*Acaena novae-zelandiae*	herb
Notelaea ligustrina	tree	*Geranium potentilloides*	herb
Pomaderris apetala	tree	*Gonocarpus teucrioides*	herb
Acacia verticillata	tree/shrub	*Gratiola peruviana*	herb
Leptospermum lanigerum	tree/shrub	*Hydrocotyle hirta*	herb
Melaleuca ericifolia	tree/shrub	*Oxalis perennans*	herb
Beyeria viscosa	shrub	*Viola hederacea*	herb
Bursaria spinosa	shrub	*Agrostis* species	grass
Cassinia aculeata	shrub	*Poa labillardierei*	grass
Coprosma quadrifida	shrub	Poaceae species	grass
Exocarpos curpressiformis	shrub	*Dianella tasmanica*	lily
Lomatia tinctoria	shrub	*Juncus pauciflorus*	rush
Olearia lirata	shrub	*Lomandra longifolia*	sagg
Ozothamnus ferrugineus	shrub	*Clematis aristata*	climber
Pimelea drupacea	shrub	*Blechnum minus*	fern
Pittosporum bicolor	shrub	*Blechnum nudum*	fern
Prostanthera lasianthos	shrub	*Blechnum wattsii*	fern
Pultenaea juniperina	shrub	*Dicksonia antarctica*	fern
Senecio hispidulus	shrub	*Polystichum proliferum*	fern
Tasmannia lanceolata	shrub	*Pteridium esculentum*	fern
Zieria arborescens	shrub	Moss species	
Carex appressa	sedge	Lichen species	

Community 9 *Eucalyptus viminalis-E. ovata-E. obliqua-Acacia dealbata-A. melanoxylon* woodland over sedgey-ferny scrub

There is no species that is present at all sites in this floristic community. However, it is characterised by the presence of *Eucalyptus ovata, E. delegatensis Acacia melanoxylon, A. verticillata, A. dealbata, Melaleuca ericifolia, Pittosporum bicolor, Exocarpos cupressiformis, Ozothamnus ferrugineus, Bursaria spinosa, Micrantheum hexandrum, Correa lawrenceana, Tasmannia lanceolata, Senecio hispidulus, Blechnum minus* and *Rubus parvifolius.*

This floristic community is found mainly in northern Tasmania in the King, Northern Slopes, Ben Lomond and Flinders bioregions, although there are also three sites in the South East bioregion and 1 site in the Northern Midlands bioregion. It is found in the catchments of the Boobyalla, George, Great Forester, Meander, Mersey, North Esk, Pipers, Ringarooma, Rubicon, South Esk, Swan, and Macquarie Rivers, the River Forth, and minor watercourses that flow to the Derwent and Tamar estuaries and the north and north-west coasts at altitudes between 10 m and 540 m.

The most common structures were:

- *Eucalyptus* woodland or open-forest over heathy, ferny, grassy and/or sedgey closed-scrub (most common);
- *Eucalyptus* woodland over heathy, ferny, grassy and/or sedgey open-scrub; and
- *Acacia* open forest over ferny-sedgey closed-scrub.

Also occurring infrequently were:

- *Eucalyptus/Acacia* open-forest or woodland over closed fernland;
- *Acacia* and *Melaleuca* scrubby-ferny-sedgey open-forest; and
- *Nothofagus* closed-forest and grassy *Carex* sedgeland.

The most frequently occurring dominant species in the tallest stratum is *Eucalyptus viminalis* followed by *E. obliqua, Acacia dealbata* and *Acacia melanoxylon.* Also occurring as infrequent dominants in this stratum are *E. delegatensis, E. ovata, E. rodwayi, E. radiata, E. regnans, E. amygdalina, Melaleuca ericifolia, Leptospermum lanigerum* and *Nothofagus cunninghamii.* The height of the tallest stratum is between 8 m and 30 m at all sites.

Pomaderris apetala is by far the most common dominant species in the second stratum followed by *Leptospermum lanigerum.* Also occurring as infrequent dominants are *Acacia melanoxylon, A. dealbata, A. mucronata, A. verniciflua, A. verticillata, Prostanthera lasianthos, Melaleuca ericifolia, M. squarrosa, Notelaea ligustrina, Banksia marginata, Coprosma quadrifida, Atherosperma moschatum, Leptospermum scoparium, Pittosporum bicolor, Tasmannia lanceolata* and *Dicksonia antarctica.*

Ferns and sedges are the dominant lifeforms in the third stratum at most sites. Of the ferns, *Blechnum nudum* is the most common dominant but *B. wattsii* and *Pteridium esculentum* also dominant at one site each. Of the sedges, *Lepidosperma ensiforme* is the most common dominant, but *Carex appressa* and *L. laterale* also occur as infrequent dominants. At four sites, shrubs were dominant in the third stratum. *Leptospermum lanigerum, Micrantheum hexandrum* and *Melaleuca squarrosa* were dominant at these sites. Herbs and grasses do not have extensive cover in this floristic community, often less than 5%. However, at several sites, where grasses were dominant and readily identifiable, *Poa labillardierei* was noted as the dominant species.

This floristic community is found adjacent to *Eucalyptus* woodlands, open and closed-forests that have a mixed grassy, heathy, ferny and sedgey understorey. It also adjoins pine and *Eucalyptus* plantations, regrowth forest and rural residential land.

No affinity exists between this community and any other described vascular community.

It is closely related floristically to Community 15. Examples of the most frequently occurring structural variants of this floristic community can be seen in Plates 21, 22, 23, 24 and 25.

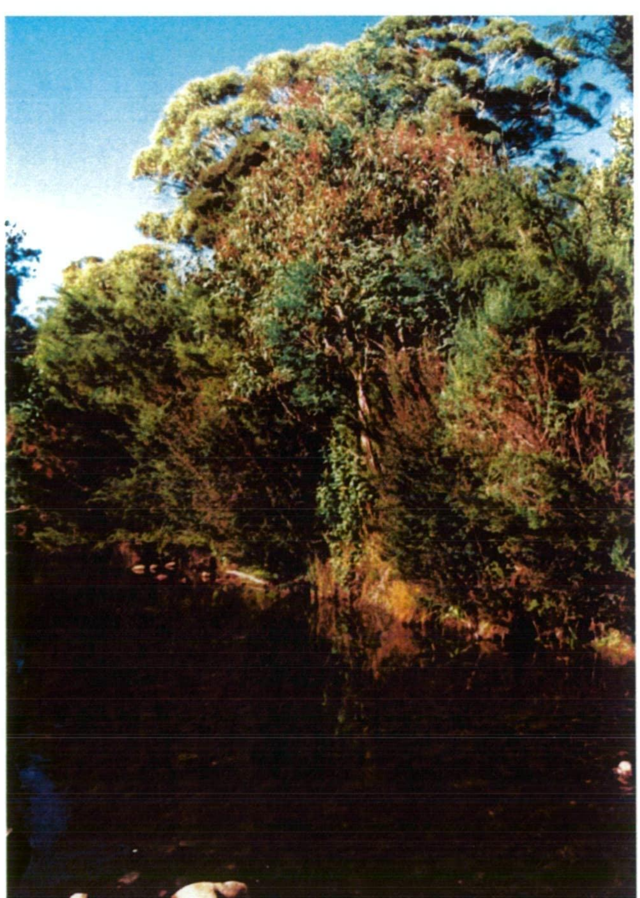


Plate 21 *Eucalyptus* woodland over closed-scrub at Site 293 – Distillery Creek.

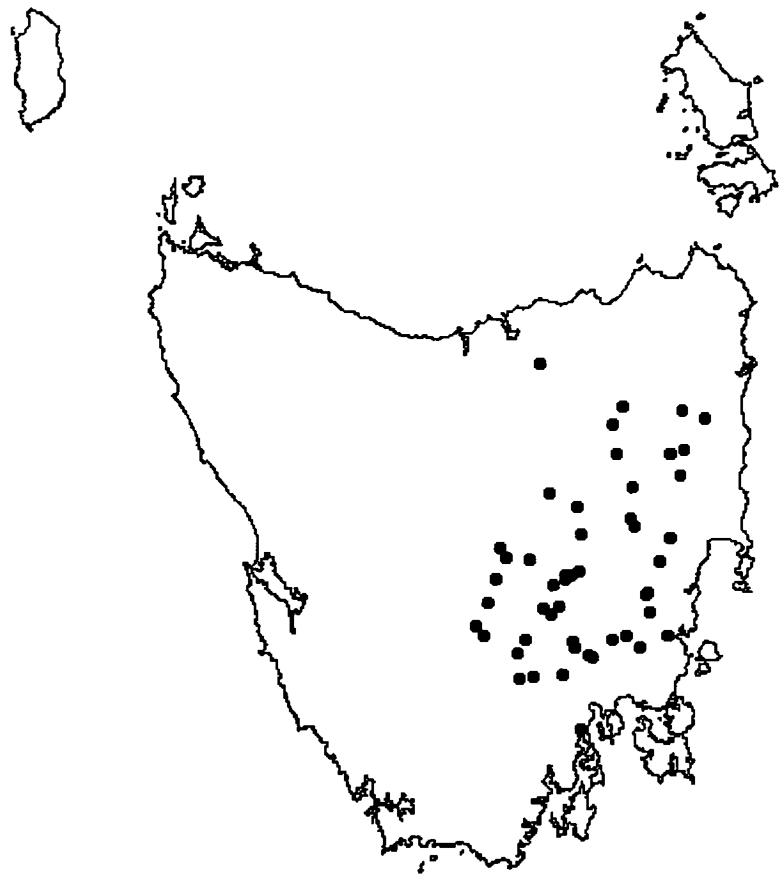
Plate 22 *Eucalyptus* woodland over open-scrub at Site 419 – Sandy Bay Rivulet.

Plate 23 *Acacia* open-forest over closed-scrub at Site 260 – Cascade River.

Plate 24 *Eucalyptus delegatensis\E. regnans* woodland over *Acacia dealbata\ Leptospermum lanigerum* heathy closed-scrub at Site 251 - Mersey River.

Plate 25 *Melaleuca ericifolia* scrubby-sedgey open-forest at Site 277 – Boobyalla River.

Community 10 ***Eucalyptus* woodland over *Pomaderris apetala-Pteridium esculentum-Poa labillardierei-Lomandra longifolia-Carex appressa* closed-scrub**



Common species

Acacia dealbata	tree	*Acaena novae-zelandiae*	herb
Acacia melanoxylon	tree	*Geranium potentilloides*	herb
Eucalyptus amygdalina	tree	*Oxalis perennans*	herb
Eucalyptus viminalis	tree	*Poa labillardierei*	grass
Leptospermum lanigerum	tree/shrub	Poaceae species	grass
Pomaderris apetala	tree/shrub	*Juncus astreptus*	rush
Beyeria viscosa	shrub	*Lomandra longifolia*	sagg
Bursaria spinosa	shrub	*Polystichum proliferum*	fern
Cassinia aculeata	shrub	*Pteridium esculentum*	fern
Coprosma quadrifida	shrub	Moss species	
Carex appressa	sedge		

Community 10 *Eucalyptus* woodland over *Pomaderris apetala-Pteridium esculentum-Poa labillardierei-Lomandra longifolia-Carex appressa* closed-scrub

This widespread community is characterised by the presence of *Eucalyptus viminalis, E. amygdalina, Pomaderris apetala, Cassinia aculeata, Poa labillardieri, Lomandra longifolia, Carex appressa, Bursaria spinosa, Acacia melanoxylon, Beyeria viscosa, Coprosma quadrifida, Olearia viscosa, Asterotrichion discolor, Lepidosperma laterale, Lepidosperma ensiforme, Polystichum proliferum* and *Leptinella longipes.*

This floristic community is found mainly in eastern Tasmania in the South East, Northern Midlands, and Ben Lomond bioregions, although there is one site in the Flinders bioregion. It occurs in the catchments of the Rivers Clyde and Ouse, the Coal, Jordan, Little Swanport, North Esk, Prosser, Scamander, South Esk and Macquarie Rivers, and along minor watercourses that drain into the Tamar estuary, D'Entrecasteaux Channel and the upper, lower and estuarine reaches of the River Derwent. It is found at altitudes from 20 m to760 m.

There is one frequently occurring structure in this community:

- *Eucalyptus* woodland over grassy-sedgey and/or ferny open or closed-scrub;

There are also 7 infrequently occurring but distinctive structural forms:

- *Acacia/Pomaderris* woodland over grassy sedgelands;
- *Acacia/Pomaderris* grassy-sedgey open-forest or closed-scrub;
- *Eucalyptus* woodland over sedgey-grassy fernland;
- *Eucalyptus* woodland over scrubby *Poa* grassland;
- *Acacia* woodland over sedgey *Poa* grassland;
- *Eucalyptus* woodland over sedgey-heathy closed-scrub; and
- *Eucalyptus/Acacia* open forest over sedgey closed-scrub.

The tallest stratum is generally between 8 m and 30 m tall with a cover of less than 25%, although, where *Eucalyptus* species are absent or sparse, the tallest stratum is often between 2 m to 8 m. Cover is usually less than 25% but at four sites, it was greater than 75%. The most frequently occurring dominant in this stratum is *Eucalyptus viminalis* followed by *E. amygdalina*. Other infrequently occurring dominants are *E. pauciflora, E. pulchella, E. rubida, E. delegatensis, E. obliqua, E. globulus, E. ovata, Acacia dealbata, A. mucronata* and *Pomaderris apetala.*

The second stratum is dominated by shrubs at most sites, although *Poa labillardierei, Lomandra longifolia* and *Carex appressa* are also dominant in this stratum at three sites. Height of the second stratum can vary from less than 1 m to over 8 m and cover varies from

6% to 100%. *Leptospermum lanigerum* and *Pomaderris apetala* are the most commonly occurring dominant shrubs in the second stratum. *Acacia dealbata, A. melanoxylon, A. mearnsii, A. mucronata, A. verticillata,* and the undescribed *Acacia* sp., also feature strongly in this stratum. Occurring as infrequent dominants are *Cassinia aculeata, Olearia viscosa, Cyathodes juniperina, Asterotrichion discolor, Bursaria spinosa, Banksia marginata, Coprosma quadrifida, Ozothamnus ferrugineus, O. thyrsoideus* and *Beyeria viscosa*.

Height of the ground stratum is usually less than 1 metre but is over 2 metres where grasses and sedges are sparse. *Poa labillardierei* and other *Poa* species are the most frequently occurring dominant species in the ground stratum of this community followed by *Lomandra longifolia* and *Carex appressa*. Other infrequently occurring dominant graminoids are *Lepidosperma laterale, L. elatius, L. ensiforme* and *Juncus astreptus*. Where ferns are dominant, *Pteridium esculentum* and *Polystichum proliferum* are the most frequently occurring species. Of the dominant shrubs in this stratum, *Leptospermum lanigerum* is the most frequently occurring. *Cassinia aculeata, Micrantheum hexandrum* and *Acacia mucronata* also occur infrequently as dominant species in the ground stratum.

All sites adjoin *Eucalyptus* woodland or open forest that is scrubby, sedgey, grassy or has bracken in the understorey. This community was also found adjacent to cleared agricultural land or pasture. It is of interest that *Eucalyptus* species are absent as dominant species in one-quarter of the riparian sites in this community despite nearly all sites being adjacent to dryland vegetation where *Eucalyptus* species dominate in the tallest stratum.

This community has affinity with *Pomaderris apetala-Coprosma quadrifida-Carex appressa-Blechnum nudum* open riparian scrub (51%) (Kirkpatrick *et al.* 1995: 150).

This community is closely related floristically to Community 7. Examples of the some of the structural variants of this floristic community can be seen in Plates 26 and 27, 28 and 29.

Plate 26 *Eucalyptus viminalis\Acacia dealbata* woodland over *A. mucronata\Leptospermum lanigerum* sedgey-grassy closed-scrub at Site 148 – Little Swanport River.

Plate 27 *Eucalyptus amygdalina* woodland over *Leptospermum lanigerum\Acacia mucronata* heathy closed-scrub at Site 119 – Macquarie River.

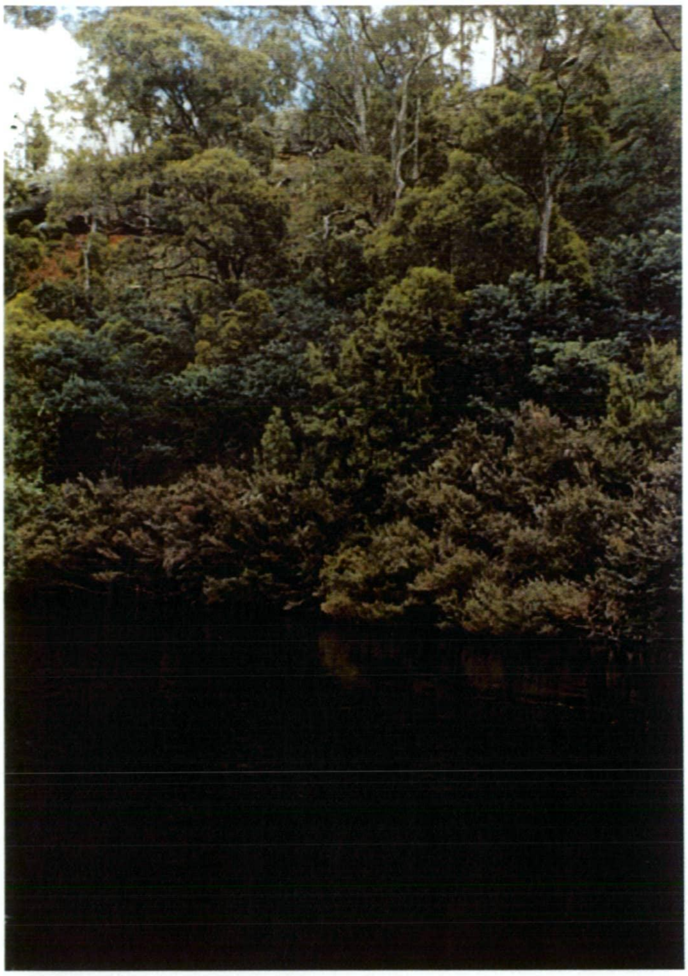
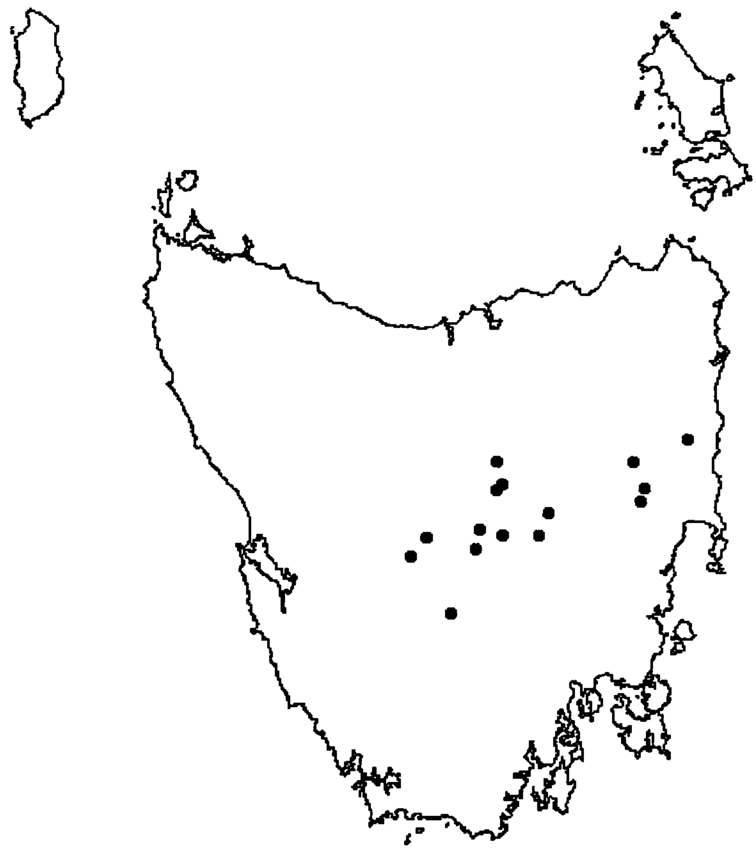


Plate 28 *Eucalyptus viminalis\E. amygdalina* woodland over *Leptospermum lanigerum\Acacia dealbata\Pomaderris apetala* sedgey-grassy closed scrub at Site 168 - South Esk River at Rostrevor.

Plate 29 *Eucalyptus* woodland over sedgey-heathy closed-scrub at Site 88 - Repulse River.

Community 11 *Eucalyptus pauciflora-E. viminalis* woodland over *Leptospermum lanigerum* grassy-sedgey closed-scrub



Common species

Acacia dealbata	tree	*Oxylobium ellipticum*	shrub
Eucalyptus amygdalina	tree	*Pultenaea juniperina*	shrub
Eucalyptus delegatensis	tree	*Tasmannia lanceolata*	shrub
Eucalyptus ovata	tree	*Schoenus* species	sedge
Eucalyptus pauciflora	tree	*Gahnia grandis*	sedge
Eucalyptus viminalis	tree	*Acaena novae-zelandiae*	herb
Notelaea ligustrina	tree	*Geranium potentilloides*	herb
Banksia marginata	shrub	*Hydrocotyle hirta*	herb
Bauera rubioides	shrub	*Hypericum japonicum*	herb
Cassinia aculeata	shrub	*Poa labillardierei*	grass
Cyathodes parvifolia	shrub	*Poa* species	grass
Epacris gunnii	shrub	Poaceae species	grass
Hakea lissosperma	shrub	*Juncus astreptus*	rush
Hakea microcarpa	shrub	*Lomandra longifolia*	sagg
Leptospermum lanigerum	shrub	*Polystichum proliferum*	fern
Lomatia tinctoria	shrub	Moss species	
Olearia phlogopappa	shrub		

Community 11 *Eucalyptus pauciflora-E. viminalis* woodland over *Leptospermum lanigerum* grassy-sedgey closed-scrub

The species that characterise this floristic community are *Eucalyptus coccifera, E. delegatensis, E. pauciflora, E. rodwayi, E. rubida, E. ovata, E. dalrympleana, Pultenaea juniperina, Hakea microcarpa, Notelaea ligustrina, Lomandra longifolia, Banksia marginata, Oxylobium ellipticum, Lomatia tinctoria, Cassinia aculeata, Coprosma hirtella* and *Almaleea subumbellata.*

This community is found in central and eastern Tasmania, predominantly in the South East and Central Highlands bioregions in the catchments of the River Clyde, River Ouse, South Esk River, Macquarie River, upper River Derwent and watercourses that flow into Arthurs Lake and Great Lake. It is found at altitudes from 220 m to 1020 m.

This community is characterised by the presence of a variety of gum-topped *Eucalyptus* species in the tallest stratum and a moderate to dense cover of woody species in the second and/or third stratum that includes *Leptospermum lanigerum* in shrub or heath form. *Poa* species, in particular, *Poa labillardierei,* are common in the ground stratum.

There are two main structural variants in this community:

- *Eucalyptus* woodland over *Leptospermum lanigerum* sedgey-grassy closed-scrub; and
- *Eucalyptus* woodland over *Leptospermum lanigerium* scrubby heath.

The tallest stratum at all sites is between 8 m and 30 m. The most common dominant trees in the tallest stratum are *Eucalyptus pauciflora* and *E. viminalis. E. delegatensis* and *E. ovata* were also present as dominants at three sites each. *E. amygdalina, E. dalrympleana, E. rodwayi, E. coccifera* and *E. rubida* also appear infrequently as dominants.

L. lanigerum was the dominant shrub in the second stratum at three-quarters of the sites in this community. *Nothofagus cunninghamii* and *Acacia dealbata* were also dominant at one site each. Other shrubs that were prominent in the second stratum were *Oxylobium ellipticum, Acacia mucronata, Hakea lissosperma, Hakea microcarpa, Banksia marginata* and *Leptospermum scoparium.*

The ground stratum in this community, dominated by shrubs, grasses and sedges, displays the greatest variation in life-form composition and cover. Where dominant species are evident, *Leptospermum lanigerum* and *Poa labillardierei* are the most common. Other species that occur as infrequent dominants are the shrubs, *Cyathodes juniperina, Olearia phlogopappa, Melaleuca gibbosa, Bauera rubioides* and *Cyathodes parvifolia*; the grass, *Themeda triandra*; and the graminoids, *Lomandra longifolia, Gahnia grandis, Juncus astreptus* and *Carex appressa.*

This riparian community is found adjacent to scrubby *Eucalyptus* woodlands and open-forests, grassy-sedgey *Eucalyptus* woodlands, and heaths where no *Eucalyptus* species are present. The majority of sites are found adjoining forestry areas, and the others are adjacent to state reserves and agricultural land.

No affinity exists between this community and any other described vascular community.

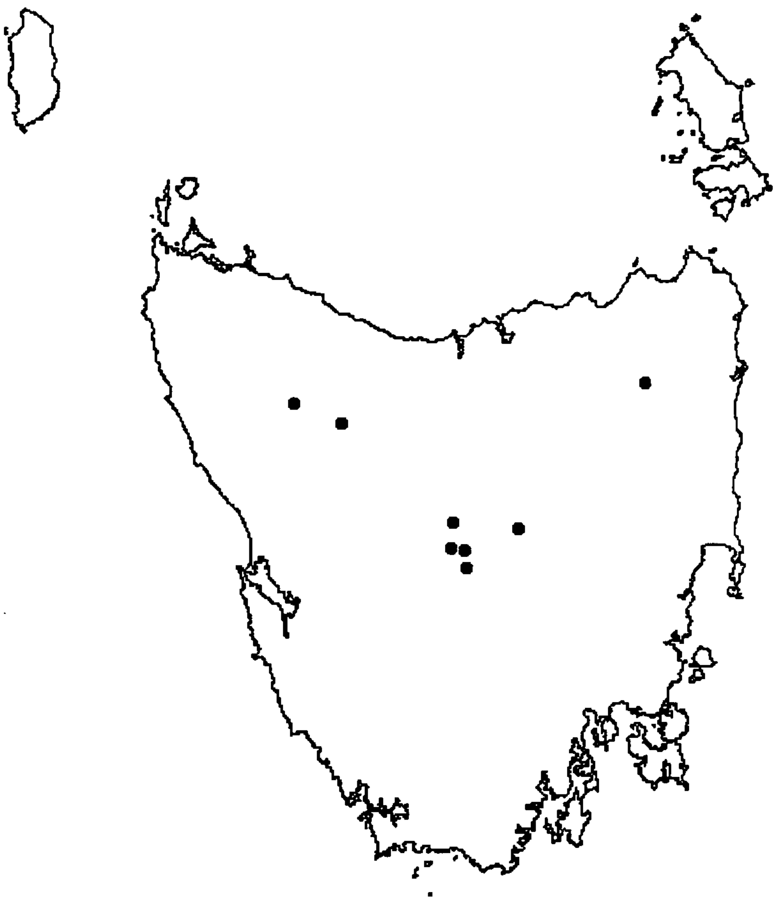
This floristic community is closely related to Community 10. Examples of the two structural variants of this floristic community can be seen in Plates 29 and 30.

Plate 30 *Eucalyptus* woodland over *Leptospermum lanigerum* sedgey-grassy closed-scrub at Site 118 – Elizabeth River

Plate 31 *Eucalyptus* woodland over *Leptospermum lanigerum* scrubby heath at Site 181 – Hydro Creek.

Plate 32 *Acacia melanoxylon* woodland over *Melaleuca squarrosa**Leptospermum lanigerum* ferny-heathy closed-scrub at Site 247 – Mountain Creek.

Community 12 ***Eucalyptus delegatensis*** **woodland over** ***Leptospermum lanigerum*** **grassy-herby-ferny closed-scrub**



Common species

Acacia dealbata	tree	*Geranium potentilloides*	herb
Eucalyptus delegatensis	tree	*Gonocarpus micranthus*	herb
Bauera rubioides	shrub	*Gonocarpus montanus*	herb
Coprosma nitida	shrub	*Hydrocotyle hirta*	herb
Cyathodes parvifolia	shrub	*Hydrocotyle sibthorpioides*	herb
Epacris gunnii	shrub	*Hypericum japonicum*	herb
Hakea microcarpa	shrub	*Lagenifera stipitata*	herb
Leptospermum lanigerum	shrub	*Leptinella reptans*	herb
Olearia phlogopappa	shrub	*Oxalis perennans*	herb
Pultenaea juniperina	shrub	*Viola hederacea*	herb
Tasmannia lanceolata	shrub	*Agrostis* species	grass
Carex appressa	sedge	*Poa labillardierei*	grass
Carex gaudichaudiana	sedge	*Blechnum nudum*	fern
Juncus australis	rush	*Blechnum penna-marina*	fern
Acaena novae-zelandiae	herb	*Polystichum proliferum*	fern
Euchiton involucratus	herb	Moss species	
Euchiton species	herb	Lichen species	

Community 12 *Eucalyptus delegatensis* woodland over *Leptospermum lanigerum* grassy-herby-ferny closed-scrub

This floristic community is characterised by the presence of *Geranium potentilloides, Hydrocoytle hirta, Blechnum penna-marina, Gonocarpus montanus, Euchiton involucratus, Oxalis perennans, Lagenifera stipitata, Gonocarpus micranthus* and *Carex gaudichaudiana*.

This community is found in the Central Highlands, Northern Slopes and Ben Lomond bioregions, predominantly in the headwaters and middle order streams of the Arthur River, River Ouse, South Esk River, upper River Derwent catchments and watercourses that flow to Great Lake and to the north coast of Tasmania. It is found at altitudes from 680 m to 960 m.

There are two distinctive structural variants in this community:

- *Eucalyptus* woodland over grassy, sedgey, heathy and/or ferny closed scrub; and
- sedgey or herby *Poa labillardierei* grasslands.

The former variant is the most common structure within this community. There is also one site along the Waratah River that is a *Carex gaudichaudiana* grassy closed-sedgeland.

The most common dominant species in the treed variant is *Eucalyptus delegatensis*. *E. rodwayi, E. amygdalina* and *E. pauciflora* also occur as dominants at individual sites. In the treeless variants, *Poa labillardierei* and *Juncus australis* occur as dominants in the tallest stratum.

In the second stratum of the treed variant, *Leptospermum lanigerum* is the most common dominant shrub occurring in over half the sites. However, *Tasmannia lanceolata* and *Coprosma nitida* also feature strongly in this stratum. *Poa labillardierei*, *Hydrocotyle* species and *Acaena novae-zelandiae* occur as dominants in the grassland and sedgeland variants.

The third stratum of this community has the greatest diversity of species and lifeforms. Pteridophyta species, mainly *Blechnum penna-marina*, occur as dominants in one third of the sites. Cyperaceae species including *Carex gaudichaudiana* are dominant at three sites. Also occurring as infrequent dominant species are the shrub, *Cyathodes parvifolia*, the herb, *Gunnera cordifolia* and moss species.

This riparian community is found adjacent to scrubby, shrubby, ferny and heathy woodland and open forest, regrowth forest and at one site, *Poa labillardierei* grasslands scattered with *Nothofagus cunninghamii*.

No affinity exists between this community and any other described vascular community.

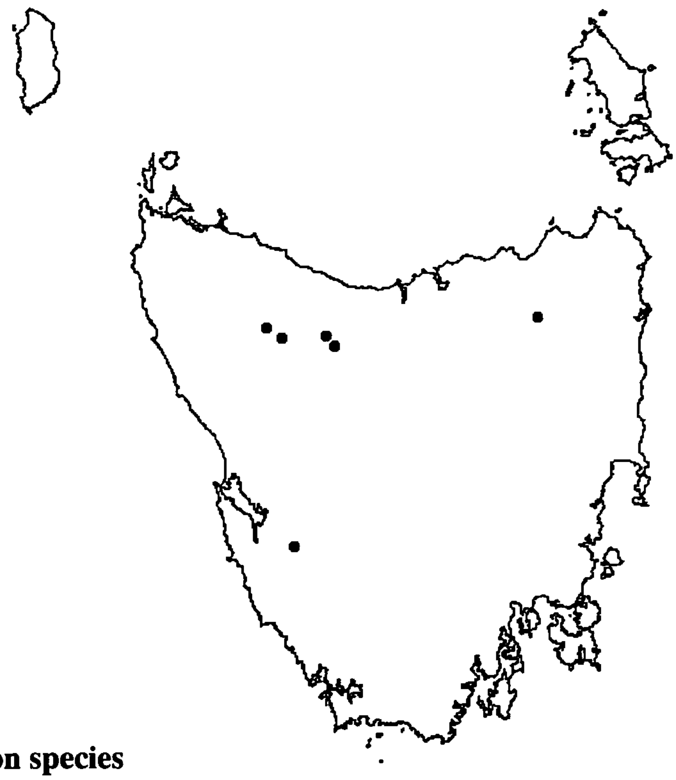
It is most closely related to Community 3. Examples of the two structural variants of this community can be found on Plates 32, 33 and 34.

Plate 33 *Eucalyptus* woodland over closed-scrub at Site 221 – Jackson Creek.

Plate 34 *Poa* grasslands at Site 199 – Newitts Creek.

Plate 35 *Eucalyptus delegatensis* open-forest over *Poa labillardierei* mossy-herby grassland at Site 458 – River Leven.

Community 13 *Nothofagus cunninghamii-Atherosperma moschatum-Poa labillardierei-Libertia pulchella-Blechnum nudum* closed-forest



Common species

Acacia dealbata	tree
Acacia melanoxylon	tree
Anodopetalum biglandulosum	tree
Atherosperma moschatum	tree
Eucalyptus delegatensis	tree
Nothofagus cunninghamii	tree
Phyllocladus aspleniifolius	tree
Pomaderris apetala	tree/shrub
Acacia mucronata	shrub
Anopterus glandulosus	shrub
Aristotelia pedunculata	shrub
Cassinia aculeata	shrub
Coprosma quadrifida	shrub
Cyathodes juniperina	shrub
Leptospermum lanigerum	shrub
Nematolepis squamea	shrub
Olearia phlogopappa	shrub
Ozothamnus thyrsoideus	shrub
Pimelea drupacea	shrub
Pimelea ligustrina	shrub
Pittosporum bicolor	shrub
Prostanthera lasianthos	shrub
Pultenaea juniperina	shrub
Tasmannia lanceolata	shrub
Telopea truncata	shrub
Carex appressa	sedge
Gahnia grandis	sedge
Schoenus nitens	sedge
Schoenus species	sedge
Uncinia tenella	sedge
Acaena novae-zelandiae	herb
Drymophila cyanocarpa	herb
Euchiton species	herb
Galium australe	herb
Geranium potentilloides	herb
Hydrocotyle hirta	herb
Lagenifera stipitata	herb
Oxalis magellanica	herb
Oxalis perennans	herb
Viola hederacea	herb
Agrostis species	grass
Poa labillardierei	grass
Poa species	grass
Juncus pauciflorus	rush
Juncus species	rush
Libertia pulchella	iris
Clematis aristata	climber
Blechnum fluviatile	fern
Blechnum nudum	fern
Blechnum penna-marina	fern
Blechnum wattsii	fern
Dicksonia antarctica	fern
Histiopteris incisa	fern
Polystichum proliferum	fern
Moss species	
Lichen species	

Community 13 *Nothofagus cunninghamii-Atherosperma moschatum-Poa labillardierei-Libertia pulchella-Blechnum nudum* closed-forest

This floristic community is characterised by the presence of *Nothofagus cunninghamii* and *Atherosperma moschatum, Poa labillardierei, Libertia pulchella, Uncinia tenella* and *Aristotelia pedunculata.*

This community is found mainly in northern Tasmania in the Northern Slopes bioregion but also occurs at one site in each of the Ben Lomond, West and Central Highlands bioregions. It occurs in the catchments of the Arthur River, River Forth, Gordon River, North Esk River and Winter Brook at altitudes from 40 m to 620 m.

There are two equally common structural variants in this community:

- *Nothofagus cunninghamii* shrubby, sedgey and/or ferny closed-forest; and
- *Eucalyptus, Acacia* or *Nothofagus* woodland over *Leptospermum lanigerum* sedgey-ferny closed-scrub.

However, there is also one structural variant at Winter Brook that occurs as *Eucalyptus delegatensis/E. dalrympleana* woodland over *L. lanigerum* ferny-sedgey closed-scrub.

Nothofagus cunninghamii is the most common dominant species in the tallest stratum. However, *E. delegatensis* over-tops *N. cunninghamii* at two sites. *Acacia dealbata* and *A. melanoxylon* may also be present as co-dominants in this stratum. The canopy of this stratum tends to be between 8 m and 30 m with a cover ranging from 6% to 100%.

Leptospermum lanigerum is the most common dominant species in the second stratum. *Atherosperma moschatum, L. riparium, Pomaderris apetala* and *Coprosma quadrifida* also occur as infrequent dominant species in this stratum. *Tasmannia lanceolata* and *Aristotelia pedunculata* are also common. The cover of this stratum also tends to vary from around 25% to over 75% depending on the site and the cover of the tallest stratum.

Ferns, most frequently *Blechnum nudum* and *Polystichum proliferum*, are the most common dominant species in the ground stratum with a cover that ranges from 5% to 100%. Herbs, grasses and graminoids do not have an extensive cover in this community, usually less than 6%. However at one site, grasses and herbs form up to 75% of the cover. At this site on the Wandle River, *Carex appressa* and *Poa labillardierei* are the dominant species.

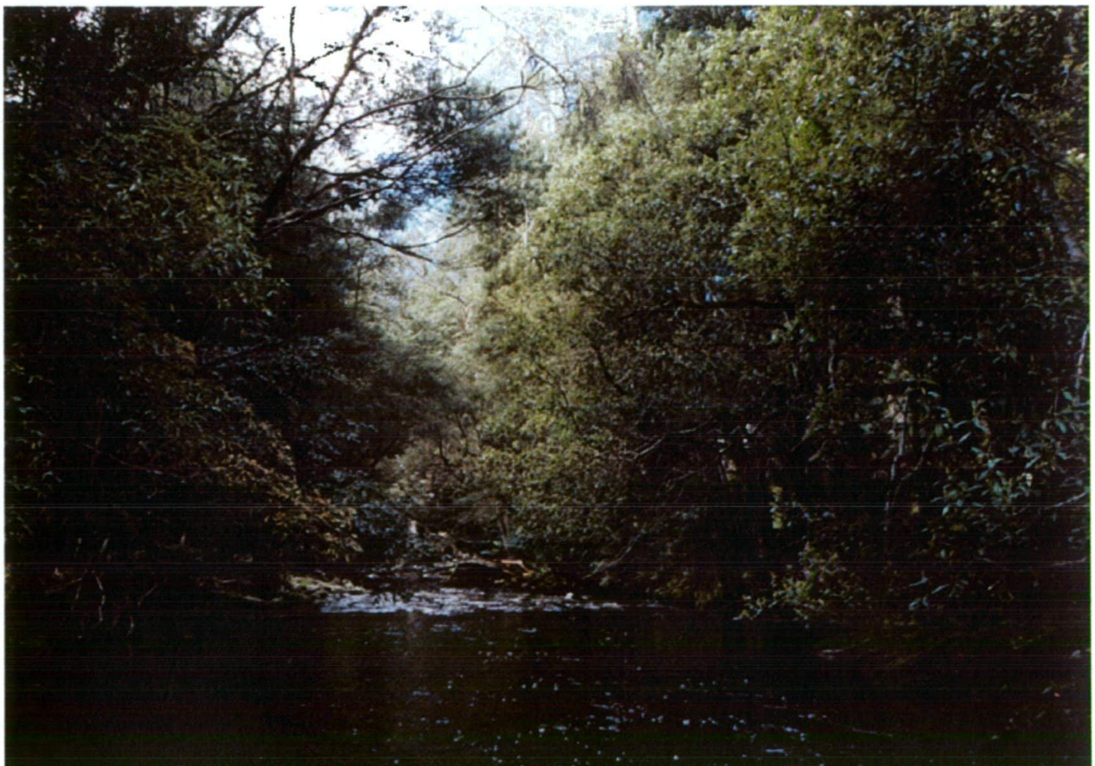
This riparian community is found adjacent to *Eucalyptus* and *Nothofagus/Acacia* scrubby forest and, at one site, heathy *Poa* grassland. Half of the sites adjoin reserves. The others are found within forestry holdings and one site is adjacent to cropping and grazing land.

No affinity exists between this community and any other described vascular community.

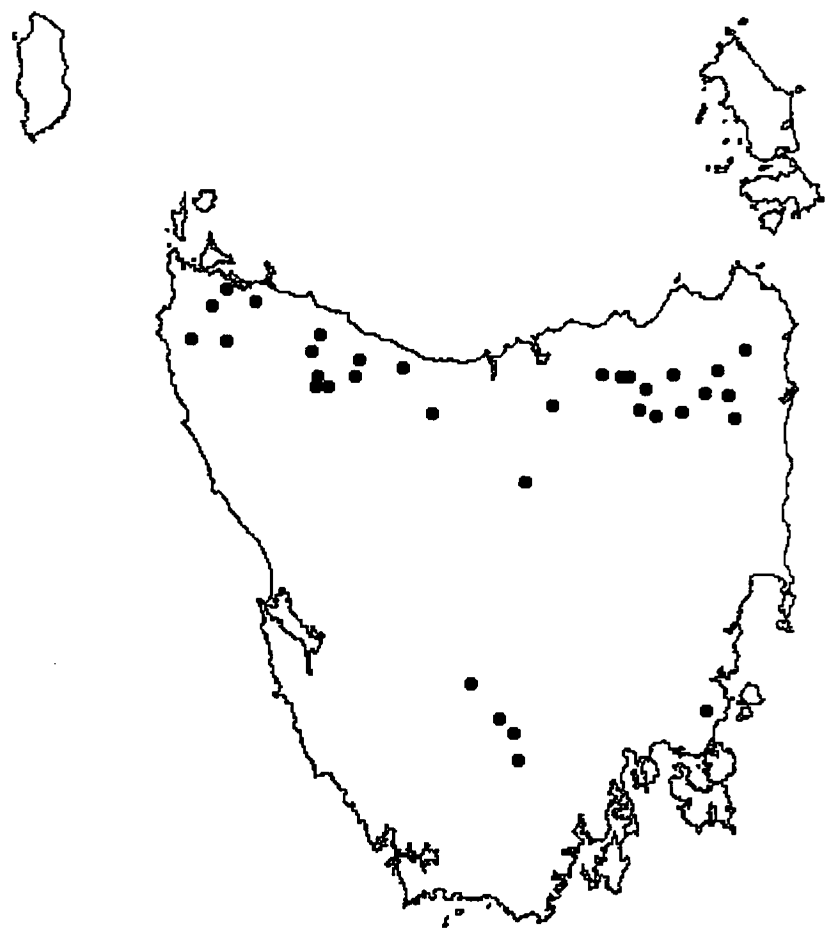
This floristic community is closely related to Community 19. Examples of the two structural variants of this floristic community can be seen in Plates 36 and 37.

Plate 36 *Nothofagus* closed-forest at Site 407- Wilmot River

Plate 37 *Eucalyptus\Acacia\Nothofagus* woodland over *Leptospermum lanigerum* closed-scrub at Site 423 – Winter Brook



Community 14 ***Acacia/Nothofagus/Atherosperma*** **woodland and forest over** ***Olearia*** **shrubland and** ***Dicksonia antarctica*** **fernland**



Common species

Acacia dealbata	tree	*Acaena novae-zelandiae*	herb
Acacia melanoxylon	tree	*Hydrocotyle hirta*	herb
Atherosperma moschatum	tree	*Oxalis perennans*	herb
Nothofagus cunninghamii	tree	*Urtica incisa*	herb
Leptospermum lanigerum	tree/shrub	*Viola hederacea*	herb
Pomaderris apetala	tree/shrub	*Blechnum nudum*	fern
Cassinia aculeata	shrub	*Blechnum wattsii*	fern
Coprosma quadrifida	shrub	*Dicksonia antarctica*	fern
Monotoca glauca	shrub	*Histiopteris incisa*	fern
Olearia argophylla	shrub	*Hypolepis rugosula*	fern
Olearia lirata	shrub	*Microsorum pustulatum*	fern
Pimelea drupacea	shrub	*Polystichum proliferum*	fern
Pittosporum bicolor	shrub	*Rumohra adiantiformis*	fern
Carex appressa	sedge	Moss species	
Juncus pauciflorus	rush	Lichen species	

Community 14 *Acacia/Nothofagus/Atherosperma* woodland and forest over *Olearia* shrubland and *Dicksonia antarctica* fernland

This community is characterised by the presence of *Olearia argophylla, Monotoca glauca, Microsorum pustulatum, Rumohra adiantiformis, Juncus pauciflorus, Urtica incisa, Muehlenbeckia gunnii, Grammitis billardierei, Hypolepis rugosula* and *Hymenophyllum flabellatum.*

This floristic community is found mainly in northern Tasmania in the King, Northern Slopes, and Ben Lomond bioregions but it also occurs in the Southern Ranges and at one site in the South East and Flinders bioregions. It occurs in the catchments of the Arthur, Brid, Duck, George, Great Musselroe, Great Forester, Huon, Meander, Montagu, North Esk, Pipers, Ringarooma, South Esk Rivers and minor catchments that flow in the south east, north and northwest coasts, the Tamar estuary and the lower and upper reaches of the River Derwent. It is found at altitudes from 20 m to 900 m.

The structure of this community is difficult to define. However, epiphytic ferns are characteristic of this community. There are two distinctive structural variants:

- *Nothofagus, Atherosperma* and/or *Acacia* open and closed-forest over *Dicksonia* fernland; and
- *Nothofagus, Atherospermum* and/or *Acacia* woodland over *Olearia* ferny shrubland.

Other structural forms represented in this community are:

- *Eucalyptus/Acacia* woodland over ferny *Leptospermum/Pomaderris* closed-scrub;
- *Acacia* open-forest over *Pittosporum/Pomaderris* ferny closed-forest;
- *Eucalyptus/Acacia* woodland over *Monotoca* ferny open-forest;
- *Acacia* shrubby-ferny open and closed-forests;
- *Acacia/Nothofagus* ferny scrubby closed-forest;
- *Acacia* woodland over *Nothofagus/Atherospermum* ferny closed-forest;
- *Eucalyptus* woodland over ferny-mossy shrubland;
- *Eucalyptus* woodland over ferny-sedgey closed-scrub;
- *Pomaderris* mossy-ferny closed-forest;
- *Eucalyptus/Acacia* open-forest over *Dicksonia* fernland; and
- *Nothofagus/Atherosperma* woodland over mossy *Anodopetalum biglandulosum* (Horizontal) closed-scrub.

The tallest stratum is generally between 8 m and 30 m tall with a cover that varies from 6 % to 100% but is generally greater than 50%. The most frequently occurring dominant species is *Acacia melanoxylon* followed by *Nothofagus cunninghamii, Acacia dealbata* and

Atherosperma moschatum. Also occurring as infrequent dominant species are *Pomaderris apetala, E. obliqua, E. regnans, E. delegatensis* and *E. viminalis.*

The height and cover of the second stratum is also variable. Height is generally between 2 m and 8 m but ranges from less than 1 m to around 20 m. Cover is generally greater than 50% but ranges from 5% to 100%. *Pomaderris apetala* is the most frequently occurring dominant species followed by *Dicksonia antarctica*. Also occurring as infrequent dominants in this stratum are *Leptospermum lanigerum, Nothofagus cunninghamii, Atherosperma moschatum, Acacia dealbata, Olearia lirata, Olearia argophylla, Anodopetalum biglandulosum, Monotoca glauca, Acacia melanoxylon, Pittosporum bicolor, Eucryphia lucida* and *Blechnum nudum.*

The height of the ground stratum is usually less than 1 m. However, cover varies from 6% to 100 %. Ferns are the most frequently occurring dominant species in this stratum with *Blechnum nudum, Polystichum proliferum* and *Dicksonia antarctica* the most common. However, at two sites in this community, the graminoids, *Lepidosperma elatius* and *Carex appressa,* were dominant in the ground stratum. At two other sites, the trees, *Olearia argophylla, Leptospermum lanigerum* and *Pittosporum bicolor* were dominant species in the ground stratum.

This community is found adjacent to *Eucalyptus* woodland, open-forest and closed-forest with an understorey that is scrubby, shrubby and/or ferny and at one site, adjacent to *Acacia* ferny-scrubby closed-forest. It also occurs adjacent to regrowth forests, *Eucalyptus* plantations and cleared agricultural land.

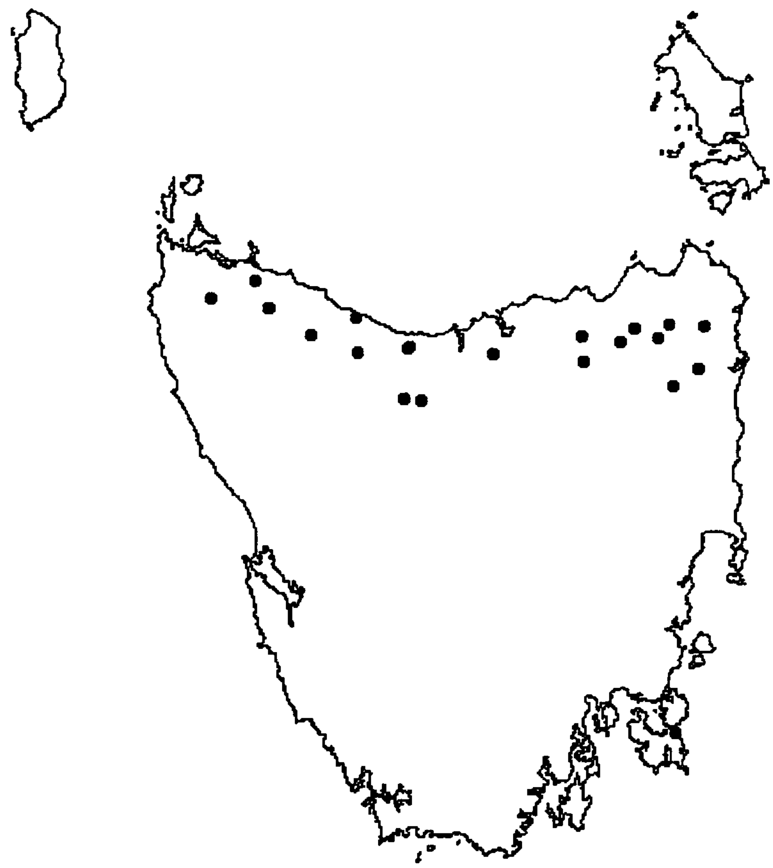
This community has affinity with the Riparian blackwood/leatherwood forest (51%), *Eucalyptus obliqua-Nothofagus cunninghamii-Polystichum proliferum-Hymenophyllum flabellatum* mixed forest (64%), and *Eucalyptus regnans-Atherosperma moschatum-Acacia dealbata-Olearia argophylla* wet sclerophyll/mixed forest (71%) (Kirkpatrick *et al.* 1995: 104, 134, 139).

It is closely related floristically to Community 15. Examples of the structural variants within this floristic community can be seen in Plates 38 and 39.

Plate 38 *Acacia melanoxylon* shrubby-ferny open-forest at Site 390 – Flowerdale River.

Plate 39 *Eucalyptus obliqua\Nothofagus cunninghamii* wet open- forest over scrubby, mossy-sedgey mixed fernland at Site 440 – Guide River.

Community 15 ***Eucalyptus obliqua/E. regnans*** **open-forest over** ***Pomaderris apetala-Olearia lirata*** **sedgey-ferny shrubland**



Common species

Acacia dealbata	tree	*Gahnia grandis*	sedge
Acacia melanoxylon	tree	*Lepidosperma ensiforme*	sedge
Atherosperma moschatum	tree	*Acaena novae-zelandiae*	herb
Eucalyptus obliqua	tree	*Gonocarpus teucrioides*	herb
Eucalyptus regnans	tree	*Hydrocotyle hirta*	herb
Eucalyptus viminalis	tree	*Viola hederacea*	herb
Nothofagus cunninghamii	tree	*Agrostis* species	grass
Acacia mucronata	tree/shrub	*Clematis aristata*	creeper
Leptospermum lanigerum	tree/shrub	*Dianella tasmanica*	lily
Pomaderris apetala	tree/shrub	*Blechnum minus*	fern
Cassinia aculeata	shrub	*Blechnum nudum*	fern
Coprosma quadrifida	shrub	*Blechnum wattsii*	fern
Monotoca glauca	shrub	*Dicksonia antarctica*	fern
Nematolepis squamea	shrub	*Histiopteris incisa*	fern
Olearia lirata	shrub	*Microsorum pustulatum*	fern
Pimelea drupacea	shrub	*Polystichum proliferum*	fern
Pittosporum bicolor	shrub	*Pteridium esculentum*	fern
Prostanthera lasianthos	shrub	*Sticherus tener*	fern
Pultenaea juniperina	shrub	Moss species	
Zieria arborescens	shrub	Lichen species	
Carex appressa	sedge		

Community 15 *Eucalyptus obliqua/E. regnans* open-forest over sedgey-ferny *Pomaderris apetala-Olearia lirata* shrubland

This community is characterised by the presence of *Pomaderris apetala, Olearia lirata, Eucalyptus obliqua, Prostanthera lasianthos, Acacia mucronata, Gahnia grandis, Dianella tasmanica, Lepidosperma ensiforme, Pultenaea juniperina, Blechnum minus* and *Sticherus tener.*

This floristic community occurs mainly in northern Tasmania in the King, Northern slopes and Ben Lomond bioregions, although there is one site on the Tasman Peninsula in the South East bioregion. It occurs in the catchments of the Blythe, Duck, George, Great Forester, Great Musselroe, Inglis, Mersey, North Esk, Ringarooma and South Esk Rivers, the River Forth and Blowhole Creek. It is found at altitudes from 5 m to 440 m.

The most frequently occurring structure in this community is:

- *Eucalyptus/Acacia* woodland or open-forest over ferny closed-scrub (5 sites).

Other riparian structures represented in this community are:

- *Eucalyptus* woodland over sedgey-ferny open and closed-forest;
- *Eucalyptus* woodland and open-forest over sedgey-shrubby fernland;
- *Eucalyptus* woodland and open-forest over sedgey-ferny shrubland;
- *Acacia/Pomaderris* ferny closed-shrubland;
- *Acacia* open-forest over shrubby fernland;
- *Leptospermum/Acacia* ferny-scrubby open-forest;
- *Leptospermum/Pomaderris* ferny scrubby open-forest; and
- *Nothofagus/Acacia* shrubby-sedgey-ferny open-forest;

The tallest stratum is between 8 m and 30 m tall with a cover ranging from 6%, to 100%. The most frequently occurring dominant species is *Eucalyptus obliqua* followed by *Acacia dealbata* and *E. regnans*. Also occurring as infrequent dominants were *A. melanoxylon, A. verticillata, A. mucronata, Nothofagus cunninghamii, E. globulus, E. ovata, Leptospermum lanigerum, Pomaderris apetala, E. viminalis* and *Atherospermum moschatum.*

In all cases, the second stratum is between 2 m and 8 m in height, but cover varies from about 20% to 100%. The most common dominant species in this stratum is *Pomaderris apetala.* Also occurring as infrequent dominants are *Leptospermum lanigerum, Acacia melanoxylon, A. dealbata, Nothofagus cunninghamii, Olearia argophylla, A. mucronata,* *Atherospermum moschatum, Pittosporum bicolor, Coprosma quadrifida, Cassinia trinerva* and *L. scoparium.*

At most sites, ferns and sedges dominate the cover of the ground stratum although at one site, *Olearia lirata* was noted as the dominant species. Of the ferns, where a dominant species could be discerned, *Blechnum nudum* and *Dicksonia antarctica* were the most commonly occurring dominants, although *Gleichenia dicarpa* also appeared as a dominant species at one site. Other common ferns in this stratum were *Blechnum wattsii, Pteridium esculentum, Blechnum minus, Sticherus tener, Histiopteris incisa* and *Polystichum proliferum.* Of the sedges, *Lepidosperma ensiforme* was dominant at one site, but *Carex appressa* was also common in this stratum.

This community is commonly found adjacent to *Eucalyptus obliqua* or *E. regnans* ferny, sedgey and/or scrubby woodland, open-forest or regrowth forest. It also occurs adjacent to *Eucalyptus* and pine plantations and cleared agricultural land.

This community has affinity with *Eucalyptus obliqua-Nothofagus cunninghamii-Monotoca glauca* mixed forest (57%) and *Eucalyptus regnans- E. obliqua-Pomaderris apetala-Olearia lirata* wet sclerophyll forest (58%) (Kirkpatrick *et al.* 1995: 136, 138).

It is closely related floristically to Community 9. An example of the most frequently riparian structure within this floristic community can be seen in Plate 40. Examples of two of the other distinctive variants can be seen in Plates 41 and 42.

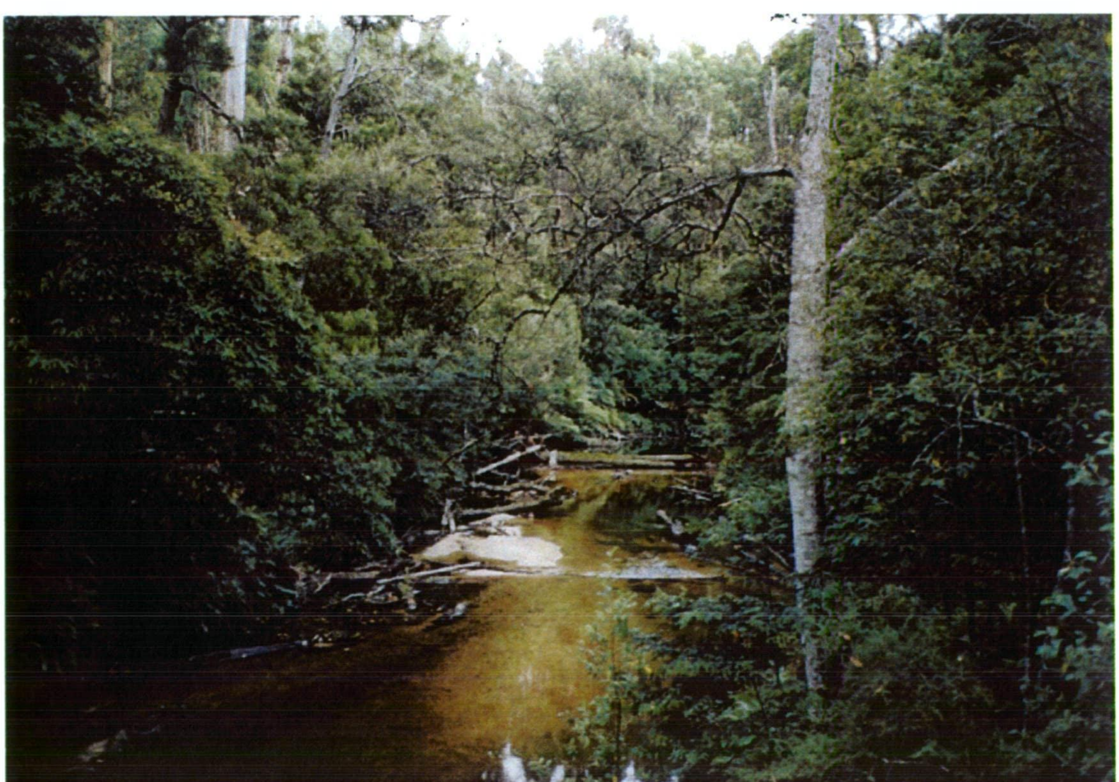
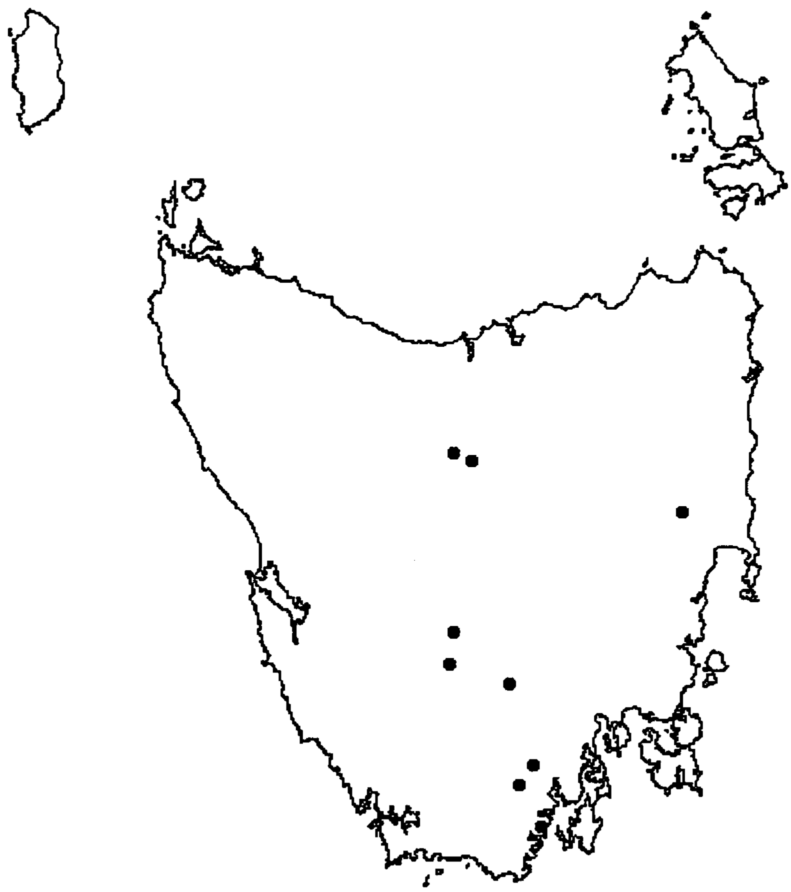


Plate 40 *Eucalyptus-Acacia* woodland over ferny closed-scrub at Site 192 – Musselroe River.

Plate 41 *Eucalyptus* woodland over shrubby fernland at Site 165 - Delvin Creek.

Plate 42 *Eucalyptus obliqua\Atherosperma moschatum* open-forest over *Pomaderris apetala* sedgey-ferny closed-scrub to open-forest at Site 437 – Black River.

Community 16 *Acacia dealbata-Pomaderris apetala-Olearia argophylla-Dicksonia antarctica* ferny-sedgey closed-scrub



Common species

Acacia dealbata	tree	*Gahnia grandis*	sedge
Acacia melanoxylon	tree	*Schoenus maschalinus*	sedge
Atherosperma moschatum	tree	*Schoenus* species	sedge
Eucalyptus delegatensis	tree	*Acaena novae-zelandiae*	herb
Eucalyptus regnans	tree	*Euchiton collinus*	herb
Nothofagus cunninghamii	tree	*Galium australe*	herb
Leptospermum lanigerum	tree/shrub	*Oxalis perennans*	herb
Pomaderris apetala	tree/shrub	*Viola hederacea*	herb
Aristotelia pedunculata	shrub	*Agrostis* species	grass
Cassinia aculeata	shrub	Poaceae species	grass
Coprosma quadrifida	shrub	*Dianella tasmanica*	lily
Correa lawrenceana	shrub	*Billardiera longiflora*	climber
Cyathodes glauca	shrub	*Clematis aristata*	climber
Gaultheria hispida	shrub	*Blechnum fluviatile*	fern
Monotoca glauca	shrub	*Blechnum nudum*	fern
Nematolepis squamea	shrub	*Blechnum wattsii*	fern
Olearia argophylla	shrub	*Dicksonia antarctica*	fern
Pimelea cinerea	shrub	*Gleichenia microphylla*	fern
Pimelea drupacea	shrub	*Polystichum proliferum*	fern
Pultenaea juniperina	shrub	*Pteridium esculentum*	fern
Tasmannia lanceolata	shrub	Moss species	
Zieria arborescens	shrub	Lichen species	

Community 16 *Acacia dealbata-Pomaderris apetala-Olearia argophylla-Dicksonia antarctica* ferny-sedgey closed-scrub

This floristic community is characterised by the presence of *Dicksonia antarctica, Acacia dealbata, Pomaderris apetala* and *Olearia argophylla* at all sites and the presence of *Eucalyptus regnans, E. delegatensis, Tasmannia lanceolata* and *Euchiton collinus.*

It is found mostly in the Southern Ranges and Northern Slopes bioregions but there is also one site within the South East bioregion. Sites are located within the catchments of the Upper and Lower River Derwent, Meander River, Mersey River, Swan River and two watercourses that drain into the D'Entrecasteaux Channel. It is found at altitudes between 80 m and 660 m.

Even though there are relatively few sites in this community, there are four structural variants. In order of frequency of occurrence they are:

- *Eucalyptus* or *Nothofagus* woodland over ferny or sedgey closed-scrub;
- *Acacia* or *Nothofagus* ferny closed-forest;
- *Acacia* or *Eucalyptus* woodland over ferny open-scrub; and
- *Atherosperma* woodland over *Dicksonia antarctica* fernland.

The most commonly occurring dominant species in the tallest stratum are *Acacia dealbata* and *Nothofagus cunninghamii.* However, *Atherosperma moschatum, E. delegatensis, E. obliqua, E. regnans,* and *Leptospermum lanigerum* also occur as infrequent dominants in this stratum.

Pomaderris apetala is present at all sites and is the most common dominant species in the second stratum of this community. *Coprosma quadrifida, Nematolepis squamea, Beyeria viscosa, Dicksonia antarctica, Acacia verticillata, Leptospermum lanigerum* and *Nothofagus cunninghamii* also occur as dominant species at individual sites.

Ferns are the dominant life-form in the ground stratum with a cover ranging from 26% to 100%. Herbs, graminoids and grasses, if present, seldom exceed 25% cover. *Blechnum nudum* and *B. wattsii* are the most commonly occurring ferns but *Gleichenia microphylla, Pteridium esculentum, Polystichum proliferum, Blechnum fluviatale, Hymenophyllum australe* and *Blechnum penna-marina* may also be present. *Carex appressa* and *Dianella tasmanica* featured strongly at two sites along the Florentine River.

In most cases, this riparian community is adjacent to *Eucalyptus regnans* ferny-shrubby open-forest, or woodland (often in association with *E. amygdalina, E. viminalis, E. obliqua* and/or *E. globulus*) with the remainder of sites adjacent to *E. delegatensis* woodland over shrubby closed-forest. It is noted that the major land use adjacent to eight of the sites is forestry with grazing being the major land use adjoining the site at Castle Forbes Bay Rivulet.

This community has affinity with *Eucalyptus obliqua-Nothofagus cunninghamii-Monotoca glauca* mixed forest (54%) and *Eucalyptus regnans-E. obliqua-Pomaderris apetala-Olearia lirata* wet sclerophyll forest (Kirkpatrick *et al.* 1995: 136, 138).

This floristic community is closely related to Community 15. Three common structural variants of this community are represented in Plates 43, 44 and 45.

Plate 43 *Eucalyptus* woodland over closed-scrub at Site 65 – Styx River

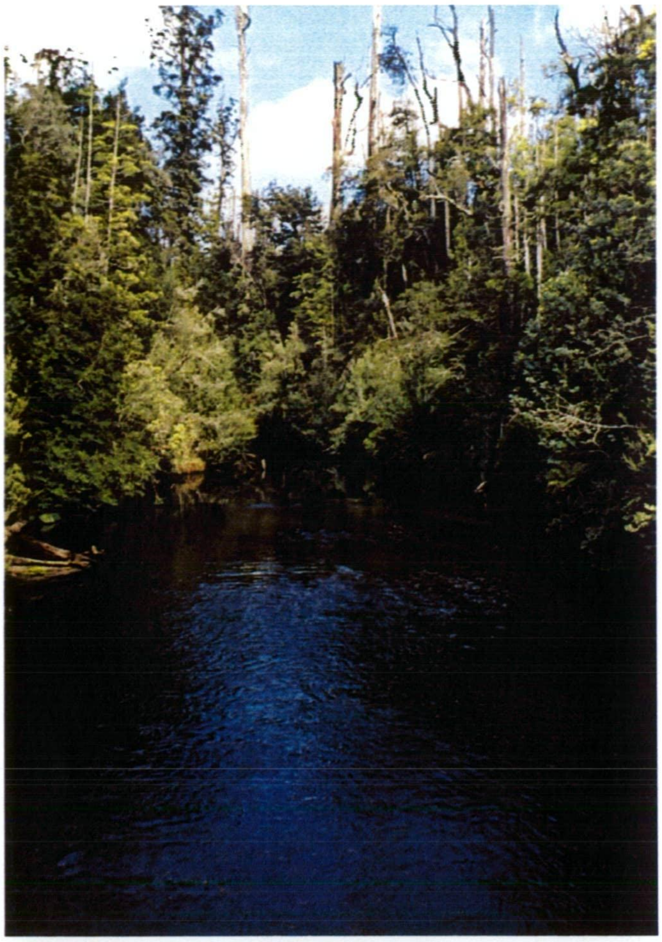
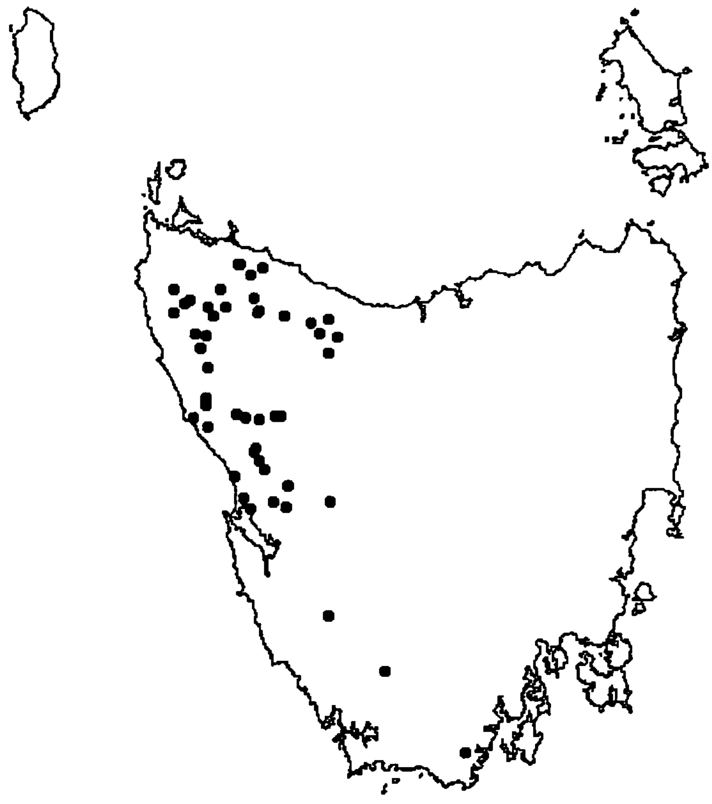


Plate 44 *Acacia-Nothofagus* ferny closed-forest at Site 120 – Florentine River.

Plate 45 *Acacia dealbata woodland* over *Pomaderris apetala\Leptospermum lanigerum* ferny closed-forest at Site 233 – Meander River.

Community 17 *Acacia melanoxylon-Nothofagus cunninghamii-Eucryphia lucida-Acacia mucronata* mossy-sedgey-ferny forest and closed-scrub



Common species

Acacia dealbata	tree	*Tasmannia lanceolata*	shrub
Acacia melanoxylon	tree	*Carex appressa*	sedge
Atherosperma moschatum	tree	*Gahnia grandis*	sedge
Eucalyptus nitida	tree	*Isolepis* species	sedge
Eucalyptus obliqua	tree	*Baloskion tetraphyllum*	rush
Nothofagus cunninghamii	tree	*Juncus pauciflorus*	rush
Phyllocladus aspleniifolius	tree	*Juncus* species	rush
Acacia mucronata	tree/shrub	*Dianella tasmanica*	lily
Acacia verticillata	tree/shrub	*Clematis aristata*	climber
Leptospermum lanigerum	tree/shrub	*Acaena novae-zelandiae*	herb
Pomaderris apetala	tree/shrub	*Hydrocotyle hirta*	herb
Anopterus glandulosus	shrub	*Viola hederacea*	herb
Cenarrhenes nitida	shrub	*Blechnum minus*	fern
Coprosma quadrifida	shrub	*Blechnum nudum*	fern
Cyathodes juniperina	shrub	*Blechnum wattsii*	fern
Epacris impressa	shrub	*Dicksonia antarctica*	fern
Eucryphia lucida	shrub	*Gleichenia microphylla*	fern
Leptospermum riparium	shrub	*Histiopteris incisa*	fern
Leptospermum scoparium	shrub	*Hypolepis rugosula*	fern
Melaleuca squarrosa	shrub	*Microsorum pustulatum*	fern
Monotoca glauca	shrub	*Polystichum proliferum*	fern
Nematolepis squamea	shrub	*Pteridium esculentum*	fern
Pimelea drupacea	shrub	*Sticherus tener*	fern
Pittosporum bicolor	shrub	Moss species	
Prostanthera lasianthos	shrub	Lichen species	

Community 17 *Acacia melanoxylon-Nothofagus cunninghamii-Eucryphia lucida-Acacia mucronata* mossy-sedgey-ferny forest and closed-scrub

This widespread community is characterised by the presence of *Nothofagus cunninghamii, Acacia mucronata, Nematolepis squamea, Eucalyptus nitida, Eucalyptus obliqua, Leptospermum riparium, Gleichenia microphylla, Histiopteris incisa* and *Monotoca glauca.*

This floristic community occurs mainly in northwestern Tasmania in the King, Northern slopes and West bioregions, although there is one site in the Southern Ranges bioregion. It occurs in the catchments of the Arthur, D'Entrecasteaux, Franklin, Gordon, Henty, Huon, King, Pieman, Detention, Black, Inglis, Blythe, and Emu Rivers and the River Leven. It is found at altitudes from 5 m to 420 m.

There is a diverse range of structural variants in this community. There are, however, two frequently occurring structures: shrubby-ferny open or closed-forests; and woodland over ferny-sedgey closed-scrub. These structures can be separated into three frequently occurring groups: forest, woodland and scrub where there are no *Eucalyptus* species dominant in the tallest stratum; forest, woodland and scrub where *Eucalyptus* species are dominant in the tallest stratum; and forest, woodland and scrub with a mixture of *Eucalyptus* and non-*Eucalyptus* species in the tallest stratum.

The most commonly occurring structural forms in the first and largest group are:

- *Nothofagus/Acacia* ferny-sedgey-scrubby closed-forest; and
- *Acacia* woodland, open or closed-forest over sedgey-ferny closed-scrub.

Other structural types occurring infrequently in the non-*Eucalyptus* group are:

- *Eucryphia/Nothofagus* open-forest over ferny closed-scrub;
- *Acacia/Leptospermum* sedgey-ferny closed-scrub;
- *Nothofagus* open-forest over *Eucryphia* mossy-ferny-sedgey closed-forest;
- *Acacia/Nothofagus* closed-forest over *Leptospermum* ferny-heathy-sedgey open-scrub;
- *Acacia* woodland over *Nothofagus/Leptospermum* ferny closed-forest
- *Eucryphia/Nothofagus* scrubby-ferny closed-forest; and
- *Acacia* ferny-scrubby closed-forest.

In the group where *Eucalyptus* species are dominant in the tallest stratum, there are two recurring structural variants:

- *Eucalyptus* woodland over mossy-ferny-sedgey closed-scrub; and
- *Eucalyptus* woodland over heathy-ferny-sedgey open and closed-scrub.

Other structural variants in this group are:

- *Eucalyptus* open-forest over *Acacia/Eucryphia* open-forest over ferny-sedgey closed-scrub;
- *Eucalyptus* woodland over *Pomaderris/Atherosperma* mossy-ferny open-forest; and
- *Eucalyptus* woodland over *Acacia* shrubby-ferny closed-forest.

In the mixed group, there were two recurring riparian structures:

- *Eucalyptus nitida/Nothofagus cunninghamii* open-forest over mossy-ferny-sedgey closed-scrub; and
- *Eucalyptus/Acacia* woodland and open-forest over ferny-sedgey closed-scrub or closed-forest.

The tallest stratum is between 8 m and 30 m tall with a cover ranging from 6%, to 100%. The most frequently occurring dominant species is *Acacia melanoxylon* followed by *Nothofagus cunninghamii, Eucalyptus obliqua* and *E. nitida.* Also occurring as infrequent dominants are *Acacia dealbata, A. mucronata, Eucryphia lucida, Eucalyptus delegatensis, E. ovata, E. viminalis, Leptospermum lanigerum* and *L. scoparium.*

The height of the second stratum varies between 1 m and 20 m and cover varies from about 20% to 100%. The most common dominant species in this stratum is *Leptospermum lanigerum* followed by *Eucryphia lucida, Leptospermum riparium, Acacia melanoxylon* and *A. mucronata.* Also occurring as infrequent dominants are *Pomaderris apetala, A. dealbata, Nothofagus cunninghamii, Anopterus glandulosus, L. scoparium, Melaleuca squarrosa, Acradenia frankliniae* and *Baloskion tetraphyllum.*

Shrubs, ferns and graminoids dominate the cover of the ground stratum. Of the shrubs, *Leptospermum lanigerum* and *L. riparium* are the most frequently occurring dominants. Also occurring as infrequent dominants are *Eucryphia lucida, L. scoparium, A. mucronata, P. apetala, Atherosperma moschatum* and *Phyllocladus aspleniifolius.* Of the ferns, *Blechnum nudum* and *Polystichum proliferum* were the most commonly occurring dominants although *Gleichenia microphylla, Sticherus tener* and *Histiopteris incisa* also appeared as infrequent dominants. Other common ferns in this stratum were *Blechnum wattsii, Dicksonia antarctica, Hypolepis rugosula, Microsorum pustulatum, Blechnum minus* and *Pteridium esculentum.* Of the graminoids, *Baloskion tetraphyllum* was the most frequently occurring dominant. Also occurring as infrequent dominants were *Baloskion australe, Carex appressa, Lepidosperma elatius,* and *Lomandra longifolia.*

At nearly half the sites, this community is found adjacent to regrowth forests, pine and *Eucalyptus* plantations and lands cleared for rough grazing. It also occurs within reserves adjacent to rural residential area. It also frequently occurs adjacent to *Eucalyptus* scrubby-ferny open and closed-forests, *Eucalyptus* woodland over closed-scrub and heathy buttongrass plains and at five sites, scrubby heathlands or sedgelands. It also occurs adjacent to *Nothofagus* shrubby closed-forest, *Acacia melanoxylon* scrubby closed-forest and *A. melanoxylon* woodland over ferny closed-scrub.

This community has affinity with Tea-tree mesophytic scrub forest (55%) and *Eucalyptus obliqua-Melaleuca squarrosa-Monotoca glauca* wet sclerophyll forest (51%) (Kirkpatrick *et al.* 1995: 106, 135).

It is closely related floristically to Community 19. Examples of the two most frequently occurring riparian structures within each main group of this floristic community can be seen in Plate 46, 47, 48, 49 and 50.

Plate 46 *Nothofagus/Acacia* ferny-sedgey-scrubby closed-forest at Site 268 – King River.

Plate 47 *Acacia* open-forest over sedgey-ferny closed-scrub at Site 307 – Henty River.

Plate 48 *Eucalyptus* woodland over mossy-ferny-sedgey closed-scrub at Site 183 – Mystery Creek.

Plate 49 *Eucalyptus* woodland over heathy-ferny-sedgey closed-scrub at Site 360 – Stanley River.

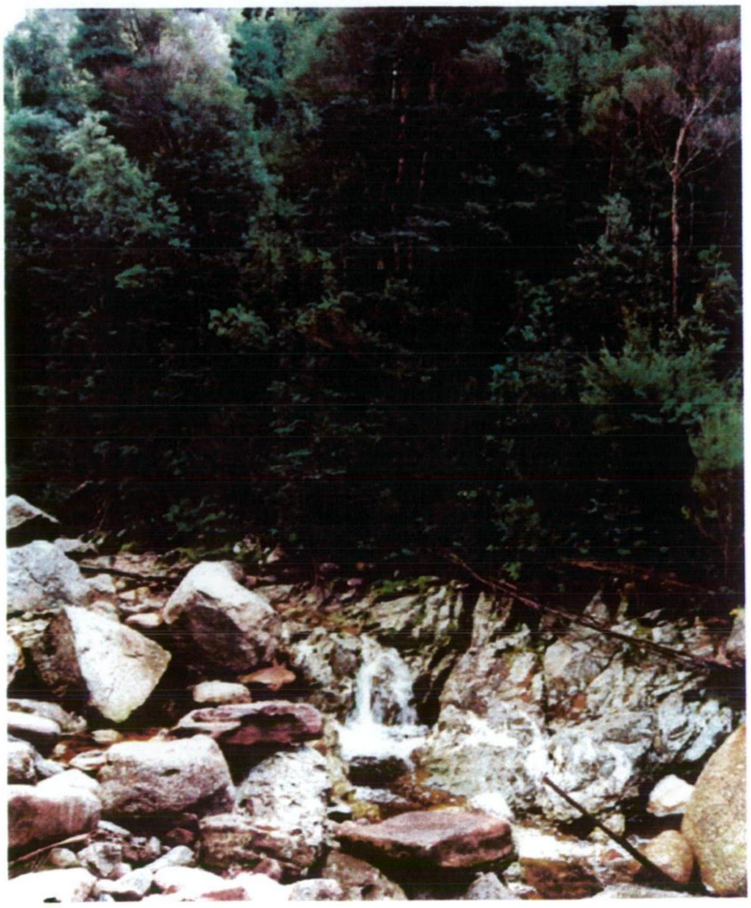
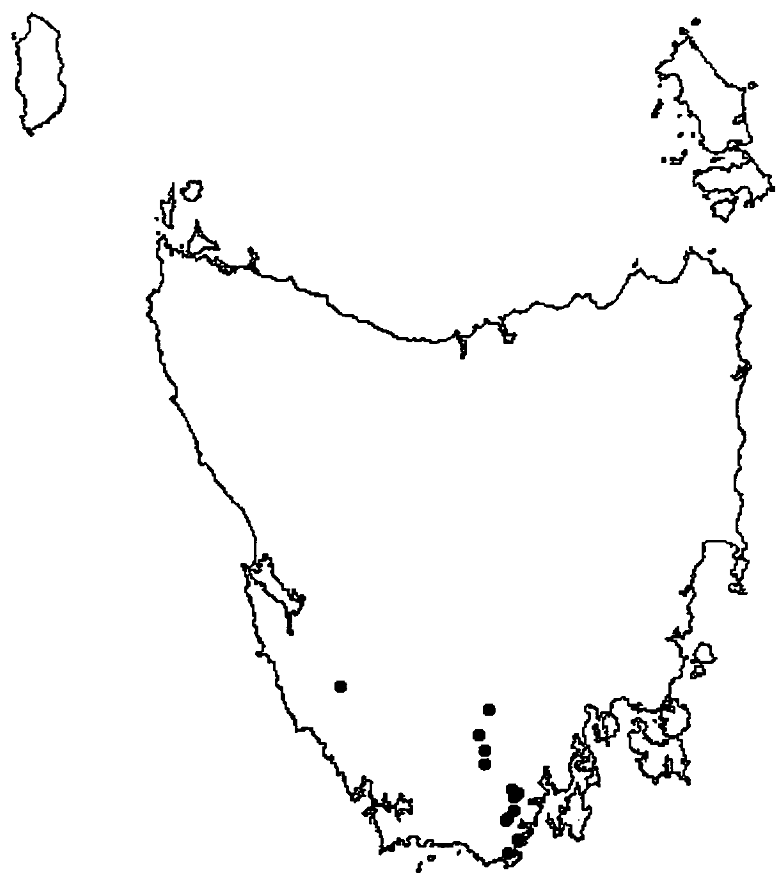


Plate 50 *Eucalyptus nitida*/ *Nothofagus cunninghamii* open-forest over mossy-ferny-sedgey closed-scrub at Site 269 – Travellers Creek.

Community 18 *Nothofagus cunninghamii-Acacia verticillata-Gahnia grandis* ferny closed-scrub



Common species

Acacia dealbata	tree	*Olearia stellulata*	shrub
Acacia melanoxylon	tree	*Orites diversifolia*	shrub
Eucalyptus regnans	tree	*Pimelea cinerea*	shrub
Nothofagus cunninghamii	tree	*Pimelea drupacea*	shrub
Acacia verticillata	tree/shrub	*Prostanthera lasianthos*	shrub
Leptospermum lanigerum	tree/shrub	*Tasmannia lanceolata*	shrub
Pomaderris apetala	tree/shrub	*Gahnia grandis*	sedge
Acacia riceana	shrub	*Juncus* species	rush
Anopterus glandulosus	shrub	*Acaena novae-zelandiae*	herb
Bauera rubioides	shrub	*Drymophila cyanocarpa*	herb
Cassinia aculeata	shrub	*Gonocarpus teucrioides*	herb
Coprosma quadrifida	shrub	*Viola hederacea*	herb
Epacris impressa	shrub	*Blechnum nudum*	fern
Eucryphia lucida	shrub	*Blechnum wattsii*	fern
Leptospermum scoparium	shrub	*Dicksonia antarctica*	fern
Melaleuca squarrosa	shrub	*Gleichenia microphylla*	fern
Monotoca glauca	shrub	*Sticherus tener*	fern
Nematolepis squamea	shrub	Moss species	

Community 18 *Nothofagus cunninghamii-Acacia verticillata-Gahnia grandis* ferny closed-scrub

There is no species that occurs at every site in this community. However, this community is characterised by the presence of *Acacia verticillata, Eucalyptus regnans, A. riceana, A. dealbata, Olearia stellulata, Melaleuca squamea, Gleichenia dicarpa, Drymophila cyanocarpa, Pimelea cinerea* and *Carex fascicularis.*

This floristic community occurs mainly in the Southern Ranges bioregions, although there is one site in the West bioregion. It occurs in the catchments of the Catamaran, D'Entrecasteaux, Esperance, Gordon, Huon, and Lune Rivers and Creekton Rivulet. It is found at altitudes from sea level to 360 m.

The two most frequently occurring riparian structures in this community are:

- *Eucalyptus* woodland and open-forest over sedgey-ferny open or closed-scrub; and
- *Nothofagus* woodland and open-forest over sedgey-ferny closed-scrub.

Other riparian structures represented in this community are:

- *Leptospermum/Acacia* grassy open-scrub; and
- *Nothofagus/Pittosporum* ferny-sedgey closed-forest.

The tallest stratum is generally between 8 m and 30 m tall with a cover ranging from 6% to 100%. The most frequently occurring dominant species is *E. obliqua* followed by *Nothofagus cunninghamii* and *E. regnans.* Also occurring as infrequent dominants are *E. globulus, E. nitida, Atherospermum moschatum, Acacia verticillata* and *Leptospermum lanigerum.*

The height of the second stratum varies between 1 m and 10 m and cover varies from 6% to 100%. The most common dominant species in this stratum are *Leptospermum lanigerum* and *Acacia verticillata.* Also occurring as infrequent dominants are *Anodopetalum biglandulosum, Eucryphia lucida, Pittosporum bicolor, Pomaderris apetala* and *Nothofagus cunninghamii.*

At most sites, ferns and sedges dominate the cover of the ground stratum although at one site, *Bauera rubioides* was noted as the dominant species. Of the ferns, where a dominant species could be discerned, *Blechnum nudum* was the most commonly occurring dominant, although *Gleichenia dicarpa, G. microphylla, and Sticherus tener* also appeared as dominant species at individual sites and *Blechnum wattsii* was common. Of the sedges, *Gahnia grandis* was co-dominant at four sites. Grasses and herbs do not appear extensively in this community although at the Esperance River, *Ehrharta tasmanica* was noted as the dominant species.

This community is commonly found adjacent to *Eucalyptus obliqua*, *E. regnans* or *E. nitida* shrubby or scrubby woodland and open-forest in areas where forestry activity is the major land use. At one site, along the Olga River, this community was located in a reserve adjacent to heathland.

No affinity exists between this community and any other described community.

It is closely related floristically to Community 17. An example of the riparian structures within this floristic community can be seen in Plates 51, 52, 53 and 54.

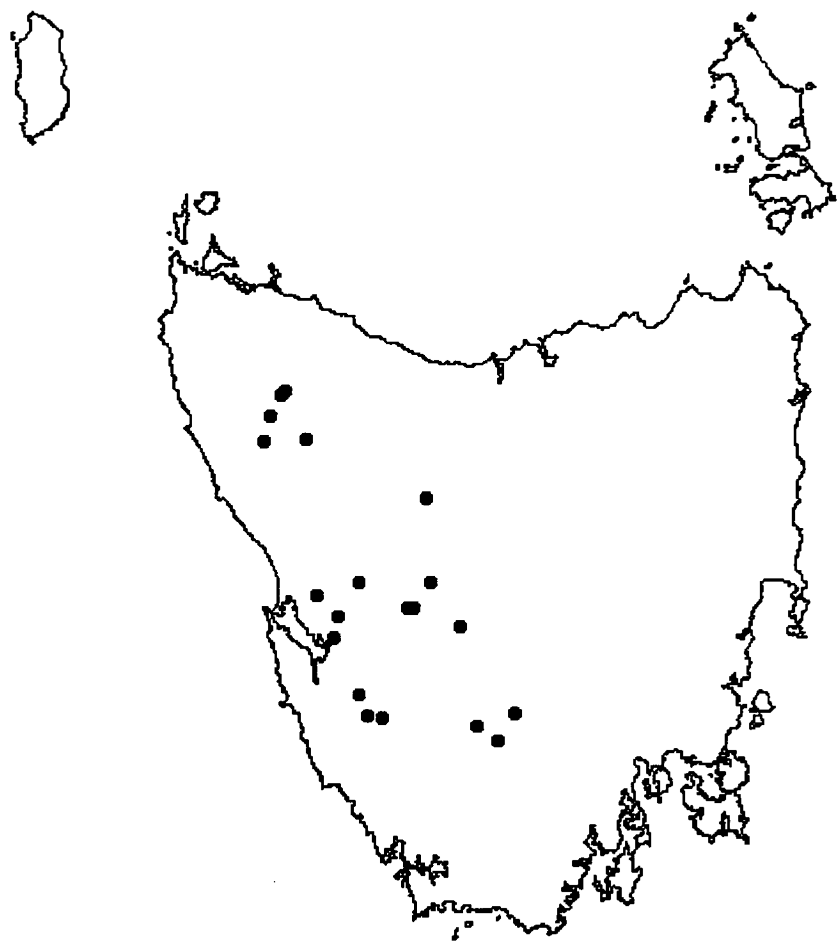
Plate 51 *Eucalyptus nitida* woodland over scrubby *Bauera rubioides\Gleichenia microphylla* closed-heath at Site 444 – Olga River.

Plate 52 *Nothofagus* open-forest over closed-scrub at Site 21 – Mesa Creek

Plate 53 *Nothofagus cunninghamii\Pittosporum* bicolor ferny-sedgey closed-forest at Site 23 – Peak Rivulet.

Plate 54 *Eucalyptus* woodland over closed-scrub at Site 24 – Picton River.

Community 19 ***Nothofagus-Eucryphia-Phyllocladus-Trochocarpa-Libertia*** **shrubby closed-forest**



Common species

Acacia dealbata	tree	*Gahnia grandis*	sedge
Acacia melanoxylon	tree	*Acaena novae-zelandiae*	herb
Atherosperma moschatum	tree	*Hydrocotyle hirta*	herb
Nothofagus cunninghamii	tree	*Viola hederacea*	herb
Phyllocladus aspleniifolius	tree	*Agrostis* species	grass
Leptospermum lanigerum	tree/shrub	*Juncus pauciflorus*	rush
Anodopetalum biglandulosum	shrub	*Libertia pulchella*	iris
Anopterus glandulosus	shrub	*Clematis aristata*	climber
Cenarrhenes nitida	shrub	*Blechnum nudum*	fern
Coprosma nitida	shrub	*Blechnum wattsii*	fern
Coprosma quadrifida	shrub	*Dicksonia antarctica*	fern
Cyathodes juniperina	shrub	*Grammitis billardierei*	fern
Eucryphia lucida	shrub	*Histiopteris incisa*	fern
Gaultheria hispida	shrub	*Hypolepis rugosula*	fern
Pimelea drupacea	shrub	*Microsorum pustulatum*	fern
Prostanthera lasianthos	shrub	*Polystichum proliferum*	fern
Tasmannia lanceolata	shrub	*Sticherus tener*	fern
Trochocarpa cunninghamii	shrub	Moss species	
Carex appressa	sedge	Lichen species	

Community 19 *Nothofagus-Eucryphia-Phyllocladus-Trochocarpa-Libertia* shrubby closed-forest

This community is characterised by the presence of *Nothofagus cunninghamii, Libertia pulchella, Anopterus glandulosus, Trochocarpa cunninghamii, Coprosma nitida, Cenarrhenes nitida, Trochocarpa gunnii, Archeria eriocarpa, Oxalis magellanica, Hakea lissosperma, Richea pandanifolia* and *Blechnum fluviatile.*

This floristic community occurs in western Tasmania in the West and Southern Ranges bioregions. It occurs in the catchments of the Arthur, Franklin, Gordon, King, Pieman, Styx, Bird, Hugel and Little Florentine Rivers and the River Derwent. It is found at altitudes from 40 m to 940 m.

The most frequently occurring riparian structure in this community is:

- *Nothofagus/Eucryphia* shrubby closed-forest.

Other riparian structures represented in this community are:

- *Nothofagus/Acacia* woodland over heathy-ferny closed-scrub or closed-forest;
- *Nothofagus/Eucryphia* open-forest over *Anodopetalum biglandulosum* closed-scrub;
- *Nothofagus/Phyllocladus* shrubby closed-forest;
- *E. coccifera* woodland over *Leptospermum/Atherospermum* mossy shrubland; and
- *Leptospermum* closed-scrub over ferny-sedgey grassland.

The tallest stratum is generally between 8 m and 30 m tall with a cover ranging from 25% to 100%. The most frequently occurring dominant species is *Nothofagus cunninghamii* followed by *Eucryphia lucida* and *Acacia melanoxylon.* Also occurring as infrequent dominants in this stratum are *Leptospermum lanigerum, Atherosperma moschatum, Eucalyptus nitida, E. coccifera* and *Phyllocladus aspleniifolius.* In nearly all cases, the second stratum is between 2 m and 8 m in height but cover varies from about 25% to 100%. This stratum has the greatest diversity of species. The most common dominant species in this stratum is *Eucryphia lucida* followed by *Anopterus glandulosus.* Also occurring as infrequent dominants are *Leptospermum lanigerum, L. riparium, Atherosperma moschatum, Anodopetalum biglandulosum, Trochocarpa cunninghamii, Cenarrhenes nitida, Pomaderris apetala, Acradenia frankliniae, Dicksonia antarctica, Gaultheria hispida, Hakea lissosperma, Nematolepis squamea,* and *Nothofagus cunninghamii.*

The most common lifeform in the ground stratum is fern with *Polystichum proliferum* the most commonly occurring dominant. *Blechnum wattsii, Blechnum nudum, Dicksonia antarctica, Histiopteris incisa* and *Sticherus tener* also occur as infrequent dominants. Of the shrubs, *Bauera rubioides* and *Trochocarpa cunninghamii* occur as infrequent dominants as does the herb, *Libertia pulchella*.

This riparian community is most frequently found adjacent to ferny-shrubby closed-forest overtopped by very tall *Eucalyptus* species or *Nothofagus cunninghamii*, although one site is found adjacent to *E. coccifera* heathy open-forest.

This community has affinity with Thamnic leatherwood swamp forest (50%), Thamnic fern swamp forest (53%), Thamnic leatherwood/*Trococarpa* swamp forest (54%), Thamnic celery top pine swamp forest (54%) Riparian blackwood/leatherwood forest (55%) and *Leptospermum lanigerum-Phyllocladus aspleniifolius-Nothofagus cunninghamii* over *Anopterus glandulosus-Anodopetalum biglandulosum-Telopea truncata* (51%) (Kirkpatrick *et al.* 1995: 100, 101, 104, 119).

It is closely related floristically to Community 17. An example of the most frequently occurring riparian structure within this floristic community can be seen in Plate 53. Examples of the other five variants can be seen in Plates 54, 55, 56, 57 and 58.

Plate 55 *Nothofagus-Eucryphia* closed-forest at Site 72 - Styx River.

Plate 56 *Nothofagus-Acacia* woodland over closed-scrub at Site 447 – Gordon River.

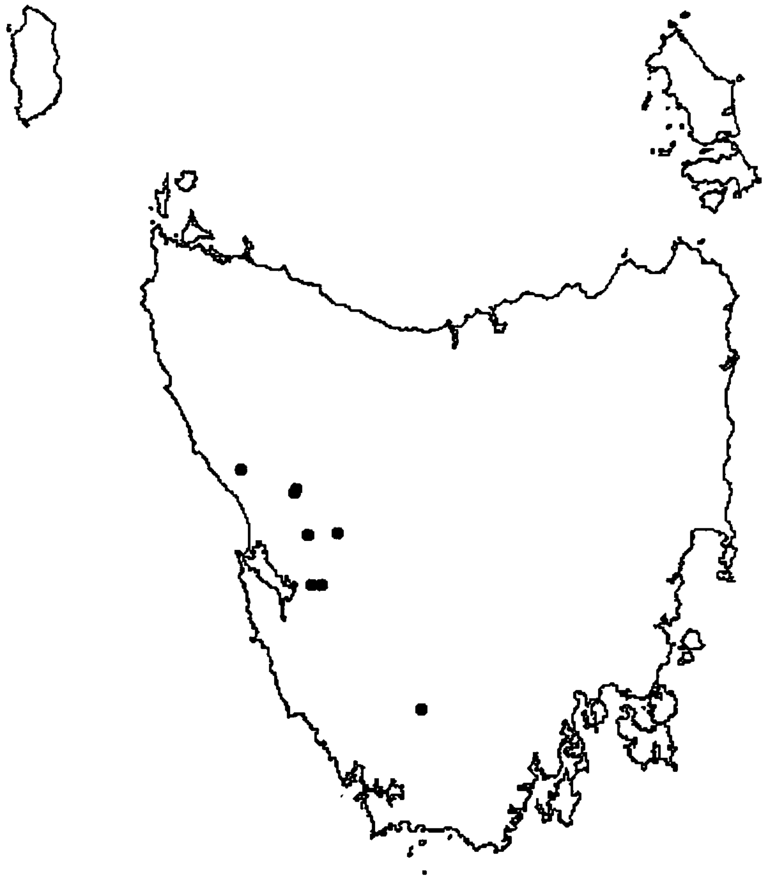
Plate 57 *Nothofagus-Eucryphia* open-forest over Horizontal scrub at Site 127 – Little Florentine River.

Plate 58 *Nothofagus-Phyllocladus* shrubby closed-forest at Site 229 – River Derwent

Plate 59 *Eucalyptus coccifera* woodland over *Leptospermum/ Atherosperma* mossy shrubland at Site 176 – Lady Barron Creek

Plate 60 *Leptospermum* closed-scrub over ferny-sedgey grassland at Site 454 - Magnet Creek

Community 20 ***Eucalyptus nitida* woodland over *Leptospermum-Baloskion tetraphyllum-Gymnoschoenus sphaerocephalus* ferny-sedgey closed-scrub**



Common species

Eucalyptus nitida	tree	*Telopea truncata*	shrub
Acacia mucronata	tree/shrub	*Gahnia grandis*	sedge
Banksia marginata	shrub	*Gymnoschoenus sphaerocephalus*	sedge
Bauera rubioides	shrub	*Baloskion tetraphyllum*	rush
Epacris gunnii	shrub	*Empodisma minus*	rush
Epacris impressa	shrub	*Eurychorda complanata*	rush
Epacris lanuginosa	shrub	*Leptocarpus texax*	rush
Hakea epiglottis	shrub	*Diplarrena moraea*	iris
Leptospermum glaucescens	shrub	*Xyris muelleri*	graminoid
Leptospermum nitidum	shrub	*Ehrharta* species	grass
Leptospermum scoparium	shrub	*Ehrharta tasmanica*	grass
Melaleuca squamea	shrub	*Gonocarpus teucrioides*	herb
Melaleuca squarrosa	shrub	*Blechnum minus*	fern
Nematolepis squamea	shrub	*Blechnum nudum*	fern
Olearia stellulata	shrub	*Gleichenia dicarpa*	fern
Philotheca virgata	shrub	*Histiopteris incisa*	fern
Pimelea linifolia	shrub	*Sticherus tener*	fern
Prostanthera lasianthos	shrub	Moss species	
Pultenaea juniperina	shrub	Lichen species	
Sprengelia incarnata	shrub		

Community 20 *Eucalyptus nitida* woodland over *Leptospermum-Baloskion tetraphyllum-Gymnoschoenus sphaerocephalus* ferny-sedgey closed-scrub

This floristic community is characterised by the presence of *Eucalyptus nitida, Acacia mucronata, Baloskion tetraphyllum, Nothofagus cunninghamii, Gymnoschoenus sphaerocephalus, Diplarrena latifolia, Calorophus elongatus, Gaultheria hispida* and *Lepidosperma filiforme.*

It is located only in the West bioregion. Sites are located within the catchments of the Franklin, Gordon, Henty, Huon, King and Pieman Rivers at altitudes between 160 m and 770 m.

There are two recurring structural variants in this community:

- *Eucalyptus, Acacia* or *Nothofagus* woodland over sedgey-ferny-heathy closed-scrub; and
- *Leptospermum* open-scrub over heathy, ferny-grassy buttongrass sedgelands.

At one site, Spence Creek, the riparian structure was *Acacia/Melaleuca* closed-scrub over *Bauera* heath.

The tallest stratum of the first variant ranges in height between 8 m and 30 m with the most commonly occurring dominant species being *Eucalyptus nitida.* However, *Acacia mucronata, A. melanoxylon,* and *Nothofagus cunninghamii* also occur as infrequent dominants. *Leptospermum nitidum, Almaleea subumbellata* and *Melaleuca squamea* occur as infrequent dominants in the tallest stratum of the latter variant. *Eucryphia milliganii* and *Agastachys odorata* are also strongly associated with this variant. The height of the tallest stratum in the second variant is between 2 m and 8 m. The tallest stratum in both variants does not usually exceed 25% cover.

Shrubs have the greatest cover in this community with most sites having shrub cover between 50% and 100%. *Acacia mucronata* and *Leptospermum scoparium* are the most frequently occurring dominant species in this stratum. *Leptospermum nitidum, Monotoca glauca, Nematolepis squamea, Melaleuca squarrosa* and *Bauera rubioides* also occur as infrequent dominants. *Leptospermum glaucescens* also features strongly in this community. *Gymnoschoenus sphaerocephalus* and *Leptocarpus tenax* occur as dominant species in the second stratum at individual sites.

The ground stratum has the greatest variation in life-forms and variety of species. *Bauera rubioides* is the most frequently occurring dominant shrub species. However, *Monotoca glauca* and *Leptospermum scoparium* also feature strongly at two sites. Dominant sedges in this stratum include *Gymnoschoenus sphaerocephalus, Lepidosperma laterale* and *Schoenus* species. However, *Baloskion tetraphyllum, Empodisma minus, Tetraria capillaris, Xyris muelleri, Baumea arthrophylla, Lepidosperma filiforme, Gahnia grandis* and various *Juncus* species may also be present. Of the ferns, *Gleichenia microphylla* occurs as a dominant species at one site. However, *Gleichenia dicarpa, Sticherus tener, Blechnum minus, Blechnum nudum, Histiopteris incisa, Gleichenia alpina, Polystichum proliferum* and *Dicksonia antarctica* may also be present. If grasses are present, they are most commonly *Ehrharta* species, in particular, *E. tasmanica*.

This riparian community is adjacent to scrubby, heathy or sedgey buttongrass plains and/or *Eucalyptus nitida* scrubby woodland or open-forest over grassy-sedgey heath.

No affinity exists between this community and any other described vascular community.

This floristic community is closely related to Community 21. The structural variants of this community are represented in Plates 61, 62 and 63.

Plate 61 *Eucalyptus* woodland over closed-scrub at Site 205 – Cardigan River.

Plate 62 *Leptospermum* open-scrub over heathy, ferny-grassy buttongrass sedgelands at Site 311- Newton Creek.

Plate 63 *Eucalyptus nitida* woodland over *Leptospermum scoparium\Acacia mucronata* sedgey-heathy-ferny closed-scrub at Site 365 – Heemskirk River.

Community 21 ***Eucalyptus nitida*** **woodland over** ***Gleichenia dicarpa-Persoonia juniperina-Philotheca virgata*** **ferny closed-scrub**

Common species

Eucalyptus delegatensis	tree	*Spyridium gunnii*	shrub
Eucalyptus nitida	tree	*Tasmannia lanceolata*	shrub
Acacia mucronata	shrub	*Telopea truncata*	shrub
Aristotelia pedunculata	shrub	*Gymnoschoenus sphaerocephalus*	sedge
Epacris impressa	shrub	*Isolepis* species	sedge
Banksia marginata	shrub	*Lepidosperma gunnii*	sedge
Bauera rubioides	shrub	*Lepidosperma laterale*	sedge
Epacris lanuginosa	shrub	*Euchiton* species	herb
Hakea epiglottis	shrub	*Gonocarpus teucrioides*	herb
Goodia lotifolia	shrub	*Mitrasacme pilosa*	herb
Grevillea australis var. *linearifolia*	shrub	*Myriophyllum pedunculatum*	herb
Leptospermum glaucescens	shrub	*Rubus gunnianus*	herb
Leptospermum riparium	shrub	*Ehrharta* species	grass
Leptospermum scoparium	shrub	*Baloskion tetraphyllum*	rush
Lomatia polymorpha	shrub	*Leptocarpus texax*	rush
Pittosporum bicolor	shrub	*Xyris muelleri*	graminoid
Melaleuca squarrosa	shrub	*Diplarrena moraea*	iris
Orites acicularis	shrub	*Astelia alpina*	lily
Pomaderis apetala	shrub	*Gleichenia dicarpa*	fern
Pultenaea juniperina	shrub	*Histiopteris incisa*	fern
Sprengelia incarnata	shrub	Moss species	

Community 21 *Eucalyptus nitida* woodland over *Gleichenia dicarpa-Persoonia juniperina-Philotheca virgata* ferny closed-scrub

This floristic community is characterised by the presence of *Gleichenia dicarpa* and either *Persoonia juniperina* or *Philotheca virgata.*

It is found in the King and West bioregions in the catchments of the Arthur, Tasman, Horton and Nelson Bay Rivers and Comstock Creek This community is found at altitudes between 160 m and 350 m.

The structure of this community is typically *Eucalyptus nitida* woodland over heathy, sedgey and/or ferny *Melaleuca squarrosa, Leptospermum scoparium* or *Acacia mucronata* closed-scrub.

The most commonly occurring dominant species in the tallest stratum is almost exclusively *E. nitida*, although at Eighty Creek, *Melaleuca squarrosa* was the dominant species in the tallest stratum as *E. nitida* had a cover of less than 5%. *Eucalyptus obliqua* may also be present.

Leptospermum scoparium and *Melaleuca squarrosa* are present at all sites and are also the most frequently occurring dominant species in the second stratum. However, *Acacia mucronata, Leptospermum nitidum* and *Hakea epiglottis* also occur as infrequent dominant species in this stratum. *Leptospermum glaucescens, Epacris impressa, Sprengelia incarnata, Banksia marginata, Aotus ericoides* and *Lomatia polymorpha* may also be frequently present along with the indicator species, *Persoonia juniperina* and *Philotheca virgata*. Typically, the second stratum has a cover between 50% and 100%.

Restionaceae species, predominantly *Baloskion tetraphyllum, Empodisma minus, Calorophus elongatus, Eurychorda complanata* and *Acion hookeri*, are the most frequently occurring dominant species in the ground stratum. *Bauera rubioides* is present at all sites and was the dominant species in this stratum at two sites. *Gymnoschoenus sphaerocephalus* was the dominant species at one site. Of the ferns, *Gleichenia dicarpa* is present at all sites and was co-dominant at Comstock Creek. However, *Blechnum nudum, Histiopteris incisa, Selaginella uliginosa, Sticherus tener,* and *Pteridium esculentum* may also be present.

No affinity exists between this community and any other described vascular community.

This riparian community is found adjacent to *Eucalyptus nitida* scrubby woodland, regrowth forest and sedgey heath.

This floristic community is closely related to Community 20. Two examples of the riparian structure can be seen in Plates 64 and 65.

Plate 64 *Eucalyptus nitida* woodland over *Melaleuca squarrosa* closed-scrub at Site 333 – Nelson Bay River.

Plate 65 *Eucalyptus nitida* woodland over *Acacia mucronata* closed-scrub at Site 338 - Lindsay River.

3.4.5 Species richness in riparian floristic communities

The relative species richness of the riparian floristic communities is shown in Table 3.6.

Community	Mean number of species	Standard Deviation
1	48.7	16.0
6	48.0	19.0
2	43.2	14.7
3	41.8	15.1
9	41.1	9.5
13	40.2	12.2
17	38.7	9.0
15	37.7	9.6
12	37.3	7.0
16	37.3	6.4
8	36.4	8.9
19	36.3	9.5
7	35.2	10.8
20	34.9	10.7
21	34.2	5.6
11	34.1	8.9
5	33.8	8.7
4	32.5	8.7
14	30.7	7.6
10	28.0	7.7
18	27.3	5.8

Table 3.6: Mean species richness of riparian floristic communities.

The mean species richness of all reference sites is 35.5 with a standard deviation of 10.5.

In general, sites in alpine areas have the highest species richness (Community 1) followed by sites in lowland reaches of rivers that arise in the eastern tiers of Tasmania (Community 6). However, there is considerable variation in the number of species that occur at the sites that comprise these two communities. Species richness is lowest along rivers within the Southern Ranges bioregion (Community 18). Community 18 is predominantly sedgey-ferny closed-scrub with a canopy of *Eucalyptus* species or Myrtle (*Nothofagus cunninghamii*) woodland or open-forest. Community 10 also has low species richness. It is a widespread community located in the drier midlands and northeast highlands of Tasmania, predominantly within the Southeast and Ben Lomond bioregions. This community is characterised by *Eucalyptus* woodlands over ferny-grassy-sedgey closed-scrub. Variability in species richness is much lower in the latter communities than for the communities with high species richness.

3.5 Environmental relationships

This section presents the results of statistical analysis of the reference riparian data set with a specific focus on the geographic, hydrologic, climatic and environmental variables that are significant for the presence of riparian vascular plant species and floristic assemblages. The main questions addressed are:

- Of the variables measured, estimated or described during the field survey, which variables are significantly related to the floristic composition of riparian vegetation?
- Which of the significant variables have the strongest relationships with riparian floristic composition?

3.5.1 Significant variables related to riparian floristic composition

Forty-six variables significantly differentiated between riparian floristic communities (Table 3.7; Appendix 7). Aspect and the height of the Stratum 3 were found to be not significant. No result could be obtained for soil texture, geology, channel shape, bank shape, bank slope, bank slope variability, channel control and stream zone, because of the structure of the data.

The results of the Principal Components Analysis of significant variables are provided in Table 3.8, together with the Eigenvalues for each factor. There was a decrease in additional explanation after four factors, which accounted for 51% of the variation. The heaviest loadings in the first factor are on rainfall variables and these are negatively loaded. Temperature variables and altitude have the greatest loading in the second factor and the loadings are positive. The hydrologic and local geomorphologic variables (Table 2.16) are loaded heavily on the third principal factor, and variables associated with the vegetation (Table 2.16) provide the heaviest loadings in the fourth factor. F-values for response of riparian communities to principal factors using ANOVA are included in Table 3.7. The variations in the four principal factors between riparian communities are illustrated in Figures 3.7 – 3.10.

The floristic communities most strongly differentiate on rainfall variables (Table 3.7) as they do on the rainfall factors scores (Table 3.8). Rainfall in the wettest quarter, rainfall in the coolest quarter, and mean annual rainfall, have the highest F ratios (Table 3.7) and highest loadings in Factor 1 (Table 3.8). Rainfall variables also account for some of the differences between 5 of the floristic communities. Communities 20 is differentiated from the other communities by its high rainfall (Table 3.7; Figure 3.7), but Community 2 also has a strong response to the rainfall factor (Figure 3.7). Communities 4, 6 and 10 show variation in response to low rainfall.

Variable	F	P	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Easting	24.60	0.000						↑	2nd ↑														↓
Northing	15.50	0.000																		↓			
Altitude	43.40	0.000	↑			↓																	
Surrounding Landform	4.58	0.000	↓			↓															↑		
Stream slope	6.83	0.000				↓												↑					
Flow permanence	4.66	0.000										↓											
Average width of channel	4.43	0.000				↑								↓									
Floodplain	3.69	0.000																		↓			
Position in catchment	6.37	0.000				↓								↑									
Catchment area above site	2.50	0.000				↑																↓	
Organic	3.55	0.000																		↑		↓	
Sand/Silt/Clay	6.53	0.000					↑											↓					↑
Gravel	2.32	0.001					↓						↑										
Cobble	3.97	0.000				↓	↓						↑										
Bedrock	2.93	0.000								↑							↓	↑					
Soil pH	8.80	0.000				↑		↑															↓
Soil EC	3.30	0.000				↑																	
Riparian structure (Forest/non-forest)	*	0.000													1	1	1				1		
Stratum 1 height	10.20	0.000	↓																				
Stratum 1 cover	7.63	0.000	↑																				
Stratum 2 height	5.38	0.000	↓														↑		↑	↑			
Stratum 2 cover	2.62	0.000	↓												↓				↑	↑			↑
Stratum 3 cover	2.21	0.000																			↓		↑

Key to symbols: ↑ = most, highest, widest, steepest or most variable. ↓ = least, lowest, narrowest, flattest or least variable. 1 = forest. *Significant using Chi-squared test

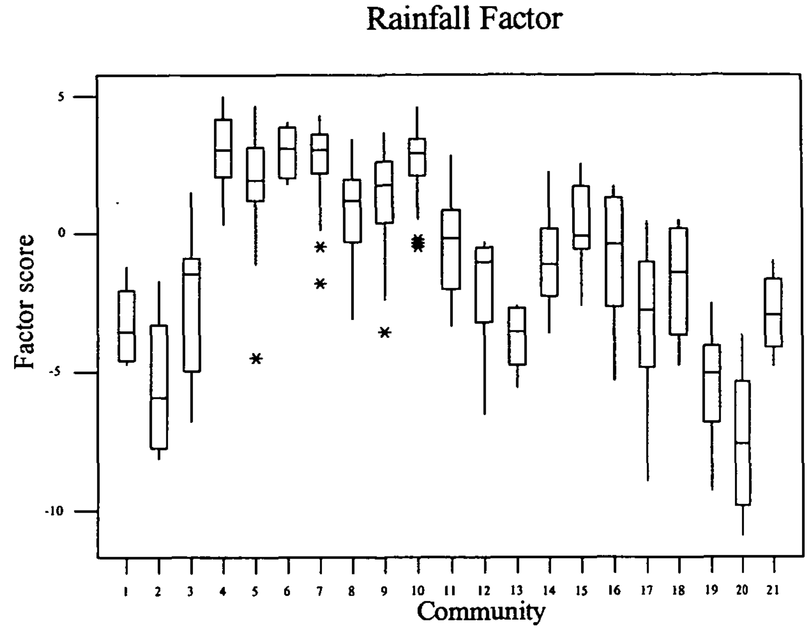
Table 3.7: Summary of significant geographic, climatic and abiotic and biotic environmental factors that differentiate between riparian floristic communities.

Variable	F	P	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Trees	12.30	0.000	↓												↑	↑				↑			
Shrubs	3.80	0.000												↓									
Prostrate shrubs	4.53	0.000						↑															↑
Herbs	6.56	0.000	↑											↑								↓	
Graminoids	8.40	0.000				↑															↓		
Grasses	15.20	0.000	↑																				
Pteridophytes	21.40	0.000						↓								↑							
Annual Mean Temperature	34.70	0.000	↓			↑																	
Min Temp Coolest Month	25.60	0.000	↓			↑																	↑
Max Temp Warmest Month	31.00	0.000	↓																				
Annual Temp Range	9.44	0.000									↑												↓
Mean Temp Coolest Quarter	32.00	0.000	↓			↑																	
Mean Temp Warmest Quarter	34.50	0.000	↓			↑																	
Annual Mean Rainfall	55.40	0.000										↓										↑	
Rainfall Wettest Month	56.00	0.000						↓				↓										↑	
Rainfall Driest Month	41.20	0.000						↓				↓										↑	
CV Monthly Rainfall	24.30	0.000						↓							↑								
Rainfall in Wettest Quarter	59.40	0.000						↓														↑	
Rainfall in Driest Quarter	42.00	0.000				↓		↓				↓											
Rainfall Coolest Quarter	58.60	0.000						↓				↓										↑	
Rainfall Warmest Quarter	41.30	0.000				↓						↓										↑	
Mean Rainfall Driest Month	36.90	0.000										↓										↑	
Mean Rainfall Driest Quarter	37.10	0.000				↓						↓										↑	
Rainfall Factor	34.08	0.000																					
Temperature Factor	16.55	0.000																					
Hydrology Factor	11.60	0.000																					
Vegetation Factor	5.80	0.000																					

Table 3.7 (contd): Summary of significant geographic, climatic and abiotic and biotic environmental factors that differentiate between riparian floristic communities.

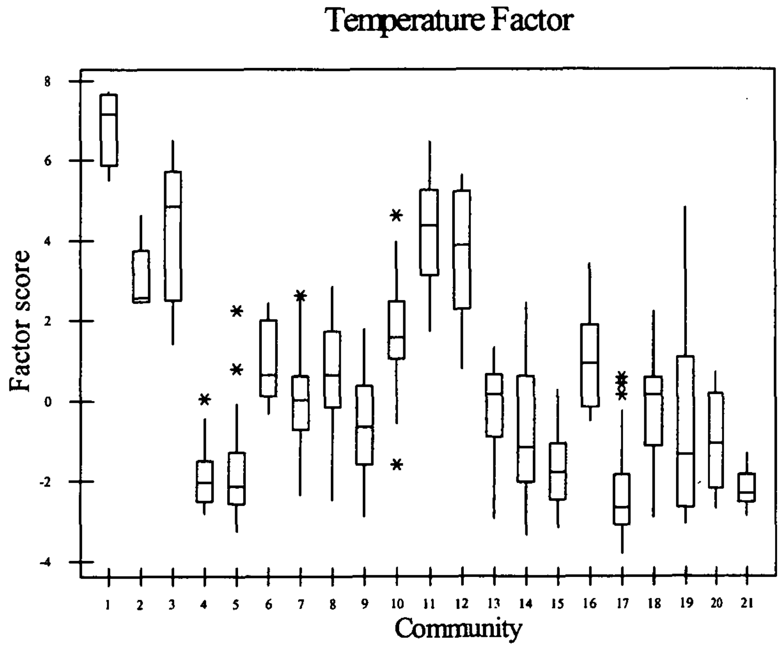
	Factor 1	Factor 2	Factor 3	Factor 4
Eigenvalue	11.366	7.453	3.876	3.339
Proportion	0.223	0.146	0.076	0.065
Variable	**PC1**	**PC2**	**PC3**	**PC4**
Eastings	0.186	-0.148	-0.041	-0.024
Northing	0.005	0.193	0.107	-0.183
Altitude	- 0.130	**-0.258**	0.132	-0.181
Surrounding Landform	0.041	0.070	**0.295**	-0.015
Stream Slope	0.057	0.144	**0.272**	0.086
Flow Permanence	-0.098	0.076	0.128	0.092
Average width of channel	-0.041	0.101	0.136	0.241
Floodplain	-0.001	0.090	**0.287**	0.067
Position in catchment	0.059	0.152	0.165	0.241
Organic	0.002	0.089	-0.082	-0.084
Sand/Silt/Clay	0.014	0.195	0.191	-0.179
Gravel	-0.023	-0.124	-0.159	0.179
Cobble	-0.032	-0.167	-0.164	0.197
Bedrock/boulders	-0.045	-0.154	-0.211	0.178
Soil Texture	0.047	-0.069	-0.022	0.074
Soil pH	0.127	-0.064	0.063	0.064
Soil EC	0.040	0.025	0.110	0.098
Riparian structure	0.091	-0.153	0.072	0.214
Stratum 1 height	0.020	0.059	-0.257	-0.072
Stratum 1 cover	-0.090	0.115	0.079	-0.141
Stratum 2 height	0.027	0.062	-0.243	-0.082
Stratum 2 cover	0.013	0.012	-0.075	**0.275**
Stratum 3 cover	0.021	0.027	0.034	-0.101
Trees	-0.054	0.163	-0.177	-0.201
Shrubs	0.024	-0.029	-0.026	**0.334**
Prostrate shrubs	-0.015	-0.038	0.034	0.109
Herbs	-0.007	-0.023	0.233	-0.062
Graminoids	0.105	0.019	0.173	0.102
Grasses	0.103	-0.124	0.232	0.050
Pteridophytes	-0.073	0.136	-0.207	-0.183
Stock usage	0.099	-0.059	0.090	0.017
Catchment area above site	-0.012	0.107	0.180	0.216
Annual mean temperature	0.177	**0.260**	-0.106	0.105
Minimum temp. coolest month	0.093	**0.293**	-0.094	0.142
Maximum temp. warmest month	0.186	0.224	-0.110	0.039
Annual temperature range	0.125	-0.062	-0.028	-0.116
Mean temp. coolest quarter	0.148	**0.280**	-0.107	0.126
Mean temp. warmest quarter	0.187	**0.250**	-0.097	0.076
Mean temp. wettest quarter	0.197	0.105	-0.124	0.164
Mean temp. driest quarter	0.113	0.238	-0.083	-0.032
Annual mean rainfall	**-0.274**	0.097	-0.002	0.069
Rainfall wettest month	**-0.266**	0.133	0.009	0.018
Rainfall driest month	**-0.266**	0.047	-0.035	0.115
CV monthly rainfall	-0.110	0.202	0.073	-0.173
Rainfall wettest quarter	**-0.270**	0.129	0.008	0.020
Rainfall driest quarter	**-0.264**	0.060	-0.037	0.124
Rainfall coolest quarter	**-0.268**	0.133	0.014	0.010
Rainfall warmest quarter	**-0.263**	0.060	-0.037	0.127
Mean rainfall coolest quarter	**-0.259**	0.015	-0.035	0.121
Mean rainfall warmest quarter	**-0.260**	0.030	-0.037	0.128

Table 3.8: Results of Principal Components Analysis of significant variables that influence riparian floristic distribution. (PC = principal component; Bold highlights show high loadings in each factor.)



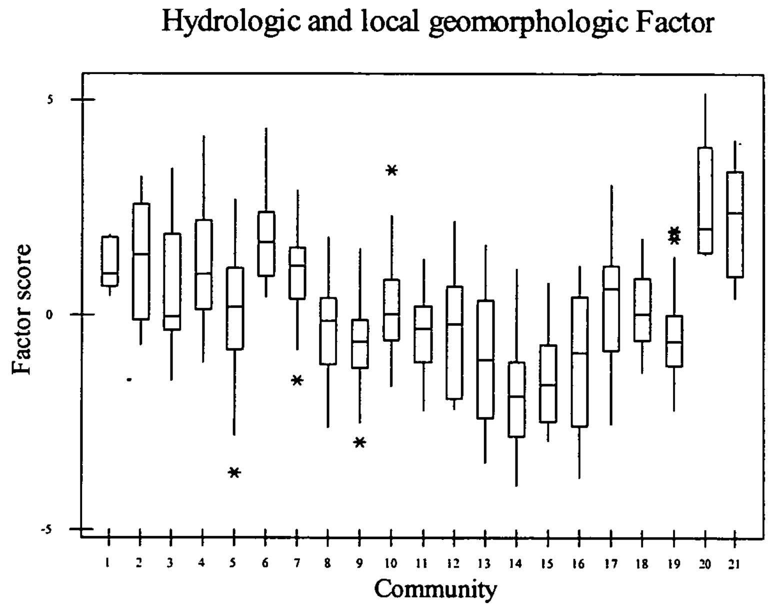
(The box shows the values between the first quartile value (Q_1) (bottom) and the third quartile value (Q_3) (top) and the median. The whiskers extend to the lowest and highest observations defined by the following limits: Lower Limit: $Q_1 - 1.5 (Q_3 - Q_1)$; Upper Limit: $Q_3 + 1.5 (Q_3 - Q_1)$. Outliers are points outside of the lower and upper limits and are plotted with asterisks.)

Figure 3.7: Variation in factor related to rainfall between riparian communities.



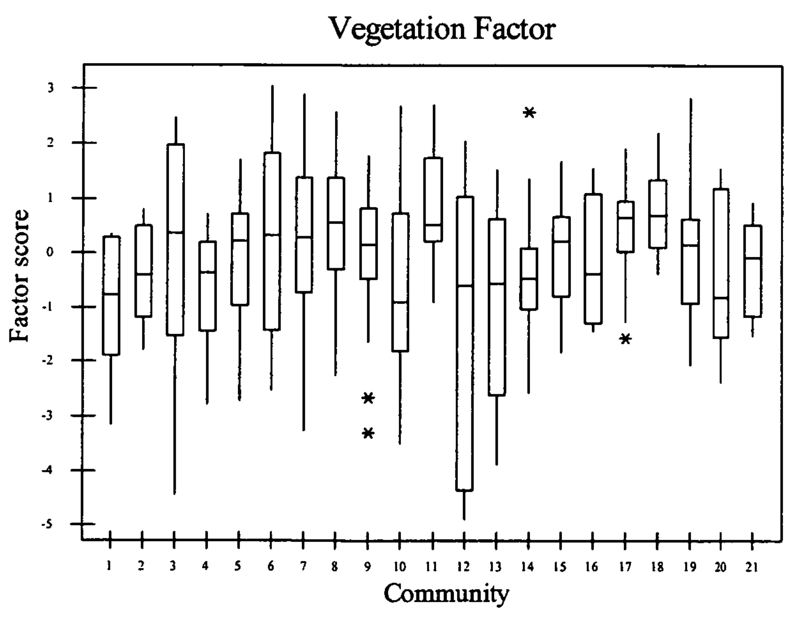
(The box shows the values between the first quartile value (Q_1) (bottom) and the third quartile value (Q_3) (top) and the median. The whiskers extend to the lowest and highest observations defined by the following limits: Lower Limit: $Q_1 - 1.5 (Q_3 - Q_1)$; Upper Limit: $Q_3 + 1.5 (Q_3 - Q_1)$. Outliers are points outside of the lower and upper limits and are plotted with asterisks.)

Figure 3.8: Variation in factor related to temperature and altitude between riparian communities.



(The box shows the values between the first quartile value (Q_1) (bottom) and the third quartile value (Q_3) (top) and the median. The whiskers extend to the lowest and highest observations defined by the following limits: Lower Limit: $Q_1 - 1.5\ (Q_3 - Q_1)$; Upper Limit: $Q_3 + 1.5\ (Q_3 - Q_1)$. Outliers are points outside of the lower and upper limits and are plotted with asterisks.)

Figure 3.9: Variation in factor related to hydrology and local geomorphology between riparian communities.



The box shows the values between the first quartile value (Q_1) (bottom) and the third quartile value (Q_3) (top) and the median. The whiskers extend to the lowest and highest observations defined by the following limits: Lower Limit: $Q_1 - 1.5\ (Q_3 - Q_1)$; Upper Limit: $Q_3 + 1.5\ (Q_3 - Q_1)$. Outliers are points outside of the lower and upper limits and are plotted with asterisks.)

Figure 3.10: Variation in factor related to vegetation between riparian communities.

Interestingly, Community 13 (mainly found along the northern slopes) has been differentiated by high variation in monthly rainfall.

Temperature variables account for some of the differences between 4 of the floristic communities (Table 3.7; Figure 3.8). Annual mean temperature and mean temperature of the warmest quarter have the highest F-ratios (Table 3.7) and minimum temperature of the coolest month and mean temperature of the coolest quarter have the highest loadings in the second factor, along with altitude. Community 1 is strongly differentiated by low temperatures and Community 4 by high temperatures. Communities 3, 11 and 12 are also differentiated by low temperatures (Figure 3.8). The annual temperature range is highest at Community 9 (north and northeast of the state) and lowest at Community 21 (north-west coast) (Table 3.7). The Community with the highest temperature median is Community 17, but Communities 4 and 5 are also differentiated by higher temperatures than other riparian communities (Figure 3.8).

After the climate variables, Easting had the next highest F-ratio (Table 3.7). Communities 6 and 7 were strongly differentiated from the other communities on the basis of their easterly locations. Community 21 has the most westerly location.

Some floristic communities have extreme values for one or more hydrologic and geomorphic variables (Table 2.16; Table 3.7; Figure 3.9). The highest F-ratios were for stream slope and position in the catchment (Table 3.7). Along with these variables, slope of the surrounding landform received the highest loading in the third factor (Table 3.8). These variables account for some of the differences between 7 floristic communities. Community 19 is differentiated by steepness of the surrounding landform, Community 16 by the steepness of stream slopes, Community 10 by the low flow permanence, Community 12 by the narrow width of the channel, and Community 18 by the narrow width of the floodplain. Community 4 was strongly differentiated from the other communities on the basis of multiple hydrologic and geomorphic factors. However, the floristic composition of Communities 20 and 21 also differs from the other communities in response to hydrologic and local geomorphic factors (Figure 3.9).

The vegetation also has a relationship with floristic composition. The proportion of ferns, grasses and trees in riparian communities has high F-ratios followed by the height of the tallest stratum (Table 3.7). The highest factor loadings in the fourth factor are for the proportion of shrubs and height of the second stratum (Table 3.8). Variables associated with structure, cover and composition of vegetation account for differences between 12 floristic communities (Table 3.7). The floristic variation in Communities 8,11,17 and 18 can be attributed to their response to the vegetation factor (Figure 3.10). The forest structures of

Communities 13, 14, 15 and 19, differentiate them from the other communities (Table 3.7). Prostrate shrubs are strongly associated with Communities 6 and 21.

Differences in soil acidity and the composition of riparian substrate accounted for some of the variation between 11 floristic communities (Table 3.7). Of these variables, soil pH and the presence or absence of fine-grained particles in the substrate had the highest F-ratios. The high soil pH associated with estuarine soils was expected, but interestingly, Community 6 was also differentiated from the other communities based on its higher pH values. Community 21 had the lowest average pH values. It occurs on siliceous soils of the west. Communities 5, 11 and 16 are differentiated from the other communities based on substrate composition (Table 3.7). Community 5 has the highest proportion of fine sediments in the riparian substrate and the lowest proportions of gravel and cobble. Community 11 has the highest proportions of gravel and cobble in the riparian substrate. The riparian substrate of Community 16 has the highest proportion of bedrock and boulders in the substrate and the lowest proportion of fine sediments.

Many of the floristic communities are differentiated from other communities on the basis of multiple geographic, environmental and climatic variables (Table 3.7). This is especially evident in Communities 1, 4, 6, 10 and 21. For two of the communities, there are no variables that were measured, estimated or described that differentiate them from the others based on extremes (Communities 2 and 3). However, these communities have distinct intermediate environments (Figures 3.7 - 3.10).

3.5.2 Relationships between significant variables and riparian floristic composition

In the vector analysis (Figures 3.11-3.13), some of the variables are clustered together indicating that they have similar linear relationships with riparian floristics: for example, the rainfall variables; and the majority of temperature variables. The rainfall factor is consistently clustered with Easting, as well as soil pH and annual temperature range.

The length of the vectors for altitude and temperature also indicate that these two parameters have a strong linear relationship with riparian vegetation. Annual temperature range also explains some differences in floristic composition independently of the other temperature variables. The temperature factor is clustered with the other temperature variables in Figure 3.13, but is more closely associated with northing in Figure 3.12.

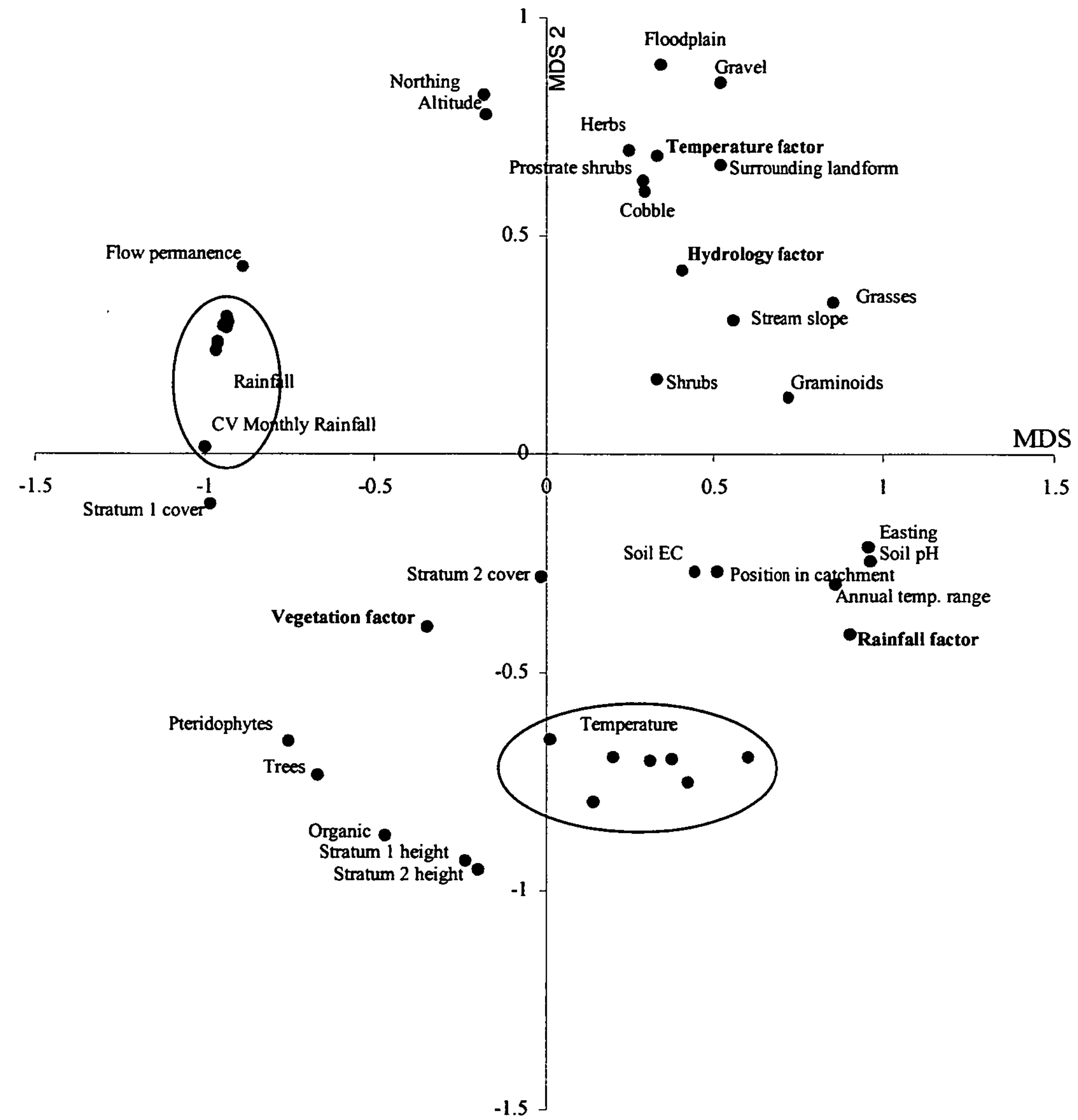


Figure 3.11: Axes 1 and 2 of MDS ordination showing geographic, environmental and climatic variables that are significant for the distribution of riparian vascular plant species in Tasmania. (Symbol indicates head of vector from the origin.)

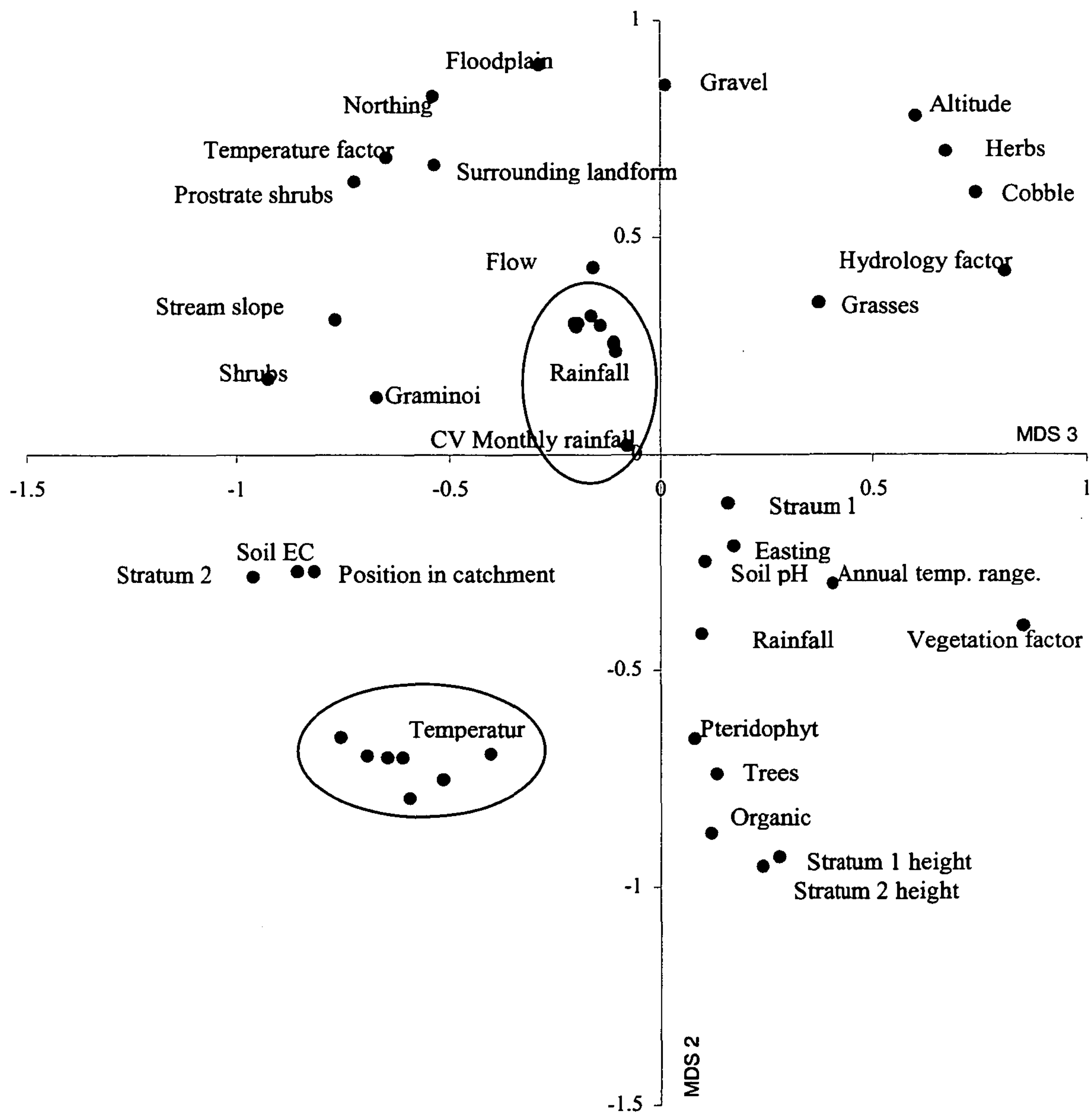


Figure 3.12: Axes 2 and 3 of MDS ordination showing geographic, environmental and climatic variables that are significant for the distribution of riparian vascular plant species in Tasmania. (Symbol indicates head of vector from the origin.)

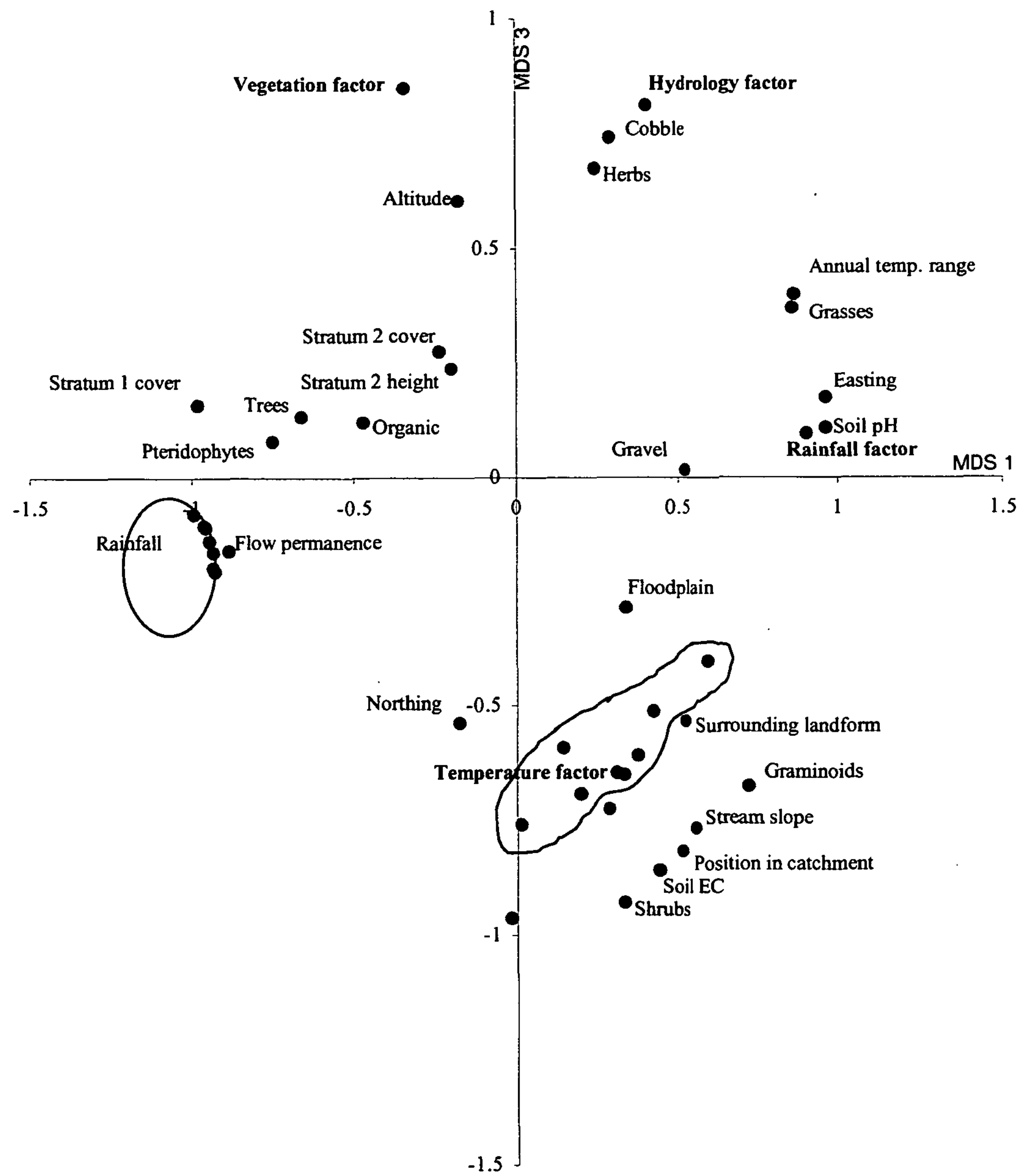


Figure 3.13 Axes 1 and 3 of MDS ordination showing geographic, environmental and climatic variables that are significant for the distribution of riparian vascular plant species in Tasmania. (Symbol indicates head of vector from the origin.)

Sample variable	R	P
Easting	0.6426	0.000
Northing	0.1267	0.050
Altitude	**0.8647**	**0.000**
Surrounding Landform	0.3887	0.000
Stream slope	0.4144	0.000
Flow permanence	0.3524	0.000
Average width of channel	0.3311	0.000
Floodplain	0.2973	0.000
Position in catchment	0.4443	0.000
Catchment area above site	0.2186	0.000
Organic	0.3849	0.000
Sand/Silt/Clay	0.4111	0.000
Gravel	0.3191	0.000
Cobble	0.3898	0.000
Bedrock	0.3141	0.000
Soil pH	0.4859	0.000
Soil EC(uS)	0.5153	0.000
Stratum 1 height	0.4637	0.000
Stratum 1 cover	0.4393	0.000
Stratum 2 height	0.4171	0.000
Stratum 2 cover	0.2721	0.000
Trees	0.5345	0.000
Shrubs	0.3907	0.000
Prostrate Shrubs	0.3376	0.000
Herbs	0.3932	0.000
Graminoids	0.5443	0.000
Grasses	0.6517	0.000
Pteridophytes	0.7057	0.000
Annual mean temperature	**0.8289**	**0.000**
Minimum temperature of coolest month	0.7602	0.000
Maximum temperature of warmest month	0.7908	0.000
Annual temperature range	0.4976	0.000
Mean temperature of coolest quarter	0.8135	0.000
Mean temperature of warmest quarter	0.8208	0.000
Mean temperature of wettest quarter	0.7387	0.000
Mean temperature of driest quarter	0.6513	0.000
Annual mean precipitation	0.8008	0.000
Precipitation of wettest month	0.8125	0.000
Precipitation of driest month	0.2465	0.040
Coefficient of variation of monthly precipitation	0.4440	0.000
Precipitation of wettest quarter	0.8193	0.000
Precipitation of driest quarter	0.7412	0.000
Precipitation of coolest quarter	**0.8244**	**0.000**
Precipitation of warmest quarter	0.7401	0.000
Mean precipitation of driest month	0.7638	0.000
Mean precipitation of driest quarter	0.7652	0.000
Rainfall factor	**0.8377**	**0.000**
Temperature factor	0.7525	0.000
Geomorphology factor	0.5175	0.000
Vegetation factor	0.1348	0.043

Table 3.9: Results of vector-fitting analysis in ordination space including all significant quantitative and ordered multi-state variables. (Bold highlight indicates sample variables with the strongest relationship.)

There is also some clustering of the rainfall and flow permanence variables, the height of strata 1 and 2 with trees and the proportion of organic material in the riparian substrate, and temperature and position in the catchment. In addition, the presence of herbs tends to be closely associated with the proportion of cobble which in turn are consistently clustered with the hydrology factor. Shrubs and stream slope are also consistently clustered.

In ordination space, all four principal factors have strong linear relationships with riparian vegetation (Figures 3.11 - 3.13). Overall, rainfall has the strongest linear relationship with riparian floristics. An analysis of variance for riparian floristic communities and the four principal factors shows that the greatest variability between communities is explained by rainfall factors (Table 3.9). However, the results of vector-fitting analysis in ordination space including all significant quantitative, ordered multi-state variables and the principal factors shows that the strongest relationship between riparian vegetation and its environment results from altitude ($R = 0.8647$) (Table 3.9).

3.6 Discussion

3.6.1 Vascular plant species in the riparian zone

Results of the field survey indicate that approximately 49% of Tasmania's known vascular plant species are found in the riparian zone. As only a small area of Tasmania's remaining native riparian vegetation was surveyed, it is possible that the majority of Tasmania's native vascular species could occur in riparian habitats. As well as the Tasmanian species (Buchanan 1999), four undescribed species were found during the survey.

It is generally accepted that riparian lands provide refuge for native plant species (Tubman & Price, 1999: 3). This aspect of riparian lands is supported by the present study where, as well as the undescribed species, a large number of threatened species was also found in the riparian zone (Table 3.4).

Species richness varies considerably between sites that comprise the communities that have been assessed to have a high degree of "naturalness". As all the survey sites were "reference" sites, low species richness does not necessarily imply highly disturbed riparian vegetation or riparian vegetation in poor condition. However, high species richness could be considered to also represent high biological diversity.

The highest species richness was found along a middle-reach of the Little Swanport River in eastern Tasmania, and the lowest species richness occurred at a headwaters reach of Falls Rivulet in the Southern Ranges. The results for the Little Swanport River support the general view that the highest species diversity occurs in the middle reaches of streams (Hughes 1987; Tabacchi 1996). It is noted, however, that in Tasmania, the highest species richness within riparian communities (Table 3.6), occurs in the alpine community (Community 1), which typically comprises headwater reaches. Many middle-reaches were surveyed in Communities 5, 6, 7, 8, 9, 10, 17 and 19, but most of these communities have comparatively low species richness. Natural physical disruptions of the geomorphic upstream/downstream continuum can induce an irregular, non-structured pattern, and human-induced disturbance (streamflow regulation, corridor fragmentation, land use) affects the longitudinal patterns of species richness through loss of habitat or through species introductions (Tabacchi 1998). Seasonality was also significantly related to species richness (Hughes, 1987).

The knowledge that most native vascular species occur infrequently in riparian vegetation (Table 3.2) could be used to improve the success rate of riparian native rehabilitation and revegetation projects. It can be inferred from the data that locally occurring native vascular species have a higher chance of successfully colonizing the riparian zone than native species than may be common in other regions.

There were only 2 species in Tasmania that are considered to be obligate riparian species (Table 3.3). However, there were 77 vascular plant taxa found predominantly in the riparian zone and they could be considered as riparian plants. Sadly, around 30% of these riparian plants are listed in the *Threatened Species Protection Act 1995*. There are only 2 trees amongst the riparian plants (Table 3.3), *Eucalyptus ovata* (Black gum) and *Lagarostrobos franklinii* (Huon Pine). The majority of riparian plants are shrubs, herbs and sedges.

While the extent of the invasion of exotic species into native riparian vegetation was not measured, there are a considerable number of exotic species colonizing riparian areas (Table 3.5). In many areas around the State, the riparian vegetation when viewed from afar appears to be in native condition, but closer inspection reveals extensive infestation of exotic species, especially in the ground stratum. Of special note is blackberry, *Rubus fruticosus,* which has colonized considerable riparian areas in the Southern Ranges, Southeast and Northern Slopes bioregions. As many of the species that are found in the riparian zone are herbs and graminoids, and these occur in the ground stratum, the major consequences of extensive infestations of many of the exotic species in the riparian zone is a loss of light required for photosynthesis, a loss of space for growth because of competition, and alterations in nutrient loads and substrate conditions because of the deciduous nature of many exotic species. In many riparian areas, the long-term consequence of invasion by exotic species is most probably the loss of local native species.

3.6.2 Riparian floristic communities

The species which characterise riparian communities are varied and are generally found in the second and third strata. For some communities, there are a few, very distinctive characteristic species. For example, a site containing the two species, *Gleichenia dicarpa* and *Persoonia juniperina*, would easily be classified into Community 21 (p.72). However, for other communities, some of the species which characterise them may also be common to other communities – e.g. *Acacia dealbata* is listed in the key for Communities 8, 9, 16 and 18. In addition, there are a large number of species that characterise some communities – e.g. Community 8.

Some of the riparian communities were quite distinctive and had very few similarities with other communities (Figures 3.5 and 3.6). However, four of the larger communities had quite a number of floristic similarities with other communities. Generally, based on the location of sites and the general descriptions of the riparian communities, there was a distinctive biogeographic distribution of communities across the state.

As well as providing a mechanism for field identification, the purpose of classifying assemblages of species into communities is primarily for mapping and conservation purposes. Regional, state and national audits of vegetation rely on the identification of observable and repeatable units (NLWRA 2002) and in most systematic assessments of future conservation areas units rather than species are stipulated (Pressey & Logan, 1998). The 21 riparian floristic communities derived from the analysis of the dataset provide a good platform from which to map riparian communities at the statewide scale, and to make recommendations for conservation.

However, the classification of riparian reaches into communities based on floristics creates a degree of difficulty for mapping of the communities using only remote sensing technology. The structural diversity of riparian communities is evident from the descriptions of the communities. Based on the observed site descriptions and the protocols for describing riparian structure, riparian communities have a number of structural manifestations, with the exception of Community 1. The range extends from two structural manifestations (Community 2) to 16 (Community 17). Even within a community where there is generic structural classification (e.g. closed-forest), the species that dominate the generic structure can be quite varied, which in turn creates difficulties for classifying riparian reaches into communities for mapping purposes. For example, in Community 17, there are six structural manifestations described as open-forest and each of these manifestations would appear visually different using remote-sensing technology as there are significant visual differences between a *Eucalyptus/Nothofagus* open-forest and *Eucalyptus/Acacia* open-forest. However, the description, *Eucalyptus/Acacia* open-forest, also exists within Community 14. Another example is the Boobyalla River (Sites 276 and 277). The two sites are only a few kilometers apart and have similar structural classifications – *Melaleuca ericifolia* closed-forest and *Melaleuca ericifolia* open-forest respectively. However, the floristics of each site places Site 276 in Community 4 (estuarine) and Site 277 in Community 9. The sites have 11 species in common (42% and 50% of total respectively), but there are a quite a few environmental factors that differentiate between the two communities and thus the two sites. The majority of species that define a riparian floristic community are found in the second or ground stratum and are therefore, not easily mapped without field-truthing. Nevertheless, there was statistically significant differentiation of floristic composition between forest and non-forest.

3.6.3 Environmental relationships with riparian floristic composition

Of the variables used for the survey, most of them were significant for the presence of vascular plant species in the riparian zone (Table 3.7). Aspect and the height of the third stratum were found to be not significant. These results were not unexpected. Aspect is significant for other terrestrial vegetation types because of its association with moisture availability (Kirkpatrick & Nunez 1980). For example, north-facing slopes are exposed to drying winds and face the sun towards midday, making them much drier than south-facing slopes. However, moisture for riparian vegetation is generally, reliably sourced from subsurface flow and overflow from streamflow. This could minimise the effects of drying winds and excessive solar radiation. Because of the scale used, the height of the third stratum was recorded as 1 m for all sites.

As stated in Chapter 2.1.12, geology and soils data may have been more appropriately sampled on the basis of hydraulic conductivity. The relationship to riparian floristics of many of the geomorpological variables, and the geology and soil variables was not made clear. Considerably more work can be done in this area.

The factors and variables that have a strong relationship with the distribution of riparian vegetation are altitude, rainfall, temperature, hydrological and geomorphic variables and, to a lesser extent, the vegetation itself.

Altitude is very much linked to temperature and rainfall which, in turn, can determine species survival. "Some species have limited tolerance to frost or are absent from part of an altitudinal gradient either because environmental conditions do not allow their germination or growth to reproductive age, or because they are competitively inferior to multigenerational selective processes" (Kirkpatrick and Gibson, 1999: 129). Riparian floristic composition and altitude have been shown to have a strong relationship in other studies (Curry & Slater, 1986; Askey-Doran, 1993; Wintle, 2002). The minimum temperature of the coolest month has the strongest relationship with floristic variation. This result is in keeping with inferences drawn by White (1979) that extreme seasonal and annual events may cause changes in riparian vegetation.

Rainfall and temperature variables are not commonly used in analyses in riparian vegetation studies at the reach and catchment scales, possibly because accurate and reliable climate data are difficult to collect in the field and/or do not usually exist for remote locations. Also, at the small to medium-sized catchment scale, it could reasonably be assumed that differences in rainfall and temperature variables would be minor and therefore not significantly related to variation in riparian vegetation floristics. However, Wintle (2002), who also used BIOCLIM, found that mean annual temperature and mean annual rainfall were significant in differentiating between floristic communities in two neighbouring east coast catchments and that some of the floristic differences between the catchments could be attributed to differences in mean annual rainfall.

Even though the resolution of the climate data is coarse, the results highlight the fact that all plants have a basic requirement for water. In many areas, even in the riparian zone, a considerable proportion of a plant's water requirements must come directly through precipitation. This would especially be true in riparian areas adjoining ephemeral and intermittent streams.

Rainfall is intrinsically linked with catchment hydrology. All the factors that were selected as surrogates to determine the effect of catchment hydrology on the distribution of riparian vegetation were identified as significant – landform, the gradient of the surrounding landform, stream slope, flow permanence, average width of channel, floodplain, position in the catchment and catchment area above the survey site.

The flow regime of a catchment controls the forces governing the appearance and supply of water to riparian areas (Tabacchi *et al.* 1998). Extreme events and infrequent, less extreme events shape the riparian system but in very different ways. Wolman & Miller (1960) pointed out that, although extreme events may play an important role in shaping some floodplains, it is the less extreme and more frequent flooding events that probably are most influential. The results of studies conducted in Oregon, USA (Chapin *et al.* 2002) and Poland (Wassen *et al.* 2003) show that: there is a strong dependency of riparian vegetation communities on overbank flows; the absence and presence of species and the variation in species composition of the vegetation was explained best by flood variables; and river hydrology, together with nutrient release from the soil, were significant to the vegetation composition, species richness and productivity of riparian vegetation. Maximum species richness has been observed in most cases in the middle course of rivers where intermediate hydrological disturbance occurs.

Fluvial processes such as erosion and deposition have also been shown to be important in determining the zonation of species on river banks (Lindsey *et al.* 1961, Johnson *et al.* 1976) and producing heterogeneity of habitats. Although floods are linked to the formation of geomorphic surfaces and the regeneration and even zonation of riparian vegetation, changing fluvial landforms and channel patterns have also been found to influence riparian species patterns (Wasklewicz, 2001).

The results of Tasmanian studies (Hughes, 1987; Wintle 2002) also show strong relationships between hydrological factors and riparian vegetation. Hughes found that some of the lateral and cross-section variations in floristic composition away from the river were a response to a flooding gradient, substratum stability and flow frequency. Hughes also attributed longitudinal variability in riparian communities to the mobility and dynamic geomorphology of some reaches, evidenced by erosion and undercutting of the banks and riparian vegetation. Variation in hydrological regimes have also been found to explain floristic differences in riparian vegetation communities (Wintle 2002).

The cover of all strata, the height of the first and second strata, and the proportion of life-forms in the riparian zone explain some of the floristic variation amongst riparian communities in Tasmania (Table 3.7). Vegetation cover in the riparian zone has been found to moderate average maximum and minimum soil temperatures, reduced average daily soil temperature fluctuation and decreased the number of days that the soil temperature falls below 0°C. (Bohn, 1989: 69). The frequency and depth of freezing reflect the extent to which the soil is exposed directly to air temperature. Vegetation also lowers surface wind velocity and the turbulent exchange of heat between the soil surface and the atmosphere, thus buffering temperatures at the soil surface. Furthermore, organic matter forms air pockets and roots loosen the soil, creating more air spaces that lower heat conductivity into and through the soil. (ibid: 70). In addition intensity of shade (Curry & Slater, 1986) and competition (Merry, *et al.*, 1981) also contribute to floristic variation in the riparian zone.

While major factors and variables account for a significant proportion of the variation in riparian floristics (Table 3.8), it is noted that 49% of the variation in the data is explained by a large number of the minor factors that were measured and that the floristic variation in many communities is explained by their relationship with a number of variables (Table 3.7). This reinforces the fact that the relationships between riparian vegetation and the environment are complex and difficult to define precisely. Nevertheless, the major findings of the present study indicate that the presence of native vascular species in the riparian zone and the distribution of native riparian floristic assemblages across Tasmania is attributed to a number of interrelated factors of which altitude, rainfall, temperature, hydrologic and geomorphologic factors and the vegetation itself, are the most significant.

CHAPTER 4

Riparian vegetation predictive model

4.0 Introduction

Healthy rivers are important to the nation's social, environmental and economic well-being. Riparian vegetation is a key determinant of river health because of its role in aquatic and terrestrial food supply and habitat, as a buffer against nutrient and sediment runoff, bank reinforcement and stability, and control of light and temperature.

At present, river health predictions at the state and regional scales are predominantly made using the Australian River Assessment System (AUSRIVAS) which is based on the British RIVPACS (River InVertebrate Prediction and Classification System) modelling approach (Wright 1995; Moss *et al.* 1997). The AUSRIVAS approach was developed under the National River Health Program between 1993 and 1999 (Davies 2000) and is based on the protocol for riverine bioassessment as outlined in the Monitoring River Health Initiative (MRHI) under the National River Processes and Management program.

As well as being used extensively in Tasmania (Davies 1994; Krasnicki *et al.* 2001), AUSRIVAS models have been developed for all other states and territories. The models have been used to conduct the First National Assessment of River Health (Schofield & Davies 1996) and are also used to report on river ecological health under a range of initiatives including:

- State of the Environment Reporting (national and state);
- National Water Quality Guidelines - biological component (under the newly revised version of the ANZECC 2000 guidelines);
- the National Land and Water Resources Audit;
- the National Action Plan;
- a variety of national and state catchment indicators including the Index of Stream Condition.

For the National Land and Water Resources Audit in 2002, the AUSRIVAS model was used to assess the current extent and connectivity of riparian vegetation by comparing existing coverage with coverage presumed to have existed under pre-European settlement conditions. In this audit, the riparian vegetation measure was used in conjunction with measures of aquatic biota, catchment condition, hydrological regimes and stream nutrient loads for the purpose of providing an assessment of river condition (pers. comm. Colin Creighton, Land and Water Australia 2003; NLWRA 2002). A similar modelling approach has also been developed in western North Dakota, USA, for the purpose of mapping ecological communities to evaluate and monitor ecosystem integrity and the condition of natural resources (Jensen *et al.* 2000).

AUSRIVAS models allow rapid, non-specialist sampling methods to be used for the development of predictive models using a 'reference' site database. Comparisons can then be made between observed and predicted biological communities. If the AUSRIVAS predictive modelling approach can be successfully applied at the regional or state-wide scale for riparian vegetation, then the outcome of the model could be used to predict the probable species composition of riparian vegetation at any site within the survey area and assess river health as a consequence of comparing the floristic assemblage at the site against the floristic assemblages predicted from regionally relevant reference site data. The ability to predict the composition of riparian vegetation would be of benefit to natural resource managers, agricultural producers, scientists and community members involved in river management, rehabilitation and restoration.

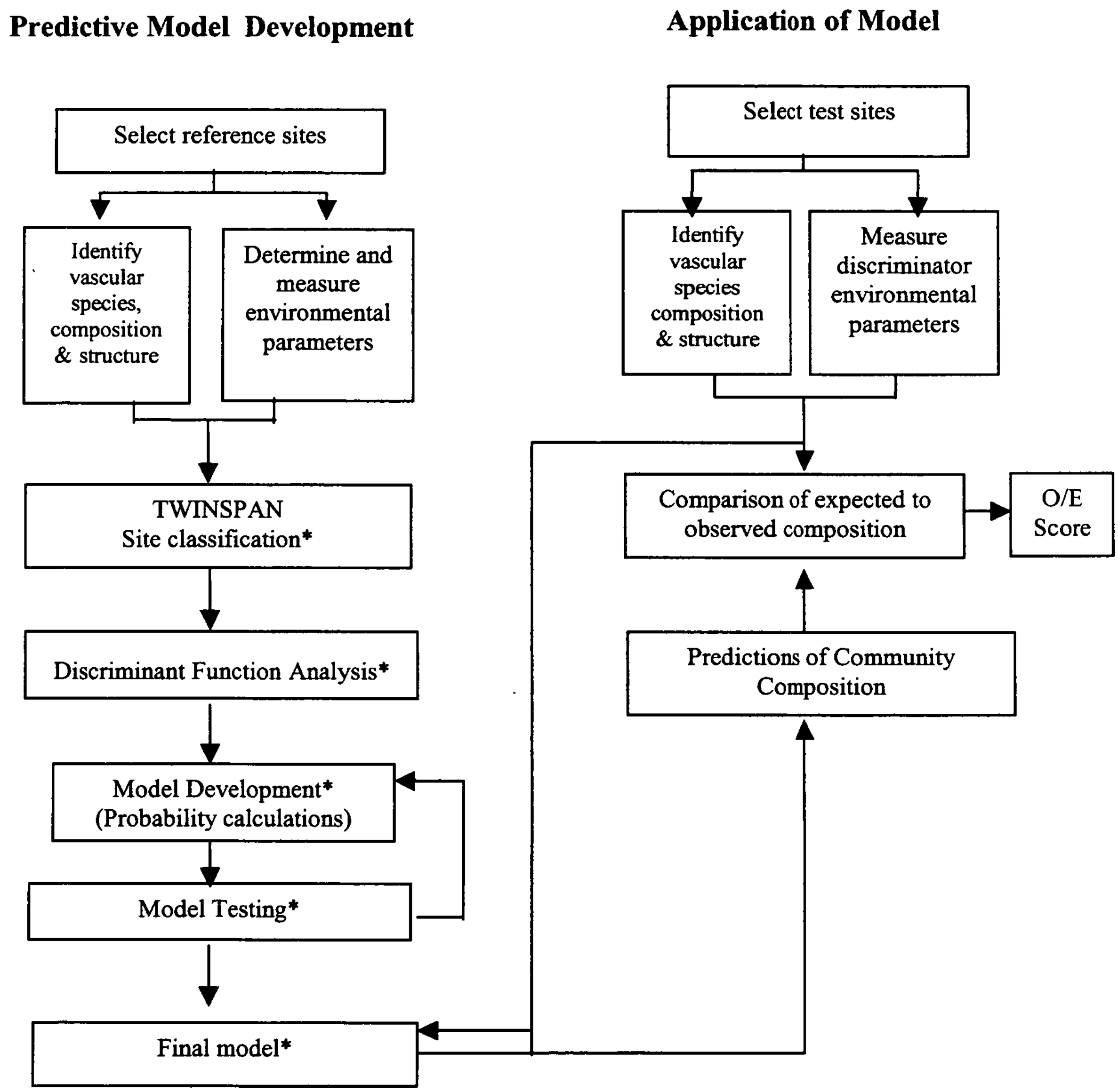
This chapter provides details of the application of the AUSRIVAS-style predictive model for a state-wide assessment of the health of native riparian vegetation and as a tool for predicting the species and community composition of riparian vegetation. The riparian vegetation data set described in Chapter 3 will be used as the reference data set along with 8 test sites documented during the field survey and not previously included in any of the analyses.

4.1 Methods and data

Presence/absence (PA) data with a value of 1 for species present, and 0 for those absent, were used from the 452 reference sites and 8 test sites sampled as described in Chapters 2 and 3. All 845 native species recorded from the 452 sites were used for the development of the predictive model, as the removal of infrequently occurring species has been shown to have little effect on the outcome of multivariate analysis (Breen *et al.* 1999) and many riparian plant species have low probabilities of occurrence (Table 3.6).

A single data set consisting of a subset of the environmental variables collected at each reference site was prepared. 35 variables were selected as potential predictor variables for Discriminant Function Analysis (DFA) and AUSRIVAS model development. Predictor variables have to:

- determine, or be a surrogate for, factors that determine natural distributions in riparian community composition at the spatial scale of this study;
- be unlikely to be significantly affected by human impacts; and
- be reliably and repeatably measured without excessive variation or subjectivity.



* Action performed for each environmental parameter separately

Figure 4.1: AUSRIVAS model overview showing process of model development to the left and how the model is used to the right.

All environmental data were scrutinised for normality using normal probability plots in SYSTAT Version 10.0 (SPSS Inc. 2000). As a result, $\log_e$ (x+1) transformations were applied to improve the normality of 11 variables.

4.2 Model development

The RIVPACS modelling approach (hereinafter called "AUSRIVAS" model) was followed (Figure 4.1; adapted from Davies 1994).

4.2.1 Site grouping

Group similarities, based on TWINSPAN classification and the percentage frequency of species in groups defined using the Bray-Curtis distance measure (Figure 3.5), were used as the basis for defining reference site groups for model development. Groups of sites were defined which were more closely related within the group (i.e. had higher mean similarity in community composition), than to those outside the group. It was considered that a minimum of six sites was needed to form a group. A single assignment of sites to groups was completed for the presence/absence data set.

4.2.2 Discriminant Function Analysis (DFA)

Discriminant Function Analysis (DFA), performed in SYSTAT v.10, was used to develop discriminant functions with an optimal subset of 'predictor' environmental variables for the purpose of calculating probabilities of group membership for sites. The stepwise, interactive procedure was used to add habitat variables one at a time, selecting at each step the variables that gave the best group discrimination based on their F statistic. At each step of the analysis, the significance of variables already included was checked and variables that were no longer significant were removed. The significance level for variables to be entered and retained by the Stepwise MDFA was set at 0.05.

Thirty-six potential predictor variables, transformed where necessary, were used in the analysis (Table 4.1). Two criteria were used to assess the adequacy of the final discriminant functions:

- significance of Wilks' lambda (U statistic – tests equality of group means, Wilkinson 1997); and
- success of re-classification of reference sites into their groups.

The latter analysis is provided within SYSTAT v.10 in two forms: direct reclassification or jacknifed reclassification with re-substitution (Tukey 1958). The latter is a more rigorous test of reclassification success and was used in the DFA.

Habitat and climatic variables used for predictive modelling	
Easting	Minimum Temperature Warmest Quarter
Northing	Minimum Temperature Wet Quarter
Altitude	Annual Mean Rainfall
Stream Slope	Rainfall Wettest Month
Bank slope variability	Rainfall Driest Month
Flow Permanence	CV Monthly Rainfall
Average Width of Channel	Rainfall in Wettest Quarter
Floodplain	Rainfall in Driest Quarter
Stream order	Rainfall Coldest Quarter
Position in Catchment	Rainfall Warmest Quarter
% Organic material	Mean Rainfall Driest Month
% Sand/Silt/Clay	Mean Rainfall Driest Quarter
% Gravel	Log Altitude
% Cobble	Log Soil electrical conductivity
% Bedrock/Boulders	Log Rainfall wettest month
Soil pH	Log Rainfall in driest quarter
Soil EC (μS)	Log Rainfall warmest quarter
Catchment area above site	Log Annual mean rainfall
Annual Mean Temperature	Log Rainfall in wettest quarter
Minimum Temperature of Coldest Month	Log Rainfall in coldest quarter
Maximum Temperature of Warmest Month	Log CV monthly rainfall
Annual Temperature Range	Log Mean rainfall in driest month
Minimum Temperature Coldest Quarter	Log Rainfall in wettest quarter

Table 4.1: Potential predictor variables used for DFA and AUSRIVAS modelling.

Discriminant functions were selected which had maximal significance of Wilks' Lambda and jacknife reclassification of reference sites, with the smallest, most parsimonious number of environmental variables. Addition of variables ceased when the value of the F-statistic for entry of remaining variables into the discriminant function fell below significance at the $p = 0.05$ level.

A minimal reclassification success rate of 70% for DFA in AUSRIVAS model development was adopted by the National River Health Program. This implies that an error of up to 30% in reclassification is acceptable. This is due to the fact that DFA reclassification on its own is too severe a test of the acceptability of the final AUSRIVAS (RIVPACS) model (Moss *et al.* 1997), as model outputs are the product of probabilities of group membership by both sites *and* species, not just sites alone. A high proportion of correct predictions of site membership in the groups is desirable prior to external testing and\or using the database for prediction of species at new sites (Davies 1994: 19). For the riparian vegetation AUSRIVAS model, a success rate of 65% or greater of reference site membership was considered adequate as a basis for model development (pers. comm. Peter Davies 2002).

4.2.3 Final model development

Once acceptable discriminant functions had been developed for the riparian vegetation PA and environmental variable data, AUSRIVAS models were then developed. The final stages of model development were as follows (after Moss *et al.* 1997; and Davies & Cook 1999), conducted in a linked series of Excel spreadsheets.

a) Let the number of discriminant functions be f. Calculate the set of f discriminant scores ($x_1 \ldots x_f$) using the discriminant function coefficients and predictor variable data for each site.

b) Calculate the Euclidean distance for each site's scores to the mean score of each TWINSPAN defined group:

$$d_j^2 = \sum_{i=1}^{f} (x_i - m_{i,j})^2$$

where d_j^2 = square of distance from site to group j, and $m_{i,j}$ = mean of function i for group j;

c) Check that each site is within the range of the discriminant function set. Let d_{min}^2 be the minimum value of d_j^2 taken over all groups. The d_j^2 is a chi-square statistic with f degrees of freedom. If this value is significant at the 1% level, then there is a < 1% probability that a genuine member of the TWINSPAN derived group most similar to the site would have discriminant scores so far from the group mean. Any attempt to predict the flora for this site would therefore be invalid.

d) Calculate the probability that each site would be a member of each group, which is proportional to the number of members of that group multiplied by the exponential of minus half the distance from the group mean, thus:

$$p_j = q_j / \sum_{i=1}^{l} (q_j)$$

where $q = n_j * \exp(-d_j^2/2)$, l = number of groups and n_j – number of members in group j;

e) Calculate the probability of occurrence at each site of each species k as the sum over all groups of the probability that a site belongs to group j multiplied by the proportion of sites in group j at which the species occurs, thus:

$$r_k = \sum_{i=1}^{l} (p_j * g_{j,k})$$

where r_k = probability of occurrence of species k, and $g_{j,k}$ = proportion of members of group j which contain species k.

f) This leads to a list of all species, each with a probability of occurrence at the site.

g) The sum of probabilities for all species predicted at each site with individual probabilities of occurrence, $0.5 \geq r_k > 0$ is calculated, giving N_{te} (number of taxa expected).

h) The number of species observed at each site is calculated to give N_{tf} (number of taxa found).

i) The observed to expected ratio (O/E) is then calculated as N_{tf}/N_{te}.

This process was conducted for the reference site data set and used to generate reference site O/E scores. Following estimation of r_k for all species, and summing all r_k values, O/E scores were calculated for all reference sites. This was plotted as a frequency histogram. The threshold value of r_k used in (g) above was varied and a value of 0.1 selected as providing an optimum balance of the number of species required for calculating N_{te} and the correlation between N_{te} and N_{tf}.

4.2.4 Banding

In the AUSRIVAS protocol, banding of the O/E values is the mechanism that is used to describe river health. Band widths are defined using the range of O/E values for all reference sites.

The 10th and 90th percentiles of the reference site O/E values were determined and used to develop the following banding scheme based on the banding scheme recommended by Barmuta *et al.* (1997) for the NRHP AUSRIVAS models (Table 4.2).

Band	Range	Description
X	Greater than 90th percentile of reference site O/E scores	More diverse than reference
A	10th to 90th percentile of reference site O/E scores	Equivalent to reference Unmodified.
B	Less than 10th percentile of reference site O/E scores minus the range of band A	Less diverse than reference Significantly modified.

Table 4.2: Banding scheme to evaluate relative riparian condition.

4.2.5 Model validation

The final AUSRIVAS model was validated internally and then used to predict the riparian composition of eight test sites not previously used for model development (see section 3.1).

(a) Internal validation

Mean O/E scores for reference sites should be equivalent to 1.0, and have an approximately normal distribution. Hence, a t-test was conducted to test that the mean reference site O/E value was not significantly different from 1.0. In addition, normal probability plots of reference O/E scores were prepared and examined for linearity and the presence of outliers. Sites with O/E scores below 0.6 were investigated more closely. Some were deleted from the model when there was some evidence to indicate that the site may have been previously or repeatedly disturbed as a result of land use practices. The 0.6 cut-off was based on the value judgement that a site missing 40% of the species expected to occur there was unlikely to represent reference conditions. The models were then reconstructed with the impaired reference sites removed. The final reference site O/E values were considered to represent the distribution of ecological health for a statewide population of reference sites.

In order to measure the accuracy of the O/E values of the reference sites and thus the validity of the reference sites used for the final model, a 'jacknife' of the entire model building process was undertaken using an independent set of reference site data for validation. Assessment of the validation model was made by checking that the independent reference site O/E's came from the same distribution as that for reference sites within the model and calculating predicted probability distributions for some species and comparing them with the actual probabilities (the proportion of sites where they occur) in the independent reference set. A sub-sample (10% of sites) was extracted by numbering the sites in the final reference dataset from 1-10 and selecting one of the groups at random.

Frequency distributions of O/E scores for sub-sample and validation sites were prepared. Differences in mean O/E scores between validation and sub-sample sites were assessed using the t-test and the Kolmogorov Smirnoff test in Systat v. 10.0.

(b) External validation - Test site assessment

The riparian data from eight test sites was prepared as for reference site data. Values for the final model predictor variables at test sites were entered into the model, appropriately transformed from prepared worksheets. The test site biological data were entered into the model Excel spreadsheets and O/E scores calculated. These scores were then also used to assign a band to each test site, using the band assignments described in Table 4.2.

Frequency distributions of O/E scores for test and reference sites were prepared. Differences in O/E scores between reference sites and test sites were also tested by Kruskal Wallis test in SYSTAT v 10.0 (using the Mann Whitney U statistic).

On entry into the final riparian AUSRIVAS model, none of the test sites failed the Chi-squared test for compatibility with the ranges of model discriminant functions (i.e. all $p > 0.05$) and thus could be safely assessed using the model.

5.2.6 Model outputs

There are two major outputs of the predictive riparian model:

- the O/E values for a site which can be used as a measure of the departure of the riparian species assemblage from that expected in the absence of human impact; and
- a list of species predicted to occur at a new site, with defined probabilities.

5.3 Results

The riparian vegetation AUSRIVAS model was developed in two stages: an initial model followed by evaluation and development of the final model.

5.3.1 Reference site classification

Six reference site groups were defined from the classification of presence-absence (PA) transformed data using all sites and all species with a number of TWINSPAN groups being amalgamated (Table 4.3). When all sites and species were used, the classification matrix depicting the affinity of sites to groups shows that all groups have sites that have commonality with other groups (Table 4.4).

Reference Site Group	TWINSPAN Riparian Communities	Number of sites
1	1	6
2	2,3,11,12	38
3	4,5,6	104
4	7,8,9,10	140
5	13,14,15,16	68
6	17,18,19,20,21	96

Table 4.3: Reference site groups derived from amalgamation of TWINSPAN riparian communities.

Groups	1	2	3	4	5	6	%correct
1	6	0	0	0	0	0	100
2	5	28	0	2	0	3	74
3	0	1	63	29	5	6	61
4	0	3	18	94	22	3	67
5	1	2	3	8	43	11	63
6	0	4	1	0	15	76	79
Total sites per group	**12**	**38**	**85**	**133**	**85**	**99**	**69**

Table 4.4: Initial reference site assignment into groups by jacknife classification following discriminant function analysis on all sites (cases in rows; categories classified into columns).

Following DFA on all sites, a number of sites classified as Group 3 had commonality with Sites in Group 4 (Table 4.4). Similarly, Group 4 sites had some commonality with Group 5 and Group 3; and Group 5 sites with Groups 6 and 4. Only Group 1 (alpine riparian vegetation) had all sites assigned exclusively to the group.

After internal validation of the sites and removal of some potentially impacted sites, 408 of the 452 sites were used for final model development using the six reference site groupings. After jacknife classification, 66% of site membership in the group was achieved and considered adequate as a basis for a final model (Table 4.5).

Groups	1	2	3	4	5	6	%correct
1	5	1	0	0	0	0	83
2	2	28	0	1	0	2	85
3	0	1	54	23	9	4	59
4	0	6	16	79	25	3	61
5	0	1	2	10	37	11	61
6	1	2	0	5	14	66	75
Total sites per group	**8**	**39**	**72**	**118**	**85**	**86**	**66**

Table 4.5: Final reference site assignment into groups by jacknife classification following discriminant function analysis on the final set of 405 reference sites (cases in rows, categories classified into columns).

4.3.2 Initial model characteristics

In the preliminary model, DFA of site groups using potential predictor variables resulted in a set of discriminant functions containing eight variables, which successfully reclassified (with jacknifing) 69% of reference sites and had a significant Wilks' lambda (0.079, $p = 0.000$). The variables and discriminant functions are shown in Table 4.6. Mean values of the predictor variables for each group and their relative influences are shown in Tables 4.7 and 4.8 respectively.

	Discriminant Function Coefficients								
Variable	Constant	Easting	Northing	Altitude	Min. Temp. Coldest Month	CV Mean Annual Rainfall	Log Altitude	Log Annual Mean Rainfall	Log Mean Rainfall Driest Month
DF1	1.2224	0.0000065	0.0000016	-0.0048	-0.1349	-0.0122	0.0966	-0.5339	-1.8361
DF2	-3.7978	0.0000016	-0.0000029	-0.0056	0.3825	0.0102	0.5621	1.9146	0.5930
DF3	-55.7329	0.0000005	0.0000097	0.0042	0.2619	-0.0968	-0.9290	0.2334	1.7372
DF4	-1.5758	0.0000147	-0.0000026	0.0028	0.4711	0.1693	-0.0838	0.2472	0.3351
DF5	58.4429	0.0000013	-0.0000123	-0.0004	-0.5294	0.0308	-0.5686	3.8451	-4.0915

Table 4.6: Initial discriminant functions developed for the PA reference data set using all sites. DF = discriminant function.

	Mean Values of Predictor Variables							
Group	Easting	Northing	Altitude	Min. Temp. Coldest Month	CV Mean Annual Rainfall	Log Altitude	Log Annual Mean Rainfall	Log Mean Rainfall Driest Month
1	468968	5363570	1076.67	-1.65	28.40	6.98	7.22	4.23
2	461738	5354480	784.21	0.07	22.56	6.65	7.12	4.27
3	527596	5384420	107.81	3.29	21.54	3.52	6.77	3.90
4	515750	5338320	232.61	2.19	20.59	5.09	6.79	3.94
5	467592	5400360	280.66	2.44	31.33	5.28	7.19	4.16
6	392451	5352280	231.25	2.93	27.69	5.04	7.57	4.56

Table 4.7: Mean values of each predictor variable for each reference site group used in the initial model.

Variable	F-to-remove
Altitude	44.81
Log Altitude	32.45
CV Mean monthly rainfall	13.84
Easting	12.42
Log Mean Rainfall Driest Month	6.64
Northing	6.09
Minimum Temperature of Coldest Month	6.07
Log Annual Mean Rainfall	5.53

Table 4.8: Relative influence of predictor variables on site distribution.

From Table 4.7 it can be seen that Group 1 has the highest mean altitude and the lowest mean minimum temperature of the coldest month. This group is located in the alpine regions of the Central Highlands. Group 2 could be considered sub-alpine and located to the south and west of Group 1. Group 2 has the second highest mean altitude and second lowest temperature values. Group 3 has the lowest mean altitude, the highest values for minimum temperature in the coldest month, the lowest values for annual mean rainfall and the lowest mean rainfall of the driest month. This group incorporates the estuarine sites and lower plains and valleys and, in general, the sites are located in the midlands and north-eastern regions of Tasmania. Group 4 has the lowest variation in mean annual rainfall. This group is generally located in the south-eastern regions of Tasmania. Group 5 has the highest variability of mean annual rainfall and sites are located predominantly in the northwest. Group 6 are the most westerly sites with the highest mean rainfall in the driest month. Altitude exerts the greatest influence in predicting the presence of riparian vegetation at sites, followed by mean annual rainfall and easting (Table 4.8).

When the AUSRIVAS model was developed using the initial discriminant function coefficients in Table 4.6, the reference site O/E scores for all sites and all species were distributed as shown in Figure 4.2.

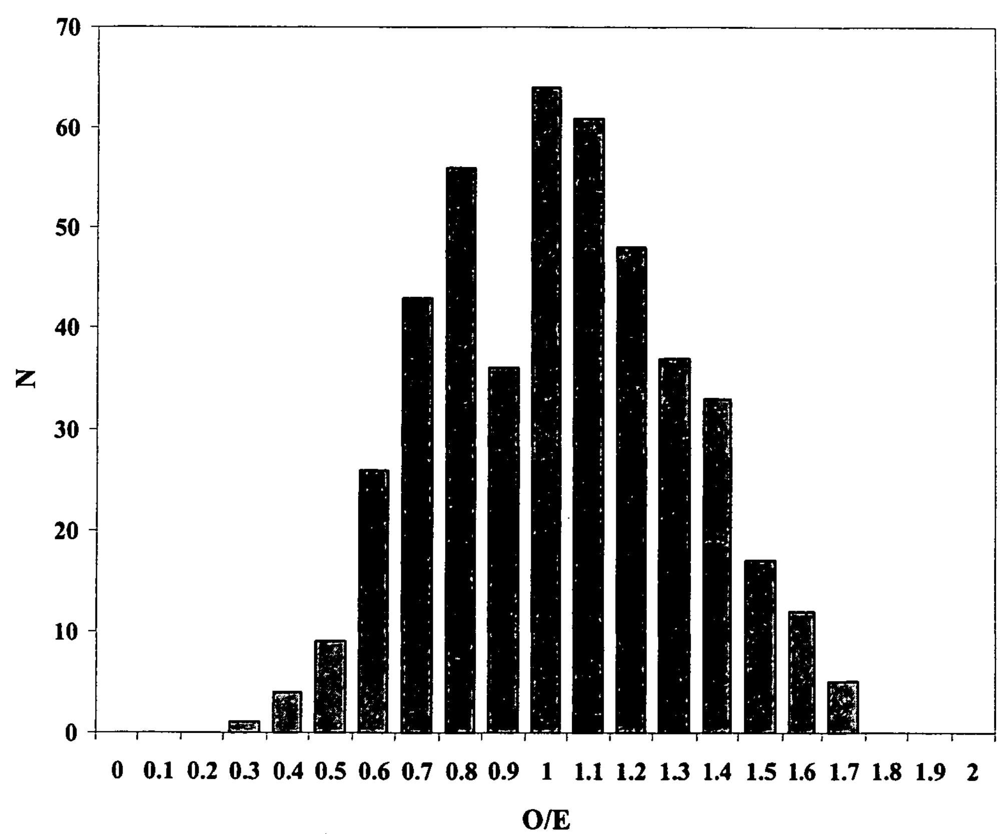


Figure 4.2: Initial frequency distribution of O/E_{pa} scores for all sites with all species included.

The reference site O/E scores for all sites and all species were moderately over-dispersed and resulted in broad band-widths, which were considered not to be optimal for assessing the condition of riparian vegetation.

Post DFA r_k values of 0.1, 0.25 and 0.5 were applied in the models to investigate if the elimination of infrequently occurring species would have any effect on reducing the spread by eliminating excessive 'noise' that may be present as a result of rare species (Davies & Cook 1999: 101). The application of a $0.1r_k$ threshold to the species, did not have a significant effect on the spread of O/E values (Tables 4.9 and 4.10). The application of the 0.25 threshold resulted in increasing the kurtosis of the curve but not reducing the skew; the 0.5 threshold resulted in a negatively skewed distribution. The application of a 0.1 threshold to the total number of species reduced the number of species used by the model by 90%. The application of a 0.5 filter reduced species by 99%.

	All Species		
Bin	**N**	**% of Sites**	**Cumulative %**
0.00	0	0.00	0.00
0.10	0	0.00	0.00
0.20	0	0.00	0.00
0.30	1	0.22	0.22
0.40	4	0.88	1.11
0.50	9	1.99	3.10
0.60	26	5.75	8.85
0.70	43	9.51	18.36
0.80	**56**	**12.39**	**30.75**
0.90	**36**	**7.96**	**38.72**
1.00	**64**	**14.16**	**52.88**
1.10	**61**	**13.50**	**66.37**
1.20	**48**	**10.62**	**76.99**
1.30	37	8.19	85.18
1.40	33	7.30	92.48
1.50	17	3.76	96.24
1.60	12	2.65	98.89
1.70	5	1.11	100.00
1.80	0	0.00	100.00
1.90	0	0.00	100.00
2.00	0	0.00	100.00

Table 4.9: Distribution of O/E scores for all sites and all species.

All species	
Mean	0.985
10%ile	0.631
90%ile	1.357

Table 4.10: Mean, 10th percentile, 90th percentile for preliminary model using all sites and all species.

When standard AUSRIVAS band widths (Barmuta *et al.* 1997) were applied, only 46.24% of sites fell within the 'A' band considered to indicate reference condition.

4.3.3 Final model characteristics

After internal validation and the removal of 44 reference sites with an O/E ratio less than 0.6, the final model was redeveloped using the remaining 408 reference sites. DFA of the site groups using potential predictor variables resulted in a set of discriminant functions containing seven variables, which successfully reclassified (with jacknifing) 66% of reference sites and had a highly significant Wilks' lambda (0.07, $p < 0.0005$). The relative influences of the predictor variables on site distribution can be seen in Table 4.11.

Variable	F-to-remove
Altitude	100.19
Log Annual Mean Rainfall	33.19
Log Altitude	29.61
Easting	20.20
CV Monthly Rainfall	9.87
Log CV Monthly Rainfall	6.83
Northing	6.50

Table 4.11: Relative influence of predictor variables on site distribution using 408 sites and all species.

Removal of the impaired sites from the data set did not significantly change the values of the major predictor variables, or the characteristics of the groups described previously. While there were fewer predictor variables in the final model, altitude, mean annual rainfall and geographic location, especially easting, were again identified as key influences on the community composition of riparian vegetation types in Tasmania.

The variables and discriminant functions for the final model are shown in Table 4.12. The mean values of each variable for each group are shown in Table 4.13. The DFA met the minimum reclassification and Wilks' lambda criteria and was adopted for developing the AUSRIVAS model.

	Discriminant Function Coefficients							
Variable	**Constant**	**Easting**	**Northing**	**Altitude (m)**	**CV Monthly Rainfall**	**Log Altitude**	**Log Annual Mean Rainfall**	**Log CV Monthly Rainfall**
DF1	-7600	-0.00032	0.00232	-0.087	-71.7	13.6	76.8	1300
DF2	-7710	-0.00034	0.00234	-0.111	-72.6	16.0	75.7	1320
DF3	-7720	-0.00030	0.00235	-0.145	-71.2	16.9	78.4	1280
DF4	-7640	-0.00031	0.00233	-0.148	-71.3	18.4	77.3	1290
DF5	-7650	-0.00030	0.00233	-0.146	-70.6	18.4	82.4	1280
DF6	-7710	-0.00033	0.00233	-0.150	-71.6	18.5	87.3	1300

Table 4.12: Discriminant functions developed for the PA reference data set using 408 sites and all species. DF = discriminant function.

		Mean Values of Predictor Variables						
Group	N	Easting	Northing	Altitude (m)	CV Monthly Rainfall	Log Altitude	Log Annual Mean Rainfall	Log CV Monthly Rainfall
1	6	468968	5363570	1076.67	28.40	6.98	7.22	3.37
2	33	462299	5350920	783.64	21.35	6.65	7.07	3.08
3	91	529385	5390140	108.76	21.82	3.59	6.76	3.05
4	129	515302	5341650	226.24	21.21	5.09	6.81	3.03
5	61	466079	5404950	277.46	31.63	5.30	7.20	3.46
6	88	389696	5358000	219.32	28.10	5.04	7.57	3.35

Table 4.13: Mean values of each final predictor variable for each reference site group.

4.3.4 Model Development

The final model was successfully developed on Excel spreadsheets for the reduced reference site presence/absence data set. Individual spreadsheets were assigned for:

- calculating Pj values for each site;
- calculating Gj,k values for each species;
- calculating Rk values for each species at each site;
- developing the lists of expected flora;
- calculating the total number of expected species; and
- calculating O/E values for each reference site (Appendix 6).

The O/E ratios were considered to adequately represent the distribution of ecological health for the population of reference sites. The results for the final model appear in Figure 4.3 and Tables 4.14 and 4.15.

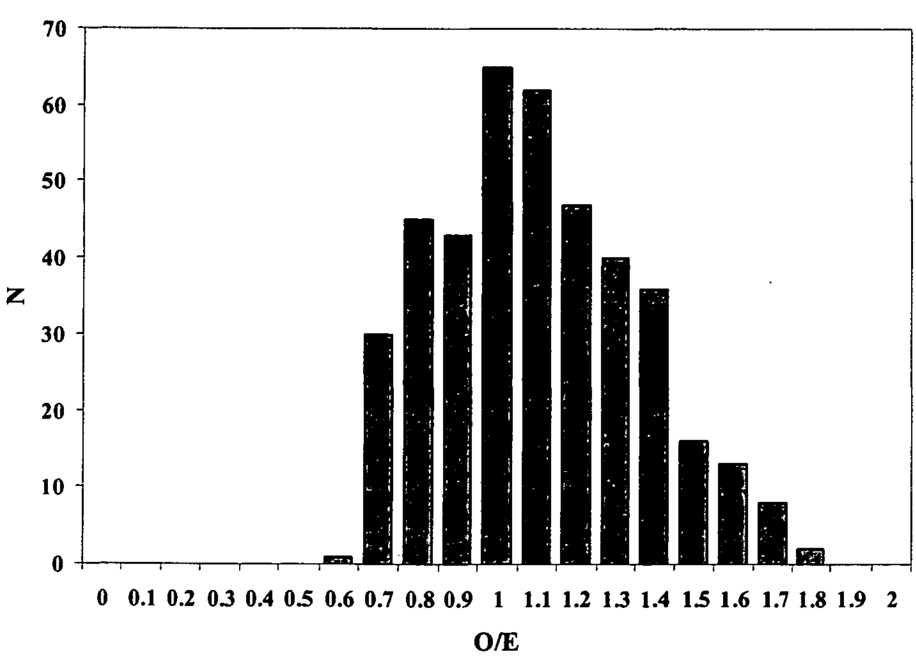


Figure 4.3: Frequency distribution of O/E_{pa} scores for the final reference set (with all species) derived from the final AUSRIVAS model.

Bin	Frequency	% of sites	Cumulative %
0.0	0	0.00	0.00
0.1	0	0.00	0.00
0.2	0	0.00	0.00
0.3	0	0.00	0.00
0.4	0	0.00	0.00
0.5	0	0.00	0.00
0.6	1	0.25	0.25
0.7	**30**	**7.35**	**7.60**
0.8	**45**	**11.03**	**18.63**
0.9	**43**	**10.54**	**29.17**
1.0	**65**	**15.93**	**45.10**
1.1	**62**	**15.20**	**60.29**
1.2	**47**	**11.52**	**71.81**
1.3	**40**	**9.80**	**81.62**
1.4	**36**	**8.82**	**90.44**
1.5	16	3.92	94.36
1.6	13	3.19	97.55
1.7	8	1.96	99.51
1.8	2	0.49	100.00
1.9	0	0.00	100.00
2	0	0.00	100.00

Table 4.14: Distribution of reference site O/E scores for the final model. (Values in bold indicate values falling between the 10^{th} and 90^{th} percentile.)

Final Model	
Mean	1.052
10%ile	0.722
90%ile	1.392
stdev	0.25
n	408

Table 4.15: Mean, 10^{th} percentile, 90^{th} percentile, and standard deviation for the final AUSRIVAS model using validated reference sites and all species.

4.3.5 Band widths

Based on the model, appropriate band widths and bounds are shown in Table 4.16.

Band	Bounds	Description
X	> 1.39	More diverse than reference
A	0.72 – 1.39	Equivalent to reference or Unimpaired.
B	0.000-0.72	Less diverse than reference or Significantly impaired.

Table 4.16: Band characteristics for the final PA predictive model for Tasmania's riparian vegetation.

It was noted, however, that the O/E distribution is skewed. Therefore, a more precise way to evaluate test site O/E values, is to convert O/E to Log_e (O/E) and compare the lower 95%

confidence limit with the test site Log_e O/E value (Figure 4.4; Table 4.17). Thus, if the test site value is lower at the 0.05-level, then the site may be considered modified or impacted. This is equivalent to doing a two-tailed t-test at alpha 0.05.

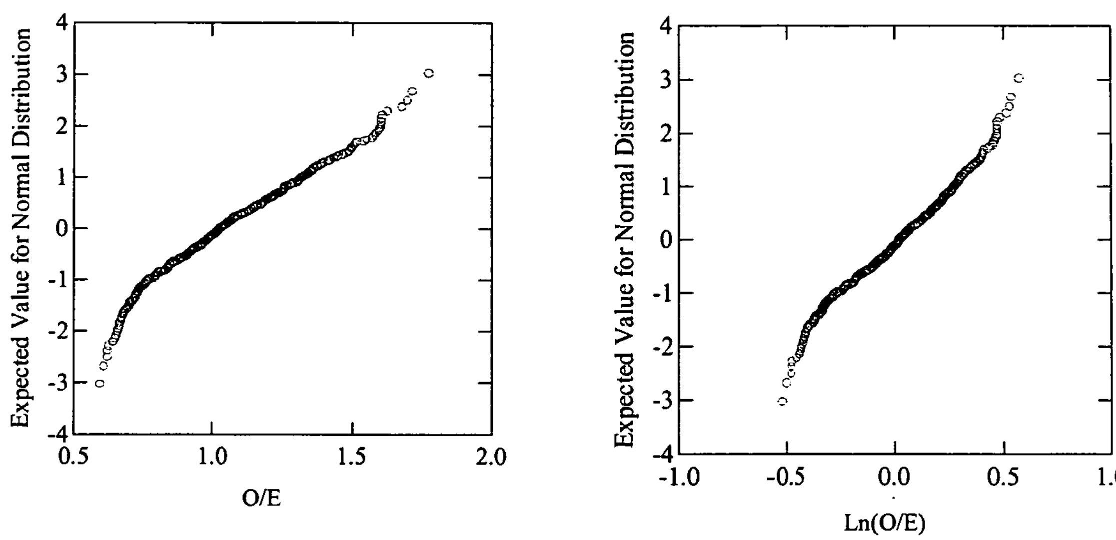


Figure 4.4: Normal probability plots for final reference site O/E values (untransformed and Log_e transformed). Both are reasonably linear with some improvement with Log_e transformation.

N of cases		408
Mean	Ln(O/E)	0.022
Standard Dev	Ln(O/E)	0.243
lower 95% conf	Ln(O/E)	-0.45

Table 4.17: Band widths and bounds using Log_e O/E values.

Using this method, a test site is considered modified or impacted if its Log_e O/E value is less than –0.45. From the results shown in Table 4.14, it can be seen that just over 90% of sites now fall within the bounds of the A Band, and 9.56% fall within the B Band, as expected.

4.3.6 Final model validation

From the 408 reference sites used for the development of the final model, 41 sites were removed and validation models were reconstructed using the remaining 367 reference sites.

DFA of the site groups using potential predictor variables resulted in a set of discriminant functions containing seven variables, which successfully reclassified (with jacknifing) 65%

of reference sites and had a highly significant Wilks' lambda (0.069, $p < 0.0005$). The relative influences of the predictor variables on site distribution can be seen in Table 4.18.

Variable	F-to-remove
Altitude	48.05
Log Rainfall wettest month	37.63
Log Altitude	25.95
Easting	19.39
CV Monthly rainfall	18.17
Northing	5.82
Mean temp. wettest quarter	5.11

Table 4.18: Relative influence of predictor variables on site distribution using 366 sites and all species.

The results for the validation model using independent reference test sites appear in Figure 4.5 and Tables 4.19 and 4.20. The O/E ratios were considered to adequately represent the distribution of ecological health for the population of validation reference sites.

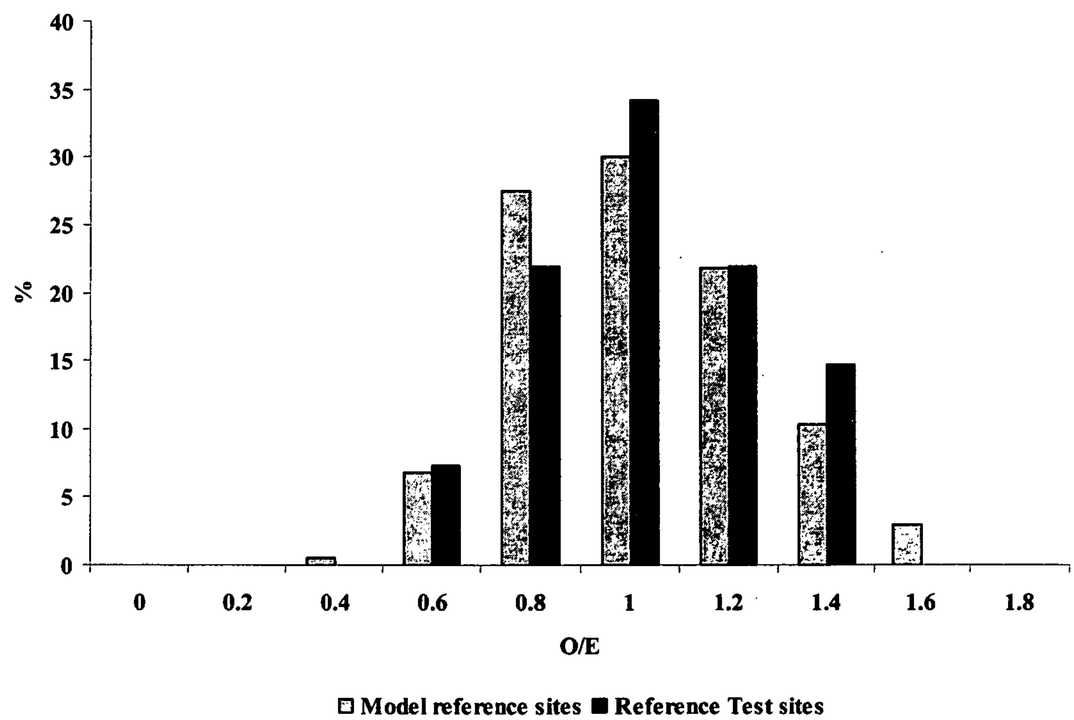


Figure 4.5: Frequency distribution of O/E_{pa} scores for the validation reference sites and independent reference test sites (with all species) derived from the validation AUSRIVAS model.

	Reference validation sites			Reference test sites		
Bin	Frequency	Frequency%	Cumulative %	Frequency	Frequency%	Cumulative %
0	0	0.00	0.00	0	0.00	0.00
0.2	0	0.00	0.00	0	0.00	0.00
0.4	2	0.54	0.54	0	0.00	0.00
0.6	25	6.81	7.36	3	7.32	7.32
0.8	101	27.52	34.88	9	21.95	29.27
1	110	29.97	64.85	14	34.15	63.41
1.2	80	21.80	86.65	9	21.95	85.37
1.4	38	10.35	97.00	6	14.63	100.00
1.6	11	3.00	100.00	0	0.00	100.00
1.8	0	0.00	100.00	0	0.00	100.00
More	0	0.00	100.00	0	0.00	100.00

Table 4.19: Distribution of reference site O/E scores for the validation model and independent reference test sites.

	Reference Validation Sites	Reference Test Sites
Mean O/E	0.919	0.904
SD	0.238	0.223

Table 4:20: Mean O/E and standard deviation for the reference sites and reference test sites from AUSRIVAS validation model.

The Kolmogorov Smirnoff test results for difference between frequency distributions of O/E's were not significant ($p > 0.4$). There were no significant differences in mean O/E values using the t-test.

The results of the re-sample model validation model support the hypothesis that the survey sites used for the development of the final AUSRIVAS riparian model can be considered to be valid reference sites and therefore can be used for the purpose of measuring ecological health within the survey area.

4.3.7 External validation

When the floristic and environmental dataset for the eight test sites was entered into the model, the O/E values fell between 0.38 and 1.86 (Table 4.21). The expected number of species that is provided as an output of the model (N Species Predicted) is the sum of the probabilities of all species expected to occur at the site.

The results of the model are consistent with field observations. The two reaches of riparian vegetation that have low O/E scores are in areas that have undergone substantial modification by forestry and/or agricultural practices. Prices Creek is a watercourse that flows into the Huon estuary at Franklin in the south and Cimitiere Creek is a modified watercourse in the north east of the State that enters Bass Strait east of George Town.

Test Site	N Species Predicted	Species Observed	O/E	Ln(O/E)	Band assignment
Prices Creek	26.31	10	0.38	**-0.97**	B
Nive River2	27.05	33	1.22	0.20	A
Ford River Tributary	47.11	32	0.68	-0.39	B/A
Pencil Pine Creek	25.86	48	1.86	0.62	X
Lemonthyme Creek	27.06	30	1.11	0.10	A
Murchison River	28.69	37	1.29	0.25	A
Montagu River	22.96	29	1.26	0.23	A
Cimitiere Creek	23.33	10	0.43	**-0.85**	B

Table 4.21: O/E scores for test sites using riparian AUSRIVAS model. (Ln O/E scores that fall below the 95% confidence level appear in bold.)

Both sites were sampled because they were the only remaining, accessible stands of native riparian vegetation within the 100 km^2 grid in which they occurred. The result for the Ford River Tributary demonstrates the difference in river health assessment that could arise using the untransformed band widths instead of the transformed values. The latter value is more representative of the health of this reach than the former.

Pencil Pine Creek is a variable watercourse with uninterrupted stands of native vegetation that vary from sedgey heath to ferny closed-forest. This site was excluded as a reference site because of uncertainty as to whether inclusion of species from obviously different riparian structures along the riparian reach would add unnecessary "noise" to the data set.

The O/E values indicate that at least five of the test sites could be included in the dataset as reference sites. The above results were interpreted as validating the consistency of the original PA models in terms of site reclassification, O/E scoring and band assignment.

4.3.8 Prediction of species composition at a site

As well as providing an interpretation of riparian vegetation condition based on species richness relative to a reference data set, the model also generates a list of species predicted to occur at a site along with a probability score for each species. According to the model, the probability of occurrence at each site of each species is the sum over all groups of the probability that a site belongs to a group multiplied by the proportion of sites in the group at which the species occurs. Therefore a species would have a high probability score if a large proportion of sites in a group had a strong affinity with one of the 6 classificatory groups used for model development and the species was present at most of the sites in the group.

Thus if all, or the majority of observed species at test sites also have high probability scores, then it is highly likely that the species lists generated by the AUSRIVAS model could be used as planting guides for the native revegetation of degraded riparian reaches anywhere within the survey area with a high degree of certainty that the species would be appropriate for the site.

A preliminary investigation of the species output of the model was undertaken addressing the following questions.

- How many species observed at a site are also predicted at the site?
- How many species not observed at a site are predicted at the site?
- How many species not predicted are observed at the site?
- How does the list of observed species for a site compare with the list of predicted species?
- Would a site be classified into the same riparian floristic community from the predicted list of species as from the observed species list?

A probability score of 0.5 is used as the arbitrary minimum value from which an assessment of the species output of the AUSRIVAS model is made, solely as a convenient marker for decision-making purposes.

For the purpose of evaluating the outputs of the model, the tools developed in Chapter 3 for the purpose of classifying sites into communities based on floristic composition will be used in conjunction with the observed species lists. The specific tools used will be the indicator species in Figure 3.4 and 3.5, the riparian floristic communities classification key in Section 3.3.3 and the community descriptions in 3.3.4.

(a) Comparison of species numbers - observed and predicted

The summary of results from the eight tests sites addressing the first three questions above is provided in Table 4.22.

Test Site	No. Species Observed	No. Species Predicted	No. Species observed and predicted	No. species observed but not predicted	No. species predicted but not observed
Prices Creek	10	85	10	0	75
Nive River2	33	108	20	13	89
Ford River Tributary	32	148	17	15	131
Pencil Pine Creek	48	102	26	22	76
Lemonthyme Creek	30	83	24	6	59
Murchison River	37	83	30	7	53
Montagu River	29	83	21	8	62
Cimitiere Creek	10	83	10	0	73

Table 4.22: Summary of statistics for species observed and predicted by the AUSRIVAS model for eight sites in Tasmania.

The model generates a large number of predicted species for each site relative to the number of species found at any site. The observed/predicted percentages range from 12% at Prices and Cimitiere Creeks to 47% at Pencil Pine Creek. However, the model's ability to predict the presence of observed species at sites ranges from 50% at Ford River Tributary to 100% at Prices and Cimitiere Creeks. While there is a significant correlation between the number of species observed and the number of species observed and predicted (Pearsons correlation = 0.873, p = 0.005), the proportion of species that are observed and predicted is only a small component of the list of predicted species generated by the AUSRIVAS model.

The number of species observed but not predicted is inconsistent. The model was able to predict the presence of all observed species at the two sites with low numbers of observed species, but around 47% of species at Ford River Tributary and Pencil Pine Creek were observed but not predicted.

There is also a large number of species predicted but not observed at all sites. The predicted list generated for the Murchison River had 1.4 times as many species as the observed list. For Prices Creek and Cimitiere Creek, the predicted lists had over 7 times as many species as the observed lists.

(b) Comparison of species lists - observed and predicted

A list of the species observed at the eight test sites is provided in Table 4.23. Where species are predicted to be present by the model, these are indicated together with their probability score. The number of species observed and predicted with a probability score ≥ 0.5 is quite low, ranging from 6% at Pencil Pine Creek to 47% at Lemonthyme Creek. In 7 of the 8 sites, *Eucalyptus* species are present, but do not score well, if at all, in the predicted lists. The only other point of interest, that could be discerned from the comparison of the species lists in Table 4.23, is that the predicted species that have a high probability score at Cimitiere Creek are a subset of those predicted and observed at the Montagu River. Similarly, there is a coincidence of species between Prices Creek and Lemonthyme Creek.

A condensed list of the species predicted to be present at the same sites is provided in Table 4.24. As there are a large number of predicted species generated by the model, the condensed list was compiled from the first 25 species at each site that includes all the species predicted to be present with a probability score of 0.5 or greater for each site. A summary table of results is provided in Table 4.25.

Prices Creek		**Nive River**		**Ford R**		**Pencil Pine Cr**	
Species observed	**Probability**	**Species observed**	**Probability**	**Species observed**	**Probability**	**Species observed**	**Probability**
Acacia dealbata	**0.86**	**Moss species**	**0.76**	***Geranium potentilloides***	**0.82**	**Moss species**	**0.76**
Coprosma quadrifida	**0.73**	***Acaena novae-zelandiae***	**0.63**	***Acaena montana***	**0.80**	***Cyathodes parvifolia***	**0.56**
Blechnum nudum	**0.69**	***Geranium potentilloides***	**0.62**	***Plantago* spp.**	**0.64**	***Tasmannia lanceolata***	**0.51**
Blechnum wattsii	0.45	*Poa labillardierei*	0.45	***Poa* spp.**	**0.50**	*Epacris gunnii*	0.48
Dicksonia antarctica	0.40	*Coprosma quadrifida*	0.41	***Hydrocotyle hirta***	**0.50**	Lichen species	0.45
Eucalyptus obliqua	0.39	*Eucalyptus delegatensis*	0.39	***Hypericum japonicum***	**0.50**	*Poa* spp.	0.43
Eucalyptus regnans	0.22	*Eucalyptus pauciflora*	0.39	*Leptospermum lanigerum*	0.36	*Coprosma nitida*	0.40
Olearia argophylla	0.21	*Hakea microcarpa*	0.36	*Cyathodes parvifolia*	0.19	*Oxylobium ellipticum*	0.34
Eucalyptus globulus	0.16	*Blechnum nudum*	0.35	*Tasmannia lanceolata*	0.19	*Gonocarpus montanus*	0.34
Leptospermum scoparium	0.15	*Acacia dealbata*	0.32	*Coprosma nitida*	0.18	*Baloskion australe*	0.34
		Carex appressa	0.32	*Hydrocotyle sibthorpioides*	0.17	*Empodisma minus*	0.32
		Polystichum proliferum	0.32	*Viola hederacea*	0.17	*Polystichum proliferum*	0.32
		Juncus australis	0.31	*Polystichum proliferum*	0.17	*Agrostis* spp.	0.31
		Olearia phlogopappa	0.29	*Lagenifera stipitata*	0.17	*Viola hederacea*	0.29
		Oxalis perennans	0.27	*Juncus pauciflorus*	0.16	*Baeckea gunniana*	0.24
		Callistemon viridiflorus	0.26	*Veronica calycina*		*Eucalyptus coccifera*	0.19
		Cassinia aculeata	0.24	*Stellaria pungens*		*Sprengelia incarnata*	0.18
		Eucalyptus dalrympleana	0.23	*Pterostylis spp.*		*Nothofagus cunninghamii*	0.17
		Carex tereticaulis	0.16	*Pimelea drupacea*		*Ozothamnus hookeri*	0.17
		Pteridium esculentum	0.14	*Oxalis perennans*		*Pimelea drupacea*	0.15
		Pomaderris apetala	0.12	*Olearia viscosa*		*Gleichenia alpina*	0.15
		Australopyrum pectinatum		*Olearia lirata*		*Grevillea australis* var. *montana*	0.14
		Blechnum wattsii		*Notelaea ligustrina*		*Pittosporum bicolor*	0.14

Table 4.23: Species observed at 8 test sites. (Predicted species with a probability score equal to or greater than 0.5 are in bold.)

Prices Creek		Nive River (contd)		Ford R (contd)		Pencil Pine Cr (contd)	
Species observed	**Probability**	**Species observed**	**Probability**	**Species observed**	**Probability**	**Species observed**	**Probability**
		Dianella tasmanica		Moss species		*Leptospermum rupestre*	0.12
		Dicksonia antarctica		*Lomatia tinctoria*		*Ehrharta tasmanica var. subalpina*	0.11
		Geranium sessiliflorum		*Hypolepis amaurorachis*		*Gymnoschoenus sphaerocephalus*	0.10
		Gonocarpus teucrioides		*Eucalyptus delegatensis*		*Abrotanella forsteroides*	
		Olearia argophylla		*Dicksonia antarctica*		*Archeria eriocarpa*	
		Pimelea cinerea		*Cyathodes glauca*		*Athrotaxis cupressoides*	
		Richea gunnii		*Blechnum nudum*		*Australopyrum pectinatum*	
		Senecio hispidulus		*Bedfordia salicina*		*Bellendena montana*	
		Senecio linearifolius		*Asplenium flabellifolium*		*Calorophus elongatus*	
		Wahlenbergia gracilis				*Deyeuxia* spp.	
						Diplarrena latifolia	
						Diselma archeri	
						Epacris serpyllifolia	
						Eucryphia lucida	
						Exocarpos strictus	
						Hibbertia procumbens	
						Histiopteris incisa	
						Hypolepis rugosula	
						Libertia pulchella	
						Orites acicularis	
						Orites revoluta	
						Oxalis magellanica	
						Richea pandanifolia	
						Richea scoparia	
						Telopea truncata	

Table 4.23: Species observed at 8 test sites (contd) (Predicted species with a probability score equal to or greater than 0.5 are in bold.)

Lemonthyme Creek		Murchison River		Montagu River		Cimitiere Creek	
Species observed	Probability	Species observed	Probability	Species observed	Probability	Species observed	Probability
Moss species	**0.88**	***Moss species***	**0.87**	***Pomaderris apetala***	**0.74**	***Pteridium esculentum***	**0.75**
Dicksonia antarctica	**0.84**	***Blechnum nudum***	**0.81**	***Pteridium esculentum***	**0.71**	***Lomandra longifolia***	**0.71**
Blechnum nudum	**0.83**	***Gahnia grandis***	**0.76**	***Moss species***	**0.70**	***Moss species***	**0.68**
Pomaderris apetala	**0.79**	***Acacia melanoxylon***	**0.75**	***Leptospermum lanigerum***	**0.65**	***Acaena novae-zelandiae***	**0.62**
Nothofagus cunninghamii	**0.74**	***Leptospermum scoparium***	**0.68**	***Lomandra longifolia***	**0.64**	*Poa labillardierei*	0.46
Acacia melanoxylon	**0.73**	***Dicksonia antarctica***	**0.68**	***Acaena novae-zelandiae***	**0.60**	*Melaleuca ericifolia*	0.26
Coprosma quadrifida	**0.73**	***Acacia mucronata***	**0.60**	***Acacia verticillata***	**0.54**	*Geranium potentilloides*	0.21
Lichen species	**0.70**	***Lichen species***	**0.59**	***Coprosma quadrifida***	**0.52**	*Euchiton spp.*	0.10
Polystichum proliferum	**0.69**	***Monotoca glauca***	**0.54**	*Carex appressa*	0.42	*Juncus pauciflorus*	0.10
Acacia dealbata	**0.66**	***Pomaderris apetala***	**0.53**	*Blechnum nudum*	0.41		
Acaena novae-zelandiae	**0.58**	***Pimelea drupacea***	**0.53**	*Bursaria spinosa*	0.39		
Leptospermum lanigerum	**0.56**	***Nematolepis squamea***	**0.50**	*Agrostis spp.*	0.33		
Histiopteris incisa	**0.55**	*Tasmannia lanceolata*	0.48	*Poaceae spp.*	0.33		
Carex appressa	**0.50**	*Polystichum proliferum*	0.46	*Eucalyptus obliqua*	0.32		
Pteridium esculentum	0.45	*Baloskion tetraphyllum*	0.46	*Hydrocotyle hirta*	0.29		
Olearia lirata	0.41	*Coprosma quadrifida*	0.43	*Melaleuca squarrosa*	0.27		
Pittosporum bicolor	0.40	*Viola hederacea*	0.39	*Juncus spp.*	0.26		
Nematolepis squamea	0.38	*Melaleuca squarrosa*	0.36	*Melaleuca ericifolia*	0.23		
Dianella tasmanica	0.24	*Eucalyptus nitida*	0.36	*Lepidosperma elatius*	0.20		
Eucalyptus viminalis	0.20	*Phyllocladus aspleniifolius*	0.35	*Isolepis spp.*	0.13		
Gleichenia microphylla	0.19	*Pteridium esculentum*	0.34	*Monotoca glauca*	0.13		
Poaceae spp.	0.18	*Cenarrhenes nitida*	0.32	*Acradenia frankliniae*			
Lepidosperma ensiforme	0.13	*Cyathodes juniperina*	0.28	*Cardamine spp.*			

Table 4.23: Species observed at 8 test sites (contd). (Predicted species with a probability score equal to or greater than 0.5 are in bold.)

Lemonthyme Creek (contd)		Murchison River (contd)		Montagu River (contd)		Cimitiere Creek (contd)	
Species observed	**Probability**	**Species observed**	**Probability**	**Species observed**	**Probability**	**Species observed**	**Probability**
Notelaea ligustrina	0.11	*Blechnum minus*	0.26	*Ehrharta spp.*			
Cyathodes glauca		*Pittosporum bicolor*	0.24	*Eucalyptus nitida*			
Eucalyptus amygdalina		*Olearia stellulata*	0.23	*Microsorum pustulatum*			
Eucalyptus dalrympleana		*Gonocarpus teucrioides*	0.22	*Plantago daltonii*			
Eucalyptus radiata subsp. robertsonii		*Dianella tasmanica*	0.22	*Pratia surrepens*			
Lomatia tinctoria		*Billardiera longiflora*	0.18	*Urtica urens*			
Ozothamnus thyrsoideus		*Eucalyptus delegatensis*	0.13				
		Archeria eriocarpa					
		Empodisma minus					
		Juncus pallidus					
		Juncus procerus					
		Lepidosperma gunnii					
		Oxylobium arborescens					
		Ozothamnus thyrsoideus					

Table 4.23: Species observed at 8 test sites (contd). (Predicted species with a probability score equal to or greater than 0.5 are in bold.)

Prices Creek		Nive River2		Ford River Tributary		Pencil Pine Creek	
Species Predicted	**Probability**	**Species Predicted**	**Probability**	**Species Predicted**	**Probability**	**Species Predicted**	**Probability**
Pomaderris apetala	**0.88**	***Leptospermum lanigerum***	**0.89**	***Empodisma minus***	**0.96**	***Leptospermum lanigerum***	**0.86**
Acacia dealbata	**0.86**	**Moss species**	**0.76**	***Agrostis* spp.**	**0.96**	**Moss species**	**0.76**
Pteridium esculentum	**0.81**	***Acaena novae-zelandiae***	**0.63**	***Baeckea gunniana***	**0.96**	***Acaena novae-zelandiae***	**0.62**
Acaena novae-zelandiae	**0.80**	***Geranium potentilloides***	**0.62**	***Hierochloe redolens***	**0.95**	***Geranium potentilloides***	**0.61**
Coprosma quadrifida	**0.73**	***Pultenaea juniperina***	**0.60**	***Richea acerosa***	**0.95**	***Pultenaea juniperina***	**0.57**
Moss species	**0.73**	***Cyathodes parvifolia***	**0.60**	***Geranium potentilloides***	**0.82**	***Cyathodes parvifolia***	**0.56**
Blechnum nudum	**0.69**	***Bauera rubioides***	**0.55**	***Baloskion australe***	**0.81**	***Bauera rubioides***	**0.53**
Leptospermum lanigerum	**0.65**	***Tasmannia lanceolata***	**0.52**	***Acaena montana***	**0.80**	***Tasmannia lanceolata***	**0.51**
Acacia melanoxylon	**0.65**	*Epacris gunnii*	0.49	***Ozothamnus hookeri***	**0.80**	*Epacris gunnii*	0.48
Carex appressa	**0.64**	*Hydrocotyle hirta*	0.47	***Grevillea australis* var. *montana***	**0.80**	*Hydrocotyle hirta*	0.47
Cassinia aculeata	**0.64**	Lichen species	0.45	***Leptospermum rupestre***	**0.80**	Lichen species	0.45
Eucalyptus viminalis	**0.60**	*Poa labillardieri*	0.45	***Ranunculus triplodontus***	**0.80**	*Poa* spp.	0.43
Lomandra longifolia	**0.53**	*Poa* spp.	0.44	***Carex gaudichaudiana***	**0.65**	*Hypericum japonicum*	0.43
Polystichum proliferum	**0.52**	*Hypericum japonicum*	0.44	**Marsupial lawn**	**0.65**	*Poa labillardierei*	0.41
Oxalis perennans	**0.51**	*Coprosma nitida*	0.41	***Plantago paradoxa***	**0.64**	*Coprosma nitida*	0.40
Poa labillardierei	0.47	*Eucalyptus delegatensis*	0.39	***Austrodanthonia* spp.**	**0.64**	*Eucalyptus delegatensis*	0.37
Blechnum wattsii	0.45	*Eucalyptus pauciflora*	0.39	***Poa costiniana***	**0.64**	*Blechnum penna-marina*	0.37
Beyeria viscosa	0.42	*Blechnum penna-marina*	0.39	***Orites acicularis***	**0.64**	*Eucalyptus pauciflora*	0.36
Lichen species	0.41	*Hakea microcarpa*	0.36	***Hydrocotyle muscosa***	**0.63**	*Blechnum nudum*	0.36
Dicksonia antarctica	0.40	*Oxylobium ellipticum*	0.36	***Bellendena montana***	**0.63**	*Gonocarpus montanus*	0.34
Poaceae spp.	0.40	*Gonocarpus montanus*	0.36	***Epacris serpyllifolia***	**0.63**	*Hakea microcarpa*	0.34
Eucalyptus obliqua	0.39	*Blechnum nudum*	0.35	***Epacris gunnii***	**0.50**	*Oxylobium ellipticum*	0.34
Gahnia grandis	0.38	Poaceae spp.	0.34	***Hydrocotyle hirta***	**0.50**	*Baloskion australe*	0.34
Eucalyptus amygdalina	0.37	*Lomatia tinctoria*	0.34	***Poa* spp.**	**0.50**	*Carex gaudichaudiana*	0.33

Table 4.24: Excerpt from predicted species lists derived from AUSRIVAS model for 8 test sites. (Species with a probability of 0.5 or higher are in bold.)

Lemonthyme Creek		Murchison River		Montagu River		Cimitiere Creek	
Species	**Probability**	**Species**	**Probability**	**Species**	**Probability**	**Species**	**Probability**
Moss species	**0.88**	**Moss species**	**0.87**	***Pomaderris apetala***	**0.74**	***Pteridium esculentum***	**0.75**
Dicksonia antarctica	**0.84**	***Nothofagus cunninghamii***	**0.87**	***Pteridium esculentum***	**0.71**	***Pomaderris apetala***	**0.75**
Blechnum nudum	**0.83**	***Blechnum nudum***	**0.81**	**Moss species**	**0.70**	***Lomandra longifolia***	**0.71**
Pomaderris apetala	**0.79**	***Gahnia grandis***	**0.76**	***Leptospermum lanigerum***	**0.65**	**Moss species**	**0.68**
Nothofagus cunninghamii	**0.74**	***Acacia melanoxylon***	**0.75**	***Lomandra longifolia***	**0.64**	***Leptospermum lanigerum***	**0.66**
Acacia melanoxylon	**0.73**	***Eucryphia lucida***	**0.74**	***Acacia dealbata***	**0.62**	***Acacia dealbata***	**0.64**
Coprosma quadrifida	**0.73**	***Dicksonia antarctica***	**0.68**	***Acaena novae-zelandiae***	**0.60**	***Acaena novae-zelandiae***	**0.62**
Lichen species	**0.70**	***Leptospermum scoparium***	**0.68**	***Acacia verticillata***	**0.54**	***Acacia verticillata***	**0.57**
Polystichum proliferum	**0.69**	***Leptospermum lanigerum***	**0.66**	***Acacia melanoxylon***	**0.54**	***Eucalyptus viminalis***	**0.57**
Acacia dealbata	**0.66**	***Acacia mucronata***	**0.60**	***Coprosma quadrifida***	**0.52**	***Eucalyptus amygdalina***	**0.56**
Atherosperma moschatum	**0.63**	**Lichen species**	**0.59**	***Eucalyptus viminalis***	**0.51**	***Coprosma quadrifida***	**0.51**
Pimelea drupacea	**0.62**	***Blechnum wattsii***	**0.57**	***Eucalyptus amygdalina***	**0.50**	***Acacia melanoxylon***	**0.51**
Blechnum wattsii	**0.62**	***Anopterus glandulosus***	**0.57**	*Carex appressa*	0.42	*Banksia marginata*	0.46
Acaena novae-zelandiae	**0.58**	***Monotoca glauca***	**0.54**	*Banksia marginata*	0.42	*Poa labillardierei*	0.46
Leptospermum lanigerum	**0.56**	***Pomaderris apetala***	**0.53**	*Blechnum nudum*	0.41	*Bursaria spinosa*	0.43
Histiopteris incisa	**0.55**	***Pimelea drupacea***	**0.53**	*Poa labillardierei*	0.41	*Carex appressa*	0.42
Carex appressa	**0.50**	***Nematolepis squamea***	**0.50**	*Gahnia grandis*	0.40	*Exocarpos cupressiformis*	0.41
Viola hederacea	0.47	*Atherosperma moschatum*	0.49	*Leptospermum scoparium*	0.39	*Lepidosperma ensiforme*	0.40
Pteridium esculentum	0.45	*Sticherus tener*	0.49	*Bursaria spinosa*	0.39	*Leptospermum scoparium*	0.39
Hydrocotyle hirta	0.45	*Tasmannia lanceolata*	0.48	*Lepidosperma ensiforme*	0.37	*Gahnia grandis*	0.39
Gahnia grandis	0.44	*Histiopteris incisa*	0.47	*Exocarpos cupressiformis*	0.37	*Blechnum nudum*	0.36
Cassinia aculeata	0.42	*Polystichum proliferum*	0.46	*Oxalis perennans*	0.34	*Oxalis perennans*	0.35
Olearia lirata	0.41	*Gleichenia microphylla*	0.46	*Agrostis* spp.	0.33	*Poaceae* spp.	0.35
Pittosporum bicolor	0.40	*Baloskion tetraphyllum*	0.46	*Poaceae* spp.	0.33	*Eucalyptus ovata*	0.35

Table 4.24: Excerpt from predicted species lists derived from AUSRIVAS model for 8 test sites (contd). (Species with a probability of 0.5 or higher are in bold.)

Test Site	No. of species observed	No. of species observed & predicted	No. of observed and predicted species with probability scores ≥ 0.5	No. of predicted species with a probability score ≥ 0.5
Prices Creek	10	10	3	15
Nive River2	33	20	3	8
Ford River Tributary	32	17	6	25
Pencil Pine Creek	48	26	3	8
Lemonthyme Creek	30	24	14	17
Murchison River	37	30	12	17
Montagu River	29	21	8	12
Cimitiere Creek	10	10	4	12

Table 4.25: Summary statistics for observed and predicted species with an AUSRIVAS probability score of 0.5 or higher at eight test sites.

In general, very few of the predicted species with high probability scores were observed - 6% at Pencil Pine Creek to 47% at Lemonthyme Creek. Conversely, there were relatively higher numbers of predicted species with high probability scores but no significant correlation between the numbers of predicted species and the numbers of species observed and predicted.

The coincidence of species between the predicted lists and observed lists with high probability scores was variable. At three sites, the number of species with high probability scores exceeded the total number of species observed and predicted at the site. Closer inspection of the species list for the Ford River Tributary indicates that the predicted list is very indicative of alpine vegetation. Pencil Pine Creek also ranked poorly in a match between observed and predicted species with high probability scores. As a general observation, if the predicted list generated for the Ford River Tributary had been generated for Pencil Pine Creek, this would have been a better match to the observed species composition than the one predicted for it. However, at Lemonthyme Creek and the Montague River, there was a greater coincidence of species between the predicted and observed lists with high probability scores.

It is noted that the predicted species list for the Nive River2 and Pencil Pine Creek are identical if considering only the predicted species with a probability score higher than 0.5. Similarly, the species lists for Montague River and Cimitiere Creek are identical but with different probability scores for the species.

(c) Comparison of community classification – observed and predicted

In all the test sites, there are at least 3 species predicted to be present with a probability score higher than 0.5. If the riparian floristic communities classification key is used, the minimum number of species required to.classify a site into a riparian community is 2 (Communities 4 and 21). Therefore, there are sufficient species with the minimum probability score at all sites from which the classification of a site into a community is possible.

Using a combination of the indicator species, the riparian floristic communities classification key and the community descriptions in conjunction with the observed species lists in Table 4.23, the researcher would have classified the riparian vegetation at the test sites as indicated in Table 4.26.

Using the same tools and methodology, the research classified the riparian vegetation at the test sites using the predicted species lists and the species with a probability score of 0.5 or higher (Table 4.27). In addition, based on the general structural attributes of various floristic combinations, the following broad rules were applied:

- Where there were *Eucalyptus* and/or *Acacia* species present in conjunction with *Lomandra longifolia*, and heathy species, the assumption will be made that this structure is more typical of the drier regions of Tasmania and will therefore be described as woodland over the predominant matrix of the understorey.
- Where *Nothofagus cunninghamii* is present in associated with shrubby species and/or wet *Eucalyptus* species, i.e. *E. regnans*, *E. obliqua* and *E. nitida*, then the assumption will be made that the structure is forest and the descriptors of the forest will be determined from the lifeform combinations that appear in the predicted species list.
- Lifeform descriptors will be determined from the numbers of different lifeforms that comprise the species list.
- No attempt will be made to predict the cover of each strata beyond the tallest stratum.

Site	Riparian Structure observed	Riparian Community classification	Reason
Prices Creek	*Dicksonia antarctica* closed fernland	16	Absence of *Lomandra longifolia; Dicksonia antarctica, Acacia dealbata, Olearia argophylla* and *Eucalyptus obliqua* present; matches community profile.
Nive River2	*Eucalyptus delegatensis* and *Acacia dealbata* woodland over *Pomaderris apetala\Olearia argophylla* ferny closed-shrubland	10	Combination of *Pomaderris apetala, Pteridium esculentum* and *Acacia dealbata*, with *Polystichum proliferum, Geranium potentilloides* and *Cassinia aculeata, Coprosma quadrifida* and *Poa labillardierei* present; matches community profile.
Ford River	*Eucalyptus delegatensis* woodland over *Leptospermum lanigerum* mossy-ferny-sedgey closed-scrub	8	Presence of *Eucalyptus delegatensis, Bedfordia salicina, Olearia lirata, Olearia viscosa*, and *Notolaea ligustrina* and *Juncus* species; matches community profile.
Pencil Pine Creek	*Eucalyptus coccifera* woodland over *Leptospermum rupestre* heathy closed-scrub to *Nothofagus cunninghamii\ Athrotaxis cupressoides* ferny, mossy scrubby forest	19	Presence of *Nothofagus cunninghamii, Libertia pulchella, Coprosma nitida, Richea pandanifolia* and *Oxalis magellanica*; matches community profile.
Lemonthyme Creek	*Acacia melanoxylon\Eucalyptus viminalis* woodland over *Pomaderris apetala\Nematolepis squamea* ferny closed-scrub	8	Presence of *Acacia dealbata, Eucalyptus viminalis, Pomaderris apetala, Coprosma quadrifida, Olearia lirata, Notelaea ligustrina, Carex appressa* and *Gleichenia microphylla* as well as *Pteridium esculentum* and *Polystichum proliferum*; matches community profile.
Murchison River	*Eucalyptus delegatensis\E. subcrenulata* woodland over *Acacia mucronata\Leptospermum scoparium* sedgey-heathy closed-scrub	17	Presence of *Dicksonia antarctica, Pomaderris apetala, Acacia mucronata, Nematolepis squamea, Eucalyptus nitida* and *Monotoca glauca*; matches community profile.
Montagu River	*Eucalyptus nitida* woodland over *Melaleuca ericifolia\Leptospermum lanigerum* sedgey-ferny closed-forest	5	Presence of *Lomandra longifolia, Pomaderris apetala, Pteridium esculentum, Acacia verticillata, Melaleuca squarrosa* and *Leptospermum lanigerum* as well as *Hydrocotyle hirta* and *Blechnum nudum*; matches community profile.
Cimitiere Creek	*Melaleuca ericifolia* herby-grassy closed-scrub	5?	Presence of *Lomandra longifolia* and loosely matches community profile.

Table 4.26: Classification of riparian vegetation into riparian floristic communities based on observed species at 8 test sites.

Site	Riparian Structure Predicted	Riparian Community classification	Reason and Comments
Prices Creek	*Eucalyptus viminalis/Acacia dealbata* woodland over sedgey-ferny scrub	10	Presence of *Lomandra longifolia, Pomaderris apetala, Acacia dealbata, Pteridium esculentum, Polystichum proliferum, Cassinia aculeata* and *Eucalyptus viminalis*. This combination of species and structural attributes is a good match to community 10 but this community has not been recorded in the bioregion where this site is found.
Nive River2	*Leptospermum lanigerum/Tasmannia lanceolata* scrub over herby heath	3	Presence of *Leptospermum lanigerum, Cyathodes parvifolia* and *Acaena novae-zelindiae*. The absence of the *Eucalyptus* species that is the key characteristic of this community would be of concern. This site occurs within the bioregion where this community is typically found.
Ford River	*Orites acicularis-Baeckea gunniana-Richea acerose-Hierochloe redolens-Poa costiniana* grassy heath	1	*Baeckea gunniana, Richea acerosa, Hierochloe redolens, Agrostis* species, *Ranunculus triplodontus* and *Epacris serpyllifolia* present. This is the classic combination for alpine heath. However, this community has not been recorded in the bioregion where this site is found.
Pencil Pine Creek	*Leptospermum lanigerum/Tasmannia lanceolata* scrub over herby heath	3	Presence of *Leptospermum lanigerum, Cyathodes parviflora* and *Acaena novea-zelindaea*. The absence of *Eucalyptus* species that is the key characteristic of this community would be of concern. This site occurs within the bioregion where this community is typically found.
Lemonthyme Creek	*Acacia dealbata/Nothofagus cunninghamii* forest over ferny-scrub	17	Presence of *Nothofagus cunninghamii, Atherosperma moschatum, Dicksonia antarctica, Histiopteris incisa, Pomaderris apetala, Carex appressa* and *Polystichum proliferum*. This is the closest match based only on the indicator species in Figure 3.5. Not a good match to the key or the community profile. This community has not been recorded in the bioregion where this site is found.
Murchison River	*Acacia melanoxylon/Nothofagus cunninghamii* forest over ferny scrub	17	Presence of *Nothofagus cunninghamii, Dicksonia antarctica, Eucryphia lucida, Pomaderris apetala, Leptospermum scoparium, Anopterus glandulosus* and *Acacia mucronata*. A better match to this community than the site above except the *Eucalyptus* species that are commonly found in association with this community are absent. This site occurs within the bioregion where this community is typically found
Montagu River	*Eucalyptus viminalis/E. amygdalina* woodland over scrub	5	Presence of *Lomandra longifolia, Pomaderris apetala, Pteridium esculentum, Acacia dealbata and Acacia verticillata* and *Leptospermum lanigerum*. Best fit based on indicator species only. The combination of species and structure is plausible within this community and this site occurs within the bioregion where this community is typically found.
Cimitiere Creek	*Eucalyptus viminalis/E. amygdalina* woodland over scrub.	5	Presence of *Lomandra longifolia, Pomaderris apetala, Pteridium esculentum, Acacia dealbata* and *Acacia verticillata* and *Leptospermum lanigerum*. Best fit based on indicator species only. The combination of species and structure is plausible within this community and this site occurs within the bioregion where this community is typically found.

Table 4.27: Classification of riparian vegetation into riparian floristic communities based on predicted species at 8 test sites.

There is considerable variation in the classification of sites into communities based on observed species and predicted species with a probability score ≥ 0.5. The community classifications for 5 of the sites based on the predicted species lists have no affinity with the classifications based on the observed species (Tables 4.26 and 4.27). However, the riparian community classifications for Murchison River, Montagu River and Cimitiere Creek are identical.

It is of interest to note that while there were a considerable number of species predicted and observed with high probability scores at Lemonthyme Creek (Table 4.23), these species did not facilitate the classification of the site into the same riparian floristic community as that based on the observed species.

4.4 Discussion

The results of the AUSRIVAS riparian predictive modelling approach and its outputs have been both promising and disappointing. On one hand, the model was able to distinguish between the majority of sites that could be considered to be relatively unmodified and those that existed in areas historically subject to agricultural production, mining or urban development. On the other hand, the model could not distinguish between reference sites with naturally occurring low numbers of species and sites whose riparian vegetation could be considered to be extensively modified by land use practices.

The model was also able to accurately predict the presence of many species at reference sites, but because of the large number of predicted species generated by the model, it is difficult to determine which of the species is most likely to occur at a site. The probability of occurrence of observed species at a site tended to fall well below 0.5 for most species, and quite a few species that were observed at a site were not predicted to be present by the model.

The large discrepancies between observed and predicted species lists can be accounted for by the model design. The probability of occurrence at each site of each species is the sum over all groups of the probability that a site belongs to a group multiplied by the proportion of sites in the group at which the species occurs. As there is considerable variation in the number of sites that comprise a group developed for AUSRIVAS model development (Table 4.3), and therefore considerable variation in the numbers and types of species found at the sites within the groups, it follows that sites which have affinity to larger groups will have more species predicted but with lower probability scores overall. The large discrepancies between observed and predicted species lists makes it difficult for a user of the lists to consistently determine which species should be selected for revegetation purposes or for ecological classification of sites into communities.

There was some success in classifying sites into riparian communities based on the predicted species output of the model using the classification tools and riparian communities descriptions developed to be used in association with the reference data set. Many of the results based on the species outputs of the model may be contradictory because of the small sample size on which the preliminary trial was done. In the researcher's opinion, there are sufficient successes in the preliminary trial of the species output of the model in the present study to warrant a more thorough investigation on a larger sample.

4.4.1 Basic assumptions about riparian species

There are some fundamental differences between the use of vascular plant species and macroinvertebrates in developing these predictive models.

The AUSRIVAS RIVPACS model was developed using macroinvertebrates for bioassessment with some basic assumptions (pers. comm. Peter Davies 2002):

- species are sensitive to ecological disturbances and pollution;
- species react to pollution and channel changes in a predictable way; and
- impact of disturbance is related to reduction in number of taxa.

These assumptions cannot be equally applied to riparian species, as little is known about the functionality or sensitivity of vascular species in the riparian zone. There is no published research in Australia or elsewhere that investigates the relationship between vascular species, genera or families and specific or broad functions in the riparian zone, their sensitivity to ecological disturbances or pollution, channel changes or species interaction. There is a broad body of research on the effect of the hydrological environment on riparian vegetation (e.g. Merritt & Cooper 2000) and the role of riparian vegetation in the riparian zone (e.g. Abernethy & Rutherfurd 1996; Tabacchi *et al.* 2000;) but none on the contribution of individual species to the riparian environment. Therefore, no broadly accepted correlations can be made between any vascular species and riparian habitat characteristics.

There are fewer taxa in an AUSRIVAS model involving macroinvertebrates, as there are difficulties associated with identifying many macroinvertebrates to species level. Mostly, family level classification is used. Universally, plant species are well documented and described to species level. An attempt was made to reclassify the vegetation data set into a more general set combining all species in a genus.

However, this process was abandoned due to a number of difficulties. There were difficulties in formulating the rules for a condensed list from such a large list of species. Some species in the riparian zone in different parts of the state have different structural forms. For example, *Leptospermum lanigerum*, *Acacia verticillata* and *Melaleuca ericifolia* occur as quite tall trees in some parts of Tasmania and low heathy shrubs in other parts. On what basis would the condensation of species to broader groups occur – e.g. structure, function? The species in some genera are shrubs and others are ground covers, e.g. *Goodenia*. Some species in a genus are quite common while others are relatively uncommon, e.g. *Poa labillardierei* compared with *Poa mollis*. What decision-making process or level of expertise would to be required in order to discern which of the species within a genus is appropriate for the revegetation of degraded reaches?

There is a direct correlation between presence and absence of macroinvertebrate species at a site relative to a reference data set and health of the site. However, the lack of vascular species diversity at a site may not be directly related to artificial disturbance factors. The results of the DFA showed that community composition in the riparian zone is closely related to topographic position, climate, and geographic location. However, a review of Tasmania's 1,766 existing native vascular species reveals that there are only two plant species that could be considered to be obligate riparian species and only 70 others that are predominantly found in the riparian zone (Table 3.3). Other studies investigating floristic distribution around Tasmania have shown that the distribution of species may be explained by a number of other factors: for instance, environmental factors such as position of the watertable in the soil and soil pH (Kirkpatrick & Wells 1987); differential frost tolerance of species (Fensham & Kirkpatrick 1992); tolerance to saline conditions or inundation (Kirkpatrick & Glasby 1981; Kirkpatrick & Harwood 1983b) and factors that contribute to endemism (Kirkpatrick & Brown 1984; Hill & Orchard 1999).

Even within a geographical location, hydrological and geomorphic factors may contribute to differential riparian species distribution. Pettit *et al.* (2001: 202) state: "Flow essentially 'drives' sediment transport and, in fluvially-dominated systems, shapes the river channel and therefore the structure of riparian landscapes (Young 1999) which can result in multiple successional stages (e.g. Malanson 1993)". These factors are independent of anthropomorphic disturbances and may or may not differ from changes in floristic composition as a consequence of changes to flow associated with artificial hydrological or geomorphic modifications or river fragmentation (e.g. Andersson *et al.* 2000b; Nilsson & Berggren 2000).

O/E results for many of the reference sites indicate that there may have been varying degrees of impact since European settlement at "reference" sites that may have altered species richness, but not necessarily the "nativeness" of vegetation. Extent and effect of past forestry, mining, hunting and agricultural practices and associated fire, logging, clearing and grazing regimes on species richness in the riparian zone are not known. Therefore, there is still some uncertainty with regard to the "reference" condition of some of the reference sites used in the final data set for model development.

4.4.2 The AUSRIVAS approach

The degree to which the AUSRIVAS model is able to predict assemblages of species at most sites around Tasmania is encouraging. AUSRIVAS is generally based on 'rapid assessment' sampling, as it has the potential to allow bioassessment of a spatial reference state with a fairly quick protocol. The sampling method used in this study for riparian species appears to be successful and could be considered a 'rapid assessment' technique. A more statistically rigorous and thorough form of sampling based on quadrats and transects was attempted in the early stages of data collection but abandoned because of the inability to accurately define a quadrat in some types of riparian vegetation (e.g. dense *Melaleuca* scrub as found at the Catamaran River estuary – Site 1) and because of the time involved to determine and establish the number of quadrats and transects that would be considered to be representative of all reaches of riparian vegetation on a state-wide basis.

There are, however, some limitations to the sampling approach used which may impact on the quality of the data set. The reference data set represents a single spot sample at a random time of year at a location that is assumed to be representative of the grid being surveyed. In many cases, this may be sufficient sampling and fully representative of other reaches in the survey area. The reference data set could be improved by undertaking the survey over a longer time frame that includes re-sampling of sites during peak flowering times. This would improve the identification of many grasses, graminoids and herbs. Increasing sampling density within the grid would also improve the data set as it was noted that the eight test sites had a further 15 native species not recorded at the other 452 sites. There is a certain degree of confidence, however, that in the time allocated and with the resources available, all the common species likely to be present in riparian reaches with the survey area were detected.

The model makes assessments only on the presence and absence of species that are present at reference sites at the time of survey. They do not directly assess the occurrence of 'new' species at modified test sites (Davies & Cook 1999: 102) though 'new' species within the overall list of species used in the model can be evaluated.

4.4.3 Uses of data set and model

AUSRIVAS has generally been used for assessments in relation to water quality and biodiversity (Wright 1995; John 1998; John 2000). At this stage of its development, the AUSRIVAS riparian predictive model could reasonably be used to assess the condition of riparian vegetation within the survey area in Tasmania. While there would be a measure of coarseness in the results, the researcher believes that the state-wide assessment of riparian vegetation condition in Tasmania derived from the AUSRIVAS model would provide a more refined assessment than the one undertaken as part of the National Land and Water Resources Audit (NLWRA 2002).

The species output of the model still needs considerable investigation and development if it is to be used as a guide to revegetation, or for ecological classification for mapping riparian vegetation at the state-wide scale. While it is now theoretically possible to generate a list of predicted species for any riparian zone within the survey area in Tasmania using just a map and the BIOCLIM data set, at the moment, the reliability and suitability of that list for any purpose is uncertain. For example, it is unlikely that the first 25 species on the predicted species list generated for the Ford River tributary would have grown well in this location as the observed vegetation at this site was described as *Eucalyptus delegatensis* woodland over *Leptospermum lanigerum* mossy-ferny-sedgey closed-scrub whereas the predicted vegetation could be described as grassy-herby alpine heath. At Lemonthyme Creek, however, most of the species on the predicted list with a high probability score were also observed and there was a close structural match between observed and predicted outputs. It is highly probable, that the 17 highest-scoring species from the predicted list of this site could form the basis of a successful revegetation effort at this site. While the Lemonthyme Creek example may be considered to be encouraging because of its revegetation potential, it is noted that the combination of predicted species with a probability score of $\geq$ 0.5 did not result in the classification of the site into the same riparian floristic community as the combination of observed species.

With the shift to regionalisation in Tasmania, there is the potential to develop refined regional AUSRIVAS riparian models for assessing the condition of riparian vegetation. It is envisaged that these data sets would be smaller that the statewide dataset but have enhanced sensitivity through regional specificity in stream types and/or flora and increased density of reference sites. Effective regional models, based on macroinvertebrate studies, have been demonstrated for the ACT (Norris 1996), the Tasmanian Mt Lyell mining region (Davies *et al.* 1996), the Hobart urban region (Foley 1998), the Hydro catchments (Davies & Cook 1999) and catchments in the southern forests (Davies & Cook 2002).

CHAPTER 5

Conservation of Native Riparian Vegetation

"The world's plant diversity is seriously threatened by deforestation and other habitat loss, destructive development, agricultural expansion, overconsumption of resources, and the spread of invasive alien species. Further loss of plant diversity is predicted through genetic erosion and narrowing of the genetic basis of many species. The disappearance of such vital and massive amounts of biodiversity provides one of the greatest challenges faced by the world community: to halt the destruction of the plant resources that are essential for meeting present and future needs. In addition, reductions in populations of utilized plants threaten the economic, cultural and physical security of local communities. Thus, conserving plant diversity at all levels, within species (genetic), between species, and among ecosystems, is fundamental." (Strahm & Chouchena-Rojas 2001: 2)

5.0 Introduction

Preoccupation with development and economic growth without adequate consideration to the functions and requirements of natural ecosystems has led to a rapid decline in the existence, integrity and viability of many of the components of nature on which we ultimately depend for our health and well-being. Nowhere are the symptoms of neglect and the negative effects of development that Strahm & Chouchena-Rojas (2001) cite more evident than along rivers and streams, especially in countries or regions endowed with high densities of watercourses. Along watercourses, the most neglected component of freshwater ecosystems is native riparian vegetation.

In many countries, the extent of native riparian vegetation has diminished to a small proportion of the original (Brinson *et al.* 1981). Tasmania, also, has had a significant proportion of its native riparian vegetation either cleared or degraded, especially in areas devoted to agriculture (Geraghty & Ratcliffe 1993) and the rate of clearance is set to increase as a result of the large number of instream dams that have been approved, and are yet to be approved in the coming years (see p.13). From the present study, viable stands of native riparian vegetation could not be detected, or were extremely sparse and inaccessible, in 60 of the grid squares surveyed (equivalent to an area of 6,000 km^2). In addition, the extent and condition of many of the riparian reaches was generally poor in agricultural, mining and urban regions and in some of the commercial forests around Tasmania.

There is a strong case to support the view that all remaining native riparian vegetation should be conserved or protected because of its natural significance, its significant functions and roles as part of freshwater ecosystems and its high economic, cultural and social values. There is also an identified need "to design and implement protective management initiatives to provide a representative system of riverine and estuarine reserves and to protect elements of the landscape that maintain river and estuary health" (NLWRA 2002: 302), thus considerably addressing one of the major shortfalls in natural resource management across Australia.

However, the reality of current protective management initiates is that only a part of the landscape can be managed primarily for conservation and this is usually a relatively small part. Lockwood *et al.* (1997) point out that, in Australia, selection of public lands for reservation as protected areas is generally a political process heavily influenced by threat and availability, and primarily determined by economic and cultural factors.

While there is little evidence in Tasmania's history to show that freshwater ecosystems have been valued primarily for their ecological and biological roles and functions, Tasmania has a strong and positive history of nature conservation and there are well-established legislative frameworks, planning principles and processes that facilitate nature conservation decision-making processes for vascular plant species and communities.

5.1 Legislative framework

Historically, conservation of biota for biodiversity outcomes has occurred through a system of formal reserves at a regional scale designed for specific biological purposes: e.g. National Parks and Nature Reserves. Sometimes, such reserves are given extra recognition by authorities of national and international standing and may also be listed on a Register of the National Estate or classified as a World Heritage Area. Because formal reserves are managed for specific outcomes according to legislative processes, there is a high degree of confidence that the outcomes will be achieved.

Until 30 December, 2002, there were three Acts that provided a mechanism for reservation of riparian vegetation and species in Tasmania: *National Parks & Wildlife Act* 1970; *Forestry Act 1920*; and *Crown Lands Act 1976*. The first two acts have provisions for formal reserves whose management objectives include the conservation of natural biological diversity and values, the preservation of the quality of water and catchment protection. The *National Parks & Wildlife Act* has since been replaced by two acts: the *Nature Conservation Act 2002* and the *National Parks and Reserves Management Act 2002*. The latter Act now covers formal reserves.

Outside formal reserves, only a small proportion of streams are bounded by riparian reserves and these are managed either under the *Crown Lands Act 1976* or by private landholders.

The *Crown Lands Act 1976* (Part VII: 57) makes provision for the reservation of riparian vegetation on crown land by the Minister - if in his or her opinion it is desirable - to the extent of at least 15 metres in width on each bank of the river, stream, lake or the high-water mark of the sea or estuary. "Desirable" not only covers conservation values, but also includes public recreation and cultural values. There are also at least 25 State legislative and regulatory restrictions that deal with harm, pollution or disruption to riparian vegetation (DPIWE 2003).

The three main differences between a secure formal reserve and all other categories of reserves are: the susceptibility of informal reserves to mining; the level of management priority and thus, funding, allocated to reserve management; and permitted uses of the reserve. Permitted uses of lands within informal reserves may include instream dams for water points, as well as mining, grazing and hunting.

Under the *National Parks and Wildlife Act 1970* and *Forestry Act 1920*, formal reserve categories that provide security of reservation for riparian plant communities are: national park; State reserve; nature reserve; game reserve; historic site; private nature reserve and forest reserves not subject to the *Mineral Resources Development Act 1995*. Informal reserves within Tasmania are listed as: conservation area, nature recreation area, regional reserve, private sanctuary, forest reserves subject to the Mineral Resources Development Act 1995, and river reserves under the *Crown Lands Act 1976* (Part VII: 57).

Secure reserves require action by both houses of the Tasmanian Parliament for dedication or revocation (RFA Tasmania, 1997, Attachment 6: 65) or are protected by an international agreement under the World Heritage Convention (Kirkpatrick *et al.* 1995: 10).

Riparian native species and communities qualify for conservation under Section 3:2(e) of the *Environment Protection and Biodiversity Conservation Act* 1999 (*EPBC Act*). The relevant objects of the Act are:

(a) to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance; and
(b) to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources; and
(c) to promote the conservation of biodiversity; and
(d) to promote a co-operative approach to the protection and management of the environment involving governments, the community, land-holders and indigenous peoples.

The *EPBC Act* provides for the enhancement of Australia's capacity to ensure the conservation of its biodiversity by including provisions to:

(i) protect native species (and in particular prevent the extinction, and promote the recovery, of threatened species) and ensure the conservation of migratory species; and
(ii) establish an Australian Whale Sanctuary to ensure the conservation of whales and other cetaceans; and
(iii) protect ecosystems by means that include the establishment and management of reserves, the recognition and protection of ecological communities and the promotion of off-reserve conservation measures; and
(iv) identify processes that threaten all levels of biodiversity and implement plans to address these processes.

5.2 Conservation practices

In addition to the context of protecting threatened species, conservation of riparian vegetation is usually considered in the context of freshwater and estuarine ecosystems (Land Conservation Council 1994; MacAlister Elliott and Partners Ltd *et al.* 2001: 10; Costanza *et al.* 1997; NLWRA 2002; Dunn 2002). While native riparian vegetation may be an essential component of all criteria and attributes usually associated with the assessment of ecological values for a river – naturalness, representativeness, diversity and richness, rarity and special features (Dunn 2002: 26) – its intrinsic values have not been as widely recognized as being of sufficient value to warrant consideration for nature conservation. This may, of course, be entirely due to a lack of information about riparian vegetation (Tait *et al.* 2000).

Riparian floristic communities are scarce among the many plant communities that have been reserved in Australia (NLWRA 2002). Reasons cited for this omission include: no geomorphic definition of the riparian zone; no single hierarchical classification scheme for extracting floristic and structural information from aerial photography and satellite imagery; and no agreement on appropriate regionalisations (ibid: 86). However, many of the relationships between riparian plant species and communities and related habitats or dependent processes are not fully understood.

In addition, the competing interests which focus on riparian lands and the fresh water on which native riparian communities depend, do not often attribute high value to other inhabitants or users of the "resources". Components of native riparian vegetation, such as trees, have commercial value. In many areas, native riparian vegetation competes with pine plantations, exotic pasture and horticultural species for existence in some of the most productive soils in the landscape, and the water "resource", on which riparian vegetation is dependent, is also highly valued for its domestic, commercial and agricultural uses.

Scientifically, concepts such as the 'river continuum theory' (Vannote *et al.* 1980), 'flood pulse theory' (Junk *et al.* 1989) and 'integrated catchment management' provide a holist framework within which to place riparian vegetation. However, these concepts require an understanding of the flow-on processes between neighbouring or related habitats that bring about interdependence of environmental elements (Bennett *et al.* 2002: 32). Testing the validity of these concepts usually requires significant interdisciplinary research effort and committed community and government participation. Practical difficulties associated with defining adequate spatial and temporal scales for ecological assessments are also well recognized (Committee of Scientists 1999; Boughton *et al.* 1999).

Riparian plant communities differ from other plant communities primarily because of interrelationships with river processes and ecosystems as well as terrestrial environments. Stream channel and floodplain morphology are governed by: the volume and timing of discharge; the volume, time and character of sediment delivery and transport; and the large-scale geological history and geomorphology of the drainage basin (Tabacchi *et al.* 1998: 499). Physical disturbances due to floods and human influences may induce the partial or complete removal of riparian vegetation and there is some evidence to suggest that in the riparian area, geomorphic processes, with infrequent and large-scale disturbances, form mosaics of various successional stages, suggesting non-equilibrium conditions in the riparian community (Suzuki *et al.* 2002).

In recent years, a community desire for healthy, sustainable watercourses for future generations to enjoy has contrasted sharply with the stark realities of river "improvements" and water development. The costs and resources associated with rehabilitating eroding riparian reaches through expensive techniques such as bank battering, rock protecting, fencing, planting, reinstating cut-off meanders and removal of toxic sediment accumulations are high, and success rates typically low (Beschta *et al.* 1994; Gippel & Collier 1998; White 2000: 119). A growing understanding of the economic values of ecosystem services provided by riparian vegetation and the complex nature of environmental and ecological interactions associated with the riparian zone, has prompted ecologists and natural resource managers to reconsider the conservation status of riparian vegetation.

The major Australian and overseas initiatives in river assessment for conservation, which includes riparian vegetation, have been recently reviewed by Dunn (2002: 11-16). The initiatives include specific conservation outcomes such as securing biotic refuges and reserve corridors for riparian plants and take geomorphology, hydrology and ecosystem functions and roles into account. The major initiatives are: National River Health Program and AUSRIVAS (Commonwealth); Wild Rivers Project (Commonwealth); Index of Stream Condition (Victoria); Stressed Rivers (New South Wales); State of the Rivers (Western Australia); Environmental Flows; Water Resource Environmental Planning (Queensland); Wild and Scenic Rivers (United States); River Invertebrate Prediction and Classification Scheme (United Kingdom); River Habitat Survey; and System for Evaluating Rivers for

Conservation (United Kingdom. These initiatives may provide sufficient nature conservation outcomes for riparian vegetation. However, as riparian vegetation is not a focus of the initiatives, there is no certainty that the conservation outcomes for native riparian vegetation will necessarily be achieved.

In a few instances, the initiatives mentioned above have resulted in the enactment of legislation which provides formal protection for rivers deemed to have high recreation, cultural and ecological values: e.g. *Wild and Scenic Rivers Act 1968* (USA); and *Heritage Rivers Act 1992* (Victoria). The native riparian vegetation associated with rivers protected by formal legislation could be considered to be well-reserved. Usually, though, only a small number of rivers within the legislative area qualify for such prestigious protection (e.g. Land Conservation Council 1990) and, therefore, these initiatives do not achieve adequate conservation outcomes for native riparian vegetation in general.

5.3 Conservation planning considerations

While the selection of lands for conservation may be a political process, conservation planning is usually based on objective and scientific principles, and sometimes on the pragmatism of natural resource managers (Pendergast *et al.* 1999). Planners and land managers separate potential conservation areas from the remainder of the landscape in various ways, sometimes solely according to the distribution of features considered significant, or by first identifying significant features and then adjusting the boundaries of proposed reserves according to existing units of tenure or to features such as roads, streams or catchment boundaries that provide distinct or manageable boundaries (Pressey & Logan 1998).

Real world planning constraints place limits on how many areas can be reasonably set aside as reserves. Therefore it is necessary to make considered recommendations for reservation of priority sites on the basis of systematic and objective processes. The methodology used over the last two decades for the selection of additional conservation areas has tended to include an algorithm-based approach. Algorithms can have weighted attributes and applied formulae, be a single stage process or iterative (Kirkpatrick 1983). The values ascribed to the selection units based on the algorithm used, become the basis of recommendations for conservation.

Since the 1980s (Kirkpatrick & Brown 1980; Kirkpatrick 1983), algorithms, in conjunction with gap analysis, have been used to facilitate reserve selection to improve biodiversity outcomes. While initially developed to achieve secure reservation for endemic and rare plant species, the concept has been expanded so that other natural features can be evaluated in order to achieve additional goals for conservation planning in the context of regional strategies (Ferrier *et al.* 2000; Margules and Pressey 2000). The concept of irreplaceability (Pressey *et al.* 1994) has been included in reserve selection algorithms and the concept of 'selection unit' has been expanded to include occurrence, frequency and extent of populations, species, assemblages, ecosystems or environmental domains in manageable-sized parts of the landscape (Lockwood *et al.* 1997; Pressey & Logan 1998).

When considering conservation for biodiversity outcomes, Cowling and Pressey (2001) strongly recommend that biodiversity pattern be coupled with evolutionary processes. This would provide greater long-term benefits for biodiversity outcomes than principles based only on the representation of pattern. Little is known about the size and spacing of riparian and fluvial reserve areas at landscape scales that are necessary to benefit the dispersal and sustainability of different plant species (Wissmar & Beschta 1998). Such information is crucial, but not always available, for the determination of evolutionary significant units, in terms of species, populations and their supporting ecosystems. Selection for reservation should also take into consideration the interconnectivity of riparian and channel ecosystems with upland areas (e.g. tributary catchments and habitats) that are most ecologically intact and contain the best existing habitats (Frissell *et al.*1993).

After priorities for riparian floristic conservation are established, there are other 'real-world' issues that planners and land managers need to consider (Pressey & Logan 1998):

- The number of selection units that can be handled by the analysis in a time that is reasonable for the intended process;
- The size of the selection unit relative to the scale of the feature being conserved;
- The size of selection units in relation to the reliability of mapping;
- The effectiveness in quantifying neighbourhood relationships among units or interactions between the features they contain;
- The ability of regular grids or hexagons to show per unit area values for criteria such as richness or unprotected features;
- Equality of the sizes of selections units over large geographic areas when factors such as map projections are an issue;
- Whether different types or sizes of units lead to different configurations of reserves;
- Convenience of conversion of selection units to management units on the ground;
- Whether the boundaries of some units are likely to change, for example as tenure parcels are exchanged and amalgamated;
- Appropriateness of boundaries for conservation management;
- Size-related considerations such as edge effects, viability of populations, and management overheads in the resulting reserves; and

- Considerations for public presentation such as the potential sensitivity of mapping parcels of private tenure rather than arbitrary grid cells that do not identify specific holdings.

These 12 practical considerations often define the scope and limits of any conservation initiative on which politicians will act. In addition, a considerable amount of the native riparian vegetation that requires conservation exists on lands in private tenure and the "rights" and powers that have been culturally attributed to individuals are not easily diminished even where it can be demonstrated that there is considerable personal and public benefit.

5.4 Conservation planning process

"Reserves have two main roles. They should sample or represent the biodiversity of each region and they should separate this biodiversity from processes that threaten its persistence." (Margules & Pressey 2000: 243). Margules & Pressey (2000) also define a systematic conservation planning framework as a process involving six stages: compiling and/or acquiring data; identifying conservation goals for the planning region; reviewing existing conservation areas; selecting additional conservation areas; implementing conservation actions; and maintaining the required values of the conservation areas. While it is not possible in the scope of the present project to realise the last two stages, it is possible to apply a traditional conservation planning process to achieve the aim of identifying priority riparian reaches for the reservation of native riparian floristic communities in Tasmania based on the information on native riparian vegetation derived from the present study.

A 5-stage planning process was developed to illustrate how priority reaches could be selected on the basis of the results presented in the preceding chapters and the observed species data in the riparian reference dataset.

Stage 1: Identification of conservation goals for riparian floristic communities.

Stage 2: Gap analysis or assessment of the current formal reservation status of native riparian plant communities on mainland Tasmania.

Stage 3: Development of criteria and an algorithm that will facilitate an adequate and representative reservation of native riparian floristic communities.

Stage 4: Ranking of all relevant sites within floristic communities surveyed according to the scores derived from the algorithm.

Stage 5: Selection of riparian reaches for reservation based on the highest scores from the algorithm outlined above.

Once priority sites are identified, issues relating to connectivity, remoteness from artificial disturbance, probability of persistence in the absence of human intervention and land tenure can be considered along with other extrinsic planning, mapping and management issues.

An example of the application of the planning process to the stage where priority reaches are identified for one described riparian floristic community is provided below.

5.4.1 Application of conservation planning process

The first step in the conservation planning process is to identify a conservation goal for riparian floristic communities. For this worked example, the conservation goal will be the conservation of one riparian floristic community that is known to be poorly-reserved or unreserved.

Many of the newly described riparian floristic communities are broadly distributed across the State. It has been demonstrated in the previous chapter that the reasons for their distributions are complex and include geographic, hydrologic, geomorphic, abiotic and biotic environmental, and climatic factors. IBRA bioregions can be used as surrogates for different environments in the absence of substantial scientific data and according to Dunn (2002), the bioregional classification that exists in Tasmania has some value as a starting point from which a comprehensive, adequate and representative reserve system can be developed for lotic communities.

Informally (Kirkpatrick *et al.* 1995: 23), floristic communities in Tasmania are considered well-reserved when:

- a viable area can be found in two or more secure or formal reserves; or
- two or more viable areas that are well separated occur in one secure or formal reserve; or
- all its known occurrences are within viable, secure reserves.

A community is considered to be poorly-reserved if it does not satisfy one of the above conditions but is found in a secure reserve and unreserved if it is not known from any secure reserve.

5.4.2 Gap analysis

The registers of Tasmania's official reserves established under the *National Parks and Wildlife Act 1970* and the *Forestry Act 1920* as at 5 December 2002 were used in association with the Tasmania Land Tenure Map (Forestry Tasmania, 2002; 1:500 000) to ascertain which of the reserves already in existence has a high probability of containing stands of native riparian vegetation and therefore riparian floristic communities. For the purposes of the gap analysis, an existing reserve was considered to contain native riparian vegetation if a watercourse appeared in association with the reserve on the Land Tenure Map. No judgment was made about the viability or condition of the riparian vegetation.

Of the reserves listed under the *National Parks and Wildlife Act 1970*, the *Crown Lands Act 1976* and the *Forestry Act 1920*, it is estimated that there are 65 secure reserves and 199 informal reserves on mainland Tasmania where there is a high probability that viable stands of native riparian vegetation occurs (Appendix 9). There are also around 900 parcels of land mapped as riparian reserves across Tasmania ranging in size from 1 ha on small watercourses such as White Kangaroo Rivulet in the Coal River Valley to the largest on one bank of the Frankland River in the west with an area of 318 ha (DPIWE Reserves Database, October 2001). Most of these river reserves are a consequence of subdivision of private land and may not necessarily be dominated by native riparian vegetation (pers. comm. Mike Askey-Doran, DPIWE 2002). The tenure of river reserves created under the *Crown Lands Act 1976* is not always known. River reserves created under the *Crown Lands Act* are also non-statutory and become Public Reserves when the RFA amendments to the *Crown Lands Act* become law. Reserves likely to contain viable stands of native riparian vegetation are not evenly distributed across the State (Figure 5.1; see Figure 3.2 for Tasmania's bioregions).

Outside of the West and Central Highlands bioregions, there are very few secure reserves on mainland Tasmania that contain extensive stands of native riparian vegetation. The Douglas-Apsley National Park and Mt William National Parks in the Southeast and Flinders bioregions respectively, are the major exceptions.

Informal reserves provide a measure of conservation for riparian vegetation. At present, there are very few areas containing riparian vegetation set aside for reservation in:

- the Northern Midlands, Southern Ranges and Northern Slopes bioregions;
- the catchments of the Derwent River, the Coal River, the Macquarie Rivers and the lowland reaches of rivers that flow to the east coast within the Southeast bioregion; and
- the lowland reaches of rivers that flow to the north coast within the King, Northern Slopes and Flinders bioregions.

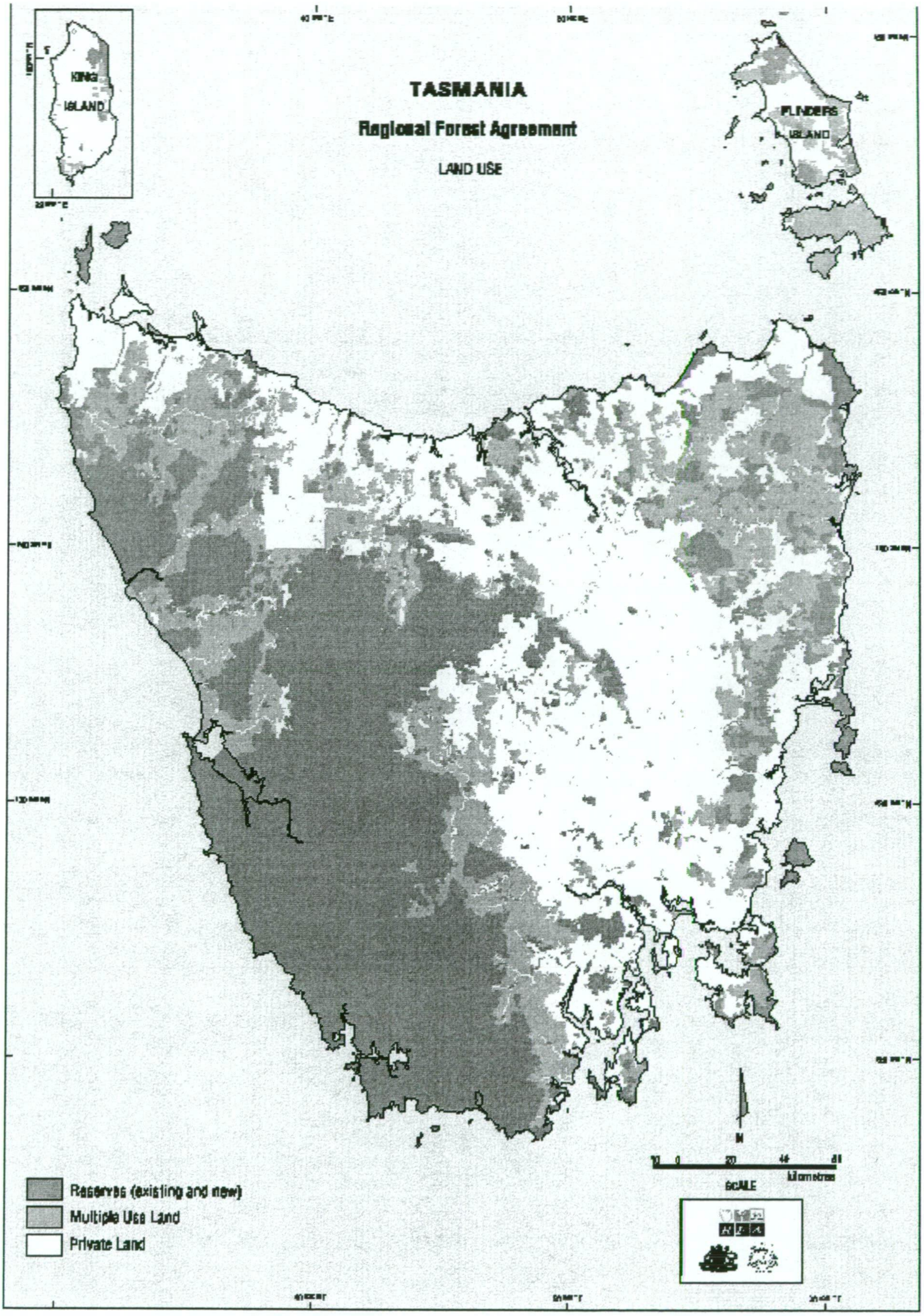


Figure 5.1: Land use map of Tasmania.
(Source: RFA Website, Commonwealth of Australia, 1999)

In order to establish an objective and consistent approach to a gap analysis, the following guidelines were established for evaluating the current reservation status of the 21 newly described native riparian vegetation communities for their floristic values in each IBRA bioregion in Tasmania.

- A riparian floristic community will be considered to be well-reserved in a bioregion if it can be located in viable areas in two or more secure reserves.
- If a riparian floristic community is found in only one secure reserve in a bioregion, it will be considered to be well-reserved in that bioregion if the full extent of native riparian vegetation in the catchment above the riparian floristic community lies within the reserve and there are high ratings on the criteria of connectivity, remoteness from artificial distrurbance and likelihood of persistence.
- A riparian floristic community will be considered to be poorly-reserved in a bioregion if it can be located in only one viable area in a secure reserve.

A summary of the results of the gap analysis for each of the 21 native riparian floristic communities is provided below. It is to be noted that the gap analysis is based only on the sites that were surveyed for this present study. It is possible that the newly described riparian floristic communities may exist in other reserves.

Community 1	*Orites acicularis-Baeckea gunniana-Richea acerosa-Hierochloe redolens-Poa costiniana* grassy heath
Reservation Status:	**Well-reserved.**
Formal Reserves:	Central Plateau Conservation Area within the World Heritage Area.
Informal Reserves:	None.
Community 2	*Eucalyptus* open-forest over *Baeckea gunniana-Gleichenia alpina-Rubus gunnianus* sedgey-ferny closed-heath
Reservation Status:	**Poorly-reserved** in Central Highlands bioregion.
Formal Reserves:	Cradle Mountain-Lake St Clair National Park.
Informal Reserves:	Vale of Belvoir Conservation Area.
Community 3	*Eucalyptus gunnii* woodland or open-forest over *Leptospermum lanigerum* herby-grassy-sedgey heath and scrub
Reservation Status:	**Unreserved** in the Central Highlands and Southern Ranges bioregions.
Formal Reserves:	None.
Informal Reserves:	Wentworth Creek Forest Reserve.

Community 4	*Melaleuca ericifolia-Lomandra longifolia-Juncus kraussii* estuarine forest and scrub
Reservation Status:	**Poorly-reserved** in the Flinders bioregion. **Unreserved** in the Northern Slopes, King and Southern Ranges bioregions.
Formal Reserves:	Mt William National Park.
Informal Reserves:	Recherche Bay Nature Recreation Area, Boobyalla River Public Reserve, Brid River Public Reserve, Tomahawk Public Reserve, Arthur-Pieman Conservation Area, Inglis River Public Reserve.
Community 5	*Melaleuca squarrosa-Leptospermum lanigerum* heathy-ferny-sedgey closed-scrub
Reservation Status:	**Well-reserved** in the Southern Ranges, West and Flinders bioregions. **Unreserved** in the King, Northern Slopes and Ben Lomond bioregions.
Formal Reserves:	Southwest National Park, Mt William National Park
Informal Reserves:	North Scottsdale Forest Reserve, Arthur-Pieman Conservation Area, Waterhouse Conservation Area.
Community 6	*Eucalyptus* woodland over *Hakea microcarpa-Poa labillardierei-Lomandra longifolia* grassy-sedgey scrub
Reservation Status:	**Poorly-reserved** in the Southeast bioregion. **Unreserved** in the Northern Midlands bioregion.
Formal Reserves:	Douglas Apsley National Park.
Informal Reserves:	Little Swanport River Public Reserve, St Pauls River Public Reserve at Royal George, Swan River Forest Reserve.
Community 7	*Eucalyptus viminalis-E. globulus-E. obliqua-E. amygdalina* woodland over *Beyeria viscosa-Exocarpos cupressiformis* sedgey, grassy, ferny or heathy closed-scrub
Reservation Status:	**Poorly-reserved** in the Flinders bioregion. **Unreserved** in Southeast, Ben Lomond, Northern Slopes and Southern Ranges bioregions.
Formal Reserves:	Mt Pearson State Reserve.
Informal Reserves:	Ansons River Reserve, Cameron Recreation Reserve, Swan River Forest Reserve.
Community 8	*Eucalyptus obliqua-E. regnans* woodland over *Acacia-Pomaderris* ferny-sedgey-grassy closed-scrub
Reservation Status:	**Unreserved** in the Southern Ranges, Ben Lomond, Southeast, Flinders and Northern Slopes bioregions.
Formal Reserves:	None.
Informal Reserves:	Castle Cary Recreation Reserve; Weavers Creek Forest Reserve; Kenmere Creek Forest Reserve and possibly the Mountain Creek Conservation Area.

Community 9	*Eucalyptus viminalis-E. ovata-E. obliqua-Acacia dealbata-A. melanoxylon* sedgey-ferny scrub
Reservation Status:	**Poorly-reserved** in Southeast and Northern Slopes bioregion. **Unreserved** in Northern Midlands, King, Ben Lomond and Flinders bioregions.
Formal Reserves:	Lost Falls Forest Reserve, Warrawee Forest Reserve.
Informal reserves:	Reedy Marsh Forest Reserve; Jackeys Creek Forest Reserve; Mersey White Water Forest Reserve; Franklin Rivulet Forest Reserve; Griffin Forest Reserve
Community 10	*Eucalyptus* woodland over *Pomaderris apetala-Pteridium esculentum-Poa labillardierei-Lomandra longifolia-Carex appressa* closed-scrub
Reservation Status:	**Unreserved** in the Southeast, Northern Midlands, Ben Lomond and Flinders bioregions.
Formal Reserves:	None.
Informal reserves:	Chauncy Vale Conservation Area; Tooms Lake Forest Reserve.
Community 11	*Eucalyptus pauciflora-E. viminalis* woodland over *Leptospermum lanigerum* grassy-sedgey closed-scrub
Reservation Status:	**Unreserved** in the Southeast and Central Highlands bioregions.
Formal Reserves:	None.
Informal reserves:	Great Western Tiers Conservation Area; Central Plateau Conservation Area (not WHA); Snowy River Forest Reserve.
Community 12	*Eucalyptus delegatensis* woodland over *Leptospermum lanigerum* grassy-herby-ferny closed-scrub
Reservation Status:	**Unreserved** in the Central Highlands, Northern Slopes and Ben Lomond bioregions.
Formal Reserves:	None.
Informal reserves:	None.
Community 13	*Nothofagus cunninghamii-Atherosperma moschatum-Poa labillardierei-Libertia pulchella-Blechnum nudum* closed-forest
Reservation Status:	**Well-reserved** in West bioregion. **Unreserved** in Ben Lomond and Northern Slopes bioregions.
Formal Reserves:	Franklin-Gordon Wild Rivers National Park.
Informal Reserves:	None.

Community 14	*Acacia/Nothofagus/Atherosperma* woodland and forest over *Olearia* shrublands and *Dicksonia antarctica* fernland
Reservation Status:	**Well-reserved** in Northern Slopes and Ben Lomond bioregions. **Poorly-reserved** in Southern Ranges, King and Southeast bioregions.
Formal Reserves:	Roger River State Reserve; Junee Cave State Reserve; Notley Gorge State Reserve; Hellyer Gorge State Reserve; St Columba Falls State Reserve; Mt Barrow State Reserve; Sandspit Forest Reserve.
Informal reserves:	Flowerdale River Forest Reserve, Evercreech Forest Reserve, Lilydale Falls Public Reserve. Special Species Management Zone within Denison Ridge Forest Reserve.
Community 15	*Eucalyptus obliqua/E. regnans* open-forest over sedgey-ferny *Pomaderris apetala-Olearia lirata* shrubland
Reservation Status:	**Poorly-reserved** in Northern Slopes, King bioregion and Ben Lomond bioregions.
Formal Reserves:	Mathinna Falls Forest Reserve, Holwell Gorge State Reserve; Dip Falls Forest Reserve.
Informal reserves:	North Scottsdale Forest Reserve, Burnie Fernglade Conservation Area.
Community 16	*Acacia dealbata-Pomaderris apetala-Olearia argophylla-Dicksonia antarctica* ferny-sedgey closed-scrub
Reservation Status:	**Poorly-reserved** in Northern Slopes and Southeast bioregions; **Unreserved** in Southern Ranges bioregion.
Formal Reserves:	Meander Forest Reserve; Meetus Falls Forest Reserve.
Informal Reserves:	None.
Community 17	*Acacia melanoxylon-Nothofagus cunninghamii-Eucryphia lucida-Acacia mucronata* mossy-sedgey-ferny forest and closed-scrub
Reservation Status:	**Well-reserved** in West and Southern Ranges bioregions. **Unreserved** in King and Northern Slopes bioregions.
Formal Reserves:	Exit Caves State Reserve; Pieman River State Reserve; Lake Pieman Forest Reserve; and possibly Franklin-Gordon Wild Rivers National Park.
Informal reserves:	Huskisson River Forest Reserve; Meridith Range Recreation Area, Trowatta Forest Reserve, Frankland River Riparian Reserve.
Community 18	*Nothofagus cunninghamii-Acacia verticillata-Gahnia grandis* ferny closed-scrub
Reservation Status:	**Well-reserved.**
Formal Reserves:	Franklin-Gordon Wild Rivers National Park; Hartz National Park, Tahune Forest Reserve.
Informal Reserves:	None.

Community 19	*Nothofagus-Eucryphia-Phyllocladus-Trochocarpa-Libertia* shrubby closed-forest
Reservation Status:	**Well-reserved.**
Formal Reserves:	Mt Field National Park; Franklin-Gordon Wild Rivers National Park; Cradle Mountain-Lake St Clair National Park.
Informal Reserves:	Maggs Mountain Forest Reserve.
Community 20	*Eucalyptus nitida* woodland over *Leptospermum-Baloskion tetraphyllum-Gymnoschoenus sphaerocephalus* ferny-sedgey closed-scrub
Reservation Status:	**Well-reserved.**
Formal Reserves:	Franklin-Gordon Wild Rivers National Park; Southwest National Park.
Informal Reserves:	Mt Dundas Recreation Area.
Community 21	*Eucalyptus nitida* woodland over *Gleichenia dicarpa-Persoonia juniperina-Philotheca virgata* ferny closed-scrub
Reservation Status:	**Unreserved** in the King and West bioregions.
Formal Reserves:	None
Informal Reserves:	Arthur-Pieman Conservation Area.

A summary of the formal reservation status of the above communities within IBRA bioregions is provided in Table 5.1. According to the criteria, 4 communities have been found to be well-reserved, 6 communities are totally unreserved and 11 communities are mixed in their reservation status across bioregions.

Within the bioregions, the least number of communities sampled occurred in the Northern Midlands bioregion and all the riparian communities within this bioregion are unreserved. The Southern Ranges had the highest number of floristic communities. Of the 11 floristic communities that occur in this bioregion, 5 are unreserved and one is poorly-reserved. Ben Lomond had the second highest number of different riparian communities. Of the 10 floristic communities present, 8 are unreserved and 1 is poorly-reserved. The Northern Slopes bioregion also stands out as an area with 10 different floristic communities, with all but 1 community unreserved or poorly-reserved. Conversely, the West bioregion has representatives of all but one of the riparian communities identified in the region in secure reservation.

Community	IBRA Bioregion								
	West	**Central Plateau**	**Southern Ranges**	**Southeast**	**Ben Lomond**	**Flinders**	**Northern Midlands**	**Northern Slopes**	**King**
1		WR							
2		PR							
3		**UR**	**UR**						
4			UR			PR		UR	UR
5	WR		WR		UR	WR		UR	UR
6				PR	UR		UR		
7			UR	UR	UR	PR		UR	
8			**UR**	**UR**	**UR**	**UR**		**UR**	
9				PR	UR	UR	UR	PR	UR
10				**UR**	**UR**	**UR**	**UR**		
11		**UR**		**UR**					
12		**UR**			**UR**		**UR**		
13	WR				UR			UR	
14			PR	PR	WR			WR	PR
15					PR			PR	PR
16			UR	PR				PR	
17	WR		WR					UR	UR
18	WR		WR						
19	WR		WR						
20	WR								
21	**UR**								**UR**

WR = Well-reserved PR = Poorly-reserved UR = Unreserved (Bold highlight indicates riparian communities that were not found in any secure reserves.)

Table 5.1: Summary of reservation status of riparian floristic communities.

5.4.3 Reservation criteria and algorithm

For the purpose of this illustration, the reference sites in Community 6 will be assessed with the aim of identifying conservation sites of high priority in each of the three bioregions in which it is found.

There are two issues that need to be considered when developing criteria for the reservation of native riparian vegetation: the presence of significant species (those listed under the *Threatened Species Protection Act 1995* and undescribed species) and the representation of riparian floristic communities.

As the stated aim is to prioritise reaches that are representative of riparian floristic communities, the number and presence of species listed under the *Threatened Species Protection Act 1995* and any undescribed species at survey sites will be indicated but no value will be attributed to their presence as this stage. However, the inclusion of data relating to the presence of threatened species makes it possible to allocate a weighting to a site where these species are present so that such sites can be adequately evaluated if the conservation outcome is directed at protecting threatened and/or undescribed species, rather than unreserved floristic communities.

The representativeness and relative floristic and biodiversity merits of sites within Community 6 will be assessed using the following 3 criteria and rating system:

Criterion 1: The riparian AUSRIVAS O/E score.

The AUSRIVAS modeling process (Chapter 4) was considered to be a good objective measure of reference condition of native riparian vegetation based on floristic composition and therefore will be used as a surrogate for structure as well as floristic composition. AUSRIVAS O/E scores for all sites can be found in Appendix 2. The banding widths in Table 4.16 will be used as the basis of the rating system for this criterion.

Rating system:	**O/E score**	
	> 1.39 =	3
	0.72 – 1.39 =	2
	0.00 – 0.72 =	1

Criterion 2: Presence of indicator species that define the riparian floristic communities as detailed in the key to riparian vegetation (see section 3.4.3).

In some of the larger communities, not all sites had the full range of indicator species that distinguished that community from all the other communities. Sites with the full range of indicator species will be considered to be more representative of the riparian floristic community than sites without the full range of indicator species.

Rating system: **Indicator species**

All present	=	4
75% - 99% present	=	3
50% - 75% present	=	2
< 50% present	=	1

Criterion 3: High species richness relative to the mean number of species for each community.

The mean values for species richness for each riparian floristic community (Table 3.1) will be used as the reference point for this criterion. It is considered that high species richness relative to a standard is equivalent to high biological diversity.

Rating system: **Species richness**

> Mean + 6	= 3
Mean ± 5	= 2
< Mean - 6	= 1

The three criteria used for site assessment provide a strong focus on floristic composition, which is the essence of a riparian floristic community as well as a loading for biological diversity. For the purpose of prioritizing sites for conservation a simple, one-stage additive algorithm will be applied to the criteria rating for each site. The highest scoring sites will be considered to be representative of the floristic community and have high biological diversity. The rating and ranking for the 9 sites in Community 6 that were assessed to be poorly-reserved or unreserved are provided in Table 5.2. The mean species count for Community 6 is 48. The indicator species for Community 6 are: *Hakea microcarpa*, *Epacris gunnii*, *Lepidosperma inop*, *Hibbertia prostrata*, *Hibbertia riparia*, *Lagenifera stipitata*, *Epacris apsleyensis*, *Grevillea australis*, *Baumea juncea*, *Baeckea ramosissima* and *Astroloma humifusum*.

Community 6 – Site information						Conservation criteria rating			Conservation priority rating	
Site Name	**Site Code**	**Bioregion**	**AUSRIVAS O/E Score**	**No. Species observed**	**Rare species present**	**AUSRIVAS Rating**	**Indicator Species rating**	**Species richness rating**	**Total algorithm score**	**Conservation ranking**
Dodges Ferry Creek	51	Southeast	0.515	21	-	2	2	1	5	5
Swan River	95	Southeast	0.911	36	1	2	3	1	6	4
Apsley River2	99	Southeast	1.094	45	3	2	4	2	7	3
Little Swanport River	107	Southeast	1.438	87	5	3	4	3	10	**1**
Apsley River3	144	Southeast	0.663	32	2	2	4	1	7	3
Blue Tier Creek	158	Southeast	0.659	46	1	1	4	2	7	3
St Pauls River3	173	Ben Lomond	0.850	62	2	2	4	3	9	**1**
St Pauls River4	174	Northern Midlands	0.751	53	4	2	4	2	8	**1**
Wye River	441	Southeast	0.975	52	1	2	4	2	8	2

Table 5.2: Site information, conservation criteria rating and ranking of all reference riparian sites in Community 6.

5.4.4 Recommendations for reservation

Based on the results of the algorithm in Table 5.2, the Little Swanport River at Site 107 would be strongly recommended for reservation. The reservation of this reach would provide adequate reservation for the Community 6 riparian floristic community in the Southeast bioregion. In addition, Sites 173 and 174 would also be recommended for reservation in the Ben Lomond and Northern Midlands bioregions respectively. From the reference dataset, it is noted that Site 173 is upstream of 174 and that, as far as can be determined, from Royal George (Site 174) beyond Site 173, native riparian vegetation still exists to the headwaters of the St Pauls River. As Sites 173 and 174 are the only representatives of Community 6 in the Northern Midlands and Ben Lomond bioregions, a strong recommendation would be made for secure reservation of the native riparian vegetation along the St Pauls River from its source in the Fingal Tier within State Forest to Royal George, a length of approximately 35 km.

For the Little Swanport River, it is noted that Site 107 occurs along an informal riparian reserve bordered by nature reserves and that there are approximately 22 km of native riparian vegetation between the cleared sections of the Little Swanport River at Swanston and the Little Swanport River estuary. As Site 107 had very high ratings for all criteria, and a high number of rare species present, it would be strongly recommended that the boundaries of the Nature Reserves be extended to include the native riparian vegetation along the remaining 22 km of the Little Swanport River that includes Site 107. The secure reservation of this reach would also provide a large measure of protection to the estuarine environment.

There are 11 different threatened species present in Community 6. An iterative analysis (Kirkpatrick, 1983) with the threatened species was performed to determine priority reaches that would conserve all the threatened species in this Community. The order of priority (from highest to lowest) for recommendation for reservation to conserve all the threatened species present in Community 6 was: Little Swanport River; St Pauls River 4; and St Pauls River 3, Swan River and Apsley River2 as equal third priority. The priority for reservation of the Little Swanport and St Pauls Rivers remains unchanged. However, if the protection of threatened species was an overriding factor for prioritizing riparian reaches for reservation, then the Swan River and Apsley River 2 would be given a higher rating than the Wye River within the Southeast bioregion.

From the categories of secure reserves in Tasmania, the classification of Nature Reserve under the *National Parks and Wildlife Act 1970* would be the most appropriate within lands in private tenure or crown land because its purpose is to conserve:

- an area of land which contains features that contribute to biological diversity and/or geodiversity and are unique, important or have representative value; and
- which should be managed primarily for the preservation of these features. (Regional Forest Agreement, 1997: Attachment 7).

A secure Forest Reserve can achieve the same purpose with lands allocated as State Forest.

The issues of width and length of riparian reserves for nature conservation are often difficult to define precisely but need clarification if sustainable outcomes are to be achieved.

5.5 Width of riparian reserve

Ideally, the width of the riparian reserve should be determined by the location of the ridge tops that define the catchment limits of the watercourse. However, bearing in mind the 'real-world' issues that constrain planners and land managers in the 21st century, discussed earlier, this cannot always be achieved.

Since valley floor characteristics are stable over periods of centuries to thousands of years, they also indicate a relatively stable set of riparian conditions. Hemstrom (1989) suggested that riparian buffers be determined by examining the stream channel in its valley floor context. In principle, wide buffers might be left where a stream flows unconstrained through alluvial deposits. In this circumstance, the interactions between the stream and terrestrial ecosystem are dynamic (e.g. bank cutting, input of woody debris, development of spawning beds) and important. A stream running through a bedrock notch, on the other hand, has little opportunity for bank cutting or other interaction with the adjacent terrestrial ecosystem. In this instance, narrower buffers, reflecting needs for shade, slope stability, legal constraints or other factors would be appropriate.

Historically, riparian buffer widths in Tasmania vary from 15 m to 30.5 m (one chain to 100 feet) between stream bank and adjoining private land. Stream management zones or riparian buffers associated with the forestry industry usually vary according to the size or location of the stream and in some cases, take other stream uses such as water supply and swimming into account (Forest Practices Board 2000; Wells 2002: 18-25). In a recent study, riparian buffer widths currently in use in states within the United States of America, Canada, Britain, Vanuata, New Zealand and Australia were sourced and compared (Wells 2002: 18-25). The riparian management zones vary from 5 m on one side for headwater streams in Britain to 200 m on one side for large streams in Western Australia.

If recommendations for Tasmanian riparian buffer widths were sought, based on current practices, the Western Australian model (Conservation Commission of Western Australia 2002: 155) would be selected as the optimum in preference to the buffers prescribed by the Tasmanian Forest Practices Code (Forest Practices Board 2000). The two main reasons for selecting the Western Australian model are because they are the most recently developed model in Australia and therefore may represent current best practice; and because there is some evidence that the narrower buffers used in Tasmanian forestry practices have been found to be inadequate to mitigate against some of the negative impacts of logging on freshwater biota (Davies & Nelson 1994) and therefore may also be even more inadequate to sustain native riparian vegetation.

The Western Australian model prescribes riparian widths of:

- 60 m for first, second and third order streams, with a minimum of 20 m on any side,
- 150 m for fourth order streams with a minimum of 50 m on any side; and
- 400 m for fifth order and above watercourses, with a minimum of 100 m on any side.

However, in addition to the above prescriptions it would also be recommended that, where extensive marshes, swamps or broad floodplains are associated with first, second or third order streams, the riparian reserves be 150 m with a minimum of 50 m on any side. Tasmania has an extensive range of marshes, swamps and broad floodplains at higher altitudes. The recommended riparian widths associated with these landscape features was determined as a consequence of averaging a number of mapped widths of floodplains, named marshes and swamps (Tasmania 1:25 000 map series).

5.6 Length of reserve

The optimum length of a riparian reserve established for the conservation of natural and biodiversity values of native riparian vegetation is ideally determined by the environmental and climatic limitations of the floristic community. However, these factors are not known specifically for the majority of the riparian floristic communities. Ideally, the optimum length will also provide a high degree of certainty that the community for which the reserve was established will persist in the absence of human intervention, as this is also the lowest cost option.

Because the ecological requirements of riparian vegetation communities are poorly understood, consideration needs to be given to:

- the geomorphology of the channel and surrounding landscape on which the floristic community is dependent for its hydrological and substrate forming regimes;
- associations with neighbouring dryland terrestrial communities on which many riparian communities are dependent for seed, food-web interactions, riparian substrate and as a buffer for exotic species, nutrients and soil erosion;
- the reliance of many plant species in the riparian zone on longitudinal connectivity for cross pollination and the maintenance of genetic diversity, especially in areas where adjacent native vegetation has been cleared; and
- the extent and condition of the native riparian vegetation in the catchment.

The length of the reserves suggested for the St Pauls and Little Swanport Rivers would provide a high degree of certainty that the native riparian vegetation would persist without any human intervention because of the present remoteness of the reaches and the high connectivity. The issue of riparian width is possibly not relevant to the Little Swanport River if the boundaries of the existing nature reserves were extended. However, along the St Pauls River, it is likely that the riparian reserve would have to be planned in greater detail, taking into account headwater reaches, the marshes associated with the headwater and middle order-reaches and the lowland reaches.

5.7 Discussion

A significant proportion of Tasmania's remaining native riparian vegetation remains unexplored, undocumented and, in many regions, unreserved and unmanaged. It is therefore critical that as much of Tasmania's remaining native riparian vegetation as possible be placed in secure reservation not only for the protection of rare species and representative floristic communities but also for the protection, health and continued survival of riverine and estuarine ecosystems.

There is a strong case to support the establishment of secure reserves within each of Tasmania's bioregions for the conservation of native riparian floristic communities as the majority of the communities are representative of unreserved or poorly-reserved floristic communities and there is substantial threat to their persistence from current land and water development practices and policies.

The specific factors that determine the sustainability of a particular native riparian floristic community at any site are still only poorly understood. "Principles for reserve design begin with the recognition of the importance of assessment in the regional context. This ensures that the protected areas encompass a wide range of communities, species and genetic biodiversity." (Dunn 2002: 37). The use of a simple algorithm to prioritise reaches of native riparian vegetation that has factors derived from regional, environmental and floristic data therefore provides a sound scientific basis on which decision-makers and natural resource managers can act.

As pointed out earlier, the two key issues for native riparian vegetation is that it be conserved and managed for the conservation of biodiversity. While the formal reserve system described in this chapter is currently the most widely used system, there are two other initiatives at the statewide scale that may achieve similar outcomes but using different mechanisms: the CAR reserve system and monetary incentives to private land holders in exchange for protection and management of riparian vegetation.

The Comprehensive, Adequate and Representative (CAR) reserve system was developed as a component of Regional Forest Agreements in place, or being negotiated across Australia (RPDC 1997). While the purpose of a CAR reserve relates to the protection of a full range of forest communities according to key criteria based on biodiversity, old-growth forest and wilderness, riparian vegetation is often included in CAR reserves in Tasmania. The CAR reserve system in Tasmania differs from the system in place in other states of Australia in that financial compensation is paid to land holders for the forfeit of productive use of the reserve areas of their land rather than forfeit of tenure (pers. comm. Australian Valuation Office 2002).

The Little Swanport River in eastern Tasmania is an example where extensive reaches of riparian vegetation have been protected within CAR reserves on private land. CAR reserves have been established along approximately 13 kilometres of the main channel of the Little Swanport River in conjunction with informal river reserves and the new Butlers Ridge Nature Reserve. This provides secure reservation for approximately 7 000 ha of native vegetation in good condition. Incorporated in the reserves is extremely diverse lowland riparian vegetation containing several rare and endemic species of flora and many kilometres of smaller ephemeral feeder tributaries whose entire catchments fall within the reserved area. While they were not all documented in the riparian survey, the riparian vegetation communities along the reserved reaches of the Little Swanport River exhibit enormous structural and floristic variation and, in many areas, the riparian species composition differs markedly from that of neighbouring non-riparian terrestrial vegetation.

The CAR reserves bordering the Little Swanport River are in the process of being declared Private Nature Reserves (pers. comm. Dr Jenny Dyring, DPIWE 2003). A small yearly management fee is paid to private landholders to manage CAR Reserves and detailed management plans are also developed for these reserves as part of the reservation process.

It is highly probable that this new system of reserves that successfully includes private land-holders, will also provide secure reservation for riparian vegetation.

At present, 60% of the CAR reserves under 97 covenants covering 17 379 ha support some form of riparian vegetation along with another 80 or so other areas of private land being assessed for further reservation (pers. comm. Dr Steven Smith, Private Forest Reserves Program, DPIWE 2003). As the CAR reserve system is relatively new in Tasmania, it is difficult to predict its success with respect to the maintenance and management of the natural values of riparian vegetation.

Another initiative being investigated at the national level in the USA include monetary incentives to private land holders in exchange for landscape level protection and management to enhance ecological resources such as riparian vegetation (Kline *et al.* 2000). The principle behind this initiative is supported by the results of a study investigating the lack of participation in government-sponsored programs to conserve riparian areas (Corbett 2002). Corbett's study indicates that "financial motivations, past behaviors, exposure to government information, and self-efficacy predicted 29 percent of the variance in intent to participate in future conservation programs" (ibid: 1).

Financial incentives for private landholders, whether linked to formal reserve systems or informal schemes provide a measure of incentive for landholders to reconsider the value of riparian vegetation. However, at the national or state-wide scales, there seems little point in developing initiatives for incentives for the conservation and management of native riparian vegetation at the local scale if the over-riding policy of the government is also to support continued development of water resources for the expansion of primary production through the construction of instream dams in the same catchments (DPIWE 2001).

Studies on remnant vegetation indicate that while size, shape and arrangement of remnants may be important for the maintenance of biodiversity, ultimately, it is the appropriate management or lack of it that determines the viability and biological diversity of these areas (Woolley & Kirkpatrick 1999). Riparian vegetation that already exists in secure reserves and any reaches that are reserved in the future need to be included in management planning as a priority. Observations during field work indicate that within secure reserves, the extent of track construction in the riparian zone to facilitate tourism, the increasing trend towards in-stream dam construction to replace discrete roadside water points, extensive networks of roads, poorly managed fire control and the diversion of flow for hydroelectric purposes are individually and cumulatively having a negative impact on the health and integrity of native riparian vegetation.

While conservation of riparian vegetation in a secure reservation affords the highest level of biological protection, it is important that management planning specifically includes native riparian vegetation, especially in areas prone to adverse impacts associated with fire, exotic species and soil erosion.

CHAPTER 6

General Discussion

6.0 Overview

Reviews of vegetation studies show that riparian vegetation is a recognised category of terrestrial vegetation (Reid *et al.* 1999; Kirkpatrick *et al.* 1995). Globally, and locally, riparian ecology has been studied extensively at the reach and catchment scales (Gregory *et al.* 1991; Malanson 1993; Naiman & Decamps 1997). However, studies investigating the nature of vascular plant species, floristic composition and an understanding of the environmental factors that contribute to floristic variation in the riparian zone at the state-wide, or broad regional, scales have not been located by the author.

Despite the fact that many native riparian floristic communities have already been altered as a consequence of development and historic land use and land management practices (e.g. Brinson *et al.* 1981; White 2000), there are a number of advantages to undertaking a broad-based regional study of native riparian vegetation.

At present, major responsibility for natural resource management, and related scientific research and resourcing lies with state and/or national bodies. A study that is able to provide an overview of attributes and influences at the scale at which decision-making occurs, can provide information that facilitates objective decision-making processes, and the distribution of scarce resources to areas where the greatest social, environmental and economic benefits can be realised. In addition, knowledge and information derived from a regional-scale study provides objective and comparative data from which decision-makers can set priorities for further research within the region, and/or for the conservation or reparation of areas of value (e.g. RPDC 1997).

The methodologies developed for broad regional studies are usually considered to be rapid assessment and while being sufficiently well-developed to achieve state and national aims, they can also be applied to local studies. Ecological rapid assessment methodologies have been successfully developed for evaluating river health at the state and national scales in the United Kingdom (RIVPACS) (Wright *et al.* 1984) and Australia (AUSRIVAS) (Davies 1994; Davies 2000) using defined sampling protocols and a reference dataset. The results of the present study indicate that a similar methodology for riparian vegetation could also be developed to assess the extent and condition of riparian floristic communities at the state and national scales.

From a natural resource management decision-making perspective, a broad-based regional study of native riparian vegetation can: provide baseline data for historic and audit purposes; underpin conservation or development initiatives; and ensure that research and resource funding is directed towards the highest priorities. While the level of scientific detail provided from a regional study may not be as great as that provided at the reach or catchment scales, the data is usually of sufficient quality to enable scientifically-substantiated options to be considered. More detailed riparian vegetation studies at the reach and catchment scales can be used in the context of the regional study to further assist the decision-making process.

6.1 Were the aims of the project achieved?

While only a fraction of the information gained through the field survey of riparian vegetation has been utilised, within the time allocated to the project and with limited resources, there is considerable evidence to indicate that all the aims of this project were satisfactorily achieved.

The native vascular species composition of 460 riparian sites, representative of a significant proportion of the riparian vegetation that exists within mainland Tasmania, has been recorded. Nearly half of Tasmania's native vascular species were documented as present in the riparian zone. Of these species, 77 could be considered to be riparian species, though the majority of these are not obligate. Of the 77 riparian species, nearly one-third are listed as threatened species in Tasmania. During the survey, 46 species listed in the *Threatened Species Protection Act 1995* as rare, endangered or vulnerable, were found in the riparian zone together with 4 undescribed species.

Twenty-one new riparian floristic communities have been identified as a consequence of statistical analysis of floristic data collected from each site. In general, the morphology of a riparian floristic community is complex. There is considerable structural variantion within the riparian communities. In addition, floristically different communities have commonality in vegetation structure. The on-ground implication of this result is that a riparian floristic community cannot easily be defined by its structure alone. However, there is a level of significance if riparian vegetation structure is classified as forest and non-forest.

The results of the present study and similar studies at the reach and catchment scales, indicate that it is the relative influences of a combination of interrelated factors that determines the presence of vascular plant species in the riparian zone and the composition and structure of riparian floristic assemblages. Biogeographic and climatic factors were identified as having the greatest influence on the vascular species composition of riparian sites. However, factors associated with the catchment and local hydrology and geomorphology, as well as local influences related to the riparian vegetation structure and species composition, were also found to explain differences in the vascular species composition of riparian reaches.

The outputs of the AUSRIVAS/RIVPACS predictive model developed from the data set were encouraging. While it was not the stated intent to collect data from pristine sites, the model indicated that of the 452 sites used for model development and testing, 408 could be considered to be in "reference" condition or reflective of riparian vegetation that may have existed prior to European settlement. The broad bands that resulted from the riparian predictive model were considered to be an adequate basis for determining whether undocumented reaches of riparian vegetation within the survey area could be considered to be in native condition or extensively modified.

The riparian AUSRIVAS/RIVPACS model also has the capability to predict the probability of a species' occurrence at a site and therefore to be able to generate a plant list for any site within the survey area. It is now theoretically possible to generate a list of predicted species for any riparian zone within the survey area in Tasmania using only a map and the BIOCLIM data set. However, the reliability and suitability of that list for any purpose is uncertain. The results of a preliminary investigation of the plant lists generated by the model indicated that there is insufficient information in the output from which to be able to develop a protocol for accurately classifying the native plant list into the 21 riparian floristic communities. In addition, there is insufficient resolution of the output list from which to develop a protocol for selecting a subset of species for revegetation or rehabilitation purposes at this stage, as there is no clear relationship between the predicted list and the list of observed species. However, from two of the eight plant lists generated by the model, it was possible to classify the riparian vegetation at the sites into the same riparian floristic communities as those selected from the observed species lists. Further work on the development of the species output of this model or the development of other models that are more sensitive to species rather than family-level inputs may yield more promising results.

There is a strong case to support the view that all remaining native riparian vegetation should be conserved or protected because of its natural significance, its significant functions and roles as part of freshwater ecosystems and its high economic, cultural and social values. However, the reality of current protective management initiatives is that only a part of the landscape can be managed primarily for conservation and this is usually a relatively small part. A 5-stage planning process was developed to illustrate how priority riparian reaches could be selected from an extensive reference dataset. The selection criteria and conservation algorithm developed as part of the planning process were based on the results of data analysis in the present study and were found to be effective for prioritizing the sites within one of the newly described riparian floristic communities.

An analysis of the secure reservation status of riparian vegetation on mainland Tasmania indicated that while three riparian floristic communities are well represented in National Parks, Nature Reserves, and secure Forest Reserves, much of Tasmania's remaining native riparian vegetation remains outside of secure reservation or unreserved. It was also evident from field observations that being in a secure reserve does not necessarily ensure good management of fragmented reaches of native riparian vegetation or their protection from upstream impacts and/or activities.

6.2 Were the methods used effective?

There is no agreement universally, nationally or even statewide on the definition of the riparian zone, the protocols for data collection or the classification template for riparian vegetation communities. There are also no agreed or widely used statistical methods that are hailed as being completely adequate to analyse complex and dynamic ecological data. In terms of project outcomes, the methods and statistical tools used in the present study have been extensively used in the past and are still in use today. There may have been some improvements in the results by using quadrats and more direct measurement, but the benefits that may have been gained in statistical rigour would have been negated by the reduced ability to survey the same area in the time available.

In general, the methods used to collect, record, store and analyse the data were satisfactory to achieve the aims of the project. Based on the results of the project, the field methodology could be refined to become a more rapid assessment protocol for data collection by eliminating variables that were found to not be significant at the 95% confidence interval: i.e. the time taken to document each site could be reduced from an average of 1 hour per site to approximately 45 or 50 minutes per site.

6.3 Benefits of the project

There are considerable local and state benefits - and possibly national benefits - that could flow from the completion of this project. There is now an extensive baseline data set and photographic record of much of Tasmania 's native riparian vegetation. The list of native species contained in each of the data sheets can be used as a guide to the rehabilitation and/or revegetation of riparian verges in Tasmania and may be useful in other parts of Australia. The differentiation and description of 21 new riparian vegetation communities can be incorporated into the statewide vegetation mapping project, TASVEG 2000.

The rapid assessment methodology, developed for riparian vegetation data collection, can be refined further by excluding factors that were found to be not significant for the presence of riparian species and communities. A standardised data collection methodology for riparian vegetation could then be used to complete the riparian vegetation survey of mainland Tasmania and its islands and also be used as the basis of a nation-wide riparian vegetation survey.

The AUSRIVAS/RIVPACS riparian predictive model can be used directly to assess whether any riparian reach within the survey area is in native condition or extensively modified. This assessment can form the basis of management prescriptions and/or contribute to the prioritisation of reaches for conservation, rehabilitation or restoration as funds become available.

The conservation planning process, together with the criteria and algorithm developed for prioritising reference riparian reaches for the purpose of nature conservation, can be used to determine which of the documented reference sites would be most appropriate for the reservation of poorly-reserved and unreserved native riparian floristic communities.

6.4 Improvements in current riparian vegetation management practices

During the course of the research project, it was observed that the major pressures on native riparian vegetation today are the cumulative effects of:

- past and present land use practices;
- water use and management; and
- current pressures and policies which aim to increase the rate or extent of primary production and power supply. (DPIWE 2001; Forestry Tasmania 2002; Hydro Tasmania 2002a).

Of greatest concern are:

- the construction of multiple in-stream dams, lakes and weirs, subsequent changes to flow, loss of biodiversity and increase in blue green algae growth;
- clearance of floodplains to the edge of watercourses to maximize agricultural production which reduces biodiversity, alters plant and animal interactions and results in high in-stream and riparian zone nutrient and sediment loads;

- stock trampling damage of riparian vegetation, substrate and banks resulting in loss and changes to substrate and high in-stream sediment and nutrient loads;
- poor management of exotic species in the riparian zone and in nearby areas which displaces native species;
- alterations to stream hydrology through excessive water extraction and abstraction, intra-basin and inter-basin transfers of water. This results in changes in environmental flows, channel morphology and associated changes in sedimentation and flooding intensity, duration and frequency;
- inadequate riparian buffer zones in urban and agricultural areas and in timber harvesting coupes resulting in high in-stream and riparian zone chemical, nutrient and sediment loads (Davies & Nelson, 1994);
- poor management of fire for weed control, fuel hazard reduction and regeneration burns in the riparian and nearby areas resulting in loss of biodiversity and high in-stream sediment loads;
- toxic chemical pollution and rubbish from present and past mining sites, agricultural areas and urban residents;
- poor roading and track construction, management and maintenance in state and forest reserves resulting in high in-stream sediment loads; and
- the cumulative effects that these actions are having on catchment and downstream riparian and estuarine ecosystem health and integrity.

In order to maintain riparian ecosystem functions, the riparian zones of developed areas in particular, need to be managed at the local and catchment scales to ensure health and viability into the future. A number of changes to existing practices are suggested based on field observations, which could substantially improve sustainable outcomes for riparian vegetation in Tasmania.

6.4.1 Tasmania's working forests

Improvements and quality control measures in the site management of Tasmanian private and public forestry operations in the riparian zone would further conserve riparian vegetation. Areas that need consideration for improvement are:

- ensuring buffer widths stipulated in the Forest Practices Code 2000 are preserved throughout the harvesting, windrow construction and revegetation processes (Plate 66);
- care is taken with placement and burning of windrows to reduce the incidence of accidental burning;

Plate 66 Riparian vegetation (on right) burned during clear felling operations. (According to the Forest Practices Code 2000, riparian buffer (on left), should be 30 m on each bank.)

- conserve all remaining stands of native riparian vegetation;
- improved weed management in the riparian zone, especially in plantation forests;
- maintaining riparian vegetation along Class 4 streams;
- care with roading beside and across watercourses;
- native revegetation of riparian zones in pine plantations where no, or very little, native riparian vegetation exists;
- appropriate management decisions that ensure that riparian vegetation does not form part of the harvesting targets for the coupe; and
- off-stream dams for watering points (it was noted that more and larger in-stream dams are being constructed in forestry areas further compromising riparian vegetation).

Tasmania's forests cover about 48% of the total area of the State, with private forests making up about 29% of the forest area - much more than in any other Australian State (Private Forests Tasmania 2002). As part of the Forest Practices Code, riparian buffers - ranging from 10 m to 40 m on each side of a watercourse depending on size of stream - are required on all watercourses adjacent to logging coupes. These buffers are effectively streamside protection areas but no formal record of species composition or riparian community classification is made from these buffers. Threatened species were recorded from riparian buffers in State and private forests during the survey.

It was observed during field work, that where adequate conservation, protection and management of riparian vegetation in the Tasmanian streamside buffers has occurred, the vegetation communities are in good condition and provided an excellent source of data for the riparian survey. There is an opportunity to conserve a significant proportion of Tasmania's riparian vegetation by formalizing the protected status of riparian buffers or streamside protection areas in Tasmania's State and private forests.

Such reserves are now coming into being in Western Australia where the stated purpose of riparian reserves is to "provide forest undisturbed by timber harvesting for biodiversity conservation and ecosystem health and vitality at the operation and landscape scales; protect water quality for biodiversity and consumptive uses; protect aesthetic and social values; and protect productive capacity, soil values and carbon pools" (Conservation Commission of Western Australia 2002: 155).

6.4.2 Rural and agricultural operations

The following areas need consideration to improve sustainable outcomes for native riparian vegetation in rural areas:

- conserve all remaining stands of native riparian vegetation (Plate 67);
- off-stream water storage so that natural flow regimes can continue and native riparian vegetation can remain connected to upstream native vegetation (Plate 68)
- control of weed invasion in the riparian zone (Plate 69);
- where stock are present, fencing off an adequate riparian buffer so that stock access can be controlled. A buffer of 60 m with a minimum of 20 m on any side is recommended in the first instance;
- also, where stock are present, repairing damaged fencing near the riparian zone together with provision of off-stream watering points;
- minimise runoff from tilled, planted and/or fertilized areas to the riparian zone as excessive nutrients can favour the spread of exotic species rather than native species;
- minimise the use of herbicides and pesticides near native riparian vegetation;
- exclude heavy machinery from the riparian zone;
- seek expert advice before burning any native vegetation in the riparian zone; and

- management of tracks and roads in the riparian zone to minimize erosion, runoff, weed and disease infestation of native riparian vegetation.

The reasons why such measures would be of benefit to the landowner and other landowners downstream have been well documented (e.g. Cripps 1999).

Plate 67 Not clearing bankside vegetation will improve outcomes for native riparian vegetation.

Plate 68 Off-stream water storage will improve outcomes for native riparian vegetation.

Plate 69 Improved management of exotic species and controls on grazing livestock in the riparian zone will improve outcomes for native riparian vegetation.

6.4.3 Urban and rural-residential holdings

The following areas need consideration to improve sustainable outcomes for native riparian vegetation in urban and rural-residential areas:

- removal of car bodies and household rubbish from the riparian zone (Plate 70);
- removal of all garden waste from the riparian zone; and
- minimization of tracks through native riparian vegetation.

Plate 70 Removal of household rubbish from riparian areas will improve outcomes for native riparian vegetation.

6.4.4 National parks, state and public reserves

The following areas need consideration to improve sustainable outcomes for native riparian vegetation in national parks, state and public reserves:

- improvements in planning for watering points (Plate 71);
- where lease arrangements exist for stock grazing on reserves, native riparian vegetation needs to be protected from trampling and grazing through fencing or creating exclusion zones for stock access; and
- fire management plans need to consider the special requirements of species that exist in stands of native riparian vegetation. Some riparian species are fire sensitive and may not recover after burning.

Plate 71 Improvements in planning for watering points for fire management purposes in national parks and reserves will improve outcomes for native riparian vegetation. (This is one of many newly constructed watering points along tributaries of Cray Creek in Mt William National Park.)

6.4.5 Mining and industrial holdings

It is recognized that commercial mining and industrial operations are already heavily regulated. However, the impacts of historical small-scale and large-scale operations continue to have negative consequences for native riparian vegetation. Remediation of public and private lands damaged by historical mining operations that impact on catchment streams would improve outcomes for native riparian vegetation (Plate 72).

Plate 72 Remediation of historic impacts of mining and industrial activities of public and private lands would improve outcomes for native riparian vegetation.

While it is recognized that there are a considerable number of landowners, forestry workers and government Rangers who already take great care of native riparian vegetation and that there is a considerable body of knowledge that supports the above practices, it was evident during the field survey, that the participation rate across the state in practices that promote healthy stands of native riparian vegetation is generally low.

6.5 Legislative and political context

It is not the intent here, to undertake a comprehensive discourse about the legislative and political context in which riparian vegetation has been considered historically, or today, as this is a broad topic. However, there are a number of major legislative and policy conflicts and anomalies that impact on native riparian vegetation that need to be stated in order to provide a context for the present study, and that need to be addressed in order to achieve sustainable outcomes for native riparian vegetation.

Riparian vegetation is a part of the environment that is recognised as a water-dependent ecosystem (ARMCANZ and ANZECC 2001: 9) and as such, should be considered as a priority under the *Water Management Act* 1999. In addition, there are 25 pieces of Tasmanian legislation that protect riparian vegetation from harm and destruction (DPIWE 2003): yet native riparian vegetation still continues to be fragmented, permanently cleared and degraded, though the rate at which this is occurring is not known.

Despite all the information, legislation, policies, principles and literature that highlight the values, functions and economic benefits of native riparian vegetation, monitoring and management of riparian revegetation is not a priority for foresters, the State government, farmers, landholders or the community.

Major inconsistencies exist between legislation concerning water use and development (*Water Management Act 1999*), and legislation protecting biodiversity by protecting rare and threatened species and biological communities (*Threatened Species Protection Act* 1995; *Environment Protection and Biodiversity Conservation Act* 1999). Whilst the intent of all three acts is to promote principles of ecologically sustainable development, the enactment of the Water Management Act 1999 in conjunction with the Tasmanian Water Development Plan, is having a detrimental outcome on native riparian vegetation.

Landholders and sectors of the aquaculture industry dependent on good quality fresh water are struggling with the concept of sustainable environmental outcomes against a background of conflicts concerning economic development, a political shift from co-operative catchment management to competition policy and the practicalities of legislative changes that appear to favour short-term outcomes for water usage for a few at the expense of long-term sustainability of freshwater ecosystems for current and future generations (DPIWE, 2001; Dyke and Dyke, 2002). It is of note, that on 22 January, 2003, the Resource Management and Planning Appeals Tribunal (http://www.rmpat.tas.gov.au/decisions/0000%20J12-2003.htm: 44) did not approve the development application for the Meander Dam because, amongst other reasons, it would cause:

> "an actual adverse effect on the environment that is of a high impact"; and "an actual adverse effect on the environment that is not negligible"; so as to constitute both material and serious environmental harm within the definition of those terms in section 5 of the *Environmental Management and Pollution Control Act 1994*".

The State Government's unprecedented response to this decision was to initiate the development of new legislation that would ensure the construction of the dam. There is still little understanding about the needs and interactions of all components of water-dependent ecosystems. With no limits to modifications of freshwater ecosystems for water storage, or comprehensive legislation to protect riparian vegetation in secure reserves, the future for native riparian vegetation looks bleak.

There are also a number of other anomalies in current legislation and practices that do not benefit the preservation of native riparian vegetation. The Forest Practices Code (Forest Practices Board, 2000) does not necessarily protect riparian zones of class 4 streams (headwaters) where riparian vegetation may be destroyed. Also, riparian reserves are considered under Part VII (Miscellaneous) of the *Crown Lands Act* (www.thelaw.tas.gov.au) as follows:

> "Where, in the opinion of the Minister, it is desirable to reserve Crown land –
>
> (a) abutting on any permanent river, stream, or lake; or
>
> (b) that is contiguous to the sea or an estuary –
>
> he shall reserve, from any sale of that crown land, land to the extent of at least 15 metres in width on each bank of the river, stream, lake, or the high-water mark of the sea or estuary."

Many of the small and medium-sized streams round the state but in particular in the north-east, east and south-east of Tasmania are ephemeral or intermittent and are not covered directly by the Act. At a time when more information is needed to ensure adequate flow to water-dependent ecosystems, there are fewer flow gauging stations today than there were 30 years ago (pers. comm. Dave Peters, DPIWE 2002a; Daley 1999).

As stated in the opening chapter (p.13), one of the objectives of the Natural Resource Management and Planning System of Tasmania is 'to promote the sustainable development of natural and physical resources and the maintenance of ecological processes and genetic diversity'. Native riparian vegetation has significant environmental values and plays a vital role in the maintenance of aquatic and terrestrial ecological processes and genetic diversity. There is a need to review legislation relating to native riparian vegetation in order to comply with the objectives of the Natural Resource Management and Planning System of Tasmania. There is also a need to review the status of native riparian vegetation in reserves, forestry riparian buffers and private land. Water-centred legislation tends to focus on modifying aquatic ecosystems to meet immediate human demands. It is timely to find a legislative and political balance between water development and the conservation of freshwater ecosystems of which riparian vegetation is an integral part.

Plate 73 Secure reserves provide protection for native riparian vegetation and management for long-term biodiversity outcomes.

6.6 Further research

A considerable proportion of Tasmania's native riparian vegetation remains unexplored and undocumented. There is also very little understanding about the interrelationships and dependencies of components of freshwater ecosystems. As a result of undertaking this project, the following major areas are offered for consideration for further research.

- Field survey of native riparian vegetation in the southwest, the Central Highlands and islands of Tasmania using the same methodology as developed for the current project. The additional reference sites could be added to the master dataset and incorporated into the predictive model.

- Field survey of marshes in Tasmania. All the marshes that were surveyed as part of the present study were identified as having high species richness. There are a considerable number of marshes across Tasmania; yet marshes, as a vegetation sub-group, remain undocumented.

- Survey of estuarine riparian vegetation. This broad category of riparian vegetation is quite complex given Tasmania's varied and extensive coastline (Edgar *et al.* 1999) and is under-represented in the survey. Without further research and investigation, it is not possible to determine whether there are floristic associations with the different estuarine types that occur around Tasmania. Further research into native estuarine riparian vegetation would enable Tasmania to address one of the shortfalls in river and estuary management: "designing and implementing protective management initiatives, to provide a representative system of riverine and estuarine reserves and to protect elements of the landscape that maintain river and estuary health (i.e. riparian and wetland areas)" (NLWRA 2002: 302).

- Research into the requirements for health of native riparian vegetation in ephemeral and intermittent riverine ecosystems. Results from the present study indicate that the highest riparian vascular plant species richness occurs in association with intermittent streams and possibly ephemeral streams.

- Research into the nature of the relationships and interrelationships between Tasmania's native riparian vegetation and the significant geographic, hydrologic, geomorphic, biotic and environmental variables identified in Chapter 3. While the present study documented the vascular plant species that comprise riparian vegetation and identified significant factors that influence the distribution of those species in the landscape at the statewide scale, little is known about what native riparian vegetation needs to survive, remain healthy and maintain species richness and diversity in the riparian zone at the catchment or sub-catchment scales in Tasmania.

- Specific research into the relationship between riparian vegetation and groundwater. As discussed in Chapter 3, surface and groundwater linkages are the predominant controls of landscape connectivity within riparian systems. Very little is known about groundwater influences on riparian vegetation in Tasmania.

- Specific research into the extent of the 70 species identified as riparian species in the present study. In addition, research investigating the requirements of these species to maintain healthy and viable populations.

- Research into the relationship between native riparian vegetation and neighbouring non-riparian native vegetation. Nearly all the plants found in the riparian zone during the present study, are known to exist in non-riparian habitats. However, some plants are predominantly found in riparian habitats. It is not known how many of Tasmania's native plants found in the riparian zone depend on longitudinal recruitment for their survival or lateral recruitment from adjoining native non-riparian vegetation.

- Further development of the riparian vegetation AUSRIVAS model (or a similar model) to refine its predictive capacity. The ability to more accurately predict the native species composition of riparian reaches and classify the vegetation into appropriate communities would facilitate the mapping of riparian vegetation at the local, statewide and national scales.

- Economic evaluation of the values, costs and benefits associated with preserving native riparian vegetation and the full extent of riparian lands (see Table 1.3) compared with the economics of commercial activities that currently occur on riparian lands, using asset management principles.

- Legislative and political frameworks and policies that impact on native riparian vegetation. This issue is complex and appears to be in a constant state of change. A comprehensive understanding of political processes, vested interests and winning strategies, would most certainly provide a valuable foundation from which to secure more positive outcomes for native riparian vegetation.

6.7 Closing statement

During the 21 months spent undertaking fieldwork around Tasmania, it was difficult to not notice the tremendous contrast between river reaches where clear water flowed beside a diverse array of native plants and those where stagnant muddy pools existed within artificially constructed in-stream barriers adjacent to deeply eroded and trampled riverbanks vegetated by one or two weed species. If riparian vegetation is to retain high environmental, social and economic values, considerable strategic planning for long-term management of all components of freshwater ecosystems needs to be undertaken at the local, catchment and state levels. The riparian zone is an area where the preservation of what remains that is native is by far the most cost effective strategy for management.

The future directions for management of riparian vegetation should include:

- gaining knowledge and understanding of remaining native riparian vegetation and the environmental conditions required to maintain or improve ecosystem health;
- making conservation and preservation of stands of native riparian vegetation in good condition a priority because of the many values, functions and roles that native stands of riparian vegetation have;
- conserving remnant stands of native riparian vegetation in areas that have undergone extensive development for its historic, cultural and scientific values;

- ensuring that management of riparian vegetation is integrated into wider water-related catchment management issues such as water quality, water quantity, inland waters ecosystem health, and estuarine health;
- ensuring that short-term strategic planning and management priority is given to the restoration of remnant riparian vegetation in good to moderate condition;
- incorporating the revegetation and rehabilitation of poor to degraded watercourse reaches in long-term strategic planning and management outcomes; and
- developing legislative controls on clearance of native vegetation near watercourses.

Key issues associated with data gathering, mapping, conservation, rehabilitation and monitoring also need to be addressed.

Full cost-benefit analyses for native riparian vegetation needs to be undertaken to establish its economic values in relation to terrestrial, aquatic and estuarine health. This would better enable riparian managers to factor risk management into decision-making processes.

The cumulative effects of artificially induced land-based and water-related disturbances and their impacts on riparian vegetation at the reach scale and in a catchment context also need to be considered and factored into legislative and administrative processes. Consideration also needs to be given to the factors that contribute to the health and integrity of riparian ecosystems.

There needs to be a better balance between rights of landowners and their responsibilities under duty of care. Land managers need more information and education about riparian values, associated cost-benefit factors at the local and catchment scales, and best practice management for the riparian zone.

All levels of government need to develop legislative and administrative frameworks and policies for water dependent ecosystems that are consistent with existing legislation. If needs be, fair and equitable enforcement of legislation to mitigate against harm to native riparian vegetation, should be considered. Legislative controls also need to be established on clearance of native vegetation that interfaces with riparian vegetation.

We live in a changing world. Native riparian vegetation has a proven ability to survive climate change as well as natural and artificial disturbances, while at the same time providing a broad range of ecosystem services. "It was Professor Ian Lowe, science policy analyst at Griffith University, who remarked that you can't run a First World economy in a Third World environment. There is a greater force than the market force. It's the natural force and there is not a water user in Australia who would disagree with this. We should attempt to work with it, not fight it." (Fullerton 2001: 328).

My deepest desire is that Tasmanians will value their native riparian vegetation enough to protect all remaining reaches from any further destruction or degradation and to enjoy the gift of free-flowing, healthy streams for generations to come.

References

Abernethy, B. and Rutherfurd, I.D. (1996) *Vegetation and Bank Stability in Relation to Changing Channel Scale.* National Conference on Stream Management in Australia, 19-23 February 1996.

ABS (2001) *Regional Statistics Tasmania 2001.* Australian Bureau of Statistics, Canberra.

Aiken, S.R. (1994) Peninsular Malaysia's protected areas' coverage, 1903-92: creation, rescission, escision, and intrusion. *Environmental Conservation,* 21: 49-56.

Alpert, P. and Kagan, J. (1998) The utility of plant community types: A practical review of riparian vegetation classification in the intermountain United States. *Natural Areas Journal* 18 (2): 124-137.

Andersson, E., Nilsson, C. and Johansson, M.E. (2000a) Plant dispersal in boreal rivers and its relation to the diversity of riparian flora. *Journal of Biogeography,* 27: 1095-1106.

Andersson, E., Nilsson, C., and Johansson, M.E. (2000b) Effects of river fragmentation on plant dispersal and riparian flora. *Regulated Rivers: Research and Management,* 16: 83-89.

ARMCANZ and ANZECC (2001) *National Principles for the Provision of Water for Ecosystems*, Draft Revised Edition, Commonwealth of Australia, Canberra.

Askey-Doran, M. (1993) *Riparian Vegetation in The Midlands and Eastern Tasmania,* Department of Environment and Land Management – Parks and Wildlife Service, Hobart.

Askey-Doran, M. and Pettit, N. (1999) Some impacts of human activity on riparian land. In Lovett and Price, P. (Eds.) *Riparian Land Management Technical Guidelines Volume One: Principles of Sound Management.* LWRRDC, Canberra. pp. 137-145.

Askey-Doran, M., Pettit, N., Robins, L. and McDonald, T. (1999) The role of vegetation in riparian management. In Lovett and Price, P. (Eds.) *Riparian Land Management Technical Guidelines Volume One: Principles of Sound Management.* LWRRDC, Canberra. pp. 97-120.

Askey-Doran, M., Potts, W., Lambourne, M. and Jordan, G. (1999) *Riparian Vegetation in Tasmania: Factors Affecting Regeneration and Recruitment.* Department of Primary Industries, Water and Environment – Parks and Wildlife Service, Hobart.

Australian and New Zealand Environment and Conservation Council (1996) *Australia: State of the Environment 1996.* Department of Environment, Sport and Territories, Canberra.

Australian and New Zealand Environment and Conservation Council, State of the Environment Reporting Task Force (2000) *Core environmental indicators for reporting on the state of the environment.* Environment Australia, Canberra.

Australian State of Environment Committee (2001) *Australia State of the Environment 2001*, Independent Report to the Commonwealth Minister for the Environment and Heritage. CSIRO Publishing on behalf of the Department of the Environment and Heritage, Canberra.

Barbour, M.T. (1991) Stream surveys - the importance of the relation between habitat quality and biological condition. *Sediment and Stream Water Quality in a Changing Environment: Trends and Explanation.* Proceedings of the Vienna Symposium, August 1991. IAHS Publication No. 203.

Barbour, M.T., Gerritsen, J., Snyder, B.D. and Stribling, J.B. (1999) Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. Second edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Washington.

Barmuta, L.A., Chessman, B.C. and Hart, B.T. (1997) *Interpretation of the outputs from AUSRIVAS.* Final report to the Land and water Resources R & D Corporation, Canberra.

Beadle, N.C.W. (1981) *The Vegetation of Australia.* Cambridge University Press, Cambridge.

Beard, J.S. (1944) Climax vegetation in tropical America. Ecology, 25: 127-158.

Bell, D.T. and del Moral, R. (1977) Vegetation gradients in the streamside forest of Hickory Creek, Will Country, Illinois. *Bulletin of the Torrey Botanical Club,* 104: 127-135.

Bennett, J., Sanders, N., Moulton, D., Phillips, N., Lukacs, G., Walker, K. and Redfern, F. (2002) *Guidelines for Protecting Australian Waterways.* Land and Water Australia. Canberra.

Beschta, R.L., Platts, W.S., Kauffman, J.B., Hill, M.T. (1994) Artificial stream restoration - money well spent or an expensive failure? *Environmental Restoration*, Proceedings of Universities Council on Water Resources Annual Meeting, pp. 76-104. UCOWR, Carbondalle, Illinois.

Bobbi, C., Nelson, M., Krasnicki, T. and Graham, B. (1999) *State of Rivers Report for Rivers in the Great Forester Catchment.* Report Series WRA 99/05-08, Department of Primary Industries, Water and Environment, Hobart.

Bohn, C. (1989) Management of Winter Soil Temperatures to Control Streambank Erosion in R.E. Gresswell, B.A. Barton, J.L. Kershner (Eds.) *Practical Approaches to Riparian Resource Management.* U.S. Bureau of Land Management, Montana. pp. 69-71.

Boughton, D. A., Smith, E. R. and O'Neill, R. V. (1999) Regional vulnerability: a conceptual framework. *Ecosystem Health*, 5: 312–322.

Breen P., Walsh, C., Nichols, S., Norris, R., Metzeling, L. and Gooderham, J. (1999) *Urban AUSRIVAS: An evaluation of the use of AUSRIVAS models for urban stream assessment.* Report No. 5, LWRRDC Occasional Paper 12/99, Victoria.

Brierley, G.J., Cohen, T., Fryirs, K. and Brooks, A. (1999) Post-European changes to the fluvial geomorphology of Bega catchment, Australia: implications for river ecology. *Freshwater Biology,* 41: 839-848.

Brinson, M.M., Swift, B.L., Planticw, R.C., and Barclay, J.S. (1981) *Riparian ecosystems: their ecology and status.* U.S. Fish and Wildlife Service, Biological Services Program FWS/OBS-81/17.

Brown, M.J. and Bayley-Stark, H.J. (1979) The plant communities of the East Risdon Nature Reserve. *The Tasmanian Naturalist,* 58: 1-11.

Brown, M.J., Kirkpatrick, J.B., and Moscal, A. (1983) *An Atlas of Tasmania's Endemic Flora.* Tasmanian Conservation Trust. Hobart.

Brunckhorst, D.J. (ed.) (1994) Marine Protected areas and Biosphere Reserves: 'Towards a New Paradigm'. *Proceedings of the 1st International Workshop on Marine and Coastal Protected Areas*, Canberra.

Brussock, P.P., Brown, A.V. and Dixon, J.C. (1985) Channel form and stream ecosystem models. *Water Resource Bulletin,* 21: 859-66.

Buchanan, A.M. (ed) (1999) *A Census of the Vascular Plants of Tasmania & Index to The Student's Flora of Tasmania.* Third Edition. Tasmanian Herbarium Occasional Publication No. 6. Tasmanian Museum and Art Gallery. Hobart.

Burbridge, A.A. (1991) Cost Constraints on Surveys for Nature Conservation. In Margules, C.R. and Austin, M.P. (Eds.) (1991) *Nature Conservation: Cost Effective Biological Surveys and Data Analysis.* CSIRO. Australia.

Bureau of Meteorology (2002) http://www.bom.gov.au

Burgman, M.A., Possingham, H.P., Lynch, A.J.J., Keith, D.A., McCarthy, M.A., Hopper, S.D., Drury, W.L., Passioura, J.A., and Devries, R.J. (2001) Method for Setting the Size of Plant Conservation Target Areas. *Conservation Biology,* 15: 603-616.

Busby, J.R. (1991) BIOCLIM – A Bioclimate Analysis and Prediction System. In Margules, C.R. and Austin, M. (Eds.) (1991) *Nature Conservation: Cost Effective Biological Surveys and Data Analysis.* CSIRO. Australia.

Busby, J.R. (1995) Bioclimatic Prediction System (BIOCLIM). Bureau of Flora and Fauna. Canberra.

Cassidy, M. (1998) Waterwatch Technical Reference Manual. DPIWE. Tasmania.

Chapin, D.M., Beschta, R.L., Hsieh, W.S. (2002) Relationships between flood frequencies and riparian plant communities in the upper Klamath Basin, Oregon. *Journal of the American Water Resources Association,* Vol. 38: 603-617.

Clarke, K.R. (1993) Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology,* 18: 117-143.

Committee of Scientists (1999) *Sustaining the people's lands: recommendations for stewardship of the national forests and grasslands into the next century.* United States Department of Agriculture, Washington DC.

Conservation Commission of Western Australia (2002) *Draft Forest Management Plan.* Nedlands.

Corbett, J.B. (2002) Motivations to participate in riparian improvement programs - Applying the theory of planned behaviour. *Science Communication,* 23 (3): 243-263.

Corbett, S. and Balmer, J. (2001) Map and description of the Warra vegetation. *Tasforests,* Vol. 13: 41-76, Forestry Tasmania, Hobart.

Costanza, R., Daly, M., Folke, C., Hawken, P., Holling, C. S., McMichael, A. J., Pimentel, D. and Rapport, D. (2000) Managing our environmental portfolio. *Bioscience,* Vol. 50: 149-155.

Costanza, R., Darge, R., Degroot, R., Farber, S., Grasso, M., Hannon, B. Limburg, K., Naeem, S., Oneill, R.V., Paruelo, J., Raskin, R. G., Sutton, P. and Vandenbelt, M. (1997) The Value of the Worlds Ecosystem Services and Natural Capital. *Nature,* 387:6630: 253-260.

Cowling, R.M. and Pressey, R.L. (2001) Rapid plant diversification: Planning for an evolutionary future. *PNAS,* Vol. 98: 5452-5457.

Cripps, E. (1999) *Riparian Land Management Technical Guidelines Volume One: Review of Legislation Relation to Riparian Management.* LWRRDC, Canberra.

CSIRO (1998) *Farming Action – Catchment Reaction. The Effect of Dryland Farming on the Natural Environment.* CSIRO, Canberra.

Curry, P. and Slater, F.M. (1986) A classification of river corridor vegetation from four catchments in Wales. *Journal of Biogeography,* 13: 119-132.

Daley, E.A. (1999) Land Cover, Climate and Stream Flow in the Coal River Catchment 1965-1997. Unpublished B.Sc.(Hons.) thesis, School of Geography and Environmental Studies, University of Tasmania. Hobart.

Daly H.E. (1992) Allocation, distribution, and scale: Towards an economics that is efficient, just, and sustainable. *Ecological Economics,* 6: 185-193.

Davidson, N. and Gibbons, A. (2001) *Gordon River Riparian Vegetation Assessment Update to IIAS.* Cooperative Research Centre for Sustainable Production Forestry, Hobart.

Davies, P.E. (1989) Relationships between Habitat Characteristics and Population Abundance for Brown Trout, *Salmo trutta* L., and Blackfish, *Gadopsis marmoratus* in Tasmanian Streams, *Australian Journal of Marine and Freshwater Research,* 40: 341-59.

Davies, P.E. (1994) *River Bioassessment Manual*, National River Processes and Management Program, Monitoring River Health Initiative, Hobart, Tasmania.

Davies, P.E. (2000) Development of a national river bioassessment system (AUSRIVAS) in Australia. In Wright, J.R., Sutcliffe, D.W. and Furse, M.T. (Eds.) *Assessing the biological quality of freshwaters.* Freshwater Biological Association, Cumbria, UK. pp. 113-124.

Davies P.E., Mitchell N.J. and Barmuta L.A. (1996) The impact of historical mining operations at Mount Lyell on the water quality and biological health of the King and Queen River catchments, western Tasmania. Mount Lyell Remediation R & D Program. Supervising Scientist Report 118, Barton ACT.

Davies, P.E. and Cook, L.S.J. (1999) The Influence of Changes in Flow Regime on Aquatic Biota and Habitat Downstream of hydro electric dams and power stations in Tasmania. Project No. 95/034, Hydro-Electric Corporation, Tasmania.

Davies, P.E. and Cook, L.S.J. (2002) Testing and refinement of AUSRIVAS for the detection, assessment and interpretation of changes in stream biodiversity associated with forestry operations. Report to Forest and Woodland Products Research and Development Corporation, Canberra, ACT. 124 pp.

Davies, P.E. & Nelson, M. (1994) Relationship between riparian buffer width and the effects of logging on stream habitat, invertebrate community composition and fish abundance. *Australian Journal of Marine and Freshwater Research,* Vol 45 (7): 1289-1305.

Davis, W.M. (1899) The geographical cycle. *Geographical Journal,* 14: 481-504.

Department of Primary Industry and Fisheries (DPIF) (1998) *SALTPAK.* Information package produced by the Department of Primary Industry and Fisheries, Launceston.

Diamond, J.M. (1975) The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. *Biological Conservation,* 7: 129.

DPIWE (2001) *Water Development Plan for Tasmania.* DPIWE. Hobart.

DPIWE (2002a) http://www.gisparks.tas.gov.au/TASVEG2000/TVMS.html

DPIWE (2002b) http://www.waterplan.tas.gov.au/

DPIWE (2003) Wetlands and Waterways Works Manual. DPIWE. Hobart.

Dufrene, M. and Legendre, P. (1997) Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs,* 67: 345-366.

Duncan, F. (1983) *Plant communities of the Douglas River region.* 85/1, Wildlife Division Technical Report, National parks and Wildlife Division, Hobart, Tasmania.

Duncan & Brown 1985

Dunn, H. (2002) *Assessing the Condition and Status of Tasmania's Wetlands and Riparian Vegetation.* Nature Conservation Branch Technical Report 02/09, Department of Primary Industry Water and Environment. Hobart.

Dyke, C. and Dyke, S. (2002) Little Swanport Case Study. Little Swanport. Tasmania.

Edgar, G.J., Barrett, N., and Graddon, D.J. (1999) *A classification of Tasmanian estuaries and assessment of their conservation significance using ecological and physical attributes, population and land use.* Tasmanian Aquaculture and Fisheries Institute, Hobart.

Environment Australia (2000) *Revision of the Interim Biogeographic Regionalisation of Australia (IBRA) and Development of Version 5.1 - Summary Report,* Sept. 2000.

Environment Australia (2002) Environment of Australia Annual Report 2001-02. Canberra.

Fensham R.J. and Kirkpatrick, J.B. (1992) The eucalypt forest-grassland/grassy woodland boundary in central Tasmania. *Australian Journal of Botany,* 40: 123-138.

Ferrier, S., Pressey, R.L. and Barrett, T.W. (2000) A new predictor of the irreplaceability of areas for achieving a conservation goal, its application to real-world planning, and a research agenda for further refinement. *Biological Conservation,* 93: 303-325.

Finnigan, J. (1992) *SALTPAK Tasmania.* Land and Water Resources Division, Department of Primary Industry and Fisheries, Tasmania.

Fischenich, J.C. and Copeland, R.R. (2001) *Environmental Considerations for Vegetation in Flood Control Channels,* ERDC TR-01-16, US Army Engineer Research and Development Centre, Vicksburg, MS.

Foley A. (1996) *Assessment of the condition of Hobart Urban streams using a RIVPACS model.* Unpublished B.Sc. Honours thesis, University of Tasmania, Hobart

Forest Practices Board (2000) Forest Practices Code, Forest Practices Board, Hobart, Tasmania.

Forestry Tasmania (2002) www.forestrytas.com.au/forestrytas/pdf_files/management_plans

Forman, R.T.T. and Gordon, M. (1986) *Landscape ecology.* John Wiley & Sons, New York.

Frissell, C.A., Liss, W.J., and Bayles, D. (1993) An integrated, biophysical strategy for ecological restoration of large watersheds. Changing Roles of Water Resources Management and Policy. American Water Resources Association, June 1993: 449-456.

Fullerton, T. (2001) Watershed: juggling the needs of farmers, politicians, conservationists, big business, ordinary people – and nature. ABC Books, Sydney.

Gaffney, R., Woolley, A. and Askey-Doran, M. (1999) Kit 6 Riparian Bush. In Kirkpatrick, J.B, and Gilfedder, L.A. (1999) *Tasmanian Bushcare Toolkit.* Department of Primary Industries, Water and Environment, Hobart.

Geraghty, P. and Ratcliffe, S. (1993) 'Riparian zone management in Tasmania: policy and practice', in S.E. Bunn, B.J. Pusey and P. Price (Eds.) *Ecology and management of riparian zones in Australia,* Occasional Paper Series No. 05/93, LWRRDC, pp. 125-130.

Gilpin, M. (1991) The genetic effective size of a metapopulation. *Biol. J. Linn. Soc.* 42: 165-175.

Gippel, C.J. and Collier, K.J. (1998) Degradation and rehabilitation of Waterways in Australia and New Zealand. In de Waal, L.C. *et al.* (Eds.) *Rehabilitation of Rivers. Principles and Implementation.* John Wiley, Chichester.

Gordon, N.D., McMahon, T.A., Finlayson, B.L. (1992) *Stream Hydrology: An Introduction for Ecologists.* John Wiley & Sons, Chichester. England.

Green, G. (1999) North West Bay River Catchment Management Plan, Kingborough Council, Hobart.

Gregory, S.V., Swanson, F.J., McKee, W.A., and Cummins, K.W. (1991) An ecosystem perspective of riparian zones. *Bioscience*, 41: 540-551.

Greig-Smith, P. (1964) *Quantitative Plant Ecology.* Butterworths. London.

Gurnell, A.M. (1995) Vegetation along river corridors: hydrogeomorphological interactions. In Gurnell, A.M. and Petts, G.E. (Eds.) *Changing River Channels.* John Wiley & Sons, Chichester. pp. 237-260.

Harris, S. and Kirkpatrick, J.B. (1991) The Distribution, Dynamics and Ecological Differentiation of *Callitris* Species in Tasmania. *Australian Journal of Botany,* 39: 187-202.

Harwood, C. (1991) Wetland Vegetation, in J.B. Kirkpatrick (Ed.) *Tasmanian Native Bush: A Management Handbook.* Tasmanian Environment Centre, Hobart. pp 110-116.

Haslam, S.M. (1978) *River Plants: The Macrophytic Vegetation of River Courses.* Cambridge University Press, Cambridge.

Hill, M.O. (1979) Twinspan – A Fortran Program for Arranging Multiple-variate Data in a Two-way Table by Classification of Individuals and Attributes. Cornell University, Ithaca.

Hill, R.S. and Orchard, A.E. (1999) Composition and Endemism of Vascular Plants. In Reid, J.B., Hill, R.S., Brown, M.J. and Hovenden, M.J. (Eds.) *Vegetation of Tasmania.* Flora of Australia Supplementary Series Number 8, University of Tasmania. Hobart. pp. 89-124.

Hill, R.S., Macphail, M.K. and Jordan, G.J. (1999) Tertiary History and Origins of the Flora and Vegetation. In Reid, J.B., Hill, R.S., Brown, M.J. and Hovenden, M.J. (Eds.) *Vegetation of Tasmania.* Flora of Australia Supplementary Series Number 8, University of Tasmania. Hobart. pp. 39-63.

Hughes, J.M.R. and Davis, G.L. (1989) *Aquatic Plants of Tasmania.* Department of Geography, University of Melbourne, Victoria.

Hughes, J.M.R. (1987) A study of Riverine Plant Communities in Tasmania, with Especial Reference to Central East Coast Rivers. PhD Thesis, School of Geography, University of Tasmania. Hobart.

Hupp, C.R. (1990) Vegetation Patterns in Relation to Basin Hydrogeomorphology. In Thornes, J.B. (ed.) *Vegetation and Erosion.* John Wiley & Sons Ltd, Chichester.

Hupp, C.R. and Osterkamp, W.R. (1996) Riparian vegetation and fluvial geomorphic processes. *Geomorphology,* 14: 277-295.

Hydro Tasmania (2002)) http://www.hydro.com.au/basslink.

Jackson, W. (1999) The Tasmanian Environment. In Reid, J.B., Hill, R.S., Brown, M.J. and Hovenden, M.J. (Eds.) *Vegetation of Tasmania.* Flora of Australia Supplementary Series Number 8, University of Tasmania. Hobart. pp. 11-38.

Jarman, S.J. and Crowden, R.K. (1978) *A Survey of Vegetation From the Lower Gordon River and Associated Catchments.* South West Tasmania Resources Survey, Occasional paper No. 12, Hobart.

Jarman, S.J., Brown, M.J. and Kantvilas, G. (1984) *Rainforest in Tasmania.* National Parks and Wildlife Service, Tasmania.

Jarman, S.J., Brown, M.J. and Kantvilas, G. (1991) *Floristic and Ecological Studies in Tasmanian Rainforest.* Tasmanian NRCP Report No. 3, Hobart.

Jarman, S.J., Kantvilas, G. and Brown, M.J. (1988) *Buttongrass Moorland in Tasmania.* Research Report No. 2. Tasmanian Forest Research Council Inc., Hobart.

Jensen, M.E., Redmond, R.L., Dibenedetto, J.P., Bourgeron, P.S. and Goodman, I.A. (2000) Application of ecological classification and predictive vegetation modeling to broad-level assessments of ecosystem health. *Environmental Monitoring and Assessment,* 64: 197-212.

Jeri, K., Household, I., and Peters, D. (2001) *Stream diversity and conservation in Tasmania: yet another new approach.* Paper presented to the Third Australian Stream Management Conference, Brisbane, 27-29 August 2001.

John, J. (1998) *Diatoms: tools for bioassessment of river health.* LWRRDC, research report, Curtin University of Technology, Perth. 388 pp.

John, J. (2000) *Diatom prediction and classification system for urban streams.* LWRRDC, Occasional Paper 14/99, report 7. Canberra. 182 pp.

Johnson, W.C. (2002) Riparian vegetation diversity along regulated rivers: contribution of novel and relict habitats. *Freshwater Biology,* 47 (4): 749-759.

Johnson, W.C., Burgess, R.L. and Keammerer, W.R. (1976) Forest overstorey vegetation and environment on the Missouri River flood-plain in North Dakota. *Ecological Monographs,* 46: 59-84.

Junk, W. J., Bayley, P. B. and Sparks, R. E. (1989) The flood pulse concept in river–floodplain systems. In *Proceedings of the International Large River Symposium*, Dodge, D.P. (Ed.) *Canadian Journal of Fisheries and Aquatic Science Special Publication*, 106: 110–127.

Kirkpatrick, J.B. and Brown, M.J. (1980) *Threatened Plants of the Tasmanian Central East Coast,* Tasmanian Conservation Trust, Hobart.

Kirkpatrick, J.B. and Brown, M.J. (1984) The paleaeogeographic significance of local endemism in Tasmanian higher plants. *Search,* 15: 112-113.

Kirkpatrick, J.B. and Dickinson, K.J.M. (1984) Vegetation Map of Tasmania, 1:500 000, Forestry Commission, Hobart.

Kirkpatrick, J.B. and Gibson, N. (1999) Towards an explanation of the altitudinal distributions of three species of *Eucalyptus* in central Tasmania. *Australian Journal of Ecology,* 24: 123-131.

Kirkpatrick, J.B. and Harris, S. (1999) Coastal, Heath and Wetland Vegetation. In Reid, J.B., Hill, R.S., Brown, M.J. and Hovenden, M.J. (Eds.) *Vegetation of Tasmania.* Flora of Australia Supplementary Series Number 8, University of Tasmania. Hobart. pp. 304-332.

Kirkpatrick, J.B. and Nunez, M. (1980) Vegetation-radiation relationships in mountainous terrain: eucalypt-dominated vegetation in the Risdon Hills, Tasmania. *Journal of Biogeography,* 7: 197-208.

Kirkpatrick, J.B. (1983) An Iterative Method for Establishing Priorities for the Selection of Nature Reserves: An Example from Tasmania. *Biological Conservation,* 25: 127-134.

Kirkpatrick, J.B. (1999) *A Continent Transformed.* Second edition. Oxford University Press, Melbourne.

Kirkpatrick, J.B. (2000) The political ecology of biogeography. *Journal of Biogeography* 27: 45-48.

Kirkpatrick, J.B. and Glasby, J. (1981) *Salt Marshes in Tasmania: Their Distribution, Community Composition and Conservation.* Department of Geography, University of Tasmania. Occasional Paper No. 8. Hobart.

Kirkpatrick, J.B. and Harwood, C.E. (1983) Conservation of Tasmanian Macrophytic Wetland Vegetation. *Papers and Proceedings of the Royal Society of Tasmania*, Vol. 117: 1-20.

Kirkpatrick, J.B. and Harwood, C.E. (1983) Plant Communities of Tasmanian Wetlands. *Australian Journal of Botany*, 31: 437-51.

Kirkpatrick, J.B. and Tyler, P.A. (1988) Tasmanian wetlands and their conservation. In McComb, A. J. and Lake, P.S. (Eds.) *The Conservation of Australian Wetlands.* Surrey Beatty & Sons Pty Ltd, NSW. pp. 1-16.

Kirkpatrick, J.B. and Wells, J.M. (1987) The vegetation of the Great Northern Plain, northeastern Tasmania. In *Papers and Proceedings of the Royal Society of Tasmania,* Vol. 121: 48.

Kirkpatrick, J.B., Barker, P., Brown, M.J., Harris, S. and Mackie, R. (1995) *The Reservation Status of Tasmanian Vascular Plant Communities,* Wildlife Scientific Report 95/4. Parks and Wildlife Service, Tasmania.

Kline, J.D., Alig, R.J. and Johnson, R.L. (2000) Forest owner incentives to protect riparian habitat. *Ecological Economics,* 33 (1): 29-43.

Krasnicki, T., Pinto, R. and Read, M. (2001) *Australia Wide Assessment of River Health: Tasmania Program Final Report.* Department of Primary Industries, Water and Environment, Hobart. Technical Report No. WRA 01/2001.

Ladson, A.R. and White, L.J. (2000) Measuring stream condition. In: Brizga, S. and Finlayson, B. (Eds.) *River Management, The Australasian Experience.* John Wiley and Sons, Chichester. pp. 265-285.

Ladson, A.R., White, L.J., Doolan, J.A., Finlayson, B.C., Hart, B.T. Lake, P.S. and Tilleard, J.W. (1999) Development and testing of an Index of Stream Condition for waterway management in Australia, *Freshwater Biology,* 41 (2): 453-468.

Lake, P.S., Barmuta, L.A., Boulton, A.J., Campbell, I.C. and St Clair, R.M. (1985) Australian streams and Northern Hemisphere stream ecology: comparisons and problems. *Proceedings of the Ecological Society of Australia,* 14: 61-82.

Land Conservation Council (1990) *Rivers and Streams – Special Investigation. Proposed Recommendations.* Land Conservation Council, Victoria.

Land Conservation Council (1994) *Final Recommendations Melbourne Area, District 2 Review.* Land Conservation Council, Victoria.

Lindenmayer, D.B. and Franklin, J.F. (2002) *Conserving forest biodiversity: a comprehensive multiscaled approach.* Island Press, Washington.

Lindsey, A.A., Petty, R.O., Sterling, D.K. and Van Asdall, W. (1961) Vegetation and environment along the Wabash and Tippecanoe River. *Ecological Monographs,* 31: 105-156.

Lockwood, M., Bos, D.G., and Glazebrook, H. (1997) Integrated Protected Area Selection in Australian Biogeographic Regions. *Environmental Management,* Vol. 21(3): 395-404.

Lynch, A.J.J., Gilfedder, L. and Kirkpatrick, J.B. (1999) The Tasmanian Endemic Shrub *Acacia axillaris:* Conservation Ecology Applied to the Question of Rarity or Vulnerability. *Australian Journal of Botany,* 47: 97-109.

MacAlister Elliott and Partners Ltd and Economics for the Environment Consultancy Ltd (2001) *Study on the Valuation and Restoration of Damage to Natural Resources for the Purpose of Environmental Liability.* Final Report. Directorate-General Environment, European Commission. UK.

Malanson, G.P. (1993) *Riparian Landscapes: Cambridge Study in Ecology.* Cambridge University Press, Cambridge.

Margules, C.R. and Pressey, R.L. (2000) Systematic conservation planning. *Nature,* Vol. 405: 243-253.

McClune, B. and Mefford, M.J. (1999) *PC-ORD. Multivariate Analysis of Ecological Data,* Version 4. MjM Software Design, Gleneden Beach, Oregon.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S. (1998) *Australian Soil and Land Survey Field Handbook.* Second edition. Australian Collaborative Land Evaluation Program, Canberra.

McGlothlin, D., Jackson, W.J. and Summers, P. (1988) Groundwater, geomorphic processes and riparian values: San Pedro River, Arizona. *Proceedings of the symposium on water use data for water resources management.* American Water Resources Association, Minneapolis, Minnesota. pp. 537-545.

McKnight, T.L. (1990) *Physical Geography,* 3rd edition, Prentice Hall, Englewood Cliffs, New Jersey.

McLaren, R.G. and Cameron, K.C. (1996) *Soil Science- Sustainable Production and Environmental protection.* Oxford University Press. Melbourne.

Mendel, L.C. and Kirkpatrick, J.B. (2002) Historical Progress of Biodiversity Conservation in the Protected-Area System of Tasmania, Australia. *Conservation Biology,* 16(6): 1520-1529.

Merritt, D.M. and Cooper, D.J. (2000) Riparian vegetation and channel change in response to river regulation: a comparative study of regulated and unregulated streams in the Green River basin, USA. *Regulated Rivers: Research & Management,* 16: 542-564.

Merry, D.G., Slater, F.M. and Randerson, P.F. (1981) The riparian and aquatic vegetation of the River Wye. *Journal of Biogeography,* 8: 313-327.

Meyer, J.L. and Swank, W.T. (1996) Ecosystem management challenges ecologists. *Ecological Applications,* 6: 738-740.

Minchin, P.R. (1987a) An evaluation of the relative robustness of techniques for ecological ordination. *Vegetatio,* 69: 89-107.

Minchin, P.R. (1987b) Simulation of multidimensional community patterns: towards a comprehensive model. *Vegetatio,* 71: 145-156.

Minchin, P.R. (1990) *DECODA: Database for Ecological Community Data.* Australian National University, Canberra.

Moss, B. (2000) Biodiversity in fresh waters - an issue of species preservation or system functioning? *Environmental Conservation,* 27: 1: 1-4.

Moss, D., Furst, M.T., Wright, J.F. and Armitage, P.D. (1997) The prediction of the macroinvertebrate fauna of unpolluted running-water sites in Great Britain using environmental data. *Freshwater Biology,* 17: 41-52.

Mueller-Dombois, D. and Ellenberg, H. (1974) *Aims and Methods of Vegetation Ecology,* John Wiley and Sons, New York.

Müller, E. (1997) Mapping riparian vegetation along rivers: old concepts and new methods. *Aquatic Botany,* 58: 411-437.

Munks, S.A. (Ed.) (1996) *A Guide to Riparian Vegetation and Its Management.* Department of Primary Industry and Fisheries, Tasmania.

Naiman, R.J. and Décamps, H. (Eds.) (1990) *The Ecology and Management of Aquatic-Terrestrial Ecotones.* Man and Biosphere Series, Vol. 4. UNESCO Paris, and Parthenon Publishing Group Ltd, Carnforth.

Naiman, R.J. and Décamps, H. (1997) The Ecology of Interfaces: Riparian Zones. *Annual Review of Ecology and Systematics,* 28: 621-658.

Naiman, R.J., Décamps, H., and Pollock, M. (1993) The role of riparian corridors in maintaining regional biodiversity. *Ecological Applications,* 3 (2): 209-212.

National Land and Water Resources Audit (NLWRA) (2001) *Australian Native Vegetation Assessment 2001,* National Land and Water Resources Audit, Canberra.

National Land and Water Resources Audit (NLWRA) (2002) *Australian Catchment, River and Estuary Assessment 2002,* Volumes 1 and 2. National Land and Water Resources Audit, Canberra.

Natural Heritage Trust (2002a) Australian Government Envirofund: Guide to Applications 2002-2003. Natural Heritage Trust. Canberra.

Natural Heritage Trust (2002b) www.nht.gov.au/extension.html.

Nilsson, C. (1986) Change in riparian plant community composition along two rivers in northern Sweden. *Canadian Journal of Botany,* 64: 589-592.

Nilsson, C., and Berggren, K. (2000) Alterations of Riparian Ecosystems Caused by River Regulation. *BioScience,* Vol. 50: 784-792.

Norris, R.H. (1996) Predicting water quality using reference conditions and associated communities. Chapter 2 in Bailey, R.C., Norris, R.H. and Reynoldson, T.B. (Eds.) '*Study Design and Data Analysis in Benthic Macroinvertebrate Assessments of Freshwater Ecosystems Using a Reference Site Approach*'. Technical Information Workshop, North American Benthological Society, 44th Annual Meeting, Kalispell Montana.

North, A., Johnson, K., Ziegler, K., Duncan, F., Hopkins, K., Ziegeler, D., and Watts, S. (1998) *Flora of Recommended Areas for Protection and Forest Reserves in Tasmania.* Forest Practices Board, Forestry Tasmania, and Parks and Wildlife Service, Tasmania.

Northcote, K.H. (1979) *A Factual Key for the Recognition of Australian Soils.* Fourth edition. Rellim Technical Publications. Glenside, South Australia.

Oxford University Press (1973) *The Shorter Oxford English Dictionary on Historical Principles.* Vol. II, Clarendon Press. Oxford.

Pannell, J.R. (1992) *Swamp Forests of Tasmania.* Forestry Commission, Tasmania.

Pearce, D., Barbier, E., Markandya, A., Barrett, S., Turner, R.K. and Swanson, T. (1989) *Blueprint for a Green Economy.* Earthscan Publications Ltd, London.

Pemberton, M. (1989) *Land Systems of Tasmania Region 7: South West.* Department of Agriculture, Tasmania.

Pendergast, J.R., Quinn, R.M. and Lawton, J.H. (1999) The gaps between theory and practice in selecting nature reserves. *Conservation Biology,* 13: 484-492.

Pettit, N.E., Froend, R.H. and Davies, P.M. (2001) Identifying the natural flow regime and the relationship with riparian vegetation for two contrasting Western Australian Rivers. *Regulated Rivers: Research & Management,* 17: 201-215.

Platts, W.S. and Nelson, R.L. (1989) Characteristics of riparian plant communities and streambanks with respect to grazing in northeastern Utah. In K.A. Hashagen (Ed.) *Practical Approaches to Riparian Resource Management.* US Bureau of Land Management. pp. 73-81.

Pressey, R.L. (2002) The first reserve selection algorithm – a retrospective on Jamie Kirkpatrick's 1983 paper. *Progress in Physical Geography,* 26(3): 434-441.

Pressey, R.L. and Cowling, R.M. (2001) Reserve Selection Algorithms and the Real World. *Conservation Biology,* 15: 275-277.

Pressey, R.L. and Logan, V.S. (1998) Size of selection units for future reserves and its influence on actual vs targeted representation of features; a case study in western New South Wales. *Biological Conservation,* 85: 305-319.

Pressey, R.L., Johnson, I.R. and Wilson, P.D. (1994) Effectiveness of alternative heuristic algorithms for identifying indicative minimum requirements for conservation reserves. *Biological Conservation,* 80: 207-219.

Price, P. and Lovett, S. (Eds.) (1999) *Riparian Land Management Technical Guidelines, Volume 2: On-ground Management Tools and Techniques*, LWRRDC. Canberra.

Private Forests Tasmania (2002) www.privateforests.tas.gov.au. Accessed October 2002.

Ramsar Convention Bureau (1996) The criteria for identifying wetlands of international importance. Ramsar, Gland.

Reid, J.B., Hill, R.S., Brown, M.J. and Hovenden, M.J. (Eds.) (1999) *Vegetation of Tasmania.* Flora of Australia Supplementary Series Number 8, University of Tasmania. Hobart.

Resh, V.H., Brown, A.V., Covich, A.P., Gurtz, M.E., Li, H.W., Minshall, G.W., Reice, S.R., Sheldon, A.L., Wallace, J.B. and Wissmar, R.C. (1988) The role of disturbance in stream ecology. *Journal of the North American Benthological Society,* 7: 433-455.

Richards, P. W., Tansley, A. G., and Watt, A. S. (1940) The recording of structure, life form and flora of tropical forest communities as a basis of their classification. *Journal of Ecology*, 28: 224-239.

RPDC (1997) Tasmanian Regional Forest Agreement 1997. www.rpdc.tas.gov.au.

Rutherfurd, I.D., Marsh, N.A. and Jeri, K. (1999) *Rehabilitating Australian streams: a procedure.* Land and Water Resources Research and Development Corporation and Co-operative Research Centre for Catchment Hydrology. Australia.

Salisbury, E.J. (1931) The standardization of descriptions of plant communities. *Journal of Ecology*, 19: 177-189.

Sala, M. and Calvo, A. (1990) Response of Four Different Mediterranean Vegetation Types to Runoff and Erosion. In Thornes, J.B. (ed.) *Vegetation and Erosion,* John Wiley & Sons Ltd, Chichester.

Savory, A. (1988) *Holistic Resource Management.* Island Press, Washington. USA.

Schofield N.S.J. and Davies P.E. (1996) Measuring the health of our rivers. *Water* (AWWA Journal), 23: 39-43.

Schumm, S.A. (1977) *The Fluvial System.* Wiley-Interscience Publication. John Wiley and Sons, New York.

Scientific Advisory Committee, *Threatened Species Protection Act (1995)* Tasmania (SAC) (2002) Guidelines for Protecting Ecological Communities – A Discussion Paper. Hobart.

Specht, R.L. (1974) *Vegetation of South Australia.* Government Printer, Adelaide.

Specht, R.L. (1981) Conservation of vegetation types. In Groves, R.H. (Ed.) *Australian Vegetation.* pp. 393-410.

Specht, R.L., Roe, E.M. and Boughton, V.H. (1974) Conservation of Major Plant Communities in Australia and Papua New Guinea. *Australian Journal of Botany,* Supplement No. 7: 1-667.

SPSS Inc. (2000) SYSTAT version 10., Chicago.

Stanford, J.A. (1998) Rivers in the landscape: introduction to the special issue on riparian and groundwater ecology. *Freshwater Ecology,* 40(3): 402-406.

State of Victoria (2002) Victoria River Health Strategy: Protecting Rivers and Streams of High Community Value. Department of Natural Resources and Environment. Melbourne.

Stein, J.L., Stein, J.A. and Nix, H.A. (1997) *The identification of wild rivers: methodology and data base development.* A report for the Australian Heritage Commission by the Centre for Resource and Environmental Studies, Australian National University, Canberra. pp. 41-42.

Strahler, A.N. (1964) 'Geology. Part II. Quantitative geomorphology of drainage basins and channel networks'. In Chow, V.T. (Ed.) *Handbook of Applied Hydrology.* McGraw-Hill, New York. pp. 4-39 to 4-76.

Strahm, W. and Chouchena-Rojas, M. (2001) *Plant Conservation Strategy.* IUCN Policy Recommendation Paper presented at the Seventh Meeting of the Subsidiary Body on Scientific, Technical, and Technological Advice (SBSTTA) to the Convention on Biological Diversity, IUCN. Montreal, Canada 12-16 November 2001.

Sustainable Development Advisory Council (1996) *State of the Environment Tasmania, Volume 1 – Conditions and Trends.* State of the Environment Unit, Land Information Services, Department of Environment and Land Management, Tasmania.

Sullivan, K.T., Lisle, C.A., Dollof, G.E., and Reid, I.M. (1987) Stream channels: the links between forests and fishes. In E. O. Salo and T. W. Cundy (Eds.) *Streamside Management: Forestry and Fishery Interactions,* University of Washington, Institute of Forest Resources. Contribution No. 57, Seattle, WA.

Sustainable Development Advisory Council (1996), *State of the Environment Tasmania (1996) Volume 1 - Conditions and Trends,* compiled by the State of the Environment Unit, Land Information Services, Department of Environment and Land Management, Tasmania.

Suzuki W., Osumi, K., Masaki, T., Takahashi, K., Daimaru, H., and Hoshizaki, K. (2002) Disturbance regimes and community structures of a riparian and an adjacent terrace stand in the Kanumazawa Riparian Research Forest, northern Japan. *Forest Ecology and Management,* 157: 285-301.

Swanson, F.J., Benda, L.E., Duncan, S.H., Grant, G.E., Megahan, W.F., Reid, L.M. and Ziemer, R.R. (1987) Mass failures and other processes of sediment production in Pacific Northwest Forest Landscapes in Salo, E.O. and Cundy, T.W. (Eds.) *Streamside management: forestry and fishery interactions.* Proceedings of a symposium, University of Washington, February 12-14, 1986. College of Forest Resources, University of Washington, Seattle. pp. 9-38.

Tabacchi, E. (1995) Structural variability and invasions of pioneer plants community in riparian habitats of the middle Adour River. *Canadian Journal of Botany,* 73: 33-44.

Tabacchi, E., Planty-Tabacchi, A.M., Salinas, M.J., and Décamps, H. (1996) Landscape structure and diversity in riparian plant communities: a longitudinal comparative study. *Regulated Rivers. Research and Management,* 12: 367 390.

Tabacchi, E., Correll, D.L., Hauer, R., Pinay, G., Planty-Tabacchi, A. and Wissmar, R.C. (1998) Development, maintenance and role of riparian vegetation in the landscape. *Freshwater Biology,* 40(3): 497-516.

Tabacchi, E., Lambs, L., Guilloy, H., Planty-Tabacchi, A., Müller, E., and Décamps, H. (2000) Impacts of riparian vegetation on hydrological processes. *Hydrological processes,* 14: 2959-2976.

Tait, J.T.P., Cresswell, I.D., Lawson, R. and Creighton, C. (2000) Auditing the Health of Australia's Ecosystems. *Ecosystem Health,* 2(2): 149-163.

Thackway R.T. and Cresswell, I.D. (1992) Environmental Regionalisations of Australia - A user-oriented approach, Environmental Resources Information Network, Australian National Parks and Wildlife Service, Canberra.

Thorp, V. (1999) *Restoring Wetlands and Waterways: A Guide to Action.* Tasmanian Environment Centre Inc., Hobart.

Thibodeaux, L.J. and Boyle (1987) Bedform-generated convective transport in bottom sediment. *Nature*, 325: 341-343.

Tubman, W. and Price, P. (1999) The significance and status of riparian land. In Lovett, S. and Price, P. (Eds.) *Riparian Land Management Technical Guidelines Volume One: Principles of Sound Management,* LWRRDC, Canberra.

Tukey, J.W. (1958) Bias and confidence in not quite large samples. *Annals of Mathematical Statistics*, 29: 614.

UNESCO (2002) Draft International Hydrological Plan - VI (2002-2007). www.unesco.org/water/ihp/ihp_six.shtml#th3.

USDA Forest Service (1985) *Riparian Ecosystems and their Management: Reconciling Conflicting uses.* USDA Forest Service General Technical Report RM-120. Tuscon, Arizona.

Vannote, R. L., Minshall, G. W., Cummins, K. W., Sedell, J. R. and Cushing, C. E. (1980) The river continuum concept. *Canadian Journal of Fisheries and Aquatic Science*, 37: 130–7.

Victorian Department of Natural Resources and Environment (1997) *An index of stream condition: reference manual,* Waterways and Floodplain Unit, Department of Natural Resources and Environment, Melbourne.

Virtual Consulting Group Australia Pty Ltd (2000) Evaluation of the LWRRDC "Rehabilitation and Management of Riparian Lands" program. LWRRDC Occasional Paper 03/00.

Ward, J.V. and Stanford, J.A. (1995) Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation. *Regulated Rivers: Research and Management,* 11: 105-119.

Wasklewicz, T.A. (2001) Riparian vegetation variability along perennial streams in Central Arizona. *Physical Geography*, 22 (5): 361-375.

Wassen, M.J., Peeters, W.H.M. and Venterink, H.O. (2003) Patterns in vegetation, hydrology, and nutrient availability in an undisturbed river floodplain in Poland. *Plant Ecology*, 165 (1): 27-43.

Water and Rivers Commission (1999) *Statewide Waterways Needs Assessment, Draft Proposals.* Water and Rivers Commission, Perth.

Wells, F. (2002) Classification and Risk Assessment of Headwater Streams in the Forestry Estate of Tasmania. Report to the Forest Practices Board and FIAT/FT Research Fund. Forest Industry Association of Tasmania/Forestry Tasmania.

Westfall, R.H., Theron, G.K., and Rooyen, N. (1997) Objective classification and analysis of vegetation data. *Plant Ecology*, 132: 137-154.

White, M.E. (2000) *Running Down: water in a changing land.* Kangaroo Press, East Roseville, New South Wales.

White, P.S. (1979) Pattern, process, and natural disturbance in vegetation. *The Botanical Review*, 45: 229-299.

White, D.S., Elzinga, C.H., Hendricks, S.P. (1987) Temperature patterns within the hyporheic zone of a northern Michigan river. *Journal of the North American Benthologcial Society*, 6: 85-91.

Wilson, E.O. and Willis, E.O. (1975) In Cody, M.L. and Diamond, J.M. (Eds.) *Ecology and Evolution of Communities*. Belknap, Cambridge, MA. pp. 522-534.

Wintle, B. (2002) The Ecology of the Riparian Vegetation in Two East Coast River Catchments, Tasmania. Unpublished B.Sc. (Hons) thesis, University of Tasmania.

Wissmar, R.C. and Swanson, F.J. (1990) Landscape disturbances and lotic ecotones. In Naiman, R.J. and Decamps, H. (Ed.) *The ecology and management of aquatic-terrestrial ecotones.* Man and Biosphere Series, Vol. 4. Vol. 4. UNESCO Paris, and Parthenon Publishing Group Ltd, Carnforth. pp. 65-89.

Wissmar, R.C., and Beschta, R.L. (1998) Restoration and management of riparian ecosystems: a catchment perspective. *Freshwater Biology*, 40(3): 571-585.

Wolman, M.G. and Miller, J.P. (1960) Magnitude and frequency of forces in geomorphic processes. *Journal of Geology*, 68: 54-74.

Woolley, A. (1999) Riparian Vegetation and Bank Condition along a Section of the Lake River in Northern Tasmania. DPIWE, Hobart.

Woolley, A. and Kirkpatrick, J.B. (1999) Factors related to condition and rare and threatened species occurrence in lowland, humid basalt remnants in northern Tasmania. *Biological Conservation*, 87: 131-142.

Wright, J.F. (1995) Development and use of a system for predicting the macro-invertebrate fauna in flowing waters. *Australian Journal of Ecology*, 20: 181-197.

Wright, J.F., Moss. D., Armitage, P.D. and Furse, M.T. (1984) A preliminary classification of running-water sites in Great Britain based on macro-invertebrate species and the prediction of community type using environmental data. *Freshwater Biology,* 14: 221-256.

Young, W.J. (1999) Hydrologic descriptions of semi-arid rivers: An ecological perspective. In Kingsford R.T. (Ed.) *A Free Flowing River: The Ecology of the Paroo River.* National Parks and Wildlife Service, Sydney. pp. 77-96.

Ziegeler, D. and Harris, S. (1994) Apsley River South Esk Pine Reserve: A survey of its vascular plants and recommendations for management. *The Tasmanian Naturalist,* 116: 45-51.

Websites

www.nps.gov/rivers/wsract.html

http://wims.dpiwe.tas.gov.au

www.thelaw.tas.gov.au

www.bom.gov.au/climate

www.npwrc.usgs.gov/resource/1998/ripveg/ripveg.htm

www.gisparks.tas.gov.au/TASVEG2000/TVMS.html

www.waterplan.tas.gov.au/

www.nht.gov.au/extension.html

www.privateforests.tas.gov.au

www.unesco.org/water/ihp/ihp_six.shtml#th3

www.rmpat.tas.gov.au/decisions/0000%20J12-2003.htm: 44

www.dpiwe.tas.gov.au

www.hydro.com.au/basslink

www.forestrytas.com.au/forestrytas/pdf_files/management_plans

www.rpdc.tas.gov.au.

APPENDIX 1
Field Survey Data Sheet

TASMANIAN RIPARIAN VEGETATION DATA SHEET **Date:............**

Site No:...... Site Name:.................................. Site Code:.............

Location: E...........N:............... Long:.................... Lat:...........................
Altitude: .... **S........**
Aspect: [1] NW [2] N & W [3] NE & SW [4] S & E [5] SE **P........**
Stream class: 1 2 3 4
Surrounding Landform pattern: [1] very steep [2] steep [3] moderately inclined [4] gently inclined [5] very gently inclined [6] level
Stream Slope: : [1] very steep [2] steep [3] moderately inclined [4] gently inclined [5] very gently inclined [6] level [7] terraced (riffles and pools)
Bank Slope: [1] vertical [2] v. steep [3] steep [4] moderate [5] gentle [6] level [7] gentle to vert [8] gentle to mod [9] gentle to v. steep [10] mod to steep [11] mod to v. steep [12] mod to vert [13] steep to v. steep [14] steep to vert
Flow Permanence: [1] Ephemeral [2] Intermittent [3] Perennial [4] Artif. Inter.[5] Artif. per.
Channel control: [1] bedrock [2] alluvial [3] bedrock and alluvial [4] alluvial and veg
Average width of channel (to base of roots of woody plants):
[1] <5m [2] 5-10m [3] 10-50m [4] >50m
Floodplain: [1] <10m [2] 10-20m [3] 20-30m [4] 30-50m [5] 50-75m [6] 75m – 100m [7] >100m
Stream zone : [1] sediment production [2] transfer [3] depositional [4] transfer and deposition [5] sediment production and transfer [6] sediment production and deposition [7] sediment production, transfer and deposition
Site Location: [1] headwater [2] middle-order [3] lowland [4] estuarine
Channel Shape: [1] Rectangular [2] trapezoidal [3] vee [4] convex [5] bowl [6] terraced [7] irregular
Bank shape: [1] vertical [2] vertical top with toe [3] undercut [4] steep [5] moderate [6] flat [7] convex [8] terraced [9] concave [10] A Composite [11] B composite [12] irregular
Riparian Substrate:

Organic	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Sand/silt/clay	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Gravel	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Cobble	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Bedrock/bould	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%

RIPARIAN SPECIES LIST

Soil texture: [1] S [2] LS [3] CS [4] SL [5] L [6] ZL [7] SCL [8] CL [9] CLS [10] ZCL [11] LC [12] LMC [13] MC [14] MHC [15] HC [16] GS [17] GSCL [18] GSL [19] GLS [20] GMC [21] GCS [22] Varies from GMC to SCL [23] GSC [24] GLMC [25] SLHC [26] LS to L
Soil pH: ....
Soil EC (μS/m): .... **Water EC (μS/m):** ....
Geology: [1] alluvial deposits [2] sandstone [3] siltstone [4] mudstone [5] dolerite [6] basalt [7] limestone [8] Mathinna Beds ....

Vegetation Structure

- Dominant stratum 1 ..... stratum 2 .... stratum 3...........
- Co-dominant stratum 1 ..... stratum 2 .... stratum 3...........
- Riparian vegetation structure: ....
- Dryland vegetation structure: ....

Stratum 1 height:	[1] <2m	[2] 2-8m	[3] 8-30m	[4] 30m+		
Stratum 1 cover:	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Stratum 2 height:	[1] <2m	[2] 2-8m	[3] 8-30m	[4] 30m+		
Stratum 2 cover:	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Stratum 3 height:	[1] <2m	[2] 2-8m	[3] 8-30m	[4] 30m+		
Stratum 3 cover:	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%

Lifeforms cover

Trees:	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Shrubs:	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Prostr Shrubs:	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Herbs: :	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Graminoids:	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Grasses:	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%
Pteridophytes:	[1] <1%	[2] 1-5%	[3] 6-25%	[4] 26-50%	[5] 51-75%	[6] 76-100%

Major land use adjoining site: [1] reserve [2] cropland/pasture [3] forestry [4] recreational [5] rural residential [6] urban [7] multiple use forest [8] ....
Stock usage of riparian area: [1] none [2] occasional/seasonal [3] frequent
Other disturbances: [1] animal [2] fire [3] landslip [4] weeds [5] human [6] flood [7] flood & fishing [8] road [9] bridge [10] tracks [11] weeds & animals [12] road & bridge [13] flood & landslip [14] fire & weeds [15] animal & rubbish [16].........

Site diagram

Comments:..
....
....
....
...

APPENDIX 2
Riparian survey site data

Site Code	Site Name	Easting	Northing	Community	Altitude (m)	AUSRIVAS O/E score	Observed species richness
1	Catamaran River	490625	5177250	4	0	0.514	19
2	D'Entrecastreaux River	492375	5182125	18	0	0.689	23
3	Lune River	492375	5192250	5	0	0.591	24
4	Esperance River	492800	5205850	18	70	0.690	27
5	Arve River	484175	5221365	8	160	0.721	23
6	Castle Forbes Bay Rivulet	495900	5226350	16	190	0.756	27
7	Prices Creek	497750	5229995	Test (16)	300	0.380	10
8	Judds Creek	497055	5246250	8	220	0.861	31
9	Mountain River	511110	5247960	8	200	0.864	32
10	Garden Island Creek	514450	5215695	8	80	0.759	23
11	North West Bay River	515970	5242050	7	160	0.864	29
12	Fawcett Rivulet	521865	5243740	8	120	0.731	26
13	Native Hut Rivulet	528935	5282120	7	220	0.642	20
14	White Kangaroo Rivulet	539800	5286165	10	180	0.758	27
15	Prosser River	568080	5288010	10	20	0.597	16
16	Sandspit River	568770	5271100	14	180	0.699	26
17	Sandspit River2	570500	5272750	8	100	1.118	38
18	Nelsons Creek	553960	5282075	10	180	0.884	26
19	Catamaran River2	488180	5174910	18	20	0.660	19
20	Lune River2	486700	5192100	18	70	0.466	18
21	Mesa Creek	487550	5193500	18	30	0.936	31
22	Creekton Rivulet	491155	5197565	18	110	0.798	23
23	Peak Rivulet	491260	5203845	18	100	0.883	31
24	Picton River	475925	5221200	18	80	1.079	36
25	Esperance River2	489900	5208350	18	140	0.678	30
26	Johns Creek	475560	5228480	18	90	1.003	37
27	Isabell Creek	472035	5236555	18	320	0.699	24
28	Russell River	485490	5243380	8	80	1.140	35
29	Russell River2	477900	5250010	18	360	0.715	28
30	Falls Rivulet	476900	5247100	14	540	0.349	10
31	Little Denison River	481460	5242570	5	120	0.989	31
32	Nicholls Rivulet	512340	5226420	8	180	0.940	30
33	Agnes Rivulet	507880	5225230	7	120	1.024	34
34	Kellaways Creek	507560	5232290	7	100	1.291	46
35	Selfs Rivulet	500320	5194615	16	80	1.151	44
36	Kermandie River	488670	5217000	16	260	1.120	40
37	Huon River	496500	5236470	7	40	1.627	59
38	Crabtree Rivulet	504350	5246820	8	180	1.238	42
39	Allens Rivulet	514470	5237295	8	220	0.874	28
40	Kermandie River	491880	5219000	8	80	1.267	38
41	Desolation Creek	502770	5211750	8	20	0.599	25
42	Roaring Bay Creek	505140	5208060	8	120	0.949	33
43	Simmonds Creek	573510	5226000	5	160	0.779	25
44	Kennedy Creek	563440	5224370	5	140	0.733	22
45	Saltwater River	558260	5235260	7	5	0.677	20
46	Newmans Creek	567650	5228650	8	80	0.928	29
47	Blowhole Creek	575950	5232800	15	80	0.568	20
48	Sounds Rivulet	570550	5244500	7	0	1.052	33
49	Wellard Rivulet	572950	5245550	8	140	0.949	31
50	Gilpins Creek	565500	5252250	7	80	1.037	35
51	Dodges Ferry Creek	551200	5255800	6	10	0.515	21

APPENDIX 2
Riparian survey site data

Site Code	Site Name	Easting	Northing	Community	Altitude (m)	AUSRIVAS O/E score	Observed species richness
52	Bream Creek	569260	5263890	7	40	0.991	33
53	Pine Creek	572700	5266950	7	20	1.284	39
54	Iron Creek	553430	5265570	7	130	1.083	33
55	Prosser River	546400	5288360	10	300	1.190	33
56	Sorell Creek	515360	5256300	8	320	1.339	44
57	Humphreys Rivulet	518700	5254080	8	240	1.447	48
58	New Town Rivulet	520800	5252900	8	240	1.070	35
59	Coffee Creek	523560	5238700	10	30	0.742	27
60	Plenty River	492070	5258360	8	370	0.798	21
61	Park Creek	491400	5265300	10	370	0.728	21
62	Ringwood Creek	506700	5258600	7	100	0.951	28
63	Tyenna River	480150	5274860	8	120	0.912	30
64	Junee River	467000	5268000	14	300	0.688	24
65	Cataract Rivulet	483200	5268200	16	120	1.193	39
66	Gee Creek	474700	5260000	14	320	0.827	29
67	River Derwent	490400	5278850	10	60	1.065	36
68	Bloomfield Creek	494980	5286200	10	300	1.018	34
69	Browns Caves Creek	520770	5281950	10	180	0.981	25
70	Jordan River	510800	5277370	7	180	0.462	15
71	Grahams Creek	508630	5278520	7	180	0.643	19
72	Styx River	462500	5261000	19	520	0.445	19
73	Strathallan Rivulet	527180	5277700	10	180	1.061	36
74	Woodlands Creek	529100	5276400	10	180	0.568	16
75	Bagdad Rivulet	519320	5284500	10	200	1.072	35
76	Exe Rivulet	515400	5317800	10	420	0.570	19
77	Exe Rivulet2	514790	5319470	10	480	0.773	23
78	Knights Marsh Creek	511770	5302930	10	240	0.680	20
79	Scamander River	599700	5411300	7	5	0.799	27
80	Catos Creek	595900	5409000	7	40	1.227	39
81	Ansons River	603400	5454000	7	5	1.178	38
82	Ringarooma River	586850	5461000	7	40	0.677	27
83	Hardwicks Creek	577900	5468950	5	20	0.808	27
84	Boobyalla River	569000	5457220	5	100	0.965	28
85	South George River	578100	5426000	14	240	0.919	36
86	Scamander River2	591500	5416260	5	100	0.821	34
87	Strettons Creek	473600	5287400	10	260	0.922	25
88	Repulse River	469400	5293300	10	160	0.910	30
89	Repulse River 2	463900	5288600	11	640	0.522	19
90	Birralee Creek	550100	5321800	7	380	0.734	27
91	Tooms River	564500	5326200	10	460	0.794	27
92	Ashgrove Creek	574500	5301150	7	100	1.334	40
93	Rocka Rivulet	569700	5319950	8	420	1.195	32
94	West Swan River	588900	5357400	7	80	1.543	54
95	Swan River	590600	5367900	6	280	0.911	36
96	St Pauls River	591800	5382400	11	540	0.863	40
97	Swan River2	591300	5366400	7	280	0.872	30
98	Apsley River	604200	5360900	7	20	1.436	55
99	Apsley River2	602100	5355700	6	2	1.094	45
100	Mitchelmore Creek	573500	5310900	7	100	1.055	40
101	Clarence River	452300	5329600	11	620	1.470	45
102	Green Hill Rivulet	518800	5319400	10	500	0.779	22

APPENDIX 2
Riparian survey site data

Site Code	Site Name	Easting	Northing	Community	Altitude (m)	AUSRIVAS O/E score	Observed species richness
103	Petherton Creek	522100	5322010	10	570	1.015	37
104	River Clyde	511600	5331200	11	800	0.701	22
105	Clarence Plains Rivulet	534400	5254300	7	60	0.746	35
106	Risdon Brook	526700	5262050	7	100	0.614	26
107	Little Swanport River	570160	5312600	6	50	1.438	85
108	Back River	564000	5292700	7	220	0.853	40
109	Pepper Creek	567050	5303700	8	360	1.218	50
110	Old Man Creek	584310	5322840	7	10	1.182	39
111	Stony River	588200	5332500	7	20	1.103	31
112	Snowy River	568540	5356640	11	640	1.247	41
113	Cygnet River	572600	5356160	16	660	0.938	30
114	West Swan River2	579150	5360600	7	320	0.982	41
115	Lost Falls Creek	573440	5344950	9	520	1.103	41
116	Lisdillon Rivulet	582100	5317980	7	10	1.055	29
117	Lisdillon Rivulet2	580000	5318350	7	40	0.900	22
118	Elizabeth River	565800	5349265	11	580	1.315	48
119	Macquarie River	569000	5338650	10	440	0.839	26
120	Florentine River	453990	5278490	16	360	1.155	41
121	Florentine River2	454380	5284900	14	360	0.986	29
122	Florentine River3	454660	5294830	16	360	1.008	31
123	Ferndale Creek	523160	5341000	10	380	0.908	27
124	Prideaux Creek	521260	5354900	10	240	0.908	24
125	Nive River	459860	5308400	8	270	1.186	43
126	Florentine River4	459170	5300660	7	200	1.336	52
127	Little Florentine River	452980	5268500	19	480	0.831	31
128	River Clyde2	508080	5329600	3	740	0.738	22
129	Fordells Creek	509500	5313940	10	480	0.492	26
130	Donnybrook Rivulet	507950	5299400	10	500	0.849	37
131	Ibbottvale Creek	503800	5302340	10	460	0.492	17
132	Paramore Creek	514650	5267230	10	20	0.567	16
133	Orford Rivulet	571700	5286700	7	10	1.230	40
134	Hermitage Road Creek	579400	5304700	7	20	0.900	25
135	Condominium Creek	447870	5243450	20	320	0.750	34
136	Huon River	442800	5234500	17	270	1.114	51
137	Clear Creek	448950	5282700	5	350	0.393	30
138	Blackburn Creek	492220	5331000	11	650	0.957	37
139	Shannon River	480180	5344450	3	920	0.736	27
140	River Ouse2	479440	5333400	11	560	0.624	32
141	Boggy Marsh Rivulet	478000	5323400	11	580	0.805	24
142	Bluegong Creek	576750	5334340	8	440	1.127	35
143	Kazies Creek	595700	5358200	7	320	0.832	35
144	Apsley River3	595170	5365470	6	220	0.663	32
145	Douglas River	604300	5373500	7	10	1.169	48
146	Piccaninny Creek	605150	5384170	8	30	0.971	35
147	Four Mile Creek	607300	5398125	7	10	1.136	38
148	Little Swanport River2	558440	5310620	10	160	0.815	29
149	Little Swanport River3	557280	5309300	10	200	0.541	27
150	Hunterson Rivulet	496600	5328000	10	640	0.793	32
151	Jean Banks Road Creek	484800	5328780	10	600	0.545	20
152	Ouse River 2	481580	5333800	10	760	0.663	22
153	McQuires Marsh Rivulet	480020	5317320	10	360	0.754	25

APPENDIX 2
Riparian survey site data

Site Code	Site Name	Easting	Northing	Community	Altitude (m)	AUSRIVAS O/E score	Observed species richness
154	Bluff River	559400	5299990	10	300	1.004	29
155	Maclaines River	574400	5294050	7	5	1.098	28
156	Hut Run Creek	551300	5345100	10	400	0.581	24
157	Elizabeth River2	549000	5349110	10	340	0.539	17
158	Blue Tier Creek	558080	5331870	6	320	0.659	46
159	Castle Cary Rivulet	557840	5380250	8	400	1.067	30
160	Aberfoyle Creek	561520	5391145	8	740	1.140	39
161	Grants Creek	574850	5395800	8	340	1.168	38
162	Fingal Rivulet	583310	5388850	7	300	1.079	45
163	Millstream Creek	590500	5398500	8	440	1.394	42
164	Evercreech Rivulet	581480	5415300	14	340	0.952	32
165	Delvin Creek	574900	5415810	15	420	1.229	37
166	Long Gully Creek	575010	5405500	10	320	0.771	23
167	Gleadow Creek	587600	5401050	10	340	0.796	20
168	South Esk River	569290	5383030	10	220	1.025	42
169	Tullochgorum Creek	576210	5384840	10	260	1.063	41
170	Storys Creek	561630	5386400	8	580	1.040	42
171	Salisbury Rivulet	550000	5365370	10	480	0.859	35
172	St Pauls River2	590020	5381100	8	520	1.350	50
173	St Pauls River3	587260	5375700	6	280	0.850	62
174	St Pauls River4	575000	5369530	6	220	0.751	53
175	St Pauls River5	562480	5370090	11	220	0.670	34
176	Lady Barron Creek	469925	5274500	19	940	0.651	36
177	Tyenna River 2	485700	5274580	7	80	0.499	25
178	River Derwent 2	498900	5266100	10	40	1.021	35
179	Poatina Creek	493400	5370710	8	360	0.866	34
180	Palmers Rivulet	488920	5370920	11	1020	0.249	25
181	Hydro Creek	488880	5355240	11	1020	0.747	38
182	Scotch Bobs Creek	491360	5358750	11	960	0.717	26
183	Mystery Creek	487510	5187920	17	180	1.030	40
184	Buxton River	581070	5321760	7	20	1.659	58
185	Buxton River2	579290	5323310	7	100	1.163	43
186	Devils Creek	604090	5402070	7	20	0.960	27
187	Freshwater Creek	605950	5412630	5	20	0.712	34
188	Big Lagoon Creek	606350	5440375	7	5	1.010	25
189	Duck Creek	604960	5439080	7	5	0.631	26
190	Constable Creek	601200	5422400	7	40	1.127	51
191	Bosses Creek	596450	5435450	5	140	0.516	29
192	Gr Musselroe River	590630	5446310	15	160	1.135	28
193	Gr Musselroe River2	589100	5450910	8	100	1.044	42
194	Musselroe Creek	587150	5447600	14	180	1.098	28
195	Derwent Creek	593660	5425080	7	100	0.900	37
196	Power Rivulet	587650	5423970	15	240	0.952	30
197	Beckett Creek	543370	5416520	14	480	1.022	40
198	St Patricks River	544870	5424110	13	620	0.766	32
199	Newitts Creek	558650	5421740	12	820	0.530	49
200	Dorset River	566810	5426450	14	360	0.958	31
201	Merry Creek	567200	5411400	8	340	1.413	51
202	Farrells Creek	556100	5418050	14	720	1.103	37
203	North Esk River	529800	5406910	7	300	0.684	32
204	Crotty River	385960	5321180	19	200	0.627	24

APPENDIX 2
Riparian survey site data

Site Code	Site Name	Easting	Northing	Community	Altitude (m)	AUSRIVAS O/E score	Observed species richness
205	Cardigan River	403460	5335410	20	520	0.977	44
206	Ouse River3	470400	5351300	1	1000	1.613	77
207	Ouse River 4	465300	5365000	1	1120	1.228	55
208	Pine Tree Rivulet	473195	5372400	1	1040	0.947	41
209	Hunters Swamp Creek	532350	5297200	8	300	0.947	28
210	Little Pine River	465010	5348220	3	980	1.573	69
211	Serpentine Rivulet	459360	5336170	12	680	0.969	39
212	Pine River	456800	5342250	3	700	1.289	53
213	Little Pine River	455400	5362500	1	1160	0.676	30
214	Stony Creek	473900	5367410	3	1040	1.031	32
215	Black Bobs Rivulet	466240	5307010	8	320	1.136	38
216	River Derwent3	443530	5320035	11	660	1.279	36
217	Nive River2	455170	5315810	Test (10)	320	1.220	33
218	Jungle Creek	460400	5296750	8	500	0.653	24
219	Bung Bung Creek	460350	5349000	12	960	0.966	34
220	River Ouse	470240	5348535	3	920	1.104	39
221	Jackson Creek	467120	5325520	12	780	1.396	39
222	Dicks Creek	466300	5335150	12	900	1.030	36
223	Kenmere Creek	476110	5314000	8	500	1.367	47
224	Kenmere Creek	475650	5305750	10	200	0.754	30
225	River Dee	468440	5313130	8	520	1.410	47
226	Wentworth Creek	448900	5325350	3	740	1.550	53
227	Hugel River	430740	5337500	19	760	1.072	48
228	Navarre River	429250	5331680	2	780	1.008	40
229	River Derwent4	445100	5316970	19	640	0.513	33
230	Little Pine River3	464810	5353200	1	1020	1.058	44
231	Clarence River	444985	5335000	3	780	1.360	49
232	Lake King William Rivulet	431950	5327130	2	780	1.668	50
233	Meander River	463930	5382290	16	480	1.158	44
234	Jackeys Creek	471260	5386100	9	480	0.983	38
235	Liffey River	479660	5383490	14	620	0.909	36
236	Eden Rivulet	476960	5395980	8	260	0.955	33
237	Nive River3	451320	5346960	2	840	1.323	63
238	Westons Rivulet	484700	5377000	1	1120	0.863	45
239	Tims Creek	564530	5401510	9	400	1.341	47
240	Pig Run Creek	544970	5406900	10	500	0.799	36
241	Ford River Tributary	551090	5404975	Test (8)	400	0.680	32
242	Nile River	540010	5397760	10	310	1.062	48
243	Camden Rivulet	535890	5419970	14	900	0.446	20
244	Weavers Creek Tributary	533750	5409385	8	600	1.065	46
245	Buffalo Brook	552050	5378340	9	240	1.320	52
246	Ben Lomond Rivulet	541570	5382600	10	220	0.733	24
247	Mountain Creek	515850	5343065	11	840	1.215	43
248	Upper Lake River	493370	5346350	12	940	0.992	36
249	Dove River	413485	5388280	2	960	0.685	40
250	Pencil Pine Creek	410400	5394200	Test (19)	940	1.860	48
251	Mersey River	434980	5380430	9	540	1.336	66
252	Roarer Creek	428990	5378750	19	660	1.352	48
253	Mersey River2	435300	5391250	8	440	1.280	59
254	Lemonthyme Creek	429200	5393200	Test (8)	660	1.110	30
255	Dale Brook	456900	5390120	9	340	1.379	46

APPENDIX 2
Riparian survey site data

Site Code	Site Name	Easting	Northing	Community	Altitude (m)	AUSRIVAS O/E score	Observed species richness
256	Dale Brook2	455500	5386870	16	600	1.022	38
257	Great Forester River	552400	5455700	9	40	1.254	37
258	Surveyors Creek	550575	5451740	5	40	1.424	54
259	Three Mile Creek	546780	5440500	5	60	1.191	43
260	Cascade River	568150	5443120	9	200	1.079	37
261	Black Rivulet	566100	5439840	15	400	0.922	33
262	Franklin River	418900	5325650	19	400	1.398	56
263	Collingwood River	411400	5331500	17	360	1.335	59
264	Nelson River	395500	5337900	19	400	0.732	29
265	Bird River	383800	5311000	19	140	0.802	34
266	Dacrydium Creek	395210	5308240	20	700	0.317	19
267	Spence River	389800	5307900	20	360	0.384	19
268	King River	378800	5331700	17	80	1.394	59
269	Travellers Creek	385500	5328900	17	280	1.150	45
270	Taffys Creek	422340	5325580	19	540	1.035	43
271	King River Tributary	388150	5334900	20	270	0.697	44
272	Linda Creek	386770	5341200	17	240	0.732	32
273	King River2	365000	5327360	17	5	1.186	43
274	Henty River	356400	5346030	17	5	1.019	32
275	Dundas Rivulet	368560	5362620	17	230	1.046	33
276	Boobyalla River2	573950	5472500	4	5	0.716	26
277	Boobyalla River 3	572300	5469150	9	10	0.669	22
278	Tomahawk River	564100	5463700	5	80	1.037	28
279	Cray Creek Tributary	602470	5468260	5	60	0.580	28
280	Gumbill Creek	601520	5475400	4	20	0.631	26
281	Musselroe Road Creek	599000	5473600	5	40	0.677	27
282	Gr Musselroe River3	591340	5467700	7	20	0.877	26
283	Tomahawk River 2	563300	5475300	4	0	0.715	34
284	Brid River	533500	5459750	4	0	0.673	24
285	Patersonia Rivulet	527750	5427600	15	440	1.410	45
286	Lisle Creek	526500	5435000	14	250	0.946	28
287	Brid River	534600	5446480	5	100	0.835	35
288	Little Forester River	530900	5434400	14	180	1.060	29
289	Golconda Creek	526500	5441000	15	120	0.743	22
290	Second River	517700	5435500	14	200	0.973	26
291	Pipers River	519820	5424590	5	400	0.670	34
292	West Arm Creek	538400	5428600	14	560	0.677	25
293	Distillery Creek	520830	5413350	9	180	1.307	52
294	Distillery Creek2	517750	5413050	9	120	1.131	34
295	Curries River	495600	5458200	4	0	0.589	27
296	Curries River2	497600	5454500	7	40	0.675	17
297	Williams Creek	495600	5443600	7	60	1.241	38
298	Fourteen Mile Creek	497100	5439950	7	0	0.715	25
299	Ransom River	589750	5433800	9	120	1.404	42
300	Main Creek	573900	5438300	14	420	0.846	29
301	Ringarooma River2	571900	5447500	15	140	1.232	33
302	Wyniford River	579500	5451450	7	100	1.338	40
303	Pipers River Tributary	510900	5454090	5	60	1.095	31
304	Pipers Brook Tributary	513450	5449800	5	100	1.337	34
305	Dead Horse Creek	507400	5447100	9	60	1.064	30
306	Back Creek	504850	5451200	5	80	0.936	27

APPENDIX 2
Riparian survey site data

Site Code	Site Name	Easting	Northing	Community	Altitude (m)	AUSRIVAS O/E score	Observed species richness
307	Henty River2	373250	5349750	17	120	1.185	44
308	Farrell Rivulet	370750	5355400	17	200	0.941	39
309	Dundas Rivulet2	367500	5359950	17	200	0.976	35
310	Tyndall Creek	380950	5357200	20	520	1.291	44
311	Newton Creek	381300	5359220	20	520	0.628	33
312	Murchison River	385200	5375200	Test (17)	520	1.290	37
313	Blythe River	412400	5441400	8	80	0.858	25
314	Blythe River2	410200	5432700	15	300	1.491	47
315	Inglis River	385450	5442100	15	300	1.436	48
316	Inglis River2	384400	5437300	17	420	1.509	47
317	Hellyer River	378900	5434950	14	210	0.987	33
318	Hellyer River2	383850	5429830	14	240	1.236	39
319	Parrawe Creek	377420	5429860	14	290	1.072	34
320	Calder River	384300	5451300	9	80	1.023	30
321	Inglis River3	382350	5448600	9	100	1.208	38
322	Wilson Creek	369420	5473210	5	5	1.539	53
323	Detention River	368910	5473330	4	0	0.882	32
324	Black River	357240	5476680	4	0	0.798	25
325	Montagu River	325760	5483620	Test (5)	0	1.260	29
326	Welcome River	311100	5486000	5	5	1.038	34
327	Welcome River2	313800	5477700	5	20	1.227	55
328	Welcome River3	315150	5464200	9	40	0.757	27
329	Fixters Creek	326900	5469200	14	40	0.991	35
330	Doctors Creek	303300	5464900	5	40	0.825	37
331	Nelson Bay River	305900	5444000	5	10	0.613	29
332	Rebecca Creek	306800	5437750	5	10	0.943	41
333	Nelson Bay River2	317500	5437400	21	160	0.601	32
334	Frankland River	321800	5438400	17	120	1.269	45
335	Stephens Rivulet	327820	5443980	17	60	1.004	35
336	Arthur River	330600	5446400	17	40	0.943	33
337	Arthur River2	304000	5452750	4	0	0.903	37
338	Lindsay River	330880	5422750	21	200	0.665	41
339	Eighty Creek	334860	5414260	21	350	0.524	27
340	Donaldson River	340500	5408160	17	220	1.152	36
341	Guthrie Creek	340300	5390900	17	230	0.977	36
342	Savage River	339900	5389700	17	40	0.768	28
343	Arnon River	554310	5445250	15	100	1.221	35
344	Hang Dog Creek	552210	5436270	14	300	0.706	26
345	Gr Forester River	546740	5437850	15	140	1.298	41
346	Ransom Beach Creek	557700	5478650	5	5	0.421	28
347	Biddle Creek	504330	5437145	7	130	1.162	49
348	Saltwater Creek	502400	5428830	10	20	1.029	28
349	Cimitiere Creek	486200	5454100	Test (5)	130	0.430	10
350	York Town Rivulet	476150	5443780	5	80	0.990	32
351	Browns Creek	472250	5438800	5	100	0.847	30
352	Sheepwash Creek	467500	5443300	5	10	0.907	24
353	Franklin River2	468130	5430660	9	40	1.258	38
354	Brushy Rivulet	478000	5416960	9	280	1.260	42
355	Anderson Creek	480550	5431950	15	100	0.968	31
356	Farm Creek	382500	5380350	17	200	1.083	38
357	Huskisson River	370200	5378600	17	120	1.186	36

APPENDIX 2

Riparian survey site data

Site Code	Site Name	Easting	Northing	Community	Altitude (m)	AUSRIVAS O/E score	Observed species richness
358	Salmon Creek	361900	5380110	17	120	0.732	24
359	Boco Creek	379700	5380600	17	200	1.117	40
360	Stanley River	357630	5381370	17	240	1.046	37
361	Pieman River	339700	5386900	17	40	1.222	38
362	Newdegate Creek	333160	5379480	17	40	1.013	36
363	Duck Creek	340800	5374700	17	120	0.697	24
364	Big Rocky Creek	338890	5368050	5	40	0.773	44
365	Heemskirk River	351820	5369200	20	160	1.045	42
366	Tasman River	344780	5368800	21	200	0.662	35
367	Wakefield Creek	349550	5356700	5	90	0.597	38
368	Comstock Creek	354800	5359280	21	200	0.697	40
369	Manuka River	361200	5333700	17	20	0.944	32
370	Sailor Jack Creek	375500	5332000	19	260	0.592	25
371	Brookstead Creek	574600	5372000	10	280	1.341	43
372	South Esk River2	571230	5409050	9	260	1.550	45
373	Little Forester River2	529620	5461570	4	5	0.877	34
374	Great Forester River3	548900	5459450	7	20	0.977	24
375	Great Forester River4	544885	5460470	5	20	0.890	25
376	Little Forester River3	526800	5455800	5	20	1.286	43
377	Tam O'Shanter Creek	505710	5461100	4	10	1.057	36
378	Salmon River	316700	5453290	14	60	1.203	37
379	Salmon River2	321300	5452000	17	80	0.960	31
380	Rapid River	340410	5442140	17	80	0.833	32
381	Little Rapid River	350950	5442000	17	220	0.790	27
382	Dodds Creek	343540	5436900	17	210	0.742	26
383	Horton River	334560	5432460	21	200	0.743	30
384	Leigh River	333895	5426885	17	220	1.156	44
385	Horton River2	340140	5425150	17	220	0.804	28
386	Leigh River2	336620	5419110	17	240	0.733	28
387	Roger River	333240	5452550	14	60	1.004	31
388	Arthur River3	348280	5452610	17	80	1.153	31
389	Mill Creek	332270	5461140	15	60	0.758	26
390	Flowerdale River	379900	5455500	14	100	1.161	33
391	Flowerdale River2	375900	5446700	14	260	0.778	25
392	Dip River	357670	5466780	17	80	1.384	47
393	Black River2	365390	5460200	17	140	1.372	42
394	Dip River2	363460	5455880	15	220	1.490	46
395	Inglis River5	392000	5462550	4	0	1.133	46
396	Arthur River4	370360	5439990	17	160	1.011	29
397	Keith River	369000	5438900	17	160	1.108	34
398	Cann Creek	367750	5447100	17	180	1.284	39
399	River Leven	425370	5443870	4	0	1.588	50
400	River Leven2	420800	5438630	14	20	1.261	42
401	Minnow Creek	452800	5413930	9	120	1.324	44
402	Minnow River2	443770	5407800	15	260	1.273	42
403	O'Neills Creek	434850	5408800	15	380	1.380	41
404	Excells Creek	434860	5417820	14	240	0.965	33
405	Wilmot River	435600	5430160	9	60	1.503	39
406	Wilmot River2	429930	5421700	9	120	1.422	46
407	Wilmot River3	422500	5408700	13	460	1.294	44
408	Marine Creek	447675	5425420	9	80	1.309	35

APPENDIX 2
Riparian survey site data

Site Code	Site Name	Easting	Northing	Community	Altitude (m)	AUSRIVAS O/E score	Observed species richness
409	Goldie Creek	437440	5435340	15	40	1.169	37
410	Forth River	436740	5434740	15	20	1.003	42
411	Mersey River	451660	5429600	9	10	1.542	63
412	Mersey River2	449300	5435750	4	0	1.174	39
413	Emu River	409220	5451100	15	5	1.558	57
414	Guide River	399450	5442900	14	160	0.677	27
415	Emu River2	400020	5432310	17	380	1.415	53
416	Rubicon River	463380	5426080	9	20	1.543	47
417	Gum Scrub Creek	465260	5426680	7	160	0.909	52
418	Rubicon R. Tributary	467510	5412450	9	220	0.833	26
419	Sandy Bay Rivulet	523200	5249000	9	200	1.343	52
420	Detention River2	372820	5464480	17	60	1.384	45
421	Blythe River3	405090	5426770	17	400	1.214	43
422	River Leven3	415550	5424380	17	100	1.188	43
423	Winter Brook	417830	5414500	13	380	1.663	52
424	River Leven4	409810	5416000	17	400	1.414	45
425	Blythe River4	410310	5434380	17	280	1.044	43
426	Gowans Creek	492510	5421560	14	260	0.430	26
427	Pipers Lagoon Creek	492635	5419405	9	220	1.297	39
428	Supply River	486150	5424820	9	100	1.000	36
429	Black Sugarloaf Creek	482500	5415120	7	200	1.326	45
430	Western Creek	466000	5398350	5	260	1.113	45
431	Meander River	475500	5404810	9	220	1.338	44
432	Liffey River	486810	5385285	9	280	1.067	37
433	Brumbys Creek	492235	5380810	9	260	1.331	37
434	Lake River	506615	5362820	10	220	0.759	28
435	Lobster Creek	460020	5403970	9	140	1.318	47
436	Black River3	359180	5466590	17	60	1.286	45
437	Black River4	356315	5470730	15	40	1.508	50
438	Deep Creek	347790	5471525	14	40	1.183	34
439	Scopus Creek Tributary	334180	5477350	14	40	0.588	20
440	Guide River Tributary	397100	5435190	14	400	1.291	54
441	Wye River	584450	5340910	6	30	0.975	52
442	Gordon River	410210	5266770	17	80	1.401	63
443	Gordon River 2	399760	5273177	19	40	0.978	40
444	Olga River	401450	5262515	18	80	0.779	27
445	Denison River	407190	5272650	19	80	0.953	45
446	Franklin River	397760	5286990	13	40	0.524	30
447	Gordon River3	396020	5284050	19	40	1.117	39
448	Wandle River	381200	5419900	13	580	1.146	56
449	Twyford Creek	390480	5413600	13	580	0.651	27
450	Savage River	349515	5406260	19	100	1.083	40
451	Little Donaldson River	352600	5418240	19	300	0.909	43
452	Clearwater Creek	358380	5427340	19	480	0.738	28
453	Litte Rapid River2	360150	5430075	19	440	0.932	39
454	Magnet Creek	369990	5406776	19	620	0.544	26
455	Coldstream River	374790	5406860	3	640	0.909	45
456	Waratah River	378970	5410520	12	640	0.613	23
457	Hatfield Creek	388230	5401675	3	680	0.725	21
458	River Leven5	402990	5400530	12	640	1.421	41
459	Lake Lea Creek	408710	5401775	2	840	0.554	23
460	Iris River	413400	5399300	3	800	1.151	49

APPENDIX 3

Grids where no reference stands of native riparian vegetation could be found

Geocordinates of 10 km x 10 km grids on mainland Tasmania (based on National Mapping grid square system)	
No native riparian vegetation	**A headwaters remnant possible but inaccessible at time of survey**
4543	4535
4544	4537
4640	4637
4740	4830
4828	4831
4829	5026
4840	5028
4938	5033
4939	5038
4940	5233
5036	5429
5037	5435
5039	5539
5129	5839
5136	5848
5137	5945
5138	
5139	
5229	
5230	
5231	
5236	
5237	
5238	
5239	
5330	
5331	
5332	
5333	
5335	
5336	
5337	
5338	
5339	
5426	
5427	
5430	
5431	
5432	
5433	
5436	
5437	
5527	
5847	

Coordinants define the bottom left-hand corner of the 10 km x 10 km grid.

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.0000	0.6908	**0.5732**	0.9290	0.8801	0.8586	0.9047	0.8741	0.8778	0.8721	0.8022	0.7076	0.8649	0.9044	0.8991	0.8925	0.9027	0.9240	0.8681	0.8933	0.9235
2	0.6908	0.0000	**0.5543**	0.8887	0.8011	0.7983	0.8396	0.8087	0.8030	0.8330	0.6454	0.6875	0.7721	0.8583	0.8311	0.8168	0.7952	0.8515	0.7630	0.6824	0.7398
3	0.5732	0.5543	0.0000	0.8350	0.7395	0.7278	0.7679	0.7026	0.7153	0.7246	0.5498	**0.4480**	0.7021	0.7945	0.7681	0.7599	0.7613	0.8256	0.7261	0.7567	0.8028
4	0.9290	0.8887	0.8350	0.0000	**0.4725**	0.6396	0.4828	0.5988	0.5551	0.5738	0.7205	0.8046	0.7647	0.7287	0.6485	0.7287	0.7044	0.7424	0.7876	0.7949	0.7914
5	0.8801	0.8011	0.7395	0.4725	0.0000	0.6184	**0.4216**	0.4414	0.4278	0.5238	0.6059	0.7017	0.6542	0.5820	0.4611	0.5738	0.4843	0.5695	0.6135	0.5652	0.6367
6	0.8586	0.7983	0.7278	0.6396	0.6184	0.0000	**0.5016**	0.6391	0.6236	0.5700	0.6169	0.7190	0.7555	0.7704	0.7328	0.7598	0.7407	0.7935	0.7985	0.8079	0.8472
7	0.9047	0.8396	0.7679	0.4828	0.4216	0.5016	0.0000	0.3722	0.4008	**0.3522**	0.5850	0.7140	0.6651	0.6122	0.5314	0.5771	0.5955	0.6357	0.6807	0.7456	0.8137
8	0.8741	0.8087	0.7026	0.5988	0.4414	0.6391	0.3722	0.0000	**0.3217**	0.3922	0.5526	0.6152	0.5539	0.4690	0.3695	0.4172	0.4902	0.5576	0.5589	0.7047	0.8066
9	0.8778	0.8030	0.7153	0.5551	0.4278	0.6236	0.4008	0.3217	0.0000	0.4071	0.5719	0.6211	0.5059	0.4436	**0.3146**	0.4604	0.4613	0.6139	0.5390	0.7124	0.7971
10	0.8721	0.8330	0.7246	0.5738	0.5238	0.5700	**0.3522**	0.3922	0.4071	0.0000	0.5328	0.6479	0.6352	0.5936	0.5516	0.5853	0.6394	0.7118	0.6734	0.7978	0.8751
11	0.8022	0.6454	0.5498	0.7205	0.6059	0.6169	0.5850	0.5526	0.5719	**0.5328**	0.0000	0.5593	0.6341	0.6965	0.6669	0.6446	0.6737	0.7163	0.6498	0.7276	0.8030
12	0.7076	0.6875	**0.4480**	0.8046	0.7017	0.7190	0.7140	0.6152	0.6211	0.6479	0.5593	0.0000	0.5968	0.6711	0.6742	0.6692	0.6797	0.7759	0.6430	0.7951	0.8515
13	0.8649	0.7721	0.7021	0.7647	0.6542	0.7555	0.6651	0.5539	0.5059	0.6352	0.6341	0.5968	0.0000	0.4503	0.4628	0.4695	0.4465	0.5732	**0.3908**	0.6968	0.8251
14	0.9044	0.8583	0.7945	0.7287	0.5820	0.7704	0.6122	0.4690	0.4436	0.5936	0.6965	0.6711	0.4503	0.0000	**0.3164**	0.4233	0.3826	0.5622	0.4211	0.7112	0.8416
15	0.8991	0.8311	0.7681	0.6485	0.4611	0.7328	0.5314	0.3695	**0.3146**	0.5516	0.6669	0.6742	0.4628	0.3164	0.0000	0.3755	0.3334	0.5161	0.4485	0.6414	0.7481
16	0.8925	0.8168	0.7599	0.7287	0.5738	0.7598	0.5771	0.4172	0.4604	0.5853	0.6446	0.6692	0.4695	0.4233	**0.3755**	0.0000	0.4308	0.4822	0.4648	0.6504	0.8020
17	0.9027	0.7952	0.7613	0.7044	0.4843	0.7407	0.5955	0.4902	0.4613	0.6394	0.6737	0.6797	0.4465	0.3826	0.3334	0.4308	0.0000	0.3730	**0.3255**	0.5137	0.6715
18	0.9240	0.8515	0.8256	0.7424	0.5695	0.7935	0.6357	0.5576	0.6139	0.7118	0.7163	0.7759	0.5732	0.5622	0.5161	0.4822	**0.3730**	0.0000	0.4878	0.5489	0.7148
19	0.8681	0.7630	0.7261	0.7876	0.6135	0.7985	0.6807	0.5589	0.5390	0.6734	0.6498	0.6430	0.3908	0.4211	0.4485	0.4648	**0.3255**	0.4878	0.0000	0.6000	0.7668
20	0.8933	0.6824	0.7567	0.7949	0.5652	0.8079	0.7456	0.7047	0.7124	0.7978	0.7276	0.7951	0.6968	0.7112	0.6414	0.6504	0.5137	0.5489	0.6000	0.0000	**0.4641**
21	0.9235	0.7398	0.8028	0.7914	0.6367	0.8472	0.8137	0.8066	0.7971	0.8751	0.8030	0.8515	0.8251	0.8416	0.7481	0.8020	0.6715	0.7148	0.7668	**0.4641**	0.0000

APPENDIX 4 Table of values derived from the Bray-Curtis distance measure of percentage frequency of species in groups.
(Lowest value (bold) depicts similarity with corresponding group. Cases in rows, comparisons in columns)

APPENDIX 5

List of vascular plant taxa (alphabetical) found in the riparian zone

Abrotanella forsteroides	*Archeria eriocarpa*
Acacia axillaris	*Argentipallium dealbatum*
Acacia dealbata	*Aristotelia peduncularis*
Acacia genistifolia	*Asperula conferta*
Acacia mearnsii	*Asperula gunnii*
Acacia melanoxylon	*Asperula gunnii* var. *curta*
Acacia mucronata	*Asperula gunnii* var. *gunnii*
Acacia myrtifolia	*Asperula pusilla*
Acacia riceana	*Asperula* spp.
Acacia siculiformis	*Asplenium appendiculatum*
Acacia sophorae	*Asplenium bulbiferum*
Acacia sp.	*Asplenium flabellifolium*
Acacia stricta	*Asplenium hookerianum*
Acacia terminalis	*Asplenium* spp.
Acacia verniciflua	*Astelia alpina*
Acacia verticillata	*Astelia alpina* var. *aplina*
Acacia verticillata var. *latifolia*	*Asterotrichion discolor*
Acacia verticillata var. *verticillata*	*Astroloma humifusum*
Acaena echinata	*Astroloma pinifolium*
Acaena montana	*Atherosperma moschatum*
Acaena novae-zelandiae	*Athrotaxis cupressoides*
Acaena ovina	*Athrotaxis selaginoides*
Acaena spp.	*Australina pusilla* subsp. *muelleri*
Acianthus spp.	*Australina pusilla* subsp. *pusilla*
Acion hookeri	*Australopyrum pectinatum*
Acradenia frankliniae	*Austrodanthonia caespitosa*
Acrotriche serrulata	*Austrodanthonia penicillata*
Actinotus suffocata	*Austrodanthonia pilosa*
Adiantum aethiopicum	*Austrodanthonia* spp.
Agastachys odorata	*Austrostipa pubinodis*
Agrostis avenacea	*Austrostipa rudis* subsp. *australis*
Agrostis parviflora	*Austrostipa scabra*
Agrostis spp.	*Austrostipa semibarbata*
Agrostis venusta	*Austrostipa* spp.
Ajuga australis	*Austrostipa stipoides*
Allocasuarina littoralis	*Austrostipa stuposa*
Allocasuarina monilifera	*Baeckea gunniana*
Allocasuarina paludosa	*Baeckea leptocaulis*
Allocasuarina verticillata	*Baeckea ramosissima*
Allocasuarina zephyrea	*Baloskion australe*
Almaleea subumbellata	*Baloskion tetraphyllum*
Alyxia buxifolia	*Banksia marginata*
Amperea xiphoclada	*Bauera rubioides*
Amphibromus spp.	*Baumea acuta*
Anodopetalum biglandulosum	*Baumea arthrophylla*
Anopterus glandulosus	*Baumea gunnii*
Aotus ericoides	*Baumea juncea*
Aphanes australiana	*Baumea rubiginosa*
Apium prostratum	*Baumea* spp.
Apium prostratum var. *filiforme*	*Baumea tetragona*
Apodasmia brownii	*Bedfordia linearis*

APPENDIX 5

List of vascular plant taxa (alphabetical) found in the riparian zone

Bedfordia salicina
Bellendena montana
Beyeria viscosa
Billardiera longiflora
Billardiera longiflora var. *alpina*
Billardiera scandens
Blandfordia punicea
Blechnum chambersii
Blechnum fluviatile
Blechnum minus
Blechnum nudum
Blechnum patersonii
Blechnum penna-marina
Blechnum spp.
Blechnum wattsii
Boronia anemonifolia
Boronia citriodora
Boronia pilosa
Boronia rhomboidea
Bossiaea cinerea
Bossiaea cordigera
Bossiaea obcordata
Bossiaea prostrata
Bossiaea riparia
Brachyscome angustifolia
Brachyscome decipiens
Brachyscome nivalis
Brachyscome spp.
Bulbine bulbosa
Bursaria spinosa
Callistemon pallidus
Callistemon viridiflorus
Callitriche spp.
Callitris oblonga
Callitris rhomboidea
Calochlaena dubia
Calorophus elongatus
Calytrix tetragona
Cardamine gunnii
Cardamine spp.
Carex aff. diandra
Carex appressa
Carex archeri
Carex barbata
Carex breviculmis
Carex fascicularis
Carex flaviformis
Carex gaudichaudiana
Carex inversa
Carex iynx
Carex longebrachiata

Carex polyantha
Carex raleighii
Carex spp.
Carex tasmanica
Carex tereticaulis
Carpha alpina
Cassinia aculeata
Cassinia trinerva
Cassytha melantha
Cassytha pubescens
Celmisia asteliifolia
Cenarrhenes nitida
Centaurea solstitialis
Centaurea spp.
Centrolepis fascicularis
Centrolepis monogyna
Centrolepis spp.
Centrolepis strigosa
Cheilanthes austrotenuifolia
Chiloglottis spp.
Chionogentias gunniana
Chionogentias spp.
Chrysocephalum apiculatum
Chrysocephalum semipapposum
Clematis aristata
Clematis microphylla
Clematis spp.
Clematis vitalba
Colobanthus apetalus
Comesperma retusum
Comesperma spp.
Comesperma volubile
Coprosma hirtella
Coprosma moorei
Coprosma nitida
Coprosma perpusilla subsp. *perpusilla*
Coprosma pumila
Coprosma quadrifida
Correa backhouseana
Correa lawrenceana
Correa reflexa var. *reflexa*
Corybas spp.
Cotula alpina
Cotula australis
Cotula coronopifolia
Craspedia glauca
Craspedia paludicola
Crassula helmsii
Crassula sieberana
Crepidomanes venosum
Ctenopteris heterophylla

APPENDIX 5

List of vascular plant taxa (alphabetical) found in the riparian zone

Cyathea australis	*Drymophila cyanocarpa*
Cyathea cunninghamii	*Ehrharta acuminata*
Cyathodes divaricata	*Ehrharta distichophylla*
Cyathodes glauca	*Ehrharta juncea*
Cyathodes juniperina	*Ehrharta* spp.
Cyathodes parvifolia	*Ehrharta stipoides*
Cyathodes pendulosa	*Ehrharta tasmanica*
Cyathodes platysoma	*Ehrharta tasmanica* var. *subalpina*
Cyathodes spp.	*Einadia nutans* subsp. *nutans*
Cynoglossum australe	*Eleocharis acuta*
Cyperaceae spp.	*Eleocharis gracilis*
Cyperus eragrostis	*Eleocharis pusilla*
Cyperus lucidus	*Elymus scaber*
Cyperus spp.	*Empodisma minus*
Cyphanthera tasmanica	*Epacris acuminata*
Cystopteris tasmanica	*Epacris apsleyensis*
Daviesia latifolia	*Epacris exserta*
Daviesia ulicifolia	*Epacris gunnii*
Deschampsia caespitosa	*Epacris impressa*
Deyeuxia carinata	*Epacris lanuginosa*
Deyeuxia densa	*Epacris mucronulata*
Deyeuxia gunniana	*Epacris obtusifolia*
Deyeuxia monticola	*Epacris petrophila*
Deyeuxia quadriseta	*Epacris serpyllifolia*
Deyeuxia spp.	*Epacris* spp.
Dianella tasmanica	*Epacris tasmanica*
Dichelachne crinita	*Epacris virgata*
Dichelachne micrantha	*Epilobium billardierianum*
Dichelachne spp.	*Epilobium billardierianum* subsp. *cinereum*
Dichondra repens	*Epilobium pallidiflorum*
Dichopogon strictus	*Epilobium rotundifolium*
Dicksonia antarctica	*Epilobium sarmentaceum*
Dillwynia glaberrima	*Epilobium* spp.
Dillwynia sericea	*Epilobium tasmanicum*
Diplarrena latifolia	*Erythranthera australis*
Diplarrena moraea	*Eucalyptus amygdalina*
Diplasium australe	*Eucalyptus archeri*
Diplaspis hydrocotyle	*Eucalyptus brookerana*
Discaria pubescens	*Eucalyptus coccifera*
Diselma archeri	*Eucalyptus dalrympleana*
Distichlis distichophylla	*Eucalyptus delegatensis*
Dodonaea filiformis	*Eucalyptus globulus*
Dodonaea viscosa	*Eucalyptus gunnii*
Doodia australis	*Eucalyptus nitida*
Doodia caudata	*Eucalyptus obliqua*
Drosera arcturi	*Eucalyptus ovata*
Drosera binata	*Eucalyptus pauciflora*
Drosera peltata	*Eucalyptus pulchella*
Drosera peltata subsp. *auriculata*	*Eucalyptus radiata* subsp. *robertsonii*
Drosera pygmaea	*Eucalyptus regnans*
Drosera spp.	*Eucalyptus rodwayi*

APPENDIX 5

List of vascular plant taxa (alphabetical) found in the riparian zone

Eucalyptus rubida	*Grammitis magellanica*
Eucalyptus sieberi	*Grammitis magellanica* subsp. *nothofageti*
Eucalyptus spp.	*Grammitis poeppigiana*
Eucalyptus subcrenulata	*Grammitis* spp.
Eucalyptus tenuiramis	*Gratiola nana*
Eucalyptus vernicosa	*Gratiola peruviana*
Eucalyptus viminalis	*Gratiola pubescens*
Euchiton argentifolius	*Grevillea australis*
Euchiton collinus	*Grevillea australis* var. *erecta*
Euchiton involucratus	*Grevillea australis* var. *linearifolia*
Euchiton sp.	*Grevillea australis* var. *montana*
Euchiton traversii	*Grevillea australis* var. *subulata*
Euchiton umbricola	*Grevillea australis* var. *tenuifolia*
Eucryphia lucida	*Gunnera cordifolia*
Eucryphia milliganii	*Gymnoschoenus sphaerocephalus*
Euphrasia collina	*Gynatrix pulchella*
Euphrasia striata	*Hakea epiglottis*
Eurychorda complanata	*Hakea lissosperma*
Exocarpos cupressiformis	*Hakea megadenia*
Exocarpos strictus	*Hakea microcarpa*
Festuca plebeia	*Hakea* spp.
Gahnia filum	*Haloragis heterophylla*
Gahnia grandis	*Helichrysum pumilum*
Gahnia sieberiana	*Helichrysum rutidolepis*
Gahnia spp.	*Helichrysum scorpioides*
Gahnia trifida	*Hemarthria uncinata*
Galium australe	*Hemichroa pentandra*
Galium ciliare	*Hibbertia aff. riparia*
Galium spp.	*Hibbertia empetrifolia*
Gaultheria hispida	*Hibbertia hirsuta*
Geranium potentilloides	*Hibbertia hirticalyx*
Geranium sessiliflorum	*Hibbertia procumbens*
Geranium solanderi	*Hibbertia prostrata*
Geranium spp.	*Hibbertia riparia*
Gleichenia alpina	*Hibbertia sericea*
Gleichenia dicarpa	*Hibbertia serpyllifolia*
Gleichenia microphylla	*Hierochloe fraseri*
Gonocarpus humilis	*Hierochloe redolens*
Gonocarpus micranthus	*Histiopteris incisa*
Gonocarpus montanus	*Hovea heterophylla*
Gonocarpus serpyllifolius	*Huperzia australianum*
Gonocarpus spp.	*Huperzia varia*
Gonocarpus tetragynus	*Hydrocotyle callicarpa*
Gonocarpus teucrioides	*Hydrocotyle capillaris*
Goodenia elongata	*Hydrocotyle hirta*
Goodenia humilis	*Hydrocotyle muscosa*
Goodenia lanata	*Hydrocotyle pterocarpa*
Goodenia ovata	*Hydrocotyle sibthorpioides*
Goodia lotifolia var. *lotifolia*	*Hydrocotyle* spp.
Goodia lotifolia var. *pubescens*	*Hymenanthera dentata*
Grammitis billardieri	*Hymenophyllum australe*

List of vascular plant taxa (alphabetical) found in the riparian zone

Hymenophyllum cupressiforme	*Juncus sarophorus*
Hymenophyllum flabellatum	*Juncus* spp.
Hymenophyllum marginatum	*Juncus subsecundus*
Hymenophyllum peltatum	*Juncus vaginatus*
Hymenophyllum rarum	*Kelleria dieffenbachii*
Hymenophyllum spp.	*Kunzea ambigua*
Hypericum gramineum	*Lagarostrobos franklinii*
Hypericum japonicum	*Lagenifera stipitata*
Hypolaena fastigiata	*Lastreopsis acuminata*
Hypolepis amaurorachis	*Lepidosperma concavum*
Hypolepis glandulifera	*Lepidosperma elatius*
Hypolepis muelleri	*Lepidosperma ensiforme*
Hypolepis rugosula	*Lepidosperma filiforme*
Hypolepis spp.	*Lepidosperma forsythii*
Hypoxis spp.	*Lepidosperma globosum*
Indigofera australis	*Lepidosperma gunnii*
Isoetes gunnii	*Lepidosperma inops*
Isolepis alpina	*Lepidosperma laterale*
Isolepis aucklandica	*Lepidosperma longitudinale*
Isolepis cernua	*Lepidosperma oldfieldii*
Isolepis crassiuscula	*Lepidosperma* spp.
Isolepis fluitans	*Leptinella longipes*
Isolepis inundata	*Leptinella reptans*
Isolepis marginata	*Leptocarpus tenax*
Isolepis montivaga	*Leptomeria drupacea*
Isolepis nodosa	*Leptorhynchos squamatus*
Isolepis producta	*Leptospermum glaucescens*
Isolepis spp.	*Leptospermum laevigatum*
Isolepis tasmanica	*Leptospermum lanigerum*
Isotoma fluviatilis	*Leptospermum nitidum*
Juncus acuminatus	*Leptospermum riparium*
Juncus amabilis	*Leptospermum rupestre*
Juncus antarcticus	*Leptospermum scoparium*
Juncus astreptus	*Leucopogon australis*
Juncus australis	*Leucopogon collinus*
Juncus bassianus	*Leucopogon ericoides*
Juncus caespiticius	*Leucopogon hookeri*
Juncus curtisiae	*Leucopogon lanceolatus*
Juncus falcatus	*Leucopogon montanus*
Juncus filicaulis	*Leucopogon oreophilus*
Juncus gregiflorus	*Leucopogon parviflorus*
Juncus holoschoenus	*Leucopogon virgatus*
Juncus kraussii	*Libertia pulchella*
Juncus pallidus	Lichen species
Juncus pauciflorus	*Lilaeopsis polyantha*
Juncus planifolius	Lily species
Juncus prismatocarpus	*Limosella australis*
Juncus procerus	*Linum albidum*
Juncus ratkowskyanus	*Linum marginale*
Juncus revolutus	*Linum* spp.
Juncus sandwithii	*Liparophyllum gunnii*

List of vascular plant taxa (alphabetical) found in the riparian zone

Lissanthe strigosa
Lobelia alata
Lomandra longifolia
Lomatia polymorpha
Lomatia tinctoria
Luzula densiflora
Luzula flaccida
Luzula modesta
Luzula poimena
Luzula spp.
Lycopodiella lateralis
Lycopodium deuterodensum
Lycopodium fastigiatum
Marsupial lawn
Mazus pumilio
Melaleuca ericifolia
Melaleuca gibbosa
Melaleuca pustulata
Melaleuca squamea
Melaleuca squarrosa
Mentha diemenica
Micrantheum hexandrum
Microsorum pustulatum
Microstrobos niphophilus
Milligania densiflora
Milligania longifolia
Mimulus repens
Mitrasacme pilosa
Mitrasacme pilosa var. *stuartii*
Monotoca elliptica
Monotoca empetrifolia
Monotoca glauca
Monotoca linifolia
Monotoca scoparia
Monotoca submutica
Moss species
Muehlenbeckia adpressa
Muehlenbeckia axillaris
Muehlenbeckia gunnii
Myriophyllum amphibium
Myriophyllum pedunculatum
Myriophyllum spp.
Nematolepis squamea
Nematolepis squamea subsp. *retusa*
Neopaxia australasica
Nertera depressa
Notelaea ligustrina
Nothofagus cunninghamii
Notodanthonia semiannularis
Nymphoides exigua
Odixia angusta

Olearia algida
Olearia argophylla
Olearia erubescens
Olearia floribunda
Olearia glandulosa
Olearia hookeri
Olearia lirata
Olearia obcordata
Olearia persoonioides
Olearia phlogopappa
Olearia phlogopappa var. *brevipes*
Olearia phlogopappa var. *microcephala*
Olearia phlogopappa var. *subrepanda*
Olearia pinifolia
Olearia stellulata
Olearia tasmanica
Olearia viscosa
Orchidaceae spp.
Oreobolus oxycarpus
Oreobolus spp.
Oreomyrrhis ciliata
Oreomyrrhis eriopoda
Oreomyrrhis gunnii
Oreomyrrhis sessiliflora
Oreomyrrhis spp.
Orites acicularis
Orites diversifolia
Orites revoluta
Ourisia integrifolia
Oxalis magellanica
Oxalis perennans
Oxalis spp.
Oxylobium arborescens
Oxylobium ellipticum
Ozothamnus antennaria
Ozothamnus ericifolius
Ozothamnus expansifolius
Ozothamnus ferrugineus
Ozothamnus hookeri
Ozothamnus ledifolius
Ozothamnus obcordatus
Ozothamnus purpurascens
Ozothamnus rosmarinifolius
Ozothamnus scutellifolius
Ozothamnus spp.
Ozothamnus thyrsoideus
Ozothamnus turbinatus
Parsonsia brownii
Patersonia fragilis
Patersonia occidentalis
Pelargonium australe

List of vascular plant taxa (alphabetical) found in the riparian zone

Pelargonium spp.
Pellaea falcata
Pentachondra involucrata
Pentapogon quadrifidus
Persicaria praetermissa
Persoonia gunnii
Persoonia juniperina
Persoonia muelleri
Philotheca verrucosa
Philotheca virgata
Phragmites australis
Phyllanthus australis
Phyllanthus gunnii
Phyllocladus aspleniifolius
Picris angustifolia
Pimelea cinerea
Pimelea drupacea
Pimelea filiformis
Pimelea flava
Pimelea glauca
Pimelea humilis
Pimelea ligustrina
Pimelea linifolia
Pimelea nivea
Pimelea pauciflora
Pimelea sericea
Pimelea spp.
Pittosporum bicolor
Pittosporum undulatum subsp. *Xemmettii*
Plantago antarctica
Plantago bellidioides
Plantago coronopus
Plantago daltonii
Plantago glabrata
Plantago glacialis
Plantago hispida
Plantago paradoxa
Plantago spp.
Plantago tasmanica
Plantago triantha
Poa clelandii
Poa costiniana
Poa fawcettiae
Poa gunnii
Poa hiemata
Poa hookeri
Poa labillardierei
Poa labillardierei var. *acris*
Poa mollis
Poa rodwayi
Poa sieberiana

Poa spp.
Poa tenera
Poaceae spp.
Podocarpus lawrencei
Polycarpon tetraphyllum
Polystichum proliferum
Pomaderris apetala
Pomaderris aspera
Pomaderris elachophylla
Pomaderris elliptica
Pomaderris oraria
Pomaderris paniculosa
Pomaderris phylicifolia
Pomaderris pilifera
Pomaderris racemosa
Pomaderris spp.
Poranthera microphylla
Potamogeton australiensis
Potamogeton tricarinatus
Prasophyllum spp.
Pratia pedunculata
Pratia spp.
Pratia surrepens
Prionotes cerinthoides
Prostanthera lasianthos
Prostanthera rotundifolia
Pseudognaphalium luteo-album
Pteridium esculentum
Pteridophyta spp.
Pteris comans
Pterostylis melagramma
Pterostylis nutans
Pterostylis spp.
Pultenaea daphnoides
Pultenaea fasciculata
Pultenaea gunnii
Pultenaea gunnii var. *baeckeoides*
Pultenaea gunnii var. *gunnii*
Pultenaea juniperina
Pultenaea stricta
Ranunculus amphitrichus
Ranunculus arvensis
Ranunculus collinus
Ranunculus decurvus
Ranunculus glabrifolius
Ranunculus gunnianus
Ranunculus lappaceus
Ranunculus nanus
Ranunculus pascuinus
Ranunculus pimpinellifolius
Ranunculus scapigerus

APPENDIX 5

List of vascular plant taxa (alphabetical) found in the riparian zone

Ranunculus spp.	*Spyridium gunnii*
Ranunculus triplodontus	*Spyridium lawrencei*
Restionacaea spp.	*Spyridium obcordatum*
Rhagodia candolleana	*Spyridium obovatum* var. *obovatum*
Rhytidosporum alpinum	*Spyridium obovatum* var. *velutinum*
Rhytidosporum procumbens	*Spyridium ulicinum*
Richea acerosa	*Stackhousia gunnii*
Richea dracophylla	*Stackhousia monogyna*
Richea gunnii	*Stellaria flaccida*
Richea milliganii	*Stellaria pungens*
Richea pandanifolia	*Sticherus lobatus*
Richea procera	*Sticherus tener*
Richea scoparia	*Sticherus urceolatus*
Rorippa dictyosperma	*Stylidium graminifolium*
Rubus gunnianus	*Styphelia adscendens*
Rubus parvifolius	*Tasmannia lanceolata*
Rubus spp.	*Telopea truncata*
Rumex brownii	*Tetracarpaea tasmanica*
Rumex dumosus	*Tetragonia implexicoma*
Rumex spp.	*Tetraria capillaris*
Rumohra adiantiformis	*Tetratheca aff. pilosa*
Rytidosperma nudiflorum	*Tetratheca pilosa*
Sagina diemensis	*Tetratheca procumbens*
Sagina spp.	*Tetratheca* spp.
Samolus repens	*Teucrium corymbosum*
Sarcocornia blackiana	*Thelymitra* spp.
Schoenus apogon	*Themeda triandra*
Schoenus brevifolius	*Tmesipteris obliqua*
Schoenus calyptratus	*Tmesipteris* spp.
Schoenus carsei	*Todea barbara*
Schoenus fluitans	*Trachymene anisocarpa*
Schoenus latelaminatus	*Trachymene humilis*
Schoenus lepidosperma subs. lepidosperma	*Triglochin procerum*
Schoenus maschalinus	*Triglochin* spp.
Schoenus nitens	*Triglochin striatum*
Schoenus pygmaeus	*Trochocarpa cunninghamii*
Schoenus spp.	*Trochocarpa disticha*
Schoenus/Isolepis spp.	*Trochocarpa gunnii*
Scleranthus biflorus	*Trochocarpa thymifolia*
Selaginella uliginosa	*Typha domingensis*
Selliera radicans	*Typha* spp.
Senecio glomeratus	*Uncinia elegans*
Senecio gunnii	*Uncinia flaccida*
Senecio hispidulus	*Uncinia nervosa*
Senecio lautus	*Uncinia riparia*
Senecio linearifolius	*Uncinia* spp.
Senecio minimus	*Uncinia tenella*
Senecio spp.	*Urtica incisa*
Solenogyne gunnii	*Utricularia dichotoma*
Sporadanthus tasmanicus	*Utricularia monanthos*
Sprengelia incarnata	*Utricularia* spp.

APPENDIX 5

List of vascular plant taxa (alphabetical) found in the riparian zone

Velleia montana
Veronica calycina
Veronica formosa
Veronica gracilis
Veronica spp.
Villarsia reniformis
Viola betonicifolia
Viola cunninghamii
Viola hederacea
Viola spp.
Wahlenbergia ceracea
Wahlenbergia gracilenta
Wahlenbergia gracilis
Wahlenbergia gymnoclada
Wahlenbergia saxicola
Wahlenbergia spp.
Wahlenbergia stricta
Westringia angustifolia
Westringia rubiaefolia
Wurmbea uniflora
Xanthorrhoea spp.
Xanthosia dissecta
Xyris gracilis
Xyris marginata
Xyris muelleri
Xyris operculata
Xyris tasmanica
Zieria arborescens
Zoysia macrantha

APPENDIX 6

Percentage frequency of vascular species found in more than 30% of sites in Groups 1-21

Group 1	Percentage Frequency (%)	Group 2	Percentage Frequency (%)
Agrostis species	100.00	Moss species	100
Baeckea gunniana	100.00	*Baeckea gunniana*	100
Empodisma minus	100.00	*Sprengelia incarnata*	80
Hierochloe redolens	100.00	*Rubus gunnianus*	80
Acaena montana	83.33	*Oxylobium ellipticum*	80
Baloskion australe	83.33	Lichen species	80
Geranium potentilloides	83.33	*Lepidosperma filiforme*	80
Grevillea australis var. *montana*	83.33	*Gleichenia alpina*	80
Leptospermum rupestre	83.33	*Epacris lanuginosa*	80
Ozothamnus hookeri	83.33	*Empodisma minus*	80
Ranunculus triplodontus	83.33	*Bauera rubioides*	80
Austrodanthonia species	66.67	*Baloskion australe*	80
Bellendena montana	66.67	*Pultenaea juniperina*	60
Carex gaudichaudiana	66.67	*Poa* species	60
Hydrocotyle muscosa	66.67	*Lomatia polymorpha*	60
Marsupial lawn	66.67	*Leptospermum lanigerum*	60
Orites acicularis	66.67	*Gymnoschoenus sphaerocephalus*	60
Plantago paradoxa	66.67	*Diplarrena moraea*	60
Poa costiniana	66.67	*Dichelachne* species	60
Epacris gunnii	50.00	*Calorophus elongatus*	60
Geranium sessiliflorum	50.00	*Allocasuarina zephyrea*	60
Gonocarpus serpyllifolius	50.00	*Tasmannia lanceolata*	40
Hydrocotyle hirta	50.00	*Pratia surrepens*	40
Hypericum japonicum	50.00	*Nymphoides exigua*	40
Isotoma fluviatilis	50.00	*Melaleuca squamea*	40
Poa species	50.00	*Lomatia tinctoria*	40
Pratia pedunculata	50.00	*Hakea microcarpa*	40
Senecio gunnii	50.00	*Hakea lissosperma*	40
Viola cunninghamii	50.00	*Gahnia grandis*	40
Acaena novae-zelandiae	33.33	*Eucalyptus pauciflora*	40
Almaleea subumbellata	33.33	*Epacris gunnii*	40
Bauera rubioides	33.33	*Ehrharta tasmanica*	40
Carex species	33.33	*Diplarrena latifolia*	40
Helichrysum rutidolepis	33.33	*Cotula alpina*	40
Juncus sandwithii	33.33	*Coprosma nitida*	40
Leptinella reptans	33.33	*Carex gaudichaudiana*	40
Leptospermum lanigerum	33.33	*Callistemon viridiflorus*	40
Lichen species	33.33	*Austrostipa* species	40
Lycopodium fastigiatum	33.33	*Astelia alpina*	40
Mimulus repens	33.33	*Almaleea subumbellata*	40
Moss species	33.33	*Acaena montana*	40
Myriophyllum species	33.33		
Nymphoides exigua	33.33		
Orites revoluta	33.33		
Plantago daltoni	33.33		
Poaceae species	33.33		
Ranunculus species	33.33		
Richea gunniana	33.33		
Veronica gracilis	33.33		

APPENDIX 6

Percentage frequency of vascular species found in more than 30% of sites in Groups 1-21

Group 3	Percentage Frequency (%)	Group 4	Percentage Frequency (%)
Leptospermum lanigerum	90.91	*Lomandra longifolia*	85.71
Epacris gunnii	81.82	*Melaleuca ericifolia*	85.71
Geranium potentilloides	81.82	*Pteridium esculentum*	85.71
Baloskion australe	72.73	*Acacia verticillata*	71.43
Carex gaudichaudiana	72.73	*Banksia marginata*	71.43
Cyathodes parvifolia	72.73	*Bursaria spinosa*	71.43
Empodisma minus	72.73	*Pomaderris apetala*	71.43
Acaena novae-zelandiae	63.64	*Eucalyptus amygdalina*	64.29
Bauera rubioides	63.64	Moss species	64.29
Eucalyptus gunnii	63.64	*Exocarpos cupressiformis*	57.14
Hypericum japonicum	63.64	*Lepidosperma ensiforme*	57.14
Pultenaea juniperina	63.64	*Leptinella longipes*	57.14
Callistemon viridiflorus	54.55	*Leptospermum scoparium*	57.14
Gonocarpus montanus	54.55	*Agrostis* species	50.00
Hydrocotyle hirta	54.55	*Dianella tasmanica*	50.00
Juncus australis	54.55	*Eucalyptus viminalis*	50.00
Marsupial lawn	54.55	*Gahnia filum*	50.00
Moss species	54.55	*Acaena novae-zelandiae*	42.86
Tasmannia lanceolata	54.55	*Eucalyptus ovata*	42.86
Agrostis species	45.45	*Oxalis perennans*	42.86
Blechnum penna-marina	45.45	*Phragmites australis*	42.86
Coprosma nitida	45.45	*Poa labillardierei*	42.86
Lichen species	45.45	*Schoenus nitens*	42.86
Austrodanthonia species	36.36	*Acacia dealbata*	35.71
Blechnum nudum	36.36	*Acacia sophorae*	35.71
Epacris lanuginosa	36.36	*Coprosma quadrifida*	35.71
Epilobium billardierianum	36.36	*Eucalyptus obliqua*	35.71
Eucalyptus pauciflora	36.36	*Gonocarpus teucrioides*	35.71
Gonocarpus serpyllifolius	36.36	*Lepidosperma elatius*	35.71
Grevillea australis var. *montana*	36.36	*Leucopogon australis*	35.71
Hakea microcarpa	36.36	*Melaleuca squarrosa*	35.71
Hydrocotyle sibthorpioides	36.36	*Pultenaea daphnoides*	35.71
Oxalis perennans	36.36		
Ozothamnus hookeri	36.36		
Plantago paradoxa	36.36		
Poa labillardierei	36.36		
Poa species	36.36		

APPENDIX 6

Percentage frequency of vascular species found in more than 30% of sites in Groups 1-21

Group 5	Percentage Frequency (%)	Group 6	Percentage Frequency (%)
Pteridium esculentum	88.57	*Leptospermum lanigerum*	88.89
Melaleuca squarrosa	77.14	*Lomandra longifolia*	88.89
Moss species	68.57	*Eucalyptus amygdalina*	77.78
Acacia verticillata	65.71	*Hakea microcarpa*	77.78
Leptospermum scoparium	65.71	*Poa labillardierei*	77.78
Blechnum nudum	62.86	*Acacia dealbata*	66.67
Gahnia grandis	62.86	*Acaena novae-zelandiae*	66.67
Leptospermum lanigerum	62.86	*Bursaria spinosa*	66.67
Banksia marginata	60.00	*Epacris gunnii*	66.67
Pomaderris apetala	60.00	*Eucalyptus viminalis*	66.67
Acacia melanoxylon	57.14	*Leptospermum scoparium*	66.67
Acaena novae-zelandiae	54.29	*Pomaderris apetala*	66.67
Lepidosperma ensiforme	54.29	*Themeda triandra*	66.67
Coprosma quadrifida	51.43	*Acacia mucronata*	55.56
Eucalyptus amygdalina	51.43	*Astroloma humifusum*	55.56
Eucalyptus ovata	51.43	*Callitris oblonga*	55.56
Lomandra longifolia	51.43	*Callistemon viridiflorus*	55.56
Eucalyptus obliqua	42.86	*Carex appressa*	55.56
Gonocarpus teucrioides	42.86	*Hibbertia riparia*	55.56
Agrostis species	40.00	*Lepidosperma inops*	55.56
Melaleuca ericifolia	40.00	*Acacia verticillata*	44.44
Acacia dealbata	37.14	*Allocasuarina littoralis*	44.44
Dianella tasmanica	37.14	*Bauera rubioides*	44.44
Epacris impressa	37.14	*Baumea juncea*	44.44
Lichen species	37.14	*Epacris apsleyensis*	44.44
Carex appressa	34.29	*Exocarpos cupressiformis*	44.44
Gleichenia microphylla	34.29	*Hydrocotyle hirta*	44.44
Pimelea drupacea	34.29	*Hypericum japonicum*	44.44
Blechnum minus	31.43	*Juncus* species	44.44
Hydrocotyle hirta	31.43	*Micrantheum hexandrum*	44.44
Poaceae species	31.43	*Oxalis perennans*	44.44
		Poaceae species	44.44
		Wahlenbergia species	44.44
		Acacia genistifolia	33.33
		Baloskion australe	33.33
		Banksia marginata	33.33
		Diplarrena moraea	33.33
		Eucalyptus ovata	33.33
		Grevillea australis var. *subulata*	33.33
		Grevillea australis var. *tenuifolia*	33.33
		Hibbertia prostrata	33.33
		Hibbertia serpyllifolia	33.33
		Juncus australis	33.33
		Lagenifera stipitata	33.33
		Lepidosperma elatius	33.33
		Lepidosperma laterale	33.33
		Moss species	33.33
		Ozothamnus ferrugineus	33.33

Percentage frequency of vascular species found in more than 30% of sites in Groups 1-21

Group 7	Percentage Frequency (%)	Group 8	Percentage Frequency (%)
Pomaderris apetala	87.93	*Pomaderris apetala*	93.02
Lomandra longifolia	82.76	*Acacia dealbata*	90.70
Acacia verticillata	81.03	*Blechnum nudum*	88.37
Acacia dealbata	75.86	*Acaena novae-zelandiae*	86.05
Pteridium esculentum	75.86	*Pteridium esculentum*	81.40
Eucalyptus viminalis	74.14	*Coprosma quadrifida*	79.07
Leptospermum lanigerum	74.14	*Cassinia aculeata*	76.74
Acaena novae-zelandiae	72.41	*Leptospermum lanigerum*	69.77
Moss species	68.97	Moss species	65.12
Beyeria viscosa	62.07	*Blechnum wattsii*	65.12
Exocarpos cupressiformis	62.07	*Gahnia grandis*	60.47
Poa labillardierei	62.07	*Acacia melanoxylon*	60.47
Allocasuarina littoralis	60.34	*Oxalis perennans*	53.49
Bursaria spinosa	58.62	*Eucalyptus obliqua*	53.49
Coprosma quadrifida	58.62	*Polystichum proliferum*	51.16
Acacia melanoxylon	53.45	*Carex appressa*	51.16
Eucalyptus globulus	50.00	*Beyeria viscosa*	51.16
Eucalyptus amygdalina	48.28	*Dicksonia antarctica*	46.51
Lepidosperma laterale	48.28	*Viola hederacea*	41.86
Carex appressa	44.83	*Eucalyptus viminalis*	41.86
Cassinia aculeata	44.83	*Eucalyptus regnans*	41.86
Lepidosperma ensiforme	44.83	*Bedfordia salicina*	41.86
Acacia mucronata	41.38	*Prostanthera lasianthos*	39.53
Juncus species	36.21	*Lomatia tinctoria*	39.53
Oxalis perennans	36.21	*Gonocarpus teucrioides*	37.21
Eucalyptus obliqua	34.48	*Eucalyptus amygdalina*	37.21
Banksia marginata	32.76	*Dianella tasmanica*	37.21
Gahnia grandis	32.76	*Clematis aristata*	37.21
Leptospermum scoparium	31.03	*Senecio linearifolius*	34.88
Poaceae species	31.03	*Pimelea drupacea*	34.88
Viola hederacea	31.03	*Olearia lirata*	34.88
		Juncus species	34.88
		Agrostis species	34.88
		Pultenaea juniperina	32.56
		Hypericum japonicum	32.56
		Acacia verticillata	32.56
		Olearia argophylla	30.23
		Hydrocotyle hirta	30.23

Percentage frequency of vascular species found in more than 30% of sites in Groups 1-21

Group 9	Percentage Frequency (%)	Group 9 (contd)	Percentage Frequency (%)
Moss species	93.94	*Geranium potentilloides*	36.36
Pteridium esculentum	90.91	*Melaleuca ericifolia*	33.33
Pomaderris apetala	90.91	*Tasmannia lanceolata*	30.30
Coprosma quadrifida	90.91	*Pultenaea juniperina*	30.30
Acacia dealbata	87.88	*Juncus pauciflorus*	30.30
Blechnum nudum	81.82	*Gratiola peruviana*	30.30
Leptospermum lanigerum	75.76		
Acaena novae-zelandiae	75.76		
Acacia melanoxylon	75.76		
Carex appressa	72.73		
Polystichum proliferum	69.70		
Clematis aristata	66.67		
Eucalyptus viminalis	63.64	**Group 10**	
Pittosporum bicolor	60.61	*Acacia dealbata*	91.84
Olearia lirata	60.61	*Eucalyptus viminalis*	87.76
Lichen species	60.61	*Lomandra longifolia*	87.76
Oxalis perennans	54.55	*Poa labillardierei*	85.71
Lomandra longifolia	54.55	*Pteridium esculentum*	81.63
Lepidosperma ensiforme	54.55	*Pomaderris apetala*	79.59
Eucalyptus obliqua	54.55	*Carex appressa*	75.51
Agrostis species	54.55	*Acaena novae-zelandiae*	73.47
Viola hederacea	51.52	*Cassinia aculeata*	65.31
Senecio hispidulus	51.52	Moss species	65.31
Cassinia aculeata	51.52	Poaceae species	63.27
Poa labillardierei	48.48	*Leptospermum lanigerum*	61.22
Pimelea drupacea	48.48	*Acacia melanoxylon*	55.10
Eucalyptus ovata	48.48	*Eucalyptus amygdalina*	55.10
Dianella tasmanica	48.48	*Oxalis perennans*	53.06
Blechnum wattsii	48.48	*Coprosma quadrifida*	51.02
Isolepis species	45.45	*Bursaria spinosa*	48.98
Gonocarpus teucrioides	45.45	*Geranium potentilloides*	40.82
Exocarpos cupressiformis	45.45	*Polystichum proliferum*	40.82
Prostanthera lasianthos	42.42	*Beyeria viscosa*	36.73
Notelaea ligustrina	42.42	*Juncus astreptus*	36.73
Eucalyptus amygdalina	42.42		
Bursaria spinosa	42.42		
Poaceae species	39.39		
Ozothamnus ferrugineus	39.39		
Lomatia tinctoria	39.39		
Hydrocotyle hirta	39.39		
Gahnia grandis	39.39		
Dicksonia antarctica	39.39		
Blechnum minus	39.39		
Beyeria viscosa	39.39		
Acacia verticillata	39.39		
Zieria arborescens	36.36		
Schoenus species	36.36		
Lepidosperma laterale	36.36		

APPENDIX 6

Percentage frequency of vascular species found in more than 30% of sites in Groups 1-21

Group 11	Percentage Frequency (%)	Group 12	Percentage Frequency (%)
Leptospermum lanigerum	100.00	*Geranium potentilloides*	100.0
Pultenaea juniperina	75.00	*Hydrocotyle hirta*	100.0
Moss species	75.00	*Acaena novae-zelandiae*	87.5
Acaena novae-zelandiae	68.75	*Leptinella reptans*	87.5
Poa labillardierei	62.50	Moss species	87.5
Poaceae species	56.25	*Blechnum penna-marina*	75.0
Eucalyptus pauciflora	56.25	*Cyathodes parvifolia*	75.0
Cyathodes parvifolia	56.25	Lichen species	75.0
Banksia marginata	56.25	*Coprosma nitida*	62.5
Poa species	50.00	*Eucalyptus delegatensis*	62.5
Lomatia tinctoria	50.00	*Gonocarpus montanus*	62.5
Hakea microcarpa	50.00	*Hypericum japonicum*	62.5
Hakea lissosperma	50.00	*Juncus australis*	62.5
Geranium potentilloides	50.00	*Lagenifera stipitata*	62.5
Bauera rubioides	50.00	*Oxalis perennans*	62.5
Acacia dealbata	50.00	*Tasmannia lanceolata*	62.5
Tasmannia lanceolata	43.75	*Agrostis* species	50.0
Oxylobium ellipticum	43.75	*Blechnum nudum*	50.0
Eucalyptus viminalis	43.75	*Carex appressa*	50.0
Eucalyptus delegatensis	43.75	*Euchiton involucratus*	50.0
Eucalyptus amygdalina	43.75	*Polystichum proliferum*	50.0
Cassinia aculeata	43.75	*Acacia dealbata*	37.5
Olearia phlogopappa	37.50	*Bauera rubioides*	37.5
Notelaea ligustrina	37.50	*Carex gaudichaudiana*	37.5
Lomandra longifolia	37.50	*Epacris gunnii*	37.5
Juncus astreptus	37.50	*Euchiton* species	37.5
Eucalyptus ovata	37.50	*Gonocarpus micranthus*	37.5
Epacris gunnii	37.50	*Hakea microcarpa*	37.5
Schoenus species	31.25	*Hydrocotyle sibthorpioides*	37.5
Polystichum proliferum	31.25	*Leptospermum lanigerum*	37.5
Hypericum japonicum	31.25	*Olearia phlogopappa*	37.5
Hydrocotyle hirta	31.25	*Poa labillardierei*	37.5
Gahnia grandis	31.25	*Pultenaea juniperina*	37.5
		Viola hederacea	37.5

APPENDIX 6

Percentage frequency of vascular species found in more than 30% of sites in Groups 1-21

Group 13	Percentage Frequency (%)	Group 13 (continued)	Percentage Frequency (%)
Nothofagus cunninghamii	100.00	*Clematis aristata*	33.33
Moss species	100.00	*Cassinia aculeata*	33.33
Lichen species	100.00	*Blechnum penna-marina*	33.33
Atheroperma moschatum	100.00	*Blechnum fluviatile*	33.33
Tasmannia lanceolata	83.33	*Anopterus glandulosus*	33.33
Oxalis perennans	83.33	*Anodopetalum biglandulosum*	33.33
Libertia pulchella	83.33	*Agrostis* species	33.33
Leptospermum lanigerum	83.33	*Acacia mucronata*	33.33
Aristotelia pedunculata	83.33		
Viola hederacea	66.67		
Uncinia tenella	66.67		
Polystichum proliferum	66.67		
Poa labillardierei	66.67		
Pimelea drupacea	66.67	**Group 14**	
Dicksonia antarctica	66.67	*Dicksonia antarctica*	97.06
Cyathodes juniperina	66.67	*Blechnum nudum*	91.18
Coprosma quadrifida	66.67	*Polystichum proliferum*	91.18
Carex appressa	66.67	Moss species	88.24
Blechnum nudum	66.67	Lichen species	85.29
Acaena novae-zelandiae	66.67	*Coprosma quadrifida*	82.35
Acacia dealbata	66.67	*Pomaderris apetala*	82.35
Schoenus species	50.00	*Atherosperma moschatum*	79.41
Pomaderris apetala	50.00	*Acacia melanoxylon*	76.47
Poa species	50.00	*Nothofagus cunninghamii*	76.47
Ozothamnus thyrsoideus	50.00	*Histiopteris incisa*	70.59
Lagenifera stipitata	50.00	*Acacia dealbata*	67.65
Hydrocotyle hirta	50.00	*Microsorum pustulatum*	67.65
Histiopteris incisa	50.00	*Pimelea drupacea*	64.71
Blechnum wattsii	50.00	*Blechnum wattsii*	61.76
Acacia melanoxylon	50.00	*Olearia argophylla*	61.76
Telopea truncata	33.33	*Acaena novae-zelandiae*	58.82
Schoenus nitens	33.33	*Carex appressa*	55.88
Pultenaea juniperina	33.33	*Hydrocotyle hirta*	55.88
Prostanthera lasianthos	33.33	*Juncus pauciflorus*	50.00
Pittosporum bicolor	33.33	*Pittosporum bicolor*	47.06
Pimelea ligustrina	33.33	*Oxalis perennans*	44.12
Phyllocladus aspleniifolius	33.33	*Leptospermum lanigerum*	41.18
Oxalis magellanica	33.33	*Olearia lirata*	41.18
Olearia phlogopappa	33.33	*Urtica incisa*	41.18
Nematolepis squamea	33.33	*Viola hederacea*	41.18
Juncus species	33.33	*Monotoca glauca*	38.24
Juncus pauciflorus	33.33	*Rumohra adiantiformis*	38.24
Geranium potentilloides	33.33	*Cassinia aculeata*	32.35
Galium australe	33.33	*Hypolepis rugosula*	32.35
Gahnia grandis	33.33		
Euchiton species	33.33		
Eucalyptus delegatensis	33.33		
Drymophila cyanocarpa	33.33		

APPENDIX 6

Percentage frequency of vascular species found in more than 30% of sites in Groups 1-21

Group 15	Percentage Frequency (%)	Group 16	Percentage Frequency (%)
Pomaderris apetala	95.24	*Acacia dealbata*	100.00
Dicksonia antarctica	90.48	*Dicksonia antarctica*	100.00
Moss species	90.48	*Olearia argophylla*	100.00
Olearia lirata	90.48	*Pomaderris apetala*	100.00
Acacia melanoxylon	85.71	*Blechnum nudum*	88.89
Acacia dealbata	80.95	*Coprosma quadrifida*	88.89
Blechnum nudum	80.95	Moss species	88.89
Coprosma quadrifida	80.95	*Viola hederacea*	88.89
Pteridium esculentum	80.95	*Atherosperma moschatum*	77.78
Blechnum wattsii	76.19	*Nothofagus cunninghamii*	77.78
Eucalyptus obliqua	76.19	*Tasmannia lanceolata*	77.78
Pimelea drupacea	76.19	*Acaena novae-zelandiae*	66.67
Polystichum proliferum	71.43	*Blechnum wattsii*	66.67
Cassinia aculeata	66.67	*Eucalyptus regnans*	66.67
Gahnia grandis	66.67	*Pimelea drupacea*	66.67
Lichen species	66.67	*Acacia melanoxylon*	55.56
Nothofagus cunninghamii	66.67	*Clematis aristata*	55.56
Acaena novae-zelandiae	61.90	*Eucalyptus delegatensis*	55.56
Blechnum minus	61.90	*Gahnia grandis*	55.56
Histiopteris incisa	61.90	*Leptospermum lanigerum*	55.56
Carex appressa	57.14	*Nematolepis squamea*	55.56
Hydrocotyle hirta	57.14	*Pteridium esculentum*	55.56
Leptospermum lanigerum	57.14	*Schoenus maschalinus*	55.56
Pittosporum bicolor	57.14	*Zieria arborescens*	55.56
Zieria arborescens	57.14	*Agrostis* species	44.44
Agrostis species	52.38	*Aristotelia pedunculata*	44.44
Acacia mucronata	47.62	*Cassinia aculeata*	44.44
Atherosperma moschatum	47.62	*Correa lawrenceana*	44.44
Clematis aristata	47.62	*Dianella tasmanica*	44.44
Gonocarpus teucrioides	47.62	*Euchiton collinus*	44.44
Prostanthera lasianthos	47.62	Lichen species	44.44
Viola hederacea	47.62	*Monotoca glauca*	44.44
Dianella tasmanica	42.86	Poaceae species	44.44
Monotoca glauca	42.86	*Polystichum proliferum*	44.44
Pultenaea juniperina	42.86	*Pultenaea juniperina*	44.44
Nematolepis squamea	38.10	*Schoenus* species	44.44
Sticherus tener	38.10	*Billardiera longiflora*	33.33
Eucalyptus regnans	33.33	*Blechnum fluviatile*	33.33
Eucalyptus viminalis	33.33	*Cyathodes glauca*	33.33
Lepidosperma ensiforme	33.33	*Galium australe*	33.33
Microsorum pustulatum	33.33	*Gaultheria hispida*	33.33
		Gleichenia microphylla	33.33
		Oxalis perennans	33.33
		Pimelea cinerea	33.33

APPENDIX 6

Percentage frequency of vascular species found in more than 30% of sites in Groups 1-21

Group 17	Percentage Frequency (%)	Group 17 (continued)	Percentage Frequency (%)
Nothofagus cunninghamii	97.96	*Isolepis* species	30.61
Moss species	93.88	*Pittosporum bicolor*	30.61
Acacia melanoxylon	91.84		
Blechnum nudum	91.84		
Eucryphia lucida	87.76		
Dicksonia antarctica	83.67		
Leptospermum scoparium	79.59	**Group 18**	
Acacia mucronata	77.55	*Blechnum nudum*	92.31
Gahnia grandis	77.55	*Gahnia grandis*	92.31
Leptospermum lanigerum	77.55	*Leptospermum lanigerum*	84.62
Pomaderris apetala	75.51	*Nothofagus cunninghamii*	84.62
Lichen species	73.47	*Acacia verticillata*	76.92
Blechnum wattsii	69.39	*Eucryphia lucida*	76.92
Monotoca glauca	69.39	*Leptospermum scoparium*	76.92
Nematolepis squamea	67.35	*Pomaderris apetala*	69.23
Anopterus glandulosus	65.31	*Acacia melanoxylon*	61.54
Histiopteris incisa	61.22	*Blechnum wattsii*	61.54
Pimelea drupacea	61.22	*Gleichenia microphylla*	61.54
Polystichum proliferum	61.22	*Melaleuca squarrosa*	61.54
Gleichenia microphylla	59.18	*Monotoca glauca*	61.54
Tasmannia lanceolata	57.14	*Sticherus tener*	61.54
Atherosperma moschatum	55.10	*Anopterus glandulosus*	53.85
Baloskion tetraphyllum	55.10	*Pimelea drupacea*	53.85
Eucalyptus obliqua	55.10	*Acacia dealbata*	46.15
Coprosma quadrifida	53.06	*Coprosma quadrifida*	46.15
Carex appressa	48.98	*Dicksonia antarctica*	46.15
Sticherus tener	48.98	*Eucalyptus regnans*	46.15
Acaena novae-zelandiae	44.90	Moss species	46.15
Leptospermum riparium	44.90	*Olearia stellulata*	46.15
Pteridium esculentum	44.90	*Tasmannia lanceolata*	46.15
Acacia verticillata	42.86	*Acaena novae-zelandiae*	38.46
Hydrocotyle hirta	42.86	*Cassinia aculeata*	38.46
Prostanthera lasianthos	42.86	*Drymophila cyanocarpa*	38.46
Clematis aristata	40.82	*Gonocarpus teucrioides*	38.46
Dianella tasmanica	40.82	*Nematolepis squamea*	38.46
Juncus pauciflorus	40.82	*Orites diversifolia*	38.46
Epacris impressa	38.78	*Viola hederacea*	38.46
Juncus species	38.78	*Acacia riceana*	30.77
Phyllocladus aspleniifolius	38.78	*Bauera rubioides*	30.77
Viola hederacea	38.78	*Epacris impressa*	30.77
Eucalyptus nitida	36.73	*Juncus* species	30.77
Acacia dealbata	34.69	*Pimelea cinerea*	30.77
Cyathodes juniperina	32.65	*Prostanthera lasianthos*	30.77
Melaleuca squarrosa	32.65		
Microsorum pustulatum	32.65		
Blechnum minus	30.61		
Cenarrhenes nitida	30.61		
Hypolepis rugosula	30.61		

APPENDIX 6

Percentage frequency of vascular species found in more than 30% of sites in Groups 1-21

Group 19	Percentage Frequency (%)	Group 20	Percentage Frequency (%)
Nothofagus cunninghamii	100.00	*Acacia mucronata*	87.50
Moss species	94.74	*Bauera rubioides*	87.50
Atherosperma moschatum	84.21	*Eucalyptis nitida*	87.50
Eucryphia lucida	84.21	Moss species	87.50
Libertia pulchella	78.95	*Gleichenia dicarpa*	75.00
Lichen species	78.95	*Leptospermum nitidum*	75.00
Blechnum nudum	73.68	*Melaleuca squamea*	75.00
Anopterus glandulosus	68.42	*Baloskion tetraphyllum*	62.50
Dicksonia antarctica	68.42	*Banksia marginata*	62.50
Acacia melanoxylon	63.16	*Epacris impressa*	62.50
Acaena novae-zelandiae	63.16	*Gahnia grandis*	62.50
Microsorum pustulatum	63.16	*Gymnoschoenus sphaerocephalus*	62.50
Phyllocladus aspleniifolius	63.16	*Leptocarpus texax*	62.50
Polystichum proliferum	63.16	*Leptospermum scoparium*	62.50
Viola hederacea	63.16	*Sprengelia incarnata*	62.50
Pimelea drupacea	57.89	*Ehrharta* species	50.00
Blechnum wattsii	52.63	*Ehrharta tasmanica*	50.00
Cenarrhenes nitida	52.63	*Empodisma minus*	50.00
Gahnia grandis	52.63	*Epacris gunnii*	50.00
Histiopteris incisa	52.63	*Epacris lanuginosa*	50.00
Leptospermum lanigerum	52.63	*Eurychorda complanata*	50.00
Tasmannia lanceolata	52.63	*Gonocarpus teucrioides*	50.00
Anodopetalum biglandulosum	47.37	*Hakea megadenia*	50.00
Coprosma quadrifida	47.37	*Leptospermum glaucescens*	50.00
Gaultheria hispida	47.37	*Melaleuca squarrosa*	50.00
Hypolepis rugosula	47.37	*Pultenaea juniperina*	50.00
Sticherus tener	47.37	*Sticherus tener*	50.00
Trochocarpa cunninghamii	47.37	*Blechnum minus*	37.50
Carex appressa	42.11	*Blechnum nudum*	37.50
Grammitis billardieri	42.11	*Diplarrena moraea*	37.50
Hydrocotyle hirta	42.11	*Histiopteris incisa*	37.50
Acacia dealbata	36.84	Lichen species	37.50
Clematis aristata	36.84	*Nematolepis squamea*	37.50
Agrostis species	31.58	*Olearia stellulata*	37.50
Coprosma nitida	31.58	*Philotheca virgata*	37.50
Cyathodes juniperina	31.58	*Pimelea linifolia*	37.50
Juncus pauciflorus	31.58	*Prostanthera lasianthos*	37.50
Prostanthera lasianthos	31.58	*Telopea truncata*	37.50
		Xyris muelleri	37.50

Percentage frequency of vascular species found in more than 30% of sites in Groups 1-21

Group 21	Percentage Frequency (%)
Acacia mucronata	100.00
Bauera rubioides	100.00
Eucalyptus delegatensis	100.00
Gleichenia dicarpa	100.00
Gymnoschoenus sphaerocephalus	100.00
Lepidosperma gunnii	100.00
Melaleuca squarrosa	100.00
Gonocarpus teucrioides	83.33
Hakea megadenia	83.33
Leptocarpus tenax	83.33
Leptospermum riparium	83.33
Moss species	83.33
Epacris impressa	66.67
Eucalyptus nitida	66.67
Leptospermum scoparium	66.67
Pomaderris apetala	66.67
Sprengelia incarnata	66.67
Xyris muelleri	66.67
Astelia alpina	50.00
Baloskion tetraphyllum	50.00
Banksia marginata	50.00
Epacris lanuginosa	50.00
Euchiton species	50.00
Lepidosperma laterale	50.00
Lomatia polymorpha	50.00
Mitrasacme pilosa	50.00
Orites acicularis	50.00
Spyridium gunnii	50.00
Aristotelia pedunculata	33.33
Diplarrena moraea	33.33
Ehrharta species	33.33
Goodia lotifolia	33.33
Grevillea australis var. *linearifolia*	33.33
Histiopteris incisa	33.33
Isolepis species	33.33
Leptospermum glaucescens	33.33
Myriophyllum pedunculatum	33.33
Pittosporum bicolor	33.33
Pultenaea juniperina	33.33
Rubus gunnianus	33.33
Tasmannia lanceolata	33.33
Telopea truncata	33.33

APPENDIX 7

Means and standard deviations of geographic, environmental and climatic variables significant for riparian floristic communities and MDS vector scores

Community	1		2		3		4		5		6	
Variable	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev
Eastings	468968	9821	426943	16869	447683	40392	470760	90187	487346	99548	579336	17070
Northings	5363567	10194	5359165	33889	5358968	30162	5441857	77130	5414566	80781	5341720	38244
Altitude (m)	1076.7	65.0	840.0	73.5	812.7	132.1	2.9	5.8	82.4	92.1	156.9	131.3
Surrounding Landform	4.0	0.9	4.0	0.7	3.6	0.8	4.0	1.1	3.5	0.8	3.4	1.2
Stream Slope	4.0	0.6	3.4	0.9	3.5	0.7	5.6	0.9	3.7	1.1	4.2	1.3
Bank slope variability	2.7	1.9	4.2	1.8	2.7	2.0	2.5	1.7	2.3	1.5	2.1	1.7
Flow Permanence	3.0	0.0	3.0	0.0	2.8	0.4	2.9	0.4	2.5	0.7	2.9	0.3
Flow Permanence2	3.3	0.8	3.0	0.0	3.2	0.8	2.9	0.4	2.5	0.7	2.9	0.3
Average Width of Channel	2.2	0.8	1.8	0.8	2.0	0.8	3.2	1.1	1.7	0.8	2.4	0.7
Floodplain	7.0	0.0	6.4	0.9	6.2	1.3	6.0	2.0	5.1	1.7	6.3	1.7
Position in Catchment	2.2	0.4	1.8	0.4	2.0	0.4	3.8	0.6	2.5	0.7	2.4	0.7
Organic	2.3	1.4	3.6	1.5	2.7	1.2	3.4	1.2	3.1	1.0	2.7	1.0
Gravel	2.2	1.8	2.4	1.5	1.8	1.2	1.6	1.1	1.5	0.9	2.1	1.3
Cobble	2.5	1.6	2.8	2.2	2.5	1.6	1.4	1.1	1.3	0.8	2.6	1.6
SoilTxt1	1.8	1.0	2.0	1.0	2.0	0.9	2.1	0.9	2.1	0.8	2.4	0.9
SoilTxt2	6.2	2.6	7.2	1.6	5.5	2.4	6.9	2.3	6.4	2.7	5.7	2.0
Soil pH	6.3	0.4	6.2	0.3	6.0	0.5	7.0	0.7	6.2	0.9	7.0	0.8
Soil EC (uS)	27.7	19.6	13.2	4.8	13.2	3.9	352.5	819.0	44.3	68.6	62.4	106.2
Stratum 1 height	1.2	0.4	2.2	0.8	2.5	0.8	2.6	0.5	2.7	0.6	2.8	0.4
Stratum 1 cover	5.5	0.8	3.4	0.9	3.0	0.0	4.6	1.3	4.0	1.4	3.0	0.0
Stratum 2 height	1.0	0.0	1.4	0.5	1.5	0.5	1.7	0.5	1.8	0.5	1.8	0.4
Stratum 2 cover	4.2	1.2	4.8	1.6	5.4	1.0	5.1	0.9	5.2	1.1	4.9	1.4
Trees	0.0	0.0	1.6	1.5	2.5	1.0	3.0	1.7	3.8	1.5	3.0	0.0
Shrubs	5.2	1.3	5.4	1.3	4.8	1.5	5.6	0.9	5.1	1.3	5.2	1.0
Prostrate Shrubs	0.8	1.2	0.4	0.5	0.2	0.6	0.0	0.0	0.2	0.5	1.1	1.1
Herbs	2.7	1.5	1.4	0.5	1.6	1.0	1.9	1.1	1.2	0.5	1.1	0.3
Graminoids	3.2	1.5	3.2	1.5	3.0	2.0	4.4	1.0	3.5	1.0	3.9	1.3
Grasses	4.2	1.7	1.6	1.1	2.8	1.5	2.4	1.5	1.5	0.9	3.2	1.2
Pteridophytes	0.8	1.0	1.8	1.5	0.7	0.6	1.7	1.3	3.4	1.3	0.6	0.7
Annual Mean Temperature	5.7	0.5	7.1	0.5	7.3	0.9	12.6	0.5	11.9	1.0	11.2	1.0
Minimum Temp of Coldest Month	-1.7	0.4	-0.1	0.5	0.0	1.0	4.5	0.8	3.7	1.3	2.7	0.9
Maximum Temp of Warmest Month	16.2	0.5	17.7	0.5	17.7	0.9	22.3	1.1	22.0	1.3	21.5	0.7
Annual Temp Range	17.9	0.2	17.8	0.2	17.7	0.2	17.8	1.7	18.3	2.0	18.8	0.4
Mean Temp Coldest Quarter	1.4	0.5	3.1	0.5	3.2	1.0	8.8	0.4	8.1	1.1	7.2	1.1
Mean Temp Warmest Quarter	10.3	0.5	11.5	0.4	11.6	0.8	16.5	0.7	16.0	1.1	15.3	1.0
Mean Temp Wet Quarter	1.5	0.5	3.3	0.5	3.8	1.9	9.0	0.5	8.2	1.1	10.3	2.6
Mean Temp Dry Quarter	10.3	0.5	11.5	0.4	11.6	0.8	16.5	0.8	15.9	1.1	13.2	2.3
Annual Mean Rainfall	1394.2	279.1	2075.8	569.8	1397.8	645.8	928.4	197.1	1015.6	273.8	789.3	121.0
Rainfall Wettest Month	170.5	40.3	236.4	70.7	156.3	81.5	115.9	31.6	125.6	33.1	75.7	9.2
Rainfall Driest Month	67.2	10.1	99.4	23.6	71.4	25.1	43.7	10.5	51.7	13.1	47.3	4.2
CV Monthly Rainfall	28.4	4.7	26.5	3.5	22.3	6.1	29.6	7.0	27.7	7.1	13.1	0.5
Rainfall in Wettest Quarter	471.2	112.0	674.4	197.8	442.9	231.7	318.5	79.3	352.4	90.4	210.8	27.6
Rainfall in Driest Quarter	220.7	33.1	326.0	80.9	231.3	84.4	146.7	32.5	172.6	43.4	161.3	21.2
Rainfall Coldest Quarter	470.7	112.5	662.0	196.7	439.5	233.4	317.1	77.7	349.9	87.8	198.1	35.2
Rainfall Warmest Quarter	220.7	33.1	326.0	80.9	231.3	84.4	147.8	35.6	173.4	44.0	165.8	19.2
Mean Rainfall Driest Month	68.0	7.6	107.2	18.3	78.8	21.6	45.3	15.8	52.9	15.8	47.3	4.2
Mean Rainfall Driest Quarter	223.8	24.7	351.2	64.5	255.3	73.0	151.5	47.6	176.7	51.8	161.3	21.2
MDS Vector 1	-0.04	0.16	-0.37	0.25	-0.06	0.23	0.60	0.29	0.06	0.24	0.78	0.24
MDS Vector 2	1.47	0.24	1.24	0.21	1.06	0.24	-0.15	0.22	0.02	0.33	0.46	0.22
MDS Vector 3	-0.45	0.23	0.15	0.15	-0.41	0.27	0.63	0.30	0.51	0.30	0.16	0.33

APPENDIX 7

Means and standard deviations of geographic, environmental and climatic variables significant for riparian floristic communities and MDS vector scores

Community	7		8		9		10		11		12	
Variable	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev
Eastings	556955	41678	521158	46532	486243	62338	526651	31354	506308	45672	460889	54440
Northings	5343658	75738	5306839	72729	5412271	40091	5322954	44309	5342907	24075	5365623	38611
Altitude (m)	94.5	98.4	282.1	176.0	184.8	144.7	305.3	172.3	688.7	210.8	795.0	131.7
Surrounding Landform	2.9	0.8	2.4	0.9	3.3	1.3	2.9	1.3	3.3	0.8	3.3	0.9
Stream Slope	3.5	1.0	3.0	0.7	3.4	0.8	3.1	0.9	3.3	1.0	3.5	0.8
Bank slope variability	3.5	1.7	3.7	1.6	3.4	1.8	3.4	1.8	2.5	1.6	2.1	1.4
Flow Perm2	2.3	0.8	2.7	0.6	2.8	0.6	2.1	0.7	2.7	0.6	2.3	1.0
Flow Permanence	2.5	1.0	2.8	0.8	3.0	1.0	2.2	0.9	3.1	0.9	3.0	1.9
Average Width of Channel	2.1	0.9	1.9	0.9	2.0	0.8	1.7	0.9	2.1	1.0	1.3	0.5
Floodplain	5.0	2.1	3.7	2.2	5.7	1.8	4.2	2.3	5.1	2.2	5.6	2.2
Position in Catchment	2.6	0.8	1.9	0.6	2.4	0.7	2.1	0.8	2.1	0.5	1.6	0.7
Organic	2.9	0.8	3.6	1.2	3.4	1.1	3.3	1.1	2.6	0.9	3.1	1.1
Gravel	2.5	1.1	2.2	1.1	1.9	1.2	1.9	1.0	3.1	0.8	1.8	1.0
Cobble	2.9	1.5	2.9	1.2	2.2	1.5	2.4	1.4	3.8	1.1	2.5	1.3
SoilTxt1	2.1	0.7	2.3	0.7	1.9	0.8	2.1	0.8	2.0	0.9	2.0	1.1
SoilTxt2	6.9	2.0	6.7	1.8	6.3	1.6	6.1	1.7	5.4	1.6	5.6	2.6
Soil pH	6.6	0.7	6.6	0.7	6.2	0.4	6.7	0.5	6.4	0.4	5.9	0.6
Soil EC (uS)	58.9	114.4	23.2	23.6	22.3	30.2	45.3	48.4	20.1	11.2	17.0	4.5
Stratum 1 height	2.9	0.3	3.0	0.2	3.0	0.0	2.9	0.3	3.0	0.0	2.5	0.9
Stratum 1 cover	3.2	0.7	3.3	0.8	3.7	1.0	3.3	0.9	3.0	0.4	3.6	1.2
Stratum 2 height	1.9	0.3	1.9	0.3	2.0	0.2	1.9	0.3	1.9	0.3	1.6	0.5
Stratum 2 cover	5.3	0.9	5.2	1.0	5.2	1.0	4.7	1.2	5.1	1.1	4.9	1.0
Trees	3.2	0.6	3.3	0.9	3.7	1.0	3.2	0.8	3.0	0.4	2.6	1.5
Shrubs	5.4	0.9	5.1	1.1	5.3	1.0	4.7	1.3	5.5	1.1	3.8	2.1
Prostrate Shrubs	0.2	0.8	0.0	0.2	0.0	0.0	0.0	0.1	0.2	0.4	0.0	0.0
Herbs	1.1	0.3	1.3	0.5	1.5	0.6	1.2	0.4	1.3	0.7	2.6	1.3
Graminoids	3.5	1.3	2.5	1.5	3.2	0.9	3.5	1.5	2.0	1.4	2.5	1.7
Grasses	2.7	1.2	1.8	1.0	1.9	1.2	3.4	1.1	2.7	1.2	3.0	1.9
Pteridophytes	1.8	1.4	3.4	1.5	3.5	1.5	1.9	1.3	0.8	0.9	2.0	1.6
Annual Mean Temperature	11.5	1.1	10.1	1.1	10.9	1.1	10.1	1.0	7.7	1.3	7.7	1.0
Minimum Temp of Coldest Month	2.9	0.9	2.1	0.9	2.4	1.0	1.8	0.6	0.1	1.0	0.3	1.0
Maximum Temp of Warmest Month	21.9	1.1	20.6	1.1	21.8	1.3	20.8	1.1	18.1	1.4	18.2	1.1
Annual Temp Range	18.9	0.9	18.5	0.8	19.4	1.4	18.9	0.8	18.0	0.6	17.9	0.5
Mean Temp Coldest Quarter	7.4	1.1	6.2	1.1	6.8	1.1	6.0	0.9	3.7	1.3	3.6	1.2
Mean Temp Warmest Quarter	15.7	1.1	14.2	1.1	15.2	1.1	14.3	1.0	12.0	1.2	12.0	1.0
Mean Temp Wet Quarter	9.9	2.4	7.7	2.3	7.2	1.7	9.1	2.5	4.3	1.7	4.0	1.1
Mean Temp Dry Quarter	14.0	2.4	14.0	1.3	15.2	1.2	14.1	1.0	12.0	1.3	12.4	1.8
Annual Mean Rainfall	834.9	153.0	1002.9	210.4	1065.2	277.0	734.3	155.8	1013.9	274.3	1307.0	579.4
Rainfall Wettest Month	89.2	20.8	107.9	30.2	137.8	38.1	76.1	20.3	107.5	35.8	149.9	76.9
Rainfall Driest Month	49.4	6.4	55.4	7.9	50.1	9.9	45.0	4.6	54.7	9.7	66.5	22.2
CV Monthly Rainfall	17.1	6.7	19.1	6.8	30.3	7.6	15.5	4.8	18.9	5.3	24.2	7.0
Rainfall in Wettest Quarter	248.6	58.9	302.2	81.5	376.8	102.9	213.7	55.5	303.0	99.2	429.9	216.0
Rainfall in Driest Quarter	165.4	25.0	184.2	26.9	170.2	34.0	143.8	19.4	181.5	35.5	215.6	71.3
Rainfall Coldest Quarter	236.6	67.3	292.7	86.5	375.0	105.1	199.5	62.2	300.3	97.6	436.3	219.1
Rainfall Warmest Quarter	168.7	25.5	184.7	27.0	170.3	34.3	143.9	19.6	181.5	35.5	217.5	71.0
Mean Rainfall Driest Month	50.3	9.6	57.0	13.8	50.0	10.0	46.9	11.2	58.1	18.8	70.5	19.8
Mean Rainfall Driest Quarter	168.4	34.3	189.7	45.8	170.0	34.2	149.9	38.0	192.3	63.9	228.4	63.7
MDS Vector 1	0.50	0.23	0.08	0.13	0.08	0.18	0.51	0.21	0.27	0.30	-0.07	0.31
MDS Vector 2	-0.17	0.27	-0.23	0.34	-0.10	0.20	-0.07	0.20	0.67	0.22	0.63	0.14
MDS Vector 3	0.17	0.22	-0.13	0.23	-0.07	0.18	-0.29	0.20	-0.21	0.39	-0.66	0.15

APPENDIX 7

Means and standard deviations of geographic, environmental and climatic variables significant for riparian floristic communities and MDS vector scores

Community	13		14		15		16		17		18	
Variable	**Mean**	**Stdev**	**Mean**	**Stdev**	**Mean**	**Stdev**	**Mean**	**Stdev**	**Mean**	**Stdev**	**Mean**	**Stdev**
Eastings	425773	60457	464983	88224	481557	86263	485419	37481	368054	32625	478676	24301
Northings	5394633	53003	5410865	63669	5428105	47452	5289423	71924	5393243	60234	5212077	26281
Altitude (m)	443.3	217.0	290.3	203.1	188.8	140.0	345.6	204.6	168.0	108.8	113.1	107.8
Surrounding Landform	2.8	1.2	2.3	1.1	3.0	1.5	2.3	1.0	2.7	1.2	2.7	0.8
Stream Slope	3.3	0.5	3.1	0.6	3.2	0.8	2.8	1.0	3.5	1.0	3.2	1.3
Bank slope variability	2.8	1.8	3.9	1.6	3.5	1.7	3.6	1.6	3.3	1.7	3.4	1.7
Flow Perm2	3.0	0.0	2.8	0.6	2.9	0.5	2.8	0.4	3.0	0.3	2.8	0.6
Flow Permanence	3.3	0.8	2.8	0.6	3.0	0.7	2.8	0.4	3.1	0.6	2.8	0.6
Average Width of Channel	2.2	0.8	2.0	0.8	2.0	1.0	2.4	1.0	2.8	0.8	2.0	1.1
Floodplain	5.7	2.0	4.6	2.1	5.3	2.1	3.8	1.7	5.3	1.7	3.0	2.0
Position in Catchment	2.2	0.8	1.9	0.7	2.2	0.7	2.2	0.4	2.4	0.6	2.2	0.6
Organic	3.0	0.6	4.0	1.3	3.8	1.1	4.0	1.2	3.6	1.2	4.2	1.6
Gravel	2.3	1.2	1.7	1.0	2.2	1.5	2.1	1.2	2.0	1.0	1.8	1.1
Cobble	2.0	1.1	1.9	1.0	1.9	1.0	2.8	1.4	2.4	1.3	2.1	1.3
SoilTxt1	1.3	0.5	1.8	0.9	2.0	0.8	2.3	0.9	1.7	0.7	2.2	0.8
SoilTxt2	5.8	1.2	5.7	2.0	6.8	1.9	6.8	1.6	6.0	1.8	7.6	3.1
Soil pH	6.1	0.5	6.2	0.6	5.8	0.5	6.3	0.5	5.8	0.7	5.7	0.7
Soil EC (uS)	16.7	12.4	18.9	12.5	21.2	11.4	14.1	8.2	18.2	11.9	22.5	22.3
Stratum 1 height	3.0	0.0	3.0	0.2	3.0	0.0	3.0	0.0	3.0	0.1	3.0	0.4
Stratum 1 cover	4.8	1.5	4.5	1.1	4.0	1.1	4.0	1.6	4.3	1.4	3.5	0.7
Stratum 2 height	2.0	0.0	2.0	0.3	2.0	0.2	1.9	0.3	2.0	0.3	2.1	0.5
Stratum 2 cover	4.2	1.5	4.7	0.9	5.0	0.9	4.8	1.2	5.6	0.7	5.5	1.0
Trees	4.7	1.4	4.7	1.2	4.4	1.2	4.3	1.7	4.6	1.4	3.6	1.5
Shrubs	4.3	1.4	4.1	1.2	4.8	1.0	4.2	1.7	5.4	0.9	5.5	1.0
Prostrate Shrubs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.0
Herbs	1.5	0.5	1.2	0.6	1.1	0.3	1.2	0.4	1.1	0.5	1.1	0.3
Graminoids	2.3	1.5	1.9	0.9	2.1	1.1	2.1	1.1	2.1	1.2	3.0	1.6
Grasses	1.7	1.6	1.0	0.8	1.0	0.5	1.7	1.2	1.0	0.7	1.1	0.8
Pteridophytes	3.8	1.5	5.1	1.1	4.7	1.1	4.0	1.0	3.9	1.0	4.2	1.1
Annual Mean Temperature	9.1	0.8	10.2	1.3	11.1	0.9	9.3	1.5	10.6	0.9	10.0	1.2
Minimum Temp of Coldest Month	1.6	0.9	2.4	1.6	2.9	1.2	1.6	1.4	3.5	1.1	2.4	1.0
Maximum Temp of Warmest Month	19.7	0.7	20.6	1.2	21.7	1.0	19.6	1.3	20.5	0.6	20.0	1.0
Annual Temp Range	18.1	0.4	18.1	1.6	18.7	1.5	18.0	0.6	17.0	0.9	17.5	0.5
Mean Temp Coldest Quarter	5.2	1.0	6.3	1.6	7.2	1.1	5.4	1.7	7.1	1.1	6.3	1.2
Mean Temp Warmest Quarter	13.3	0.7	14.3	1.2	15.4	0.9	13.4	1.3	14.5	0.8	13.9	1.1
Mean Temp Wet Quarter	5.3	1.2	6.6	1.8	7.2	1.1	5.8	1.8	7.2	1.1	6.8	1.3
Mean Temp Dry Quarter	13.3	0.7	14.4	1.3	15.4	0.9	13.4	1.3	14.5	0.8	13.9	1.1
Annual Mean Rainfall	1939.5	367.8	1371.5	255.2	1210.7	234.9	1238.3	317.3	1967.4	477.8	1424.5	359.1
Rainfall Wettest Month	249.8	39.5	176.5	34.9	159.6	33.3	140.0	45.8	233.3	41.2	157.6	54.0
Rainfall Driest Month	82.8	14.8	62.8	10.6	56.3	9.2	63.8	11.0	90.4	27.9	73.6	9.6
CV Monthly Rainfall	34.1	2.7	32.3	5.9	32.1	6.5	22.9	6.7	30.1	5.8	21.4	4.4
Rainfall in Wettest Quarter	679.5	90.9	489.9	94.6	441.0	86.5	394.3	128.0	656.4	126.4	431.2	124.7
Rainfall in Driest Quarter	283.0	62.6	210.2	35.0	192.3	31.2	209.1	37.0	308.1	97.5	244.0	46.2
Rainfall Coldest Quarter	676.3	85.0	485.8	97.8	440.8	86.8	385.3	125.6	650.8	122.0	420.4	118.8
Rainfall Warmest Quarter	283.0	62.6	211.1	34.6	192.5	31.4	209.1	37.0	308.3	97.5	244.9	46.2
Mean Rainfall Driest Month	84.7	18.1	65.9	15.9	56.3	9.2	72.4	18.4	88.5	24.9	102.3	26.9
Mean Rainfall Driest Quarter	290.3	79.0	220.4	50.2	192.3	31.2	237.8	60.6	301.9	87.4	337.2	85.8
MDS Vector 1	-0.47	0.18	-0.40	0.19	-0.22	0.13	-0.33	0.16	-0.51	0.16	-0.56	0.14
MDS Vector 2	0.05	0.22	-0.32	0.15	-0.26	0.22	-0.25	0.23	-0.07	0.14	-0.26	0.14
MDS Vector 3	-0.44	0.17	-0.34	0.15	-0.05	0.16	-0.21	0.13	0.11	0.16	0.40	0.15

APPENDIX 7

Means and standard deviations of geographic, environmental and climatic variables significant for riparian floristic communities and MDS vector scores

Community	19		20		21	
Variable	Mean	Stdev	Mean	Stdev	Mean	Stdev
Eastings	403292	37152	392320	27079	336230	12665
Northings	5335455	57027	5326940	40640	5405825	33470
Altitude (m)	402.0	254.6	421.3	174.1	218.3	66.5
Surrounding Landform	2.2	1.0	3.0	1.1	3.3	0.5
Stream Slope	2.9	0.7	2.9	0.4	3.3	0.5
Bank slope variability	2.6	1.9	3.0	2.1	2.5	0.8
Flow Perm2	2.9	0.5	2.6	0.7	2.8	0.4
Flow Permanence	3.2	0.8	2.6	0.7	2.8	0.4
Average Width of Channel	2.4	1.0	1.8	0.9	1.7	0.8
Floodplain	4.2	2.4	4.8	2.3	3.8	2.1
Position in Catchment	2.1	0.6	2.0	0.8	2.3	0.5
Organic	3.6	1.1	2.3	0.5	2.7	0.5
Gravel	2.2	1.0	2.9	1.0	2.0	1.1
Cobble	3.0	1.2	2.9	1.2	2.5	1.5
SoilTxt1	2.0	0.8	1.5	0.5	1.3	0.5
SoilTxt2	6.7	2.1	5.9	1.6	6.7	2.7
Soil pH	5.8	0.6	5.6	0.3	5.4	0.4
Soil EC (uS)	16.6	11.2	10.8	3.9	19.3	16.3
Stratum 1 height	3.1	0.8	2.6	0.5	2.7	0.5
Stratum 1 cover	4.9	1.4	3.1	0.4	3.2	0.4
Stratum 2 height	2.0	0.2	1.6	0.5	1.7	0.5
Stratum 2 cover	4.6	1.2	5.3	1.2	5.5	1.2
Trees	4.9	1.4	2.5	1.1	3.2	1.5
Shrubs	4.3	1.4	5.3	1.2	5.7	0.5
Prostrate Shrubs	0.2	0.7	0.1	0.4	1.0	1.3
Herbs	1.2	0.8	0.8	0.7	1.0	0.0
Graminoids	1.1	0.7	3.6	1.6	4.0	1.1
Grasses	1.1	0.8	1.5	1.2	1.7	0.5
Pteridophytes	3.2	1.5	2.5	1.3	2.8	1.0
Annual Mean Temperature	9.1	1.3	9.2	1.1	10.9	0.5
Minimum Temp of Coldest Month	1.8	1.3	2.0	0.9	4.2	0.6
Maximum Temp of Warmest Month	19.5	1.3	19.6	1.1	20.5	0.2
Annual Temp Range	17.6	0.4	17.6	0.3	16.3	0.7
Mean Temp Coldest Quarter	5.4	1.5	5.5	1.2	7.6	0.6
Mean Temp Warmest Quarter	13.2	1.2	13.3	1.0	14.6	0.3
Mean Temp Wet Quarter	5.6	1.5	5.8	1.2	7.7	0.6
Mean Temp Dry Quarter	13.2	1.2	13.3	1.0	14.6	0.3
Annual Mean Rainfall	2259.7	481.2	2811.4	402.9	1972.2	216.4
Rainfall Wettest Month	257.9	58.2	300.1	36.6	232.0	16.2
Rainfall Driest Month	104.0	22.5	136.4	28.6	92.8	19.0
CV Monthly Rainfall	26.8	4.1	22.9	2.2	30.4	5.1
Rainfall in Wettest Quarter	724.6	149.5	865.9	106.8	665.2	51.3
Rainfall in Driest Quarter	358.8	85.4	477.9	84.6	307.5	62.7
Rainfall Coldest Quarter	706.0	145.9	842.6	113.5	660.7	51.6
Rainfall Warmest Quarter	358.8	85.4	477.9	84.6	307.5	62.7
Mean Rainfall Driest Month	107.2	16.3	135.4	26.8	91.7	18.1
Mean Rainfall Driest Quarter	369.4	65.4	450.0	83.8	303.7	59.5
MDS Vector 1	-0.70	0.23	-0.64	0.17	-0.53	0.13
MDS Vector 2	0.03	0.26	0.49	0.34	0.51	0.21
MDS Vector 3	-0.23	0.19	0.64	0.30	0.89	0.14

APPENDIX 8

State and Forest Reserves where it was assessed that there was a high probability that healthy stands of native riparian vegetation and distinctive riparian floristic communities existed as at 5.12.02.

Reserve	Location and/or Forest District	Area (ha)	Primary Purpose
NATIONAL PARKS			
Ben Lomond	North-east	18192	Alpine, skifields
Cradle Mountain-Lake St Clair	West central	161443	Mountains, lakes
Douglas-Apsley	East coast	16086	Dry sclerophyll forest
Franklin-Gordon Wild Rivers	South-west	446479	Wilderness, rivers
Freycinet	East coast	16803	Coastal, granite
Hartz Mountains	South	7140	Mountains, forest
Mole Creek Karst (*part)	Central north	1345	Caves, karst landscape
Mount Field	South central	15881	Alpine, skifields
Mount William	North-east	18439	Coastal, wildlife
Narawntapu	North coast	4349	Coastal heathland
Savage River	North-west	17980	Wilderness, rain forest
Southwest	South-west	618087	Rugged wilderness
Tasman	South-east	10750	Dry sclero. forest, scenic
Walls of Jerusalem	West Central	51800	Alpine plateau
14	**Subtotal**	**1404774**	
STATE RESERVES			
Alum Cliffs	North	1540	Scenic gorge
Derwent Cliffs	South-east	4.81	Scenic
Devils Gullet (*part)	Nth Central Plateau	1108	Scenic gorge
Fairy Glade	North	39.42	Scenic fern glade
Ferndene	North	35.16	Scenic fern glade
Forth Falls	North central	54.91	Waterfall
Hastings Caves	South	119	Caves, warm pool
Hellyer Gorge	North-west	2764	Scenic, rainforest
Holwell Gorge	Central north	355.7	Scenic gorge
Junee Cave	Central south	20.23	Limestone cave
Liffey Falls (*part)	North central	108	Waterfall, forest
Marriotts Falls	South central	121.4	Waterfalls
Mount Barrow	North-east	1579	Mountain, forest
Mount Barrow Falls	North-east	80.94	Waterfalls
Mount Montgomery	North-west	299.5	Scenic
Mount Pearson	North-east	4595	Representative forest
Notley Gorge	North	11.42	Scenic fern gully
Peter Murrell	South	136	Heath, rare plants
Pieman River	West coast	3533	Scenic river
Roger River	North-west	174	Rainforest
St Columba Falls	North-east	450	Waterfall
St Marys Pass	North-east	360	Scenic
Three Thumbs	South-east	3120	Representative forest
Trevallyn	North	440	Dry schlerophyll
West Point	West Coast	580	Occupation site
Wye River	Central East	2682	Representative forest
Yellow Creek	West Coast	74	Representative forest
27	**Subtotal**	**24385.49**	

APPENDIX 8

State and Forest Reserves where it was assessed that there was a high probability that healthy stands of native riparian vegetation and distinctive riparian floristic communities existed as at 5.12.02.

Reserve	Location and/or Forest District	Area (ha)	Primary Purpose
NATURE RESERVES			
Africa Gully	South-east	29.5	Representative forest
Butlers Ridge	East Coast	2885	Representative forest
Coal River Gorge	South	209	Birds, scenic
Dismal Swamp	North-west	100	Blackwood forest
Dry Creek East	East	273.6	Representative forest
Duckholes Lagoons	Central	29.21	Rare plants
Hospital Creek	Kellevie	22	Rare endemic plant
Lake Johnston	West Coast	138	Relic forest
Rocka Rivulet	East Coast	260	Representative forest
9	**Subtotal**	**3946.31**	
GAME RESERVES			
Farm Cove	West (in WHA)	1720	Waterbirds
Lake Tiberias	Southern Midlands	983	Waterfowl lagoon
2	**Subtotal**	**2703**	
CONSERVATION AREAS			
Ansons Bay	North-east	40	Coastal
Apsley	East coast	459	Representative forest
Arthur-Pieman	North-west	101775	Wilderness
Bernafai Ridge	West coast	1282	Representative forest
Blythe River	North	936	Representative forest
Bouchers Creek	North	127	Representative forest
Burnie Fernglade	North-west	44	Fern gully
Central Plateau	Central Plateau	102575	Alpine vegetation
Chauncy Vale	Southern midlands	397.05	Sclerophyll forest
Crotty	West coast	4420	Representative forest
Dasher River	North	200	Representative forest
Denison Rivulet	South-east	51.4	Coastal
Derwent River	South-east	1568	River, marsh
Detention Falls	North-west	343	Dry sclerophyll forest
Dove River	North	860	Representative forest
Duck Bay	North-west	1900	Wetland
Egg Islands	South	163.6	Estuarine wetland
Four Mile Creek	Northern Midlands	49	Representative forest
George Town	North	121	Estuary, Waterfowl
Granite Tor	West	22220	Rainforest (RAP)
Great Western Tiers	North	22495	
Kingston Golf Course	South-east	5.98	Estuarine wetlands
Lake Beatrice	West	2970	Rainforest (RAP)
Lake Leake	East coast	589	Waterfowl
Little Boobyalla River	North-east	480	Representative forest
Medeas Cove	North-east	81	Estuary, birds
Mountain Creek	South	325	Representative forest
Musselroe Bay	North-east	1750	Coastal
Peter Murrell	South-east	130.8	Representative vegetation
Pipers River	North-east	22.21	None provided (declared 1938)
Port Cygnet	South	81	Foreshore, marsh

APPENDIX 8

State and Forest Reserves where it was assessed that there was a high probability that healthy stands of native riparian vegetation and distinctive riparian floristic communities existed as at 5.12.02.

Reserve	Location and/or Forest District	Area (ha)	Primary Purpose
CONSERVATION AREAS (contd)			
Princess River	West	8635	Representative Forest
Sandspit River	East coast	94.93	Wetland, migratory waders
Sensation Gorge	North	312	Representative forest
South Esk River	North Midlands	15.99	River, scenic
Southwest	South-west	151300	Wilderness
Swift Creek	North	462	Representative forest
Tamar River	North	4617	Estuary, waterfowl
Truganini	South-east	42.8	Representative forest
Vale of Belvoir	West Central	4295	Representative forest
Waddles Creek	East coast	420	Dry/wet sclerophyll forest
Waterhouse	North-east	6953	Coastal
42	**Subtotal**	**445608.8**	
NATURE RECREATION AREAS			
Donaldson River	North-west	30670	Representative forest
Mount Dial	North	450	Representative forest
Recherche Bay	South	280	Coastal, recreation
Reynolds Falls	North-east	11700	Representative forest
Snug Falls	South-east	81	Wet sclerophyll; falls
Snug Tiers	South-east	5575	Representative forest
6	**Subtotal**	**48756**	
REGIONAL RESERVES			
Cameron	North-east	20427	Representative forest
Castle Cary	North-east	5995	Representative forest
Dip Range	North-west	4082	Representative forest
Gog Range	North	1645	Representative forest
Leven Canyon	North	2467	Representative forest
Meredith Range	West	66920	Representative forest
Mount Dundas	North-west	38820	Representative forest
Mount Farrell	West	1800	Representative forest
Mount Heemskirk	West	10745	Representative forest
Mount Murchison	North-west	5610	Representative forest
Mount Roland	North	7145	Representative forest
Parting Creek	West	1880	Representative forest
Savage River	North-west	38820	Representative forest
St Pauls	Northern Midlands	4400	Representative forest
Tikkawoppa Plateau	West Coast	4535	Representative forest
Tyndall	West Coast	12685	Representative forest
West Coast Range	West Coast	18030	Representative forest
17	**Subtotal**	**246006**	
PRIVATE SANCTUARIES			
Kingston Golf Course	South-east	67.21	Owner
Pipers River	North-east	109.59	Owner
Sandspit River	East coast	452.87	Owners
South Esk River	North Midlands	92.63	River, scenic
4	**Subtotal**	**722.3**	

APPENDIX 8

State and Forest Reserves where it was assessed that there was a high probability that healthy stands of native riparian vegetation and distinctive riparian floristic communities existed as at 5.12.02.

Reserve	Location and/or Forest District	Area (ha)	Primary Purpose
AREAS COVENANTED FOR CONSERVATION IN PERPETUITY (ACCP)			
Jackeys Marsh	North	36.17	Threatened plants, wetland, wildlife
Orford	South-east	10.34	Grassy and riparian forest
South Springfield	South Springfield Rd	7	Threatened fauna, wet forest gullies
St Helens	North-east	7.2	Threatened plants, riparian
4	**Subtotal**	**60.71**	
SECURE FOREST RESERVE			
Hollybank FR	Bass	133	recreation
Mathinna Falls FR	Bass	447	conservation (biological)
Lost Falls FR	Derwent	495	conservation (biological)
Meetus Falls FR	Derwent	192	conservation (physical)
Brookerana FR	Derwent	60	conservation (biological)
Sandspit River FR	Derwent	232	conservation (biological)
Sand River FR	Derwent	79	conservation (biological)
Maclaines Creek FR	Derwent	448	conservation (biological)
Tahune FR	Huon	102	recreation
Meander FR	Mersey	1660	conservation (biological)
Liffey FR	Mersey	1055	conservation (biological)
Warrawee FR	Mersey	224.8	conservation (biological)
Dip Falls FR	Murchison	34	conservation (physical)
Dismal Swamp FR	Murchison	310	conservation (biological)
Lake Pieman FR	Murchison	1055	conservation (biological)
15	**Subtotal**	**6526.8**	
FOREST RESERVES **Subject to Mineral Resources Development Act**			
Evercreech FR	Bass	52	conservation (biological)
Griffin FR	Bass	15	recreation
Tombstone Creek FR	Bass	485	conservation (biological)
Mt Maurice FR	Bass	6064	conservation (biological)
Mt Victoria FR	Bass	8038	conservation (biological)
Lower Marsh Creek FR	Bass	1086	conservation (biological)
Scamander FR	Bass	210	recreation
Avenue River FR	Bass	4300	conservation (biological)
Emu Ground FR	Bass	916	conservation (biological)
Pipers River FR	Bass	200	conservation (biological)
Prossers FR	Bass	1115	conservation (biological)
Tippogoree Hills FR	Bass	920	conservation (biological)
Martins Hill FR	Bass	1186	conservation (biological)
Doctors Peak FR	Bass	3030	conservation (biological)
Sawpit Ridge FR	Bass	1710	conservation (biological)
South Esk FR	Bass	1053	conservation (biological)
Weavers Creek FR	Bass	779	conservation (biological)
Joy Creek FR	Bass	230	conservation (biological)
Ringarooma River FR	Bass	360	conservation (biological)
Derby FR	Bass	200	conservation (biological)
Den Ranges FR	Bass	400	conservation (biological)

State and Forest Reserves where it was assessed that there was a high probability that healthy stands of native riparian vegetation and distinctive riparian floristic communities existed as at 5.12.02.

Reserve	Location and/or Forest District	Area (ha)	Primary Purpose
FOREST RESERVES			
Subject to Mineral Resources Development Act (contd)			
Dismal Range FR	Bass	200	conservation (biological)
Frome FR	Bass	940	conservation (biological)
Lady Nelson FR	Bass	160	conservation (biological)
North Esk FR	Bass	625	conservation (biological)
Paradise Plains FR	Bass	440	conservation (biological)
Break O'Day FR	Bass	332	conservation (biological)
German Town FR	Bass	940	conservation (biological)
Fishers Tier FR	Bass	270	conservation (biological)
River Hill FR	Bass	340	conservation (biological)
Mt Stronach FR	Bass	1038	conservation (biological)
North Scottsdale FR	Bass	4090	conservation (biological)
Bells Marsh FR	Bass	441	conservation (biological)
Kohls Falls FR	Bass	146	conservation (biological)
Mt Horror FR	Bass	1133	conservation (biological)
Blue Tier FR	Bass	5056	conservation (biological)
Mt Puzzler FR	Bass / Derwent	410	conservation (physical)
Dickies Ridge FR	Bass / Derwent	621	conservation (biological)
Hardings Falls FR	Derwent	1009	conservation (physical)
Tooms Lake FR	Derwent	3412	conservation (biological)
Big Sassy Creek FR	Derwent	193	conservation (biological)
Lanes Tier FR	Derwent	217	conservation (biological)
Yellow Bluff Creek FR	Derwent	481	conservation (biological)
Mt Thunderbolt FR	Derwent	322	conservation (biological)
Ouse River FR	Derwent	364	conservation (biological)
Remarkable Rock FR	Derwent	389	conservation (biological)
Snowy River FR	Derwent	89	conservation (biological)
Wentworth Creek FR	Derwent	250	conservation (biological)
Kenmere Creek FR	Derwent	228	conservation (biological)
Snow Hill FR	Derwent	1327	conservation (biological)
Tarraleah FR	Derwent	619	conservation (biological)
Royal George FR	Derwent	770	conservation (biological)
Lake Binney FR	Derwent	463	conservation (biological)
Apslawn FR	Derwent	2820	conservation (biological)
Eastern Tiers FR	Derwent	4414	conservation (biological)
Lawrence Rivulet FR	Derwent	14	conservation (biological)
Lady Binney FR	Derwent	385	conservation (biological)
Cygnet River FR	Derwent	4310	conservation (biological)
Swan River FR	Derwent	3153	conservation (biological)
Buxton River FR	Derwent	3612	conservation (biological)
South Weld FR	Huon	46	conservation (physical)
Esperance River FR	Huon	150	recreation
Lutregala Creek FR	Huon	107.903	conservation (biological)
Jean Brook FR	Mersey	13	recreation
Mersey White Water FR	Mersey	233	recreation
Quamby Bluff FR	Mersey	955	conservation (landscape)
Arm River FR	Mersey	128	education
Borradaile FR	Mersey	257	conservation (biological)

State and Forest Reserves where it was assessed that there was a high probability that healthy stands of native riparian vegetation and distinctive riparian floristic communities existed as at 5.12.02.

Reserve	Location and/or Forest District	Area (ha)	Primary Purpose
FOREST RESERVES			
Subject to Mineral Resources Development Act (contd)			
Brushy Rivulet FR	Mersey	598	conservation (biological)
Caroline Creek FR	Mersey	214	conservation (biological)
Coppermine Creek FR	Mersey	670	conservation (biological)
Dogs Head Hill FR	Mersey	1523	conservation (biological)
Lobster Rivulet FR	Mersey	129	conservation (biological)
Maggs Mountain FR	Mersey	1120	conservation (biological)
Mersey River FR	Mersey	638	conservation (biological)
Millers Bluff FR	Mersey	670	conservation (biological)
Parangana Sugarloaf FR	Mersey	288	conservation (biological)
Porcupine Hill FR	Mersey	213	conservation (biological)
Reedy Marsh FR	Mersey	3880	conservation (biological)
Jackeys Creek FR	Mersey	211	conservation (biological)
Black Jack Hill FR	Mersey	664	conservation (biological)
Andersons Creek FR	Mersey	324	conservation (biological)
Long Hill FR	Mersey	558	conservation (biological)
Dove River FR	Mersey	2424	conservation (biological)
Franklin Rivulet FR	Mersey	305	conservation (biological)
Winterbrook Falls FR	Mersey / Murchison	563	conservation (biological)
Julius River FR	Murchison	85	conservation (physical)
Wes Beckett FR	Murchison	29	conservation (physical)
Balfour Track FR	Murchison	320	conservation (biological)
Teepookana FR	Murchison	625	conservation (landscape)
Badger River FR	Murchison	319	conservation (biological)
Black Creek FR	Murchison	314	conservation (biological)
Bond Tier FR	Murchison	1795	conservation (biological)
Duck River FR	Murchison	464	conservation (biological)
Henty FR	Murchison	106	conservation (biological)
Pruana FR	Murchison	3045	conservation (biological)
Lovells Creek FR	Murchison	545	conservation (biological)
Rebecca Creek FR	Murchison	346	conservation (biological)
Sumac FR	Murchison	9850	conservation (biological)
Trowutta FR	Murchison	2535	conservation (biological)
Warra Creek FR	Murchison	575	conservation (biological)
Mackintosh FR	Murchison	1026	conservation (biological)
Luncheon Hill FR	Murchison	1030	conservation (biological)
Plains Creek FR	Murchison	862	conservation (biological)
Montagu River FR	Murchison	1013	conservation (biological)
Montagu Swamp FR	Murchison	1582	conservation (biological)
Shakespeare Hills FR	Murchison	2158	conservation (biological)
Welcome Swamp FR	Murchison	163	conservation (biological)
Crayfish Creek FR	Murchison	315	conservation (biological)
Deep Gully FR	Murchison	2537	conservation (biological)
John Lynch FR	Murchison	3128	conservation (biological)
Dial Range FR	Murchison	2533	conservation (biological)
Arthur River FR	Murchison	3229	conservation (biological)

APPENDIX 8

State and Forest Reserves where it was assessed that there was a high probability that healthy stands of native riparian vegetation and distinctive riparian floristic communities existed as at 5.12.02.

Reserve	Location and/or Forest District	Area (ha)	Primary Purpose
FOREST RESERVES			
Subject to Mineral Resources Development Act (contd)			
Boco Creek FR	Murchison	930	conservation (biological)
Burns Peak FR	Murchison	950	conservation (biological)
Emu River FR	Murchison	585	conservation (biological)
Flowerdale River FR	Murchison	290	conservation (biological)
Hatfield River FR	Murchison	1100	conservation (biological)
Huskisson River FR	Murchison	700	conservation (biological)
Laurel Creek FR	Murchison	1110	conservation (biological)
Mt Kershaw FR	Murchison	260	conservation (biological)
Old Park FR	Murchison	1585	conservation (biological)
Sawmill Creek FR	Murchison	870	conservation (biological)
Dip River FR	Murchison	2732	conservation (biological)
124	**Subtotal**	**146894.9**	
Total secure reserves where native riparian vegetation is likely to exist (65)		**1439637**	
Total other reserves where native riparian vegetation is likely to exist (199)		**890752**	