



rivers and
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LandWater & Wool
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another australian wool innovation limited

Wool industry river management guide:

High rainfall zones including tableland areas

HIGH RAINFALL ZONES
including tableland areas

Main agronomic zones for wool production based on average annual rainfall, 1980–1999

Primary key:

Average rainfall (mm)

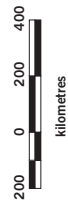


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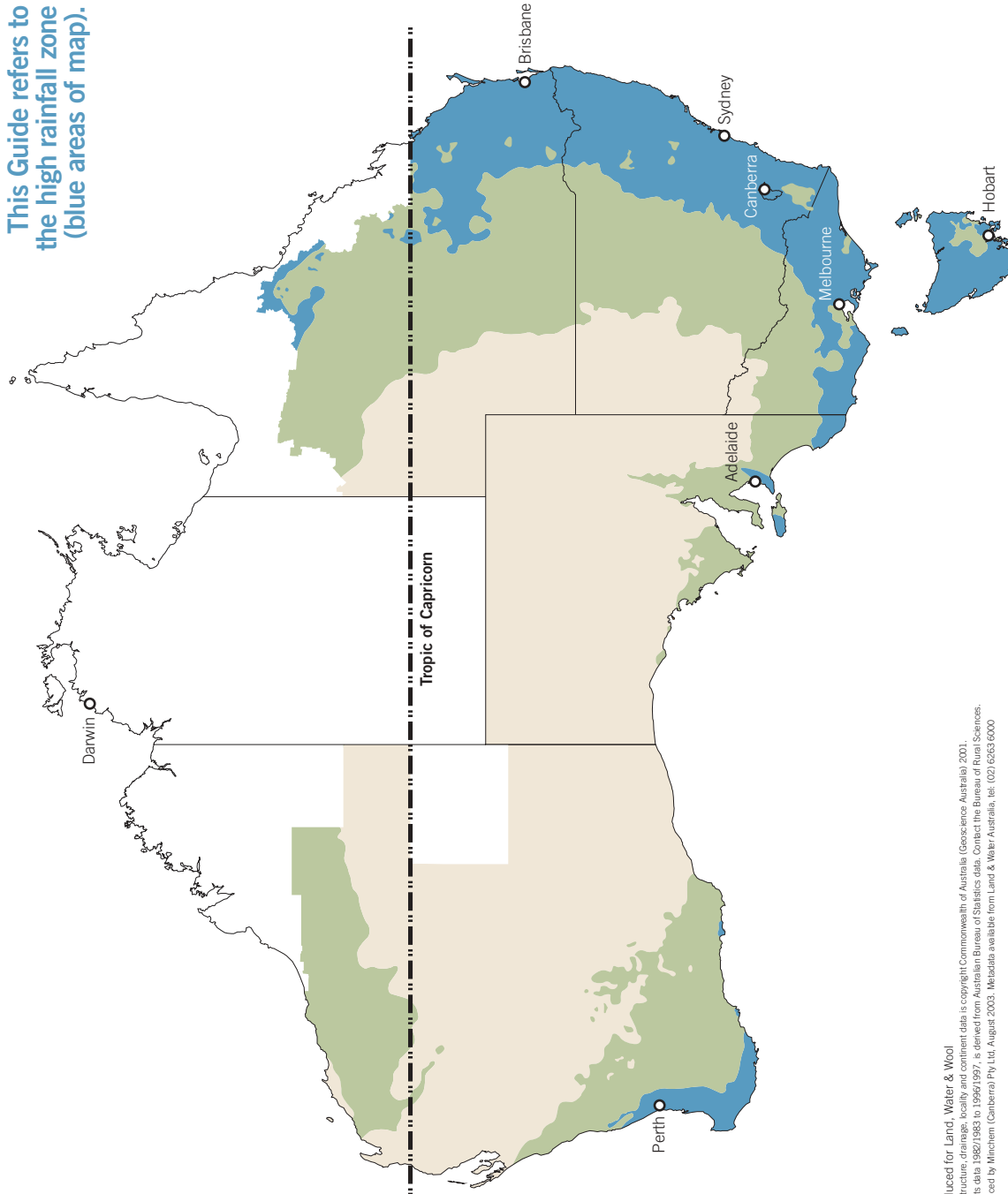
Agronomic zones



Scale 1 : 16,000,000



This Guide refers to the high rainfall zone (blue areas of map).



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Who is this Guide for?

This Guide aims to help woolgrowers and those that work with them, to improve and protect the health of water courses and riparian land on their farms, as well as to minimise the impacts of wool production on water quality and stream health. The aim is to use improved management to achieve both environmental and productive benefits. It also provides information about how these requirements can be incorporated into farm design and wool production operations. Any part of the farm that is linked to the local stream system by water flow, including those parts linked only during storm events, is covered by this River Guide. This is because what happens on them, and how they are managed, can have a significant influence on the stream's health and its water quality.

The Australian wool industry covers a broad range of rainfall and vegetation types (see map). Three zones are broadly recognised based on rainfall and these are: pastoral, sheep/wheat and high rainfall. Rather than attempt to produce a single River Guide for the entire Australian wool industry, two separate documents have been produced. One of these relates specifically to higher rainfall areas and tablelands, based on average annual rainfall being 600 mm or more. This Guide is intended to cover the higher rainfall parts of the south-west of Western Australia, high rainfall areas in the south-east of South Australia, the tablelands and higher rainfall parts of Victoria and Tasmania, and the tablelands in New South Wales and southern Queensland.

A separate Guide has been prepared for woolgrowers in lower-rainfall areas, where the average annual rainfall is in the range 300–600 mm, sometimes referred to as the sheep/wheat zone. It is intended to cover much of the wheatbelt in Western Australia, the mid-north and drier parts of the south-east in South Australia, the riverine plains and drier parts of Victoria and New South Wales, the midlands region in Tasmania, and the western slopes and plains in New South Wales and southern Queensland.

It is recognised that this division is arbitrary, but it was considered worthwhile as some of the management issues identified by woolgrowers are different between these two zones. As well, the water courses and riparian areas are different and require management practices that are designed specifically for them. In each version of the Guide, the case studies have been chosen to represent the geographic location covered.

Neither Guide addresses the management of watercourses and riparian areas in the pastoral zone. Although some of the principles in this Guide can be applied there, river systems in the pastoral zone have special characteristics and the scale of stock management and grazing units are very different. There were insufficient resources available to prepare a Guide for this zone at present, but one may be developed in the future if woolgrowers seek it.

This Guide refers to the higher rainfall (600 mm and above), including the tablelands zone in eastern states.

Wool Industry River Management Guide: High rainfall zones including tableland areas

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Land, Water & Wool is a research partnership between Australian Wool Innovation Limited and Land & Water Australia.

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Foreword

Australia's woolgrowers manage a large proportion of our natural resources and they recognise the imperative to manage these resources carefully for profitable wool production, both now and in the future.

Improved management of natural resources, including streams, creeks and adjacent riparian zones, is an integral part of farm operations and represents "good business" for the wool industry.

Notwithstanding the significant efforts made by many woolgrowers to enhance their resource base, all agricultural industries, including wool, are coming under increasing market, community and regulatory pressure to employ sustainable practices and demonstrate that they are doing so.

With most Australian woolgrowers having properties which adjoin at least one waterway, managing these water systems and keeping them healthy is a crucial part of running a profitable wool producing enterprise.

This River Guide demonstrates how woolgrowers in the higher rainfall and tablelands zone can use practical, cost effective methods for improved river management, addressing issues such as gully and streambank erosion, water quality and weed management.

The Guide is another way in which the Land, Water & Wool program, a collaboration between Australian Wool Innovation Limited and Land & Water Australia, is working to make a positive difference to productive natural resource management in the wool industry.

Len Stephens
Chief Executive Officer
Australian Wool Innovation Limited



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Tom Dunbabin, Richard Weatherley, Anwen Lovett, Lu Hogan, Renelle Jeffrey, Mike Wagg, Russell Pattinson, Peter Hanrahan, Andrew Lawson, Jann Williams, Kim Mitchell, Bruce Munday, Michael Askey-Doran, Rae Glazik, Karen Forge, Nick Reid, Sandra Brown, Kelly Hill, Ian Rutherford, Leanne Wheaton, Mark Saunders, Allison Mortlock.

Special thanks to all those woolgrowers featured in our case studies.



Chapter 1

Purpose of the Guide



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Purpose of the Guide

Sheep need access to high quality water for maximum productivity, and many wool businesses have recognised this as vital for their continued viability. Water quality is affected directly by how well small streams, creeks and gullies are managed, including those located on farms. Hence, woolgrowers have a strong financial, as well as environmental interest in achieving best practice in river and riparian management.

This Guide has been developed as a resource to assist the wool industry and woolgrowers to improve their productive use and environmental management of streams, creeks and associated riparian lands. It reflects a major emphasis of the Land, Water & Wool Program to demonstrate and publicise practical ways in which woolgrowers can increase both profitability and environmental outcomes on-farm. Some of the principles outlined here can also be applied to the management of large farm dams and drains, but the Guide is focused primarily on natural watercourses and adjacent riparian zones.

Land, Water & Wool (LWW) is a joint initiative of Australian Wool Innovation Limited and Land & Water Australia. It is an integrated natural resources management program that focuses on issues associated with sustainable wool production. For more information visit the website — www.landwaterwool.gov.au

The first step in developing this Guide was to work with woolgrowers to identify the management issues they considered most important in relation to water courses and riparian areas. To this were added research findings from a 12-year national research program supported through Land & Water Australia (for details see www.rivers.gov.au) that investigated how riparian areas function, as well as information gained from LWW-funded projects about river and riparian management located in Tasmania, South Australia and New South Wales. Bringing these sets of information together enabled the development of this Guide. This Guide has been prepared primarily for use by people with some technical knowledge who work with woolgrowers, including farm consultants and advisers, staff of government agencies, catchment management authorities, coordinators, woolgrower or Landcare groups and community organisations

For each of the management issues identified by woolgrowers, we have listed the management objective (or purpose) that can be attained within the context of commercial and environmentally sustainable wool production. This is followed by the general principles for achieving that management objective, based on the best science available today. The Guide then lists practical steps that can be taken by woolgrowers to implement those principles. Wherever possible, this is followed by a description of one or more case studies of woolgrowers who have successfully achieved the management objective. At the end of the Guide there is a rapid appraisal of riparian condition tool that can be used to assess how the current state of the stream, creek or riparian area compares with the objectives and practices; this can also be used to track changes in condition over time.

It is intended that this Guide be used to complement existing information on sustainable wool production, as well as to assist the development of other products, workshops and field days. Provided that the original source of the material in this Guide is acknowledged, reproduction of the document or of individual sections is encouraged. It is recognised that today's best practice may not be tomorrow's. It is therefore expected that this Guide may be reviewed and further improved from time to time, based on the experience of woolgrowers and as new scientific knowledge becomes available.



Background to the Australian wool industry

The Australian wool industry remains one of Australia's most important agricultural enterprises. In 2003/04 — the value of wool exports was \$2.3 billion, equivalent to around 6.3% of the gross value of all agricultural commodities. Total wool production remains second only to beef production as the most common enterprise on Australian farms. Much of the agricultural land south of the tropic of Capricorn (see map) is grazed at one time or another by sheep for wool production, and wool production is a major enterprise on native pastures in the rangelands. Native pastures also play an important role in fine wool production in areas such as Tasmania and the northern tablelands of New South Wales. The extensive nature of wool production over much of Australia means that maintaining sound environmental management is an important issue for the industry.

There were estimated to be around 40,000 broadacre farms running sheep in 2000–01. Of these, around 11,000 farms receive the majority of their income from sheep and wool production and are classified as specialist woolgrowers; they account for about 32% of Australia's total wool output. The remaining broadacre farms receive most of their income from enterprises other than sheep and wool, and are generally described as mixed enterprise farms that produce wool as part of their operation.

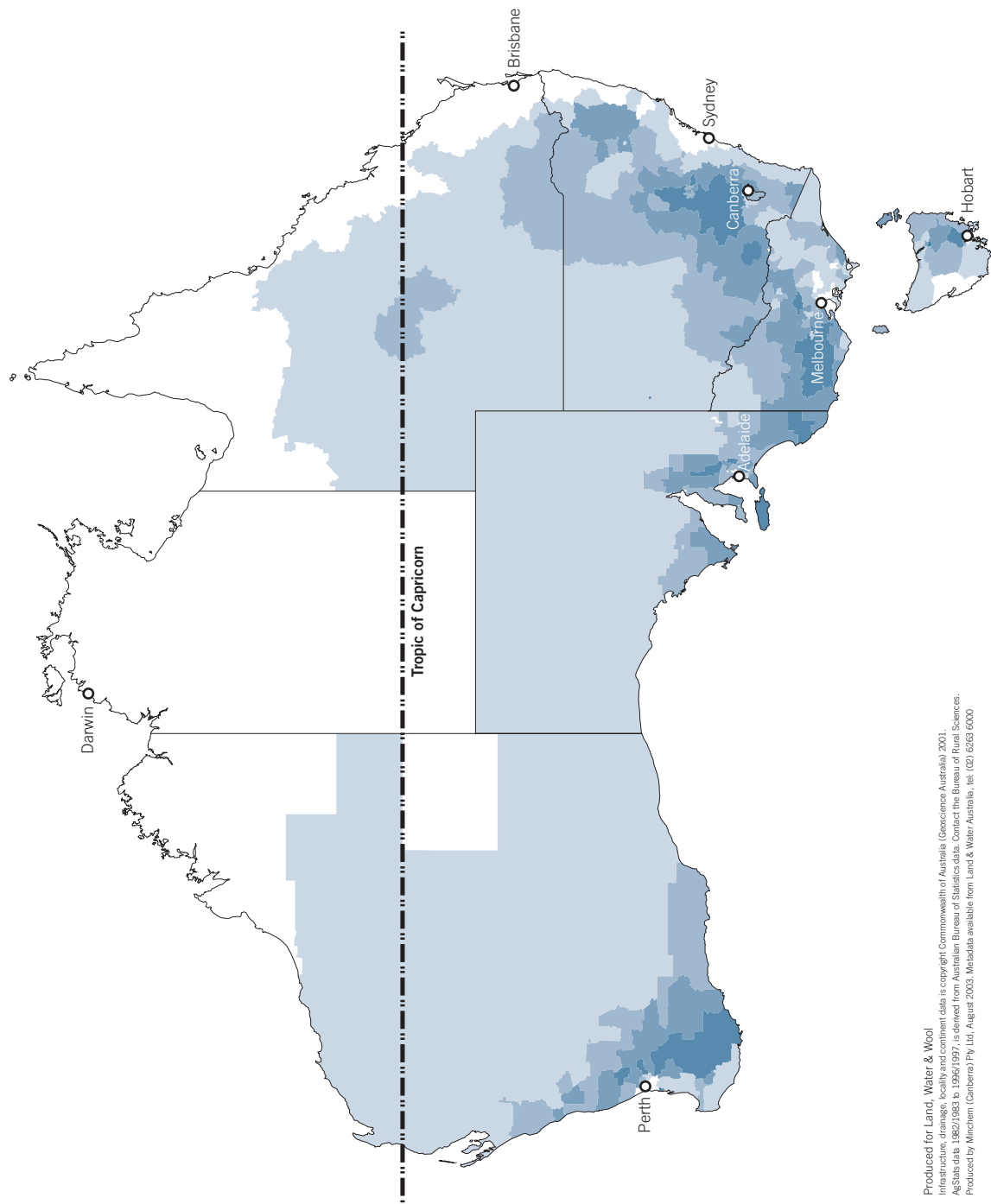
There is a wide range of wool enterprise size and profitability and, thus, a wide range in capacity to undertake substantial works to improve riparian management. There is no firm information on the number of wool-producing farms that have waterways (creeks, streams, or rivers) either running through or forming a boundary of the property. However, when it is recognised that even the management of ephemeral creeks and gullies is important for water quality downstream (including estuaries), it seems likely that the majority of wool producing farms will need to give some consideration to the management of streams, creeks and associated riparian areas. As a result, this Guide is expected to have wide application within the wool industry.

“Ephemeral”

Creeks, gullies and drainage lines that may run with water only occasionally.



Ephemeral creeks like this one may remain dry or not flow for several months, but often retain permanent pools and sometimes subsurface flow beneath their sandy bed. These features, together with periodic flood flows, make them very important parts of the landscape for native plants and animals. Photo John and Vicki Taylor.





Chapter 2

The importance of streams, creeks and riparian land



Chapter 2

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The importance of streams, creeks and riparian land

Water in the landscape

Australia is well-known as the driest inhabited continent, with a generally low and highly-variable rainfall. In this situation, it is not surprising that access to supplies of clean water is especially important for agricultural production and for rural communities, as well as to major urban centres. The limited water resources available in the southern part of Australia have already been well-developed in response to this need, particularly in the Murray-Darling Basin, but also in catchments adjacent to major urban centres. Currently, there are major concerns about the amount of water available for use, the decline in water quality, and the need to store and share water for society's varied needs. Water allocations for irrigation have not always been managed well, and over extraction has led to degradation in some river systems.

Water quantity is immediately influenced by climate, but also at a longer time-scale by land use and management practice. There is little that can be done to manage the effects of climate variability, except through increasing water storage and water use efficiency, however, land use and management is something that can be changed. We know that the clearing of catchments for agricultural development by removing deep-rooted, native perennial vegetation and replacing it with annual shallow rooted species, has resulted in more water either running-off as surface flow or infiltrating into the soil and potentially accumulating as rising groundwater. Dryland salinity and the erosion of stream beds, banks and gullies are some of the most significant negative impacts generated by this change in catchment hydrology.

“Hydrology”

Hydrology here refers to the movement of water within the landscape through both surface and sub-surface pathways, and the balance between inputs (rainfall) and outputs (streams and groundwater flow).

Water quality is a particular concern to all communities, whether rural or urban. The battle for water quality is generally won or lost in the small creeks, gullies and streams within a catchment. This is partly because these small waterways generally make up three-quarters of the total stream network within any given catchment (see diagram page 11). As well, it is far easier to manage these smaller waterways for water quality than it is to try to influence quality in a large river system where the channel is tens of metres wide. This point is not always recognised by landholders, who may disregard the importance of managing the land to optimise water quality, especially where the creek or gully may run only occasionally.

It is important to recognise that the battle for water quality is generally won or lost in the small creeks, gullies and streams within a catchment.



It is far easier to manage smaller waterways for water quality than it is to try to influence quality in a large river system where the channel is tens of metres wide.

Water storage is another issue of particular importance to woolgrowers, and in most States there is now legislation to control the storage and transfer of water. As well as these aspects of quantity, quality and storage of water for productive or consumptive uses, waterways are particularly important in the maintenance of a healthy landscape. In a seasonally dry landscape waterways are important for both plants and animals. Many animals spend part of their lifecycle in, or associated with, water courses and riparian areas, and use them as an essential source of water or habitat. Riparian areas provide a refuge for plants and animals during times of stress, such as drought or fire, and are often characterised by their own particular species that are not found elsewhere in the landscape. Water courses and riparian areas are often referred to as the arteries of the landscape, and provide an important home base and movement corridor for the maintenance and migration of plants and animals throughout the region.

Streams, creeks and riparian areas are therefore important for both production and environmental health. Sheep need access to clean water for maximum wool production, and careful management of riparian areas can provide other valuable benefits through increased feed and utilisation, as well as from shade and shelter from extreme weather; when added, these benefits can increase profit significantly. The range of production benefits is described in more detail in the following sections.

At the same time, river and riparian areas in good condition are vital for healthy ecosystems and functions, as well as to conserve Australia's unique plants and animals. Sometimes these management objectives may appear to be in conflict, but with careful thought, it is possible to improve management and achieve a win-win situation where productivity and environmental outcomes can be maintained and improved. A major aim of this Guide is to describe these opportunities and demonstrate how they can be achieved by woolgrowers. Some of these principles can also be applied to the management of large farm dams and drains.

“Riparian”

Any land which adjoins, directly influences, or is influenced by, a body of water.



Photo Mike Wagg.

Scaled diagram showing that management of small waterways in catchments is important because they generally make up three quarters of the total stream network.

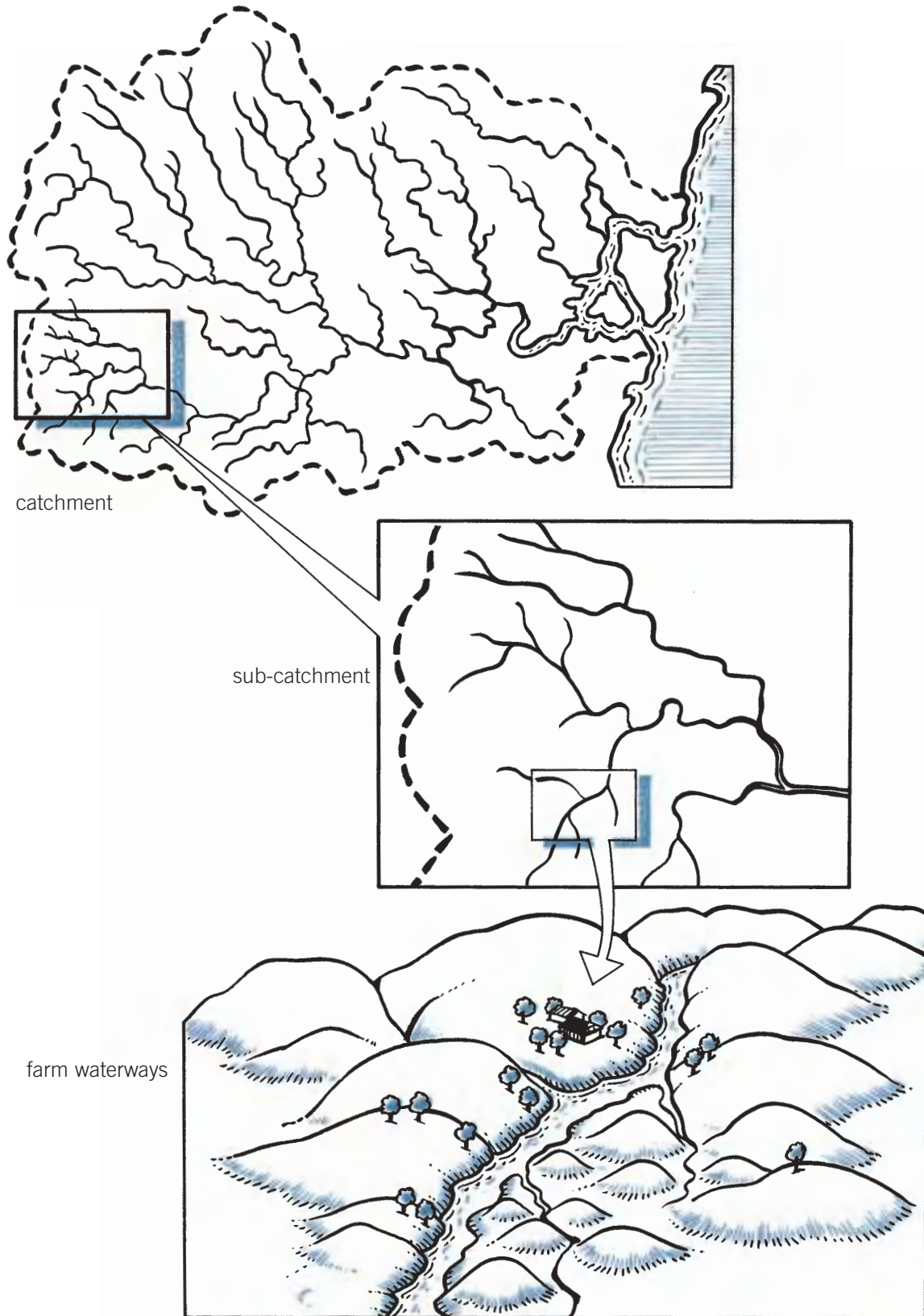


Illustration Paul Lennon.



What is riparian land?

Riparian land can be defined in a number of ways — *how* it is defined in particular situations largely depends on *why* it is being defined. The definition of riparian land provided below refers to the roles or functions that riparian land plays.

Riparian land is any land which adjoins, directly influences, or is influenced by, a body of water.

Using this definition, riparian land includes:

- the land immediately alongside small creeks and streams, including the bank itself;
- gullies and dips, including those within, or adjacent to, pasture paddocks, that sometimes run with surface water;
- land adjacent to drains or channels that empty into streams or wetlands;
- areas surrounding lakes and large dams;
- wetlands, billabongs, and floodplains that are linked with a stream or creek in times of flood; and
- vegetation dependent on groundwater supplied by a stream or creek.



Riparian land along riverbanks.
Photo LWA.



Floodplain.
Photo Michael Askey-Doran.



Pool in riparian area.
Photo Lori Gould.



Wetland. Photo NSW Murray
Wetlands Working Group.



Wetland. Photo NSW Murray
Wetlands Working Group.



River with riparian vegetation.
Photo Mike Wagg.

The width of land recognised by a woolgrower as being ‘riparian’ will depend on its purpose and management objective. For example, the riparian width required to trap soil from a cultivated paddock upslope (filter strip) may be a fraction of the width required to provide wildlife habitat, yet both may be riparian management objectives. Government legislation contains legal definitions of water courses and riparian land that woolgrowers need to be aware of, and these are described in Appendix B.

Factors that affect the condition of streams, creeks and riparian land

Riparian land changes under the influence of natural factors such as fires, unusual frosts, cyclones or floods. However, these are relatively infrequent events, allowing time for riparian land and its natural vegetative cover to recover. In contrast, the human impact since European settlement of Australia is very noticeable on riparian land, with large-scale changes in condition and health throughout much of southern Australia. The widespread clearing of riparian vegetation for agricultural or urban development, engineering works and infrastructure for dams, weirs, roads and bridges, as well as grazing by domestic stock, have had the biggest impacts.

In recent years, there have been several surveys undertaken of the condition of streams and rivers in various parts of Australia¹. Although the exact proportions differ from region to region, a general conclusion from these studies is that in southern Australia 30–40% of all streams and rivers and their adjacent riparian lands are in very poor condition, a further 30–40% are in moderate but declining condition, while only about 30% remain in good condition². Wool growing occurs in all of the catchments that make up these statistics, making the production of this Guide very timely, as it provides an opportunity for the wool industry to contribute to catchment plans to improve stream or creek condition, while maintaining or improving commercial wool production.

Major effects of ‘catchment development’ on riparian land and adjacent water courses are as follows:

- *Removing riparian trees and shade* by clearing riparian trees or natural death combined with lack of regeneration due to continuous grazing, increases the amount of light and heat reaching the stream or creek. This favours the growth of nuisance algae and weeds, and can completely change the conditions in the water so that it no longer supports native fish and other animals. Excessive in-stream weed and algal growth can trap sediments, and this can block the channel and prevent it from carrying floodwaters. When the weed and algae eventually dies and begins to decay, it deoxygenates the water and can contribute to fish kills downstream. Removal of shade can mean higher losses of a precious resource due to increased evaporation, and loss of native vegetation can also result in invasion by aggressive introduced species such as willows, privet or gorse.
- *Lack of riparian trees for habitat*. Under natural conditions, trees occasionally fall into the channel and provide an important habitat for animals and plants living in the stream. Large tree trunks and branches in the water result in a range of flow speeds, which are important for some stream animals. In streams with sandy beds, this woody material provides the only secure anchor for in-stream plants and protection for animals. Removing these branches and trunks disrupts in-stream life by reducing habitat for insects, crustaceans and fish, as well as destabilising stream beds and banks making them more prone to erosion in high flows. Loss of native riparian vegetation with no regeneration means that there is no longer any source of this important in-stream material.
- *Cropping up to the top of streambanks* increases the delivery of sediments and nutrients to water courses. Perennial groundcovers play an important role in filtering sediment from overland flow and when this cover is removed, large volumes of fine-grained sediment smother in-stream habitat and cloud the water, while the additional nutrients carried on the soil particles stimulate weed and algal growth. The increased sediment and nutrient loads also affect estuarine and marine life beyond the river mouth. Stock tracks along and up and down stream or creek banks are a major source of in-stream sediment and nutrients on grazing properties.

1 Examples are: *State of the Environment Report*, 1996; *The Condition of Rivers in the Queensland Murray Darling Basin*, D.P. Johnson 2001; *Stressed Rivers Assessment Report*, NSW DLWC 1999.

2 These estimates reflect the condition of rivers in wool-growing catchments; an initial analysis of one NSW catchment using data from the Australian Natural Resources Atlas and Data Library (NLWRA, 2002) confirms this general picture.





Fallen wood in the river provides habitat for insects, crustaceans and fish. Photo Ian Rutherford.

- *Uncontrolled stock access* to riparian lands leads to overgrazing and trampling of vegetation, the breakdown of soil structure and contamination of the water with nutrient-rich urine and faeces. Research has shown that even a low level of unmanaged grazing pressure can be enough to prevent regeneration of native riparian species. Stock dung and urine entering streams directly or washed in during heavy rains are a major source of contaminating nutrients and of disease organisms, greatly reducing the quality and value of water for downstream users.
- *Loss of riparian vegetation* and its protective root systems destabilises streambanks, often resulting in large increases in the width, depth and erosion of channels. This channel erosion can then deliver more sediment to the water course. Significant areas of valuable agricultural land can be lost as a result of channel erosion and, along with increased water turbidity, can greatly reduce water quality for downstream users. The reduction in water quality and loss of natural riparian food inputs (leaves, fruit, twigs, insects) also disrupts the food sources and life cycles of aquatic plants and animals.

“Turbidity”

Turbidity is the ‘dirtiness’ or ‘cloudiness’ in the water that results from fine clay particles suspended within the water column. When soil from bare areas of paddocks or from stream or channel banks erodes into the water, the larger sand and silt particles settle out, but the fine clay particles may remain suspended for many weeks. Turbid water is often milky brown in colour and it is not possible to see down to the stream bed; light penetration is restricted to the surface layers.

- *Removing vegetation throughout a catchment* can lead to raised water tables and salinisation of land. Salt in both surface and sub-surface flow may then drain into water courses and reduce water quality, as well as damaging in-stream plants and animals. This issue is a high priority for parts of the Murray-Darling Basin, where decreasing water quality will eventually threaten the livelihood of downstream irrigators.

“Salinisation”

Salinisation refers to the process by which rising groundwaters bring to the surface salt which had been stored lower in the soil profile. As this water is used by plants or evaporates from the soil surface, the salts are left behind. As the salt accumulates, a point is reached where plants can no longer grow, and a bare scald results, often with a white deposit of salt which may be washed into the adjacent water course during rain. This is the basic process underlying the spread of dryland, or secondary, salinity.

- *Altering the streamflow* by building dams and weirs, as well as pumping out water, can severely affect in-stream life and the habitat values of a water course. Reduced flow levels below dams, rapidly-changing water levels due to releases, and cold water from deep offtake points, all reduce the health of downstream riparian vegetation and in-stream plants and animals.
- *Removing sand and gravel*, channel straightening, and construction of levee banks and drains change the channel characteristics and can result in increased erosion. This can lead to loss of agricultural land as well as damage to infrastructure such as roads, bridges and buildings.



Sheep that have unmanaged access to riparian areas such as this one can do extensive damage to native vegetation and can lead to water quality and bank erosion problems. Photo Michael Askey-Doran.



These healthy plants (macrophytes) are a sign that the water quality and general riparian environment is good. However, in the absence of shade from adjacent trees and with increased nutrients in the water, such plants can spread unchecked and choke the stream. Photo Kay Morris.

- *Altering fire regimes* especially in combination with poorly timed grazing, and invading introduced weeds degrade riparian land.
- *Urban development* influences water quality and the condition of riparian lands.

The impacts of these disturbances are not only cumulative; they exacerbate each other. For example, clearing riparian vegetation from small creeks and streams multiplies, many times over, the impact of nutrient enrichment from surrounding land. This is because the clearing of tall vegetation also results in higher light levels and higher temperatures, creating the conditions needed to enable nuisance weeds and algae to flourish in the stream and to dominate in-stream life.

Property planning as the key to sound riparian management

By recognising and managing riparian areas as different but integral parts of the whole farm and wool enterprise, it is possible for woolgrowers to gain significant environmental and economic benefits. One of the best ways to achieve this is to encourage and work with the wool producer to develop and implement a property management plan.

By recognising and managing riparian areas as different but integral parts of the whole farm and wool enterprise, it is possible for woolgrowers to gain significant environmental and economic benefits.

Property management planning, or whole property planning as it sometimes called, is a process of planning property design and management by matching economic production to the property's ecological characteristics and resources. The process arose from a realisation that land degradation, and the flow on impact it has on reduced production and degradation of other natural resources including streams and rivers, is a sign of inappropriate land use and/or farming practices. Unless land degradation processes are halted, and where possible reversed, farm production will continue to decline, resulting in a non-viable enterprise and farming system. Effective property management planning is the key to woolgrowers getting the best from their river and riparian areas so that they can optimise production while at the same time maintaining or improving their natural resource base.

This overview of Property Management Planning is from 'Taking Control — Property Management Planning', Van der Rijt, V., Centre for Conservation Farming, Charles Sturt University.

Developing a property management plan requires the woolgrower to assess the strengths and limitations of the farm's resources, and to clarify his/her objectives regarding the future use of these resources. This combination of business plan, personal objectives, and knowledge of the property's natural resources and their capacity to support pasture and wool production, then forms the basis for preparing a future plan that outlines the direction in which the woolgrower wants to develop the farm. As this will change with time, the plan is not fixed, but changes over time to meet the grower's objectives. The plan also helps the landholder to coordinate advice from a wide range of sources such as district agronomists, soil conservationists, property planners, and financial advisers. This advice can be effectively used within a whole farm perspective.

Farm resources and objectives

The woolgrower would work through each of these areas to consider strengths, weaknesses and how this influences business and personal objectives for the future.

- personal / family goals
- enterprise type chosen
- production and management skills and limitations
- physical features of property
- land capability, areas requiring special management
- productivity levels of different land units
- financial return and cash flow
- labour input required

Preparing the property plan

The first step in the planning process is the mapping of the farm into homogenous land units (capability classes). This is done on the basis of:

1. terrain e.g. ridge, hillslope, floodplain
2. slope class
3. soil type (texture/structure/fertility)
4. timber and vegetation cover, pasture type and productivity
5. limitations e.g. waterlogging, soil acidification
6. areas with erosion hazard
7. aspect

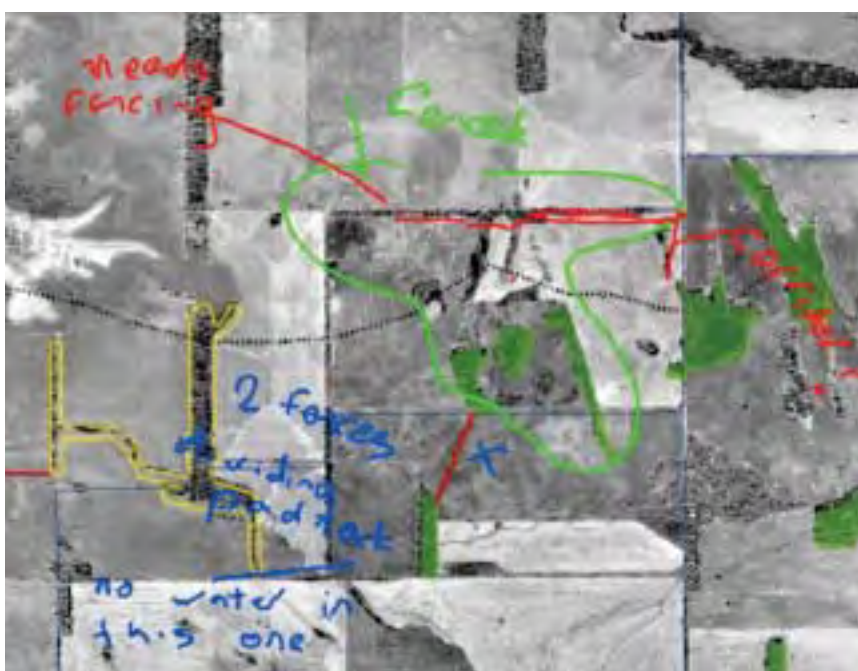


The process of mapping the farm to land units is to allow for each unit to be used to its productive potential, whilst protecting each unit according to its needs and limitations, so that degradation does not occur. This is a critical step for getting the best use and management of riparian areas, because they can be the most productive parts of the farm but they also need special attention and careful management, as described in more detail in the following sections. Where problems such as dryland salinity or high surface run-off are a problem, planning will need to be formulated on a catchment/sub-catchment basis.

The mapping process is simplified by obtaining a black and white aerial photo enlargement of the farm from the local department of natural resources/agricultural agency or catchment management authority. The land units can be marked out on the map using physical features such as trees and dams to help mark in the boundary locations. Other features that can be included on the base map include water courses and drainage lines, dams, existing trees, and any sensitive sites such as erodible soils, waterlogged areas or wildlife havens. “Protected” land that should not be cleared and that may require special use and management should also be marked in. This would include all riparian land adjacent to a stream or drainage line (the exact width will depend on the situation, current condition, and the growers’ management objectives, but generally would include at least 10 metres from the top of the bank), and land with a slope exceeding 20%.

Clear plastic overlays can be used over the aerial photo to depict other features of the property. The first overlay consists of the existing layout such as fencelines and gates, water troughs, existing soil conservation works, stock yards, buildings, roads and tracks, and powerlines. Depending on the farm and situation other overlays may include:

- soil information — soil type, pH, EC (electrical conductivity);
- paddock information — identification, current land use, seasonal productivity;
- native vegetation, windbreaks, agroforestry, proposed areas for planting or natural regeneration;
- services — power lines, telecom cables, water lines, gas pipelines;
- weed infestation.



Property maps enable features such as streams and creeks to be seen within the context of the whole farm. In this case, wildlife corridors are being mapped and a staged plan developed to replant and alter fencing lines.

Photo Andrew Huggett.

The final overlay(s) shows the future plan for the property. The woolgrower needs to be involved in the process of drawing up the future plan as it needs to meet their business and personal goals, as well as optimising the use of natural resources on their property.

Fencing the farm according to land classes enables areas to be used to their full potential, without being restricted by areas of lesser capability that require different management. It is difficult to manage each land unit according to its needs and capabilities when several land types occur in the one paddock. It is important, therefore, to look at the existing layout in comparison to the land class units when drafting future plans. These should show a range of possible layouts with proposed stages for implementation to fit in with the constraints of the farm. At this stage, it is crucial to identify all riparian areas that justify special management to make best use of their potential productivity (often higher than that of surrounding hillslopes, and with green feed later into the summer), or to address other issues such as possible stock losses during a flood, disease or weed control, or to protect water quality. These issues are described in more detail in the following sections of this Guide.

Fencing to land types often results in a greater number of smaller, odd-shaped paddocks and the capital cost can be high. This may not suit all woolgrowers, but it does provide for significant improvements in grazing management to assist in maintaining good pasture composition, feed production and utilisation, as well as disease control. Fencing or using other means of controlling stock access (e.g. siting of water points) is often the first step to better management of streams and riparian areas (see section B) to boost wool production and avoid land and river degradation.

The inclusion of laneways in the plan allows for more efficient movement of stock and vehicles around the farm. A 20–30 metre wide laneway with windbreaks provides excellent shelter following shearing or during lambing. The laneway should be wide enough for machinery operation to maintain pasture production, and reduce the risk of erosion from stock movement. In some situations heavy grazing of the laneway may enable it to function as a firebreak over summer.

Land uses

The type of farming system established is largely dependent upon the climate, particularly rainfall distribution and amount, and soil type. In a mixed farming system, the inclusion of crop and pasture rotations has many beneficial effects including:

- maintenance/improvement to soil structure and fertility, e.g. incorporation of good annual or perennial legumes in pastures;
- flexibility e.g. to alter the crop:livestock ratio to match changes in commodity prices;
- efficient use of farm resources e.g. to spread skills and labour and optimise their use;
- integrated weed management e.g. use of grazing management and crop rotations to control weeds; and
- breaking life cycles of disease organisms e.g. seasonal grazing of crop residues to reduce parasite populations in wetter riparian areas.

On grazing-only, including specialist wool properties, it may be possible to use a mix of pasture types, including native pastures, to achieve some of these benefits. Riparian areas with greater soil depth and retained moisture can make a major contribution to development of a mix of crops and pastures and hence to farming flexibility and profit.



Planning for trees

The integration of trees on the farm should take place after the basic layout has been defined and the need for trees identified. This ensures that the trees are established in the right location and for the right reason. The benefits of trees on farms include:

- reducing water and wind erosion, soil salinisation;
- providing protection and shelter for stock;
- enhancing the quality of surface and underground water supplies;
- providing diverse ecosystems to sustain wildlife and native plants which can provide natural controls of pests;
- restoring the natural beauty of the landscape; and
- providing wood and other tree products.

A minimum of 5–10% replanted tree cover has been the accepted guide for farms with little or no remaining native vegetation. Recent research suggests that for properties where grazing is the dominant enterprise, at least 30% retained tree cover over grazed grassland can be more profitable and is required to maintain vital ecosystem functions (McIntyre, McIvor & Heard, 2002). Trees in riparian areas are especially important as they provide shade to the adjacent stream, inputs to riverine food-webs, shade and shelter for stock, and help to stabilise streambanks and prevent erosion.



Planting trees can often be a social event for local communities to get to know each other and plan projects together. Photo Rae Glazik.

Geographical Information Systems

In the planning process, a number of overlays depicting data collected on the farm can be drawn over the base map. Much of this data can be drawn in freehand at the same scale as the black and white aerial photo enlargement. However this task can be difficult if results from surveys such as an electromagnetic survey are to be incorporated in the plan, or data from contour and/or soil maps which are likely to be at different scales.

A computer-based geographical information system (GIS) is capable of storing all this data using geographical references so that data at different scales can be used in the planning process. The data is digitised and stored on the computer allowing for the display of the data required, and providing for ease of alteration to existing plans. The GIS is very useful in situations requiring a catchment approach, as individual farm data can be aggregated together to display the catchment data and formulate a catchment-based plan.

Planning at the catchment level

The recent development of catchment plans and blueprints in most States and Territories provides the wool industry with an over-arching structure it can use to integrate riparian management and property development. For example, Rivercare planning places the property in the broader whole of river context and can be the gel that brings a number of landowners to the 'planning table' to work together. Appendix C in this guideline provides an overview of a sample of these catchment plans, with examples provided from wool growing regions. This snapshot provides general guidance only, and more information about the documents discussed is available from local government agencies. In addition to catchment plans, there are also Acts and regulations that may influence the management of farms with respect to riparian land, water courses and water use (see Appendix B). By developing a property management plan that incorporates these issues with wool production and applies industry best management practices on-farm, woolgrowers can be confident that they are meeting statutory requirements.



Presentation of a draft design for bird conservation at catchment level in the Wallatin Creek region, a cropping and sheep community that are working together for environmental and economic outcomes. Photo Andrew Huggett.

In summary

The basis of good management of streams, rivers and riparian areas on wool properties is to plan for their management as part of a whole property plan. This is the key to enabling woolgrowers to determine how they can use these areas to optimise pasture and wool production while also improving their environmental condition. Property management planning develops a future plan of operations based on the woolgrower's objectives and an assessment of the farm's resources. The property management plan enables the use of land units to their potential, whilst protecting them according to their limitations. With the increasing complexity of agricultural production, a property plan can be beneficial in initiating a whole farm perspective to incorporate technological advances while aiming for an ecologically sustainable farming system.

For further information

Government support is provided for property management planning, though it comes under different names depending on the State you are in. For further information in your State refer to the contacts below:

New South Wales	Department of Agriculture, www.agric.nsw.gov.au/reader/farming-systems-planner
Queensland	Department of Primary Industries & Fisheries, www.dpi.qld.gov.au/services
South Australia	Primary Industries & Resources South Australia, Farmbis www.pir.sa.gov.au
Tasmania	Department of Primary Industries, Water & the Environment, Farmbis, www.dpiwe.tas.gov.au
Victoria	Department of Primary Industries, Farmbis, www.dpi.vic.gov.au/farmbis
Western Australia	Department of Agriculture, Property Planning, www.agric.wa.gov.au



A riparian area in good condition, with a mix of trees, understorey shrubs, grasses and reeds providing a wide range of food and habitat. Photo Mike Wagg.

Chapter 3

Managing rivers, streams, creeks and riparian land

In this Chapter we discuss the management issues identified by woolgrowers and those arising from recent scientific research. For each issue, the management objective or purpose is stated, followed by a discussion of the principles of sound management to achieve that objective.

How these principles can be put into practice by woolgrowers is discussed next, and for most issues this is followed by a case study of a woolgrower who has successfully put the principles into practice.

At the end of this Chapter there is a rapid appraisal of riparian condition tool that can be used to assess the current state of a riparian area in comparison to others.

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Section A

Multiple uses and values of riparian areas



Purpose

To manage riparian areas so that a mix of environmental, economic and social benefits are achieved on-farm and in the broader community.



Multiple uses and values of riparian areas

Principles

Riparian lands and water courses have multiple uses and values. Riparian vegetation protects streams by slowing surface runoff, absorbing nutrients and trapping sediment and other contaminants before they reach the water course. Riparian vegetation can also protect adjacent agricultural production. It buffers crops and pastures from the wind and windborne material, and provides habitat for beneficial animals, especially pollinating insects. Livestock can shelter from harsh weather and graze understorey grasses and shrubs. Riparian vegetation itself can form part of the farm's production system, supplying wood products like timber, poles, posts, broombrush, firewood and charcoal, or non-wood products like seeds, essential oils, foliage, honey, bushfoods and pharmaceuticals. These products may be sold or used directly on the farm. Riparian areas and their streams and creeks are also special places for people, and are often highly valued for recreation, their beauty, and as a place to relax and enjoy nature.

In the future, some of the natural functions of riparian vegetation, like carbon storage, water filtration and salinity control may form part of the farm's production system, and be valued and traded as part of an ecosystem services market.


“What are ecosystem services?”


Ecosystem services are the benefits to humans that come from plants, animals and micro-organisms in nature interacting together as an ecological system, or ecosystem. The functioning of natural ecosystems provides ‘services’ that are essential for human health and survival. Examples of the kinds of services we receive from nature include water filtration, maintenance of soil fertility, pollination, pest control, and cultural and spiritual fulfillment.

The table beginning on the following page describes some of the ‘functions’ or ecosystem services provided by riparian areas, and highlights how this part of a farm, if managed carefully, can achieve multiple objectives.





Multiple uses and values of riparian areas

Uses/values	Description
<p>Provide water for stock and domestic use Section E, page 69</p>	<p>Riparian areas are important sources of drinking water for stock, particularly in times of drought with dams running low. However, uncontrolled stock access in riparian areas is one of the main causes of poor water quality, bank instability and declining in-stream health. By installing a reticulated water system throughout the farm, stock no longer require direct access to riparian areas, yet still benefit from the drinking water the stream or creek provides. Farm productivity is increased when these practices to improve water quality are implemented, with stock in better condition and better production when a clean source of water is provided.</p>
<p>Improved water quality Section F, page 85</p>	<p>Good management of riparian land can decrease the amount of soil and nutrients moving from cultivated fields upslope into the stream. By trapping soil and nutrients and other contaminants, water quality is improved and the loss of in-stream habitat through siltation is prevented.</p>
<p>Decreased algal growth Section F, page 85</p>	<p>Riparian vegetation helps to reduce light and temperature levels of stream ecosystems. It has been shown that this controls the growth of nuisance plants and algae, even when nutrient levels in the stream water have increased.</p>
	
<p>Nuisance algae, one result of increased nutrient levels. Photo MDBC.</p>	
<p>Decreased erosion Section G, page 97</p>	<p>Well vegetated riparian areas stabilise riverbanks and protect them in times of flood. In addition, if the surrounding riparian land is not well-vegetated with deep-rooted plants, flood-outs and stripping of topsoil from the floodplain can occur. Both forms of erosion can lead to the loss of valuable agricultural land and infrastructure such as roads, bridges, and buildings, as well as sedimentation of the stream or creek.</p>
<p>Retention of nutrients Section G, page 97</p>	<p>In addition to preventing erosion and improving water quality, riparian vegetation acts as a filter absorbing and using natural or added nutrients that might otherwise be washed into streams, stimulating the growth of nuisance plants and algae within rivers (especially where there is little shade).</p>

Uses/values	Description
<p>Denitrification Section F, page 85</p>	<p>Riparian vegetation can play an important role in reducing the amount of nitrate moving into waterways through sub-surface flow. This can help protect downstream aquatic ecosystems and lessen the risk of problems such as algal blooms occurring. This helps to protect water quality for stock use.</p>
	
<p>Woody debris in river provides valuable in-stream habitat for fish, birds and other animals. Photo Richard Weatherly.</p>	
<p>Maintaining fish stocks Section J, page 127</p>	<p>Healthy riparian vegetation helps maintain good habitat for aquatic animals, including insects and the fish that feed on them. Riparian vegetation provides important food sources including leaves, fruit and stems that fall into the stream, as well as dappled shade that provides cover for fish. The roots of vegetation provide essential habitat for fish by protecting overhanging banks, while large branches or trunks that fall into the water also provide shelter from predators and a diversity of flow speeds. Wood in streams also provides a breeding refuge for the insects and plants that fish eat.</p>
<p>Healthy ecosystems Sections J, page 127 and K, page 139</p>	<p>Good management of riparian land can prevent or minimise damage to both land-based and in-stream life following catchment development. Such damage can upset important biological balances and lead to the deterioration or even destruction of interdependent environmental systems, e.g. high nutrient from run off leading to blooms of toxic algae.</p>
<p>Maintaining river courses Section G, page 97 and H, page 107</p>	<p>Healthy riparian vegetation protects riverbanks and channels and reduces the risk of erosion. When riverbanks are cleared, increased flow can cause rivers to change their course and form new meanders or flood channels, as well as accelerated erosion of banks and the bed.</p>



Uses/values	Description
<p>Lowered water tables Section C, page 45 and F, page 85</p>	<p>Deep-rooted riparian vegetation may, in some circumstances, act to lower water tables along riverbanks, reducing the movement of salt and nutrients into streams from sub-surface flows, and helping to further stabilise the bank.</p>
	
<p>This riparian area has been fenced off from stock so that it can recover and regenerate to protect water quality, ensure stable banks are maintained, provide a source of fodder in times of drought or stress, and create habitat for native plants and animals. Photo Phil Price.</p>	
<p>Providing fodder for stock Section B, page 33</p>	<p>In many situations riparian areas support the most productive pastures due to deeper soils and retained moisture. Hence, it is a priority for woolgrowers to manage these areas to optimise production. As well, when managed carefully, riparian areas can provide fodder for stock in times of drought, or when feed is short on other parts of the farm. This grazing, combined with the protection offered by riparian areas from wind and temperature extremes, can be especially valuable, e.g. after shearing.</p>
<p>Shelter effects Section D, page 55</p>	<p>The shelter and microclimate that riparian vegetation creates can help to reduce death in newborn or newly shorn sheep, and lead to improved growth and productivity through reduction of heat or cold stress in animals. Vegetated riparian areas reduce wind speeds and this can assist growth and production of crops and pastures.</p>
<p>Decrease in insect pests Section K, page 139</p>	<p>Healthy vegetated riparian land provides habitat for insect-eating birds and insect parasites that can help to protect pastures and crops from damage. It has been shown that losing even a small number of birds can allow significantly more below-ground pasture grubs to survive and become adults.</p>

Uses/values	Description
<p>Maintaining biodiversity Section J, page 127 and K, page 139</p>	<p>Native vegetation on riparian land plays an important role in the lifecycle of many native animals and plants, including some that cannot live in other areas. It provides a wildlife corridor and helps prevent plant and animal species becoming isolated and dying out, as well as being a refuge in times of drought or fire. Floodplains and billabongs are also areas of very high biodiversity following a fresh or flood, and they support many of the surrounding terrestrial ecosystems (e.g. as a source of insects and other aquatic food).</p>
	
<p>Riparian zones provide important corridors for wildlife across the landscape. Photo CSIRO Ecosystems Services Project.</p>	
<p>Opportunities for diversification Section A, page 25</p>	<p>Some landholders have combined riparian management with agroforestry production. Others have used riparian land for producing hay or other stored forage, or for growing firewood or specialist crops. These farmers have increased the sustainability of their property while, at the same time, protecting its most valuable land.</p>
<p>Increase in capital values</p>	<p>Anecdotal evidence from real estate agents suggests that well managed riparian frontage can add up to 10% of the market value of a rural property, a valuable contribution to business finances and woolgrowers' "superannuation".</p>
<p>Recreation</p>	<p>Riparian areas provide people with access to rivers, streams and creeks that are an important recreational resource for fishing, canoeing, swimming or simply relaxing.</p>
	
<p>Protecting riparian areas provides for recreation by present and future generations. Photo Phil Price.</p>	



Uses/values	Description
Cultural and spiritual fulfilment	Rivers and riparian areas are important to people for spiritual, cultural and historical reasons. They provide people with connection to the environment, their past, present and future.
Ecotourism	Ecotourism is becoming a major source of income for rural regions, as shown by the resources being used to establish good bird watching habitat, canoe racing, walking trails and other activities compatible with rivers and their adjoining lands.

When you look at this list, it becomes apparent that managing a riparian area to achieve one objective can, at the same time, be providing a benefit elsewhere. In this Guide, we are encouraging woolgrowers and those that work with them to think about how they can get multiple uses and benefits from managing their riparian areas in ways that achieve economic, environmental and social objectives.

The following sections focus on some of the individual management objectives woolgrowers have identified as important for streams, creeks, and riparian areas. These are not mutually exclusive, and tips are provided on how to get the best overall ‘bang for your buck’ when integrating these parts of the property into an overall farming system. Managing riparian areas differently can maximise productive and environmental benefits for the wool producer. The key to sustainable management of riparian areas is to treat and manage them as a sensitive zone that requires a different management approach from other areas of the property. This River Guide will help people working with the wool industry to do this, with the case studies from other woolgrowers linking recommended management approaches to the practical realities of running a commercial wool property.



Photo courtesy Australian Wool Innovation Limited.



Section B

Stock and pasture management in riparian areas



Purpose

To manage stock and pastures in riparian areas so that productivity and environmental gains can be achieved.



Stock and pasture management in riparian areas

Principles

On many wool properties, the riparian areas adjacent to creeks or streams are highly-productive parts of the landscape. They often have deeper soils and more nutrients as a result of erosion from higher slopes and/or flood events, and are less exposed to sun and drying winds so retain soil moisture and green pasture growth longer into the dry season. For this reason, riparian areas, particularly the small floodplains adjacent to streams and creeks, may be some of the most productive areas of a wool-growing farm.



These images show the changes that have occurred along the riverbank as a result of stock exclusion. The bank is now stable, water quality has improved, and the riparian vegetation is regenerating. (Note: since these photos were taken the upstream landholder has also fenced his creek off.) Photos Bruce Mundy.





A home made 'cockies gate' that is easy to put up and down to allow stock access to a 'riparian paddock' that is strategically grazed depending on season and feed on offer. Photo Phil Price.

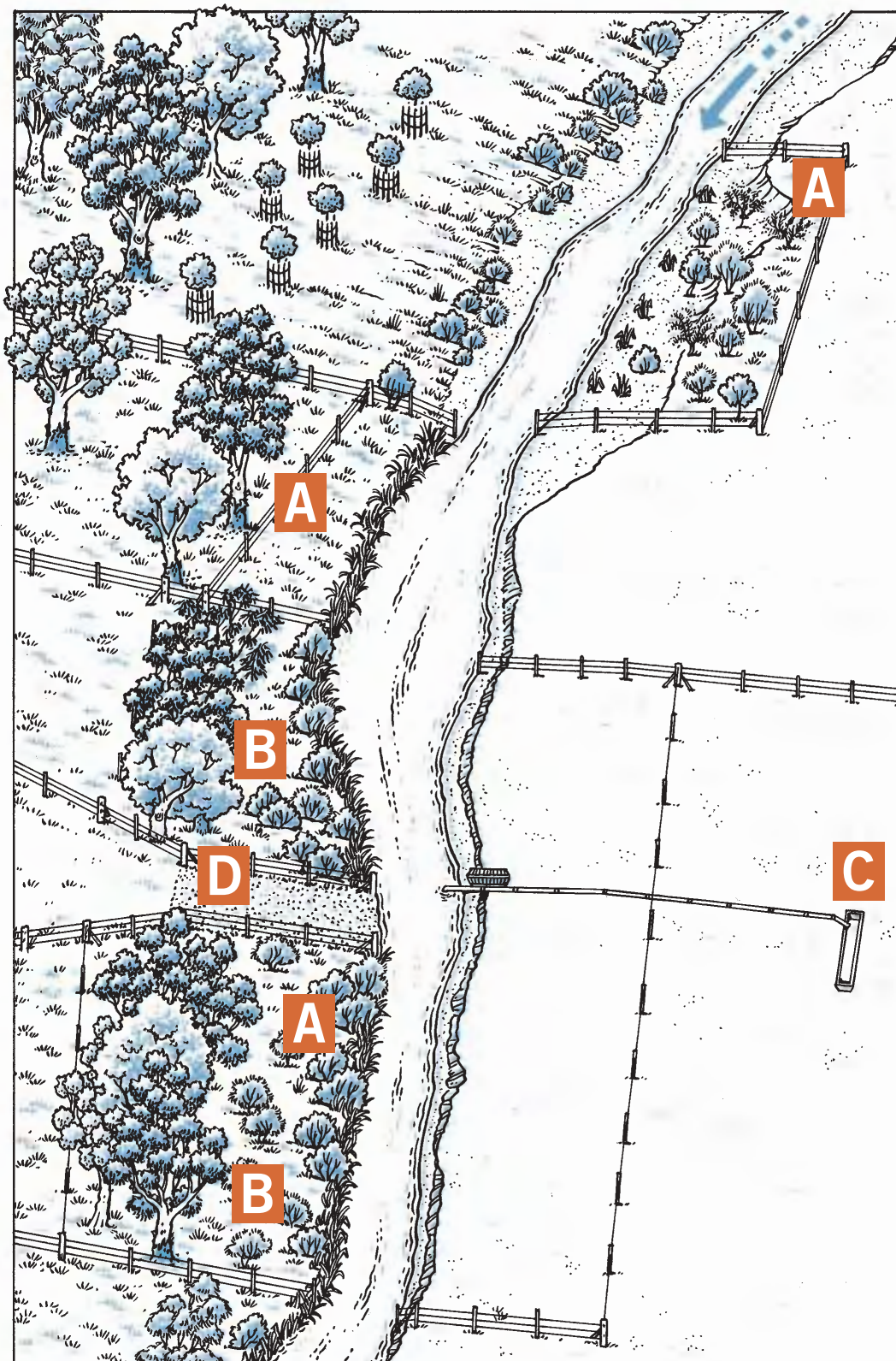
Uncontrolled access by stock to riparian areas is one of the major causes of degradation to creek or stream environments. Uncontrolled access does not optimise productivity as some areas become overgrazed (especially around 'camps'), leading to loss of valuable pasture species, whilst in other areas potential feed goes unused. Many woolgrowers are now finding that the costs involved in controlling stock access to streams and riparian areas can be recouped over time through improved pasture management that enables increased carrying capacity and wool production.

Managing riparian areas within a whole property plan is necessary if productivity and environmental gains are to be made. All areas in a farm need to be considered in terms of land capability, existing pastures, potential for pasture improvement, and likely rates of pasture production at different times of year. The plan provides the basis for an overall grazing management strategy that determines the likely carrying capacity of different areas and paddocks for different types of animals, as well as outlining when those areas should be grazed and at what intensity. The plan also covers other management issues such as fertiliser applications (both amount and timing), stock health and disease management, flood risk, and the need to spell different pastures at different times of year.

On-farm management practices

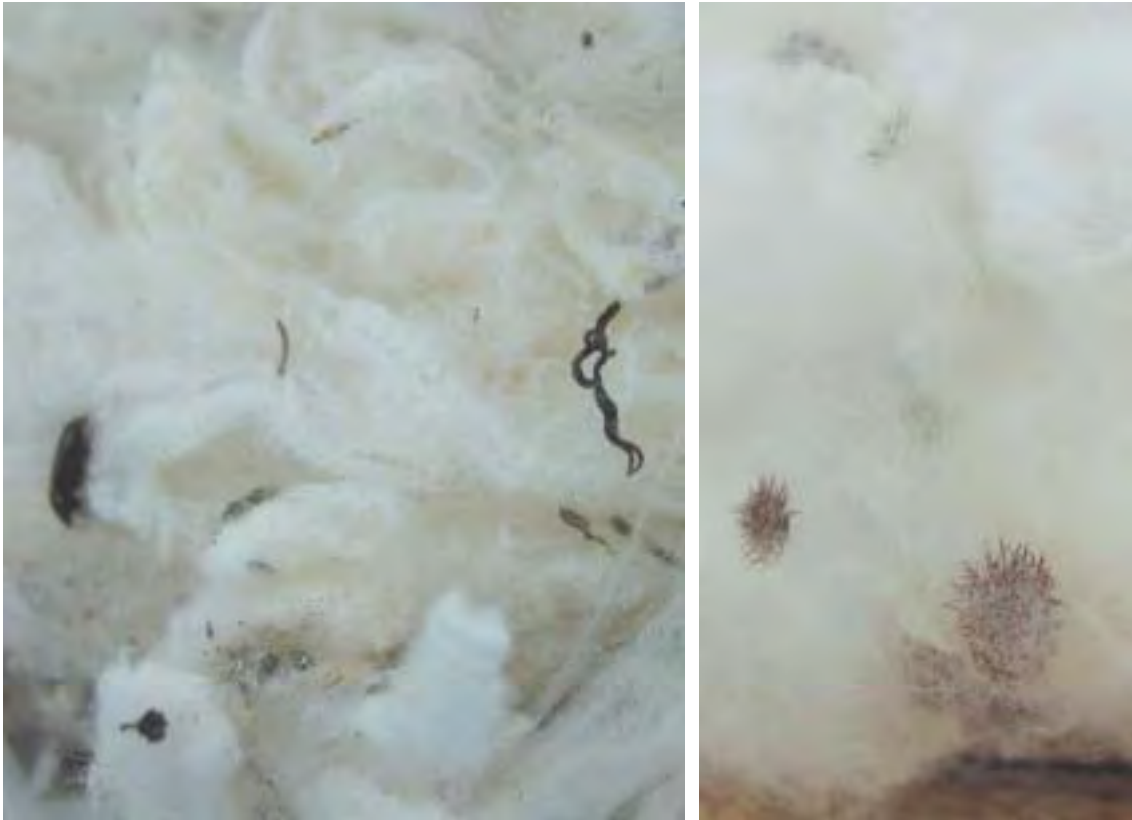
Grazing management is the most important single factor influencing the condition and productivity of riparian pastures. Woolgrowers use a range of grazing management styles, including set stocking, rotational grazing by season, and rotational or cell grazing based on feed on offer. As a general rule, set stocking is not recommended for riparian areas unless the overall stocking rate is low and there is no obvious symptom of degradation of the pasture, such as a slow decline in palatable species, a lack of their regeneration or obvious areas of bare soil and/or erosion.

1. Identify and map onto the property plan all riparian areas where different management strategies may be required to optimise pasture growth, deal with seasonal issues near water courses (flood risk, difficulty of access, parasite control in wet areas), optimise the use of shade and shelter, or achieve environmental objectives. Fencing may be required to control stock access so that the riparian area can be grazed strategically, and the options available discussed with the woolgrower.



This diagram shows how woolgrowers can gradually restore parts of their riparian land. In some parts of the stream, stock have been excluded so that natural regeneration can occur (A), in other parts revegetation has been more actively pursued to protect against bank erosion (B). Off-stream watering has been used on one side of the stream (C), whilst on the other side a gravelled stock drinking point restricts access to a small, but stable part of the streambank where damage can be controlled (D). Planning a gradual restoration strategy that can be implemented in small units, such as this diagram shows, makes it less daunting for the woolgrower to consider managing their riparian area as a different, yet integral part of their farm.

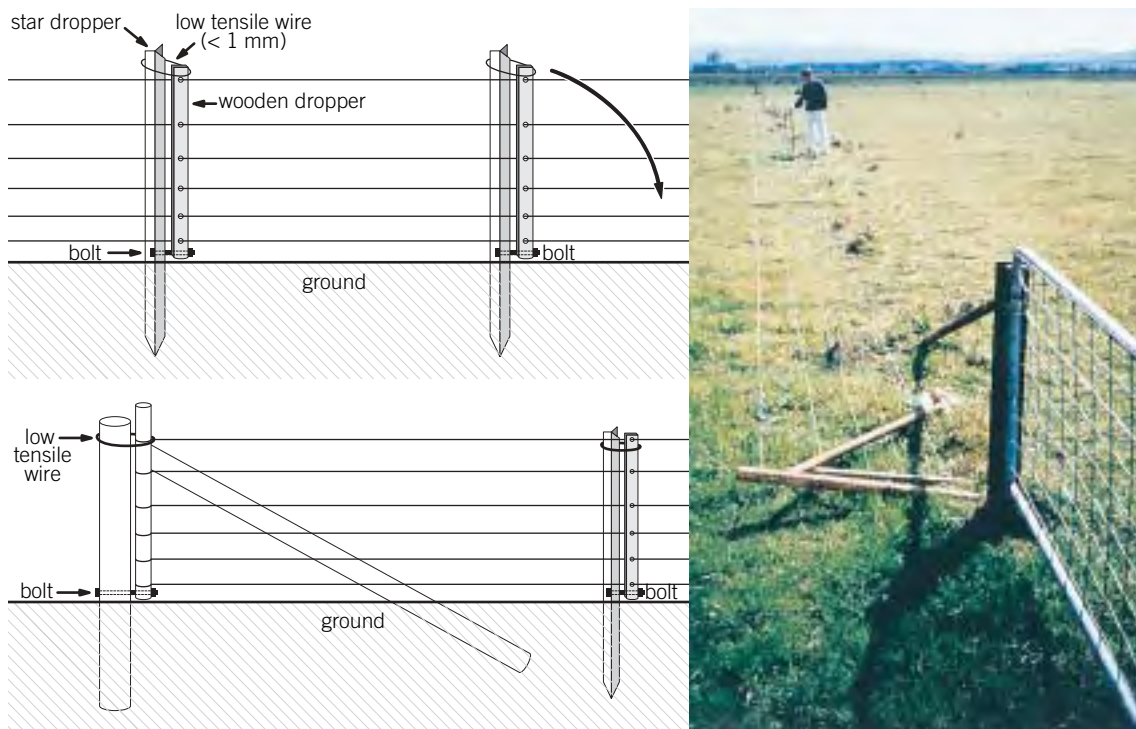




Wool quality declines when seed and shive get caught in the fleece. Photos courtesy Australian Wool Innovation Limited.

2. Establish some form of rotational grazing on the property as it is likely to provide a better long-term management regime. This might involve grazing riparian areas later in spring or summer, when other higher parts of the property have begun to dry out and lose green feed. Some woolgrowers have tested the ‘living haystack’ approach, in which riparian areas are seen as a valuable resource used to cover feed droughts on other parts of the property. Others are testing the value of cell grazing in riparian areas, and believe it may assist in increasing wool production where riparian areas are naturally highly productive due to deep soils and better moisture. It may also be possible to use rotational grazing as a way of reducing the grass seed content of spring pastures, for example, not grazing pastures when seed content is at its highest. Rotational grazing can be used to prevent pastures seeding where vegetable contamination is a problem, with other paddocks “locked up” when seed content is at its highest; work in Western Australia suggests this can reduce significantly the level of vegetable contamination (seed and shive) in wool.
3. Maintain a vigorous and competitive pasture sward to prevent invasion by unpalatable or woody weeds into riparian areas. This will also reduce soil loss and erosion during intense rainfall or periodic flooding. Spelling riparian paddocks to enable flowering, seed-set and natural regeneration of the most palatable and productive species is practised by many woolgrowers, with others using a combination of autumn spelling and occasional fire to help maintain the preferred composition and production of native riparian pastures. The time and duration of spelling should be based on observation of the growth and seeding patterns of preferred pasture species.
4. Do not graze riparian pastures during prolonged warm and wet periods if control of fluke and other internal parasites is a priority for woolgrowers. In the north, this means careful management over the summer period. In the south, riparian areas can be grazed more safely towards the end of summer, when hot and/or drier conditions have resulted in lower disease potential.

5. Monitor and control stock access to riparian areas. By monitoring the impact that stock are having on riparian pastures and streambanks, woolgrowers can move them to another paddock as soon as there are signs of damage. Some woolgrowers have found that using off-stream watering points, mineral or supplement licks, and providing shade and shelter away from the stream or creek, can be quite effective at changing animal behaviour, reducing the amount of time sheep spend in the riparian area. Depending on the woolgrowers' particular situation, these techniques may be reasonably effective at much lesser cost than fencing. Using multiple or movable watering points in a large riparian paddock can allow more complete and even use of feed, with benefits to overall production and less weed invasion into over-grazed areas around troughs.
6. In those situations where stock have access to the stream for water, provide gravelled or stone-reinforced access points. These reduce erosion and sediment run-off into the stream, and will be preferred by sheep to areas of mud where bogging and poor water quality present risks. An even better alternative is to provide off-stream watering well away from the bank and riparian area.
7. If installing fences to enable greater control of stock in and around riparian areas, there are three main types to consider.
 - Plain wire suspension fence — this is often preferred for use in areas where periodic flooding is likely. Plain wire is less likely to collect flood debris, be damaged or pushed over by flood waters. Wherever possible, the fence should be placed parallel to the direction of flood flow to minimise the debris capture. A plain wire fence is generally cheaper than fabricated mesh, although it may require droppers, and given the need for tension, there is some limitation on following the curves and meanders of a stream or creek. A plain wire fence can be cut, if necessary, when a flood is imminent and is relatively simple to replace and re-strain after the flood has passed. This practice can help to ensure that strainers and in-ground droppers remain in place.



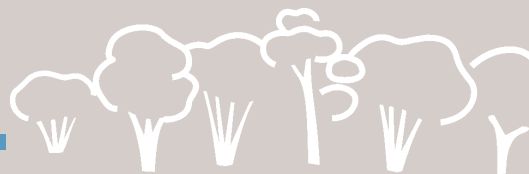
Drop/lay down fence. Upper diagram showing drop-down wooden posts at star droppers and bottom diagram showing drop-down end strainer post. Photo Ian Bell.

- Prefabricated mesh such as Ringlock or Hingejoint. These fences are more effective in controlling stock than a plain wire fence and do not require droppers. They are, however, more expensive and susceptible to collection of debris. They cannot be as readily removed or made ready for a flood, although the recent invention of a lay-down form of fencing may make this less of a problem. The lay-down fence has panels hinged at the bottom and held in place by a tensioned bolt at the top. When flood debris push against a low wire underneath the mesh, the bolt is released and the fence is then able to lay flat on the ground, where it is unlikely to collect debris or to be damaged during the flood event. Once the flood has passed, the panel can be lifted up and re-hung, using the tensioned bolt.
- Two or three-wire electric fence. This is cheap, quick to erect, and relatively flood-proof, but does require some form of electric power to operate it. With the decreasing price of solar-powered battery systems to energise electric fences, this type of fence is now often preferred by woolgrowers for use in a flood-prone area. Some woolgrowers consider an electric fence is not as effective at controlling sheep as a prefabricated mesh fence, but others disagree. Electric fences are reported to work well where pasture utilisation and height allows the bottom wire to be made “hot”, as this prevents animals pushing it up and shorting the current. Woolgrowers using a rotational grazing system, where sheep are moved to fresh feed every few days, report that 3-wire electric fences work well, perhaps because there is less tendency for animals to “push” at the fence to reach new pasture. Some woolgrowers also make it a habit when sheep prices are good, to routinely cull animals that do not respond well to an electric fence.

For some woolgrowers, combining a mesh fence located just outside the floodplain, with a simple electric fence placed closer to the stream works well, as this combination allows sheep to be kept safely out of the riparian zone when required, for example in time of flood risk or as a seasonal disease control measure, while the riparian pasture can be grazed outside those times but with stock still prevented from entering the stream itself. The electric fence can more easily follow the stream meander bends so that all the riparian pasture can be grazed. The expensive mesh fence is not at risk of flood damage, while the electric fence can be simply and cheaply replaced if damaged by an unexpected flood.



Wide fence setbacks from the river have created ‘riparian paddocks’ that are an important part of the woolgrowers rotational grazing system. These paddocks are used when shelter from extreme weather events is required for stock, or in times of drought when these ‘living haystacks’ can be strategically grazed. Photo Mike Wagg.



Case study

Tim and Karen Wright, 'Lana' and 'Kasamanca'

Location: Uralla, New South Wales
Average annual rainfall: 769 millimetres
Property size: 'Lana' 3350 hectares and 'Kasamanca' 780 hectares
Enterprises: fine wool (15.5–17.5 micron) and beef cattle
Stocking rate: 4.5 (winter) to 6.0 (summer) dse/hectare
Pasture base: moving from exotics (clover, fescue) to native pastures
Soil types: coarse and fine granites (Lana)
River management: Molong Creek, Roumalla Creek

Tim and Karen's philosophy is all encompassing and relates not only to their land but to their lives as a whole. Their 'holistic goal' is summarised as follows: "We aim to develop and maintain our property as a pleasing, ecologically balanced environment. We also aim for a chemical-free product. By doing this we believe our wool and meat production enterprises will be healthier and more cost efficient. In turn, we believe this will lead to healthier profits for the future, as well as improving human health. We endeavour to expand the horizons and the opportunities for both ourselves and the community."

Tim and Karen breed easy-care, low cost merino sheep of good constitution based on fine to superfine Merryville and Lorelmo (poll) bloodlines. The breeding flock on Lana in the early 1970s was Fonthill, to which Tim introduced Lorelmo superfine wool rams in 1980. This continued in most years until the late 1990s. So before Soft Rolling Skins came along, the Wrights were breeding that type of wool anyway. "Now we are using different bloodlines, and have bought in Merryville, Kyabra and Alfoxton rams during the past five years," says Tim. The wool is free-handling and locky, as they are steering away from deeper crimping fleeces with too much colour, and sticking to whiter, brighter more free-growing spinning wools.

"We are after very easy-care sheep — the ewes and wethers never get jetted — and we only drench once or twice a year. This means the cost of production is very low. We get a 78% wool yield, on average. The hoggets cut 15.5 micron and the adults average 17.5 micron," says Tim. The ewes cut about 4 kilograms of wool/head, the wethers 4.5 kilograms/head, and the weaners 2.5 kilograms/head.

Tim's father, Peter A. Wright, took over Lana in 1952 when it was customary to stock New England country with wethers from the Western Division of NSW. "According to one old-timer, this country used to run a quarter sheep to the acre and most of those died during the winter," said Tim. "This was when the country was burnt annually". In the mid-1960s, Peter began pasture improvement. About 20% of the property closest to the homestead and woolshed was cleared or thinned and sown (ploughed or drilled) with pasture during the 25 years to 1990. The whole property was aerially supered and seeded from about 1960. "We sowed fodder crops of oats under-sown with vetch or a cocktail of pasture species including sub and white clover, fescue, phalaris, ryegrass and red clover," said Tim. "Using pasture improvement like this, we lifted our stock numbers from 7000 dse in 1980 to 20,000 dse in 1991. We used to slowly rotate stock: two months in, two weeks rest, then back in again," he says.





Sheep at Lana in the height of the 2002 drought. Photo courtesy Nick Reid.

The problem was that this form of management barely broke even over five years after ‘improving’ a paddock, and in some ways things went backwards. “After the 1981 and 1994 droughts, the lowest yielding paddocks were the sown paddocks, and the land suffered,” said Tim. Under the old management regime of annual spring burning for green pick, wiregrass or speargrass (*Aristida ramosa*) flourished, and it continued to be a problem in the uncultivated country. Pasture problems such as pinrush (*Juncus* spp) increased in the 1980s, as the country was more intensively used. The sown country all reverted back to native species; in retrospect, this was a blessing.

By 1990, Tim and Karen decided that something had to change. They were motivated by two key considerations:

- costs of production, especially labour, but other inputs as well, had to come down;
- grazing management needed to change to better utilise the grazing animal to transfer nutrients off sheep camps, and reduce weeds and worms; in effect, to use livestock as the farm machinery for slashing, fertilising, sowing pasture, and so on.

Grazing management

Tim has learnt that sheep and cattle are generally best grazed separately: “We keep sheep and cattle separate to get the right balance between finance, livestock and range condition. Cattle always do better if they are on their own. They also open up the pasture for the sheep and reduce the worm burden. Cattle and sheep generally don’t mix, they don’t like each other. Sheep are more selective, and would otherwise take good feed away from the cattle. The two together didn’t work in the first year.”

Sometimes, Tim will deliberately run the cattle in with the sheep to stop the cattle getting too fat, and to reduce the risk of bloat if there is too much clover. The flexibility of planned grazing makes it work. Tim uses the ‘leader-follower’ system: “In a leader-follower system, cattle run two days ahead of the sheep. This solves the worm burden problem. For the leader-follower system to work, you’ve got to have the same size paddocks, 10–15 hectares of grazeable land in our case. Cattle get two days, then sheep get two days, so that the paddock experiences a four-day graze period at each rotation.” The moves are sped up in summer and slowed down in winter. “It’s only a half to one day difference between seasons so it averages out, with a minimum of 70–80 days rest, irrespective of season — never less, even in good times,” he said.



Open flats and drainage plains on Lana are lightly timbered with a healthy amount of regenerating trees as a result of planned grazing.

Photo courtesy Nick Reid.

For special stock purposes, Tim also employs a ‘split-leader’ system: “I sometimes run the first calf heifers ahead of the main mob of younger hoggets as a split leader. You can only do this in cells with lots of paddocks. You have the young heifers (maybe 20% of the dse in the farmlet) half way around the cell ahead of the main mob in a 12 o’clock to 6 o’clock fashion. “I only run the split-leader system when the pasture is growing, so that you get recovery of the pasture during the time between the young heifers and the main mob. I also use this for fattening special stock for market — it worked very well even in the last drought. “Alternatively, you can get young maiden stock cycling prior to joining. It’s a case of knowing what you want: the 20% don’t take enough from the paddocks to upset the long rest afforded the pasture between visits from the main mob. I might have 500 dse in the split leader, and 2300 dse in a main mob of wethers.”

Fencing and water

The change to planned grazing on Lana necessarily involved a new fencing and stock water plan with some major outlays: “I installed permanent fences — suspension fencing, four barbs, steels 15 metres apart, one dropper between and steel end assemblies — for \$800 per kilometre including labour back then. Today, the cost is \$1100 per kilometre including labour*. “We made our own end assemblies. My workman and I could do one kilometre per day, so it was pretty cheap. Each subdivision involved about three quarters of a kilometre of fencing, so eight paddocks meant 7–8 kilometres of fencing,” Tim said.

The re-fencing program was funded by reducing other costs, such as fertiliser and hay, and abandoning pasture sowing and renovation. The bulk of the fencing was done over six years. Tim aimed for, and achieved, a 100% return on capital over two years, through the reduction of vegetable matter in the wool. The cost of fencing and water per acre was about the same as a hundred weight of superphosphate, with a much better return. “We try to fence on the contour, not up and down. That way you get stock to move nutrients off the old camps. “Twelve months ago, we fenced the western paddocks like this, we’ve seen a big change in 12 months already. A year ago, the pasture looked dead. Those areas are now running three to four times the stock they used to.

In terms of fencing, the whole place is a laneway system. “If you’ve got a big mob to move, you leave the gates open, so one person can move them. On the main tracks, you tend to leave the gates open most of the time, so there are not too many gates to worry about. There’s a shire road running through the place, so it’s only 10 minutes from the homestead to out the back,” says Tim.

* costs vary according to situation and type of fence.





Molong Creek under planned grazing. Note the well-vegetated drainage line, riparian zone and the regrowth red gum on the banks.

Photo courtesy Nick Reid.

New stock water sources were developed progressively: “In the first and second years the water was already there in the creeks and dams. Since it was just the sheep and heifers, it wasn’t a big drain on the water supply. In the third or fourth year, we put in a tank system to water the new paddocks. “The dams were already here but we went to troughs. The cleaner the water, the better. There’s proof from Nebraska feedlot research that cattle do better on cleaner water. Stock can lose half a kilogram per day on muddy water in a dam. The stock tend to draw to the troughs. We don’t need troughs in wet seasons, but they are a good drought standby. A mix of dams and troughs gives us the best of both worlds. Troughs are also good for the leader-follower system when the cattle muck up the dam water. Dams on granite soils don’t pug up as much as on the other soil types.”

Riparian zones, wetlands

Planned grazing has had a positive effect on the vegetation in riparian zones fringing watercourses and dams on Lana. “The important thing is the rest that the riparian zone gets most of the time. Even though we run high stock densities, the planned grazing is helping the riparian zone recover, allowing vegetation to grow, erosion to heal and water quality to improve. The streambank erosion in Roumalla Creek is healed. Tilses Dam is an old irrigation dam that we use for stock water, and it’s like an artificial wetland now, with reed beds and fringing dense cover, as the stock are not in there long enough to damage it. The rotation of stock is good because the sheep and cattle don’t get the chance to hang around dams. That means you don’t get dung around the dams, nor as many nutrients ending up in the water.”

Tim and Karen’s operation at Lana is an excellent example of how wool growers are achieving the triple bottom line (i.e. economic, social and environmental success): through Holistic Management and planned grazing, they have made more time for family, friends and community; their business profitability is improving; and they are working with nature to enhance their farm ecosystem’s productivity and biodiversity, and restore its natural resource base.



This case study was prepared by Land, Water & Wool Native Vegetation and Biodiversity Sub-program Northern Tablelands Project. For more information contact Southern New England Landcare, Armidale, NSW 2350. Tel: (02) 6772 9123.

Section C

Managing riparian vegetation



Purpose

To maintain and improve the health and diversity of riparian vegetation on wool properties.



Managing riparian vegetation

Principles

The vegetation of riparian land is often more diverse and more productive than in other parts of the landscape. This is because soils are richer in nutrients than further upslope, and there is a greater availability of water, shade and shelter. Riparian soils receive nutrients from both land and water. Minerals, nutrients and sediments from upland areas are transported to lower-lying riparian lands by surface run-off after rain, while nutrients and silt may be deposited along streams during floods. Periodic flooding is particularly important in contributing to the enrichment of floodplain riparian soils along large, lowland rivers. Riparian vegetation at a particular site reflects past flood or other climatic events, as well as different landforms, soils, and land uses that exist along the stream. As a result, riparian vegetation is often complex, with increased species diversity. Some riparian plant species occur only along streams as they require the better soils and increased moisture for survival and reproduction.

Naturally healthy or rehabilitated riparian vegetation can be used for a number of purposes:

- providing shade and shelter for stock;
- lowering groundwater levels adjacent to streams;
- stabilising banks;
- trapping sediment and nutrients;
- shading streams for reduced light and temperature;
- providing wildlife habitat;
- increasing property values;
- providing fodder in times of drought;
- growing high value timbers for harvesting (providing harvesting operations do not damage the surrounding riparian land and follow planning and regulatory requirements);
- harvesting of native fruits and seeds; and
- improving in-stream life which helps to maintain fish stocks (including those in estuaries and in-shore areas).



This stretch of riparian vegetation is fulfilling a range of different functions. Photo Siwan Lovett.

For these reasons, the management of riparian vegetation on wool properties can be designed to optimise both productivity and environmental outcomes.

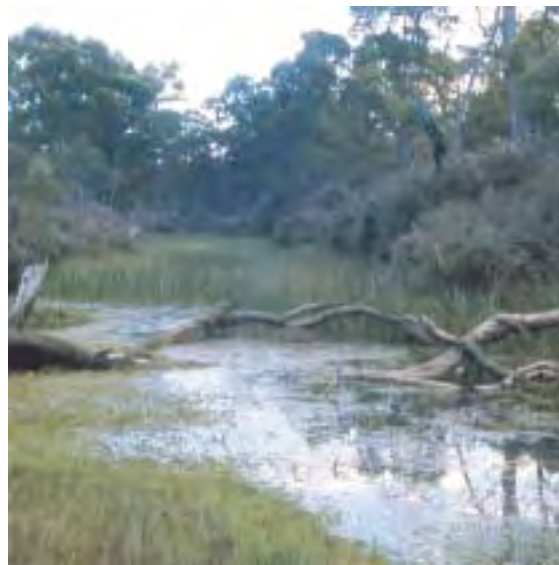


On-farm management practices

In many wool-growing districts, the natural riparian vegetation has been extensively altered, largely through grazing by domestic stock and clearing. Once native vegetation is lost, it is difficult and costly to reinstate it. In some places, scattered large trees remain, but there is often little natural understorey and native grasses have been replaced by annual and exotic species, including weeds (see box on willows page 120). Many of the native trees are old and where riparian areas are over grazed, there are no new trees to replace them. Research has shown that these changes, combined with catchment development for intensive cropping, can result in large amounts of soil being washed into stream channels. This often blocks the channel, reduces water quality and harms in-stream life. At the same time, increased light levels and water temperatures favour the growth of nuisance weeds and algae, particularly when nutrients from surrounding areas have been carried into the stream. The result is that many streams are in poor ecological condition.



This is a stream in poor condition, with very little riparian vegetation to provide shade over the channel. The sheep have direct access to the stream which means that high levels of nutrient and sediment from stock tracks would be degrading the quality of the water for stock to drink and for in-stream life.



This photo shows a riparian area in good condition, with large woody debris in the stream providing excellent habitat for fish, birds and insects.

Photos this page Michael Askey-Doran.

Some of the key management practices are as follows:

1. Survey all the streams and creeks running through or adjacent to the property so that their status and condition can be recorded. Section L in this Guide provides a method for rapid assessment of riparian condition. This on-site survey will identify opportunities for improved management of existing riparian vegetation or rehabilitation through replanting of riparian lands with local plant species. This activity may be undertaken with neighbours as part of a whole-community approach to stream and riparian management, but individual landholders can also plan and implement restoration projects on their own property.
2. Work out which part of the stream is going to be the focus of rehabilitation. The time and resources required to rehabilitate riparian vegetation means that if you are replanting it is best to replant one section of a stream each year over several years, beginning in the uppermost reaches and gradually working downstream.

3. Identify existing native vegetation that requires protection and areas where there is potential for natural regeneration as it is much easier to protect existing native vegetation than to replant it. Where native species remain on the farm and are in sufficient health to flower and produce viable seed, natural regeneration is the best and cheapest way to revegetate. Check to see whether seed is present either on plants or in the soil, and then aim to remove grazing for at least 24 months to give new plants time to establish and grow to a stage where they can survive the return of stock.
4. Consult local experts, for example Greening Australia, a river planner or government agency, to develop a plan for riparian rehabilitation. Visit local sites where there has been minimal disturbance, as this will show you what natural riparian vegetation could look like; note which species occur in which parts of the channel, banks and adjacent riparian areas. Some site preparation may be required, for example hand removal or spot-spraying of weeds, or a low intensity burn to remove dead plant material; these actions should occur before seed fall and the greatest likelihood of rains for germination.
5. Replant the northern bank first in east–west flowing streams, as this provides a maximum amount of shade for in-stream life. In consultation with local experts, select a mix of plant species focusing on the early stage or pioneer species that are favoured for their fast growth rate and ability to cope with full sun and frosts. Once established, birds, other animals, windblown seed and occasional floods are likely to bring in a diversity of additional species over time.
6. Implement a weed control strategy to protect the area being rehabilitated. Weed control prior to and following planting is often the key to successful revegetation. However, many areas have been invaded by exotic weed species following extreme disturbance of the natural vegetation, and significant time is required to remove and control these pest species, to prepare the site, to replant and to continue follow-up maintenance.
7. Avoid the tendency to ‘tidy up’ and burn fallen timber in riparian areas as this wood is important habitat for plants and animals.

For more information on managing riparian widths: Price, P., Lovett, S. & Lovett, J. 2004, ‘Managing riparian widths’, *Fact Sheet 13*, Land & Water Australia, Canberra, www.rivers.gov.au



Although this small stream looks ‘messy’, it is on the road to recovery. It has recently had willows removed, stock access controlled and native species replanted as part of a restoration strategy. Photo Michael Askey-Doran.



Replanting tips — using longstem tubestock to restore riparian lands

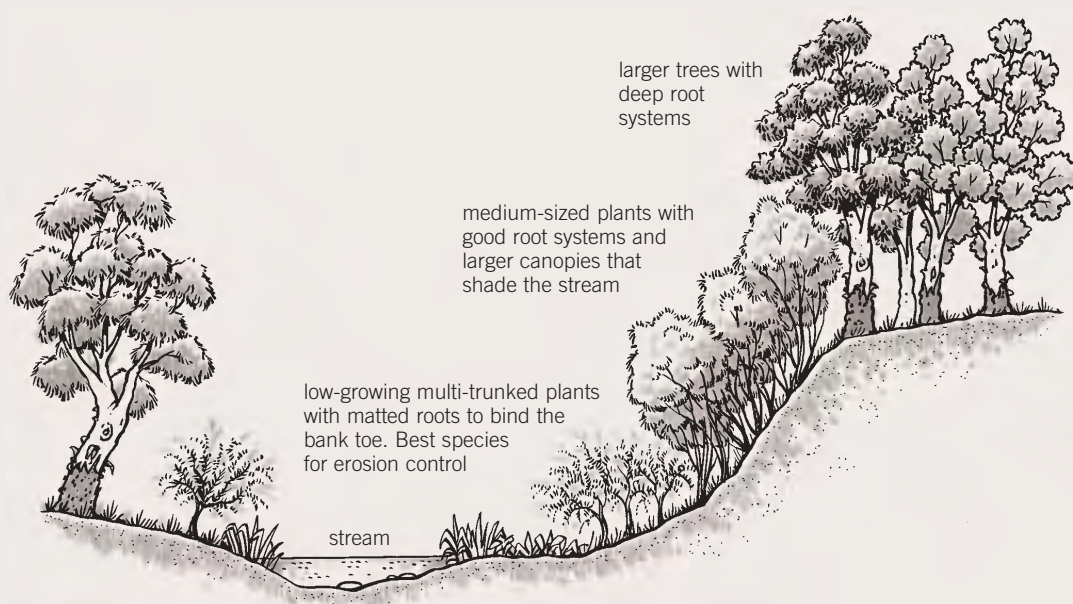
(Modified from NSW Department of Land & Water Conservation fact sheet)

Using longstem tubestock as an alternative to willows

Bill Hicks, a Hunter Valley Landcare member has developed an alternative for planting and growing native trees — longstem native tubestock, or 'longstems'. Longstems differ from regular native tubestock in the way they are grown and planted. Longstems are grown for up to 18 months using a specific nutrient and storage regime. The result is a climate-hardened plant with thick, woody, elongated stems (up to 2 metres long) with closely spaced growth nodes from which roots sprout once the longstem is planted. The longstem is planted in the streambank with its root ball buried 0.5–1.5 metres deep in the soil, leaving only the top 5–10 centimetres of the plant above the surface. Special water jets have been developed to plant longstems.

The results of trials show that longstems have the following advantages over regular native tubestock:

- increased growth rates and better survival rates — planting at depth enables longstems to access sub-surface soil moisture and potentially lessens competition with weeds;
- root establishment at depth — longstems can be planted in environments where previously only willows could be expected to have survived; and longstems achieve rapid erosion control; and
- minimal follow-up care, with the need for watering and weeding largely eliminated.



Where to use longstems

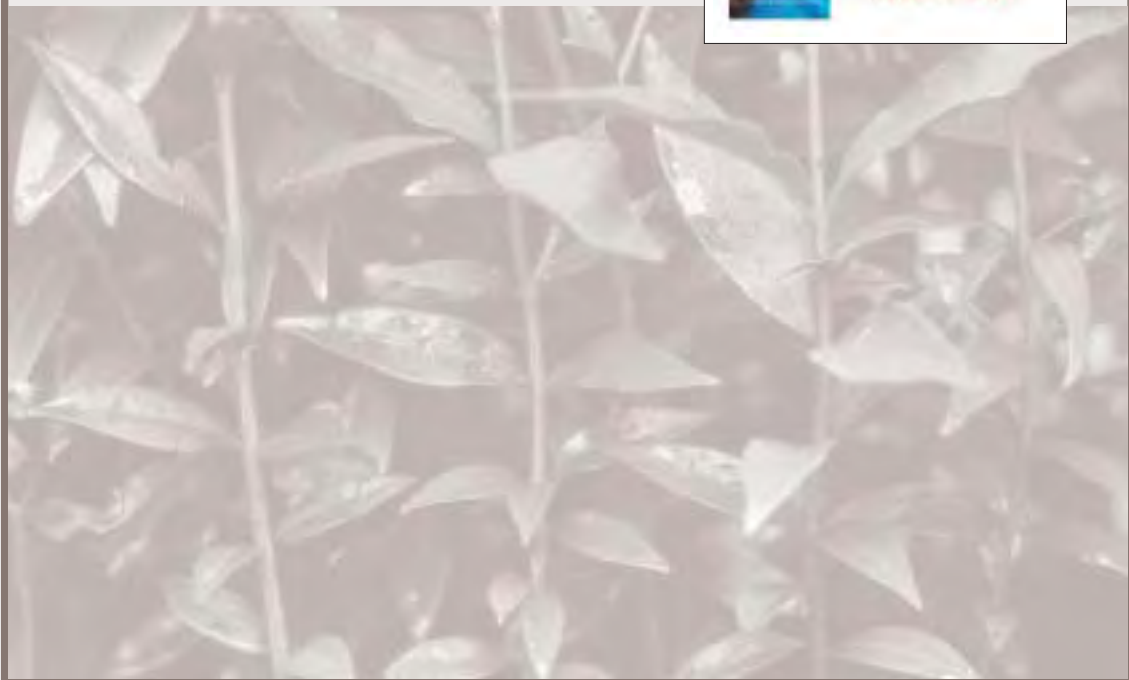
Most plant species that occur naturally along streams are considered to be suitable for longstem development due to their tolerance to sediment build-up around the stem, although it is always a good idea to trial any untested species before mass plantings take place. Longstems can potentially be planted in the riparian areas of most Australian streams. Use well-vegetated riparian areas as a guide for planting layouts. The form of the grown plants should guide selection of a planting position in the streambanks as illustrated in the diagram shown opposite.

More information

Supplies of longstems are currently limited. However, commercial production is being encouraged through regional workshops and education. A detailed brochure outlining how to grow and plant longstems is available from the New South Wales Department of Infrastructure Planning and Natural Resources. In all states, your local Catchment or Rivercare coordinators will be able to provide you with details of local longstem suppliers and the best species for your area.

Source: Department of Land & Water Conservation.
Rehabilitating Australian Streambanks with Longstem Native Tubestock. http://www.dlwc.nsw.gov.au/care/water/streambank_rehab/index.html. Includes link to Rehabilitating Australian Streambanks with Longstem Native Tubestock.

There is also a video available that can be purchased from either DIPNR Information Centre, tel: (02) 9762 8044 or from the person who developed the technique — Bill Hicks, Norkhil Technologies Pty Ltd, tel: (02) 4998 8387, E-mail: norkhil@hunterlink.net.au





Case study

Anna and Bruce Allworth, 'Talooby'

Location: Holbrook, New South Wales
Average annual rainfall: 780 millimetres
Property size: 1350 hectares
Enterprises: 10,000 merino sheep, 300 Angus Breeders equivalent 700 head
Stocking rate: 16 dse/hectare (overall)
Pasture base: 60% phalaris/sub clover, 40% annuals/sub clover
Soil types: loamy granite
River management: 9 kilometres of Billabong Creek

Anna and Bruce Allworth and their four children live in the beautiful Wantagong Valley, east of Holbrook in southern NSW. Great natural landscape assets combined with good application of science and animal husbandry know-how makes theirs a highly productive property. A major feature of the property is the 9 kilometres of creek frontage which have all been fenced. The frontages are all naturally regenerating with native grasses and water plants, with some supplementary planting of shrubs. The creek fencing was funded by the “Billabong Creek Environmental Renascence Project”, a program in early 2000 to fence and provide alternative watering points to landholders and Rural Lands’ Protection Board Travelling Stock Reserves along Australia’s longest permanent creek system. The Billabong Creek flows east to west across the Murray Catchment of NSW. It’s 1000 kilometres long, rising east of Holbrook and flowing into the Edward River at Moulamein and ultimately into the Murray. Prior to the Renascence Project, funding for off-stream watering points was not available. “This was a major sticking point” says Leanne Wheaton the project co-ordinator. “Farmers wanted to do the right thing and protect their creek banks and riparian vegetation, but the added costs of providing additional watering points put creek fencing out the equation.” The Project fenced 25% of the creek system, one of the largest creek fencing projects undertaken in the nation at the time. All fencing on Talooby was done by contractors. The fences are all electric — six plain wires. They are designed to be stock-proof even without the power.



Wantagong Valley. Photo courtesy Holbrook Landcare.





Areas fenced to control stock access, and ready for planting. Photos courtesy Holbrook Landcare.

Bruce's farming practices have been influenced by many. His father, Ross Allworth held a strong belief in looking after the land in perpetuity. "Dad never had the paddocks bare, paddocks were sown to establish a good pasture base, there was never any wash" says Bruce. Fertiliser and lime were applied regularly. Ross's husbandry of the land was far ahead of his time. After graduating as a Veterinarian from the University of Sydney, Bruce spent a year in New Zealand and then worked with the University of Melbourne's farm consultancy services providing advice to over 80 producers across Victoria, with a strong focus on running efficient and profitable farming enterprises. It was whilst working with the McKinnon Project that Bruce had a client who was one of eight farmers participating in the Potter Farmland Plan in the Western District of Victoria. The Potter Plan emphasised the farm as part of a total landscape. It stressed the importance of planting trees and shrubs for protection of stock and restoring biodiversity. This approach was applied by Bruce on his return home in 1989. As well as initially helping his father, then taking over the running of Talooby, Bruce completed a Doctorate in early 1990s in footrot control, ran his own consultancy in animal health and was the National Co-ordinator of the National Ovine Johnes Disease Program for six years. His effective balancing act in combining the efficient, the profitable, and the environmentally sustainable is the success of the property. "Knowledge brings confidence in how sheep will perform under different and difficult conditions" says Bruce, "I know how hard I can run the sheep without them becoming distressed or unproductive."

Talooby is surrounded by some large areas of native vegetation with the 23,577 hectare Woomargama National Park to the south and the 2000 hectare Morgan's Lookout to the north west. The prime agricultural land in between is substantially cleared. The creek fencing and protection works that Bruce and Anna have done provide a vital link between these major remnants along the creeks, the major wildlife highways across the landscape.

The revegetation of the property started off in small sections, using their own labour. Now they have a progressive environmental plan, with works conducted every year to cover the risk in labour, costs and weather. Fencing is done by contractors and the tree planting by themselves, their extended family, contractors, and more recently by the children. The children get a huge amount of satisfaction watching the trees they have planted grow and measuring their growth against that of 'their' trees.

Wombats were a problem along the creek banks when they were unfenced and are still present now that they are fenced. Cattle and sheep no longer create furrows down to the water. In the past their damage was obvious in the denuded banks. But the creek banks are now more robust, there is grass holding the soil on the steep banks together and phragmites and other water plants filter the water as it flows through the property. The wombats' digging activities are now of little concern. "We didn't



expect such good coverage of grass so quickly” says Bruce. “The phalaris has taken over somewhat but we will manage it with grazing once the trees and shrubs are more established. Our property is largely free of Paterson’s Curse, as there is little bare earth where it can become established, but it still is coming down the creek. However, with the fencing off the trees will soon out compete it. There is less manure in the creek which is a huge potential benefit in terms of phosphorus load and overall bank health has substantially improved.”

The Allworth’s have spent many years addressing soil erosion problems on their property and encouraging their neighbours to do the same. “Our efforts aren’t single efforts” says Bruce. “How as a community we live and deal with erosion is the difference between now and in the past. Our wonderful downstream neighbour of 50 years had never visited our erosion site, was never aware of the problems immediately upstream of her property. Getting everyone involved and enabling people to be aware of problems on adjacent farms rather than just their own is when real progress can be made.” Bruce and Anna are particularly excited about the works upstream by their neighbours. Substantial tree planting and perennial pasture establishment above them has seen once bare hillsides stable and productive. This is a great bonus for Talooby. “We are participating in the creek fencing schemes because we have a responsibility to our downstream neighbours and our community as a whole to provide better quality water.”

The Allworth’s aim to be a self-sufficient farm with a closed flock, to minimise weed invasion and control disease. Pasture management is “chaotic” but not random. Pasture is managed in a manner which is best for the pasture. There is specific grazing for weed control. Some areas are set stocked, balancing animal and pasture requirements. Rotational grazing is used at specific times and for specific pastures. There is a small amount of co-grazing. Young cattle are used to clean up the paddocks for worm control in the sheep.

“Total grazing area hasn’t been reduced by fencing the creek as the area wasn’t effective grazing land” says Bruce. Farm maps have been redone with the creeks taken out, so now they reflect true grazing area which is incredibly useful. Stock mustering and movement is easier. There is now no need to check creek areas when mustering. But it hasn’t all been clear sailing. A reticulated water system has to be checked regularly, and recently solar radiation was reduced by the thick smoke from bushfires, decreasing the output of the new solar pump for a few days.

The changing face of agriculture is obvious on Talooby. The few remaining dead ring-barked trees tell of another time when the true value of trees for their shelter and biodiversity benefits wasn’t appreciated. The scars of government attempts to re-route Scent Bottle Creek for erosion control and their consequential worsening of the problem are reminders that we need to work with and not against nature. However, the farming practices of the Allworth family shine bright. Creeks banks lined with a diversity of plant species, clean water, healthy stock and a growing diversity of bird and insect life are all signs that the agriculture practices on this farm are environmentally sustainable whilst being efficient and productive.

This case study was prepared by Leanne Wheaton.



Section D

Increasing wool production with shade and shelter



Purpose

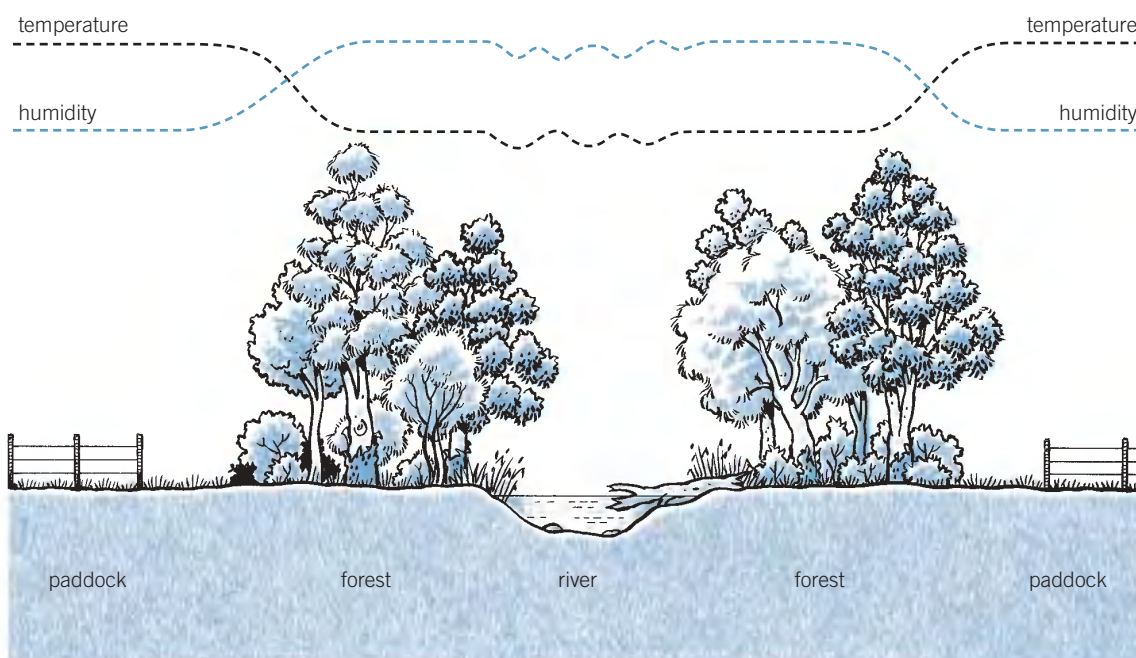
To manage riparian areas so that agricultural productivity can be improved on-farm.



Increasing wool production with shade and shelter

Principles

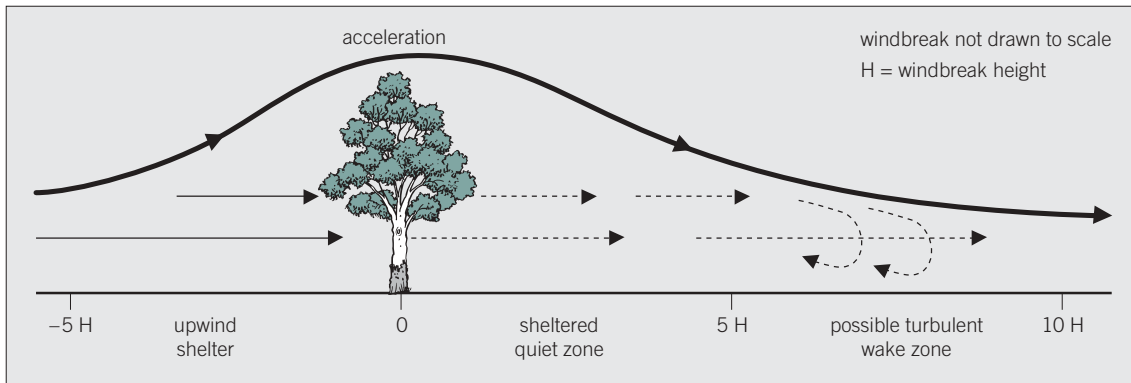
Livestock like to graze the understorey grasses and shrubs on riparian land, favouring the microclimate, feed, shelter and moisture found there. Shelter can improve livestock productivity and survival by increasing pasture supply and reducing cold and heat stress on animals. It can also assist pasture growth directly (better growing conditions) and indirectly (prevention of erosion, providing habitat for pollinators). The long-term aim of grazing on riparian land should be to improve animal health and wool production, while minimising damage to the vegetation and maintaining adequate ground cover. This can be achieved by managing the timing, intensity and duration of grazing, together with providing access to clean water.



Riparian vegetation has a moderating effect on air temperature and humidity, creating a special microclimate.
Illustration Paul Lennon.

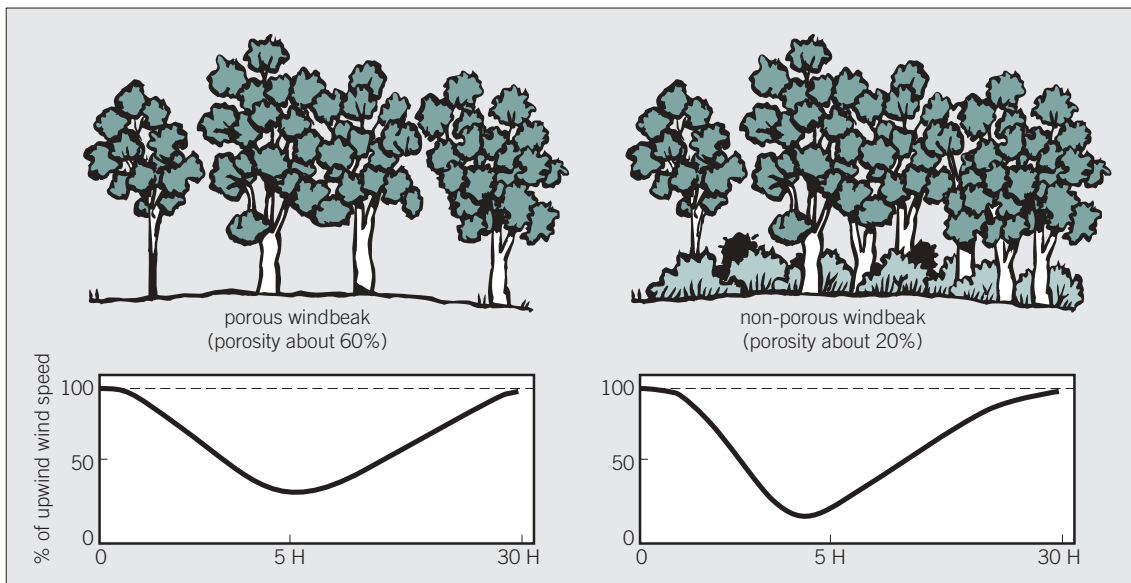
Shelter provided by riparian vegetation substantially reduces windspeed on the farm. The degree and distribution of shelter depends mainly on the height, structure and position of the windbreak. This means that the width of paddock that is protected is largely determined by the height of the windbreak, while the degree of protection (percentage reduction in wind speed) at certain parts of this shelter zone is influenced by the porosity (spaces) of the belt. The area close to a dense belt has a very high degree of wind reduction, while a more permeable belt has the best protection several windbreak heights away, although this may still be less than the maximum obtained within one height of a dense belt.





Above: The effect of a tree windbreak on airflow.

Below: The effects of a high porosity and low porosity windbreak on wind speed.



Source: *Design Principles for Farm Forestry*, 1997, Rural Industries Research & Development Corporation, Joint Venture Agroforestry Program.

The ideal windbreak has moderate porosity along both its length and height, reducing wind speed and improving microclimate. Porosity is determined by tree species, the number of rows and tree spacing. Gaps (including gates) need to be avoided as they can severely reduce the sheltering capacity of the windbreak. Foliage should extend all the way to the ground to prevent wind funneling at low levels. As an example, a 10 metre high windbreak can provide some protection over an area extending up to 300 metres downwind. Healthy native vegetation on riparian land forms an excellent windbreak as it has a mix of shrubs, grasses and trees at different layers and levels that slows down wind speed and creates a sheltered microclimate for stock to use in adjoining paddocks.

In general, to be effective windbreaks should be at least 20 H (where H is the average height of the tallest tree layer) in length. The following information draws on the findings from the National Windbreaks Program managed by the Rural Industries R&D Corporation.



Windbreak effects can be divided into three main zones:

Competition zone (-2 to +2H)

- competition for water, light and nutrients between trees and crops or pastures reduced yields at all field sites;
- gaps can lead to wind erosion and sandblasting damage;
- shading can offset increases in air temperature that result from wind shelter;
- competition will not be a major issue for riparian windbreaks that have the stream on one side, and perhaps an access track on the other.

Quiet zone (2 to 8 H)

- calmer, warmer and/or more humid by day;
- in dry conditions reduction in atmospheric water demand may lead to improved water use efficiency — translating to either more biomass for the same water use or less water use for the same biomass;
- enhanced plant development and biomass production are possible;
- an important zone for stock protection.

Wake zone (more than 8 H)

- effects of wind shelter on temperature and humidity are small;
- shelter from wind reduces the risk of direct damage to plants from leaf tearing and stripping, plant lodging and sandblasting.

The effects of porosity on wind speed are significant. In one example, the most porous windbreak, with a porosity of 70%, provided less than 40% reduction in wind speed at maximum reduction point, while one with porosity of only 30% gave a 75% reduction. Whatever the porosity, the maximum reduction in wind speed is achieved at a distance of about 5 H. There is no difference in the width of the paddock area sheltered by windbreaks of different porosities. In another example, the sheltered area extended up to about 23 H, maximum protection. Wind speed reduced to about 52% of the upwind figure, was provided at 4 H, while by 15 H the wind speed had risen to 80% of that in the open.

Wool production and quality

Shelter can increase wool production mainly by altering the microclimate in the sheltered area, and from reducing the direct effects of wind on plants and stock. Research undertaken in Armidale, NSW found that wool production in well stocked plots partially sheltered by a 1-metre-high iron fence was 43% greater than in open plots (Lynch & Donnelly, 1980) over a five-year period (most of the effect occurred in two years of well-below average rainfall). This was due to a combination of direct sheltering of the sheep and increased pasture growth. Lynch et al. (1980), quoted in Reid and Thompson (1999), showed that paired 1-metre barriers of Sarlon shade cloth (porosity 50%) reduced water loss. They argued that the “saving” of 12.3 millimetres of soil water in one month led to an increase of 15–21% in metabolisable energy intake in sheep grazing at 20 and 30 sheep/hectare on a phalaris/white clover pasture. Shelter from cold winds also reduces the amount of energy required by animals to maintain body temperature, providing more energy for weight gain and wool production.



In a more-recent trial (Reid & Thompson, 1999), plots that were protected by a windbreak ran more sheep (5.5 versus 3.9 dse/hectare), cut more wool (3.4 versus 3.0 kg greasy/hectare), maintained higher sheep body weight (13%) and in one case cut finer wool (17.8 vs 18.3 micron) than adjacent plots without a windbreak. The mean wool income of the protected and unprotected plots was, respectively, \$70.13 versus \$65.76 when sheep density was kept constant, and \$147.90 versus \$95.25 when sheep density was varied and matched to available feed. A whole-farm financial analysis, for a 1000 hectare New England grazing property with and without north-south oriented windbreaks (12 hectares) along sub-divisional fences, showed that a modest investment in establishing windbreaks (less than \$2000 per hectare of windbreak) provided an attractive rate of return for all but the lowest tested (10.5%) increase in stocking rate. Similar results could be expected from establishment of riparian windbreaks in most areas where wind effects on stock and/or pastures are significant.

Research has shown that with shorn sheep, shelter that reduces wind speed by 50% can reduce animal energy losses by 20%. Even with 3 centimetres of wool, persistent strong wind can reduce gains in liveweight or wool production. Shelter that can cut such wind speeds by 50% can increase liveweight gain by 30% (Bird, 2003). As well, ewes with access to shelter from extreme weather will produce lambs with higher birth weights and have more nutritious milk; both these factors will reduce lamb mortality (Quayle, 2001).

In addition, high wool cuts are dependent on the density of secondary follicles that form on the lamb foetus during the last six weeks of pregnancy. The number of follicles formed is dependent on the ewe's nutrition. Stressed ewes will produce lambs with fewer follicles and this trait will persist for the rest of the lamb's life. Shelter that reduces stress prior to lambing can therefore provide benefits over many years of a sheep's life (Quayle, 2001).



Shelter for newly shorn sheep is very important, particularly when extreme weather events can threaten their survival. Photo courtesy Australian Wool Innovation Limited.

In warmer regions or during periods of very hot weather, shade from riparian vegetation can also be very beneficial for sheep. Research has shown that high ambient temperatures have a detrimental effect on fertility. Heat stress 12 days before oestrus has been found to reduce fertilisation and lambing rates. Heat stress can lengthen the oestrous cycle by one or two days, dampen oestrus behaviour towards rams and reduce the length of oestrus. During the first nine days following fertilisation heat stress can also cause embryo mortality. Heat stress has also been found to depress wool growth. Therefore, access to shade during joining can be an important contributor to high lambing percentage and to subsequent wool production (Dutt, 1963, 1964; McLennan, 2005; Hopkins, Nolan & Pepper, 1980).





Shelter reduces the risk of losing newly born lambs through exposure to cold or hot weather. Photo courtesy Australian Wool Innovation Limited.

Shelter reduces deaths of newborn lambs. The average of all trials in south-east Australia shows that effective shelter reduces these losses by 50%. Wind is the major problem, but losses are greatest when accompanied by low temperature and rain. Without shelter, all lambs born on such severe days may die. A chill index has been developed (see RIRDC, 1997) to allow calculation of the effects of different wind speeds on new born lambs at different temperatures. This shows that even at an ambient temperature of 9°C, a wind speed of 30 km/hour is sufficient to bring heat loss to a critical level. Reducing the wind speed by half to 15 km/hour, decreases heat loss to a safe level. At a temperature of 3°C, wind speed should be less than 10 km/hour to prevent dangerous heat loss.

Shelter from wind also reduces losses of exposed shorn sheep. Severe weather in 1982, 1983 and 1987 in south-west Victoria resulted in a recorded 250,000 sheep dying from exposure. In contrast, losses were minor where sheep had access to shelter. The presence of native vegetation, woodlots, and intact riparian areas on farms provides insurance against such losses (Bird, 2003).

The data quoted here concern reproduction and growth rates and stock losses. Other than the results quoted earlier from Reid and Thompson, there is no data on the impact of shade and shelter on wool quality, for example reduction in fibre diameter, or tender or break points that result from severe animal stress, as well as reduced contamination from airborne dust or vegetable matter. However, these could provide additional benefits from retained or planted native vegetation in riparian areas alongside water courses.

Sheltering livestock from the weather (sun, heat, wind, cold, rain and frost) improves their condition, especially for lambs and newly shorn sheep, and can lift wool production. This is best achieved through carefully-planned, strategic use of riparian pasture paddocks adjacent to fenced-off native vegetation along the streambank. This configuration protects the native vegetation from over-grazing and damage, while enabling full use of the next door pasture at critical times of the year.



Additional agricultural productivity gains

As well as the direct effects on sheep survival, reproduction and growth from shade and shelter, riparian vegetation can also benefit pasture production in several ways. Reduction in wind speed and provision of shade can reduce pasture water use (transpiration) and loss of moisture by evaporation from the soil surface, so that more feed can be produced for the same amount of rainfall. The average increase in pasture production measured by a range of experiments was 9%, with a range of nil to 60% (latter figure from New Zealand). Overall, the direct benefits to pasture production are small, but they can be significant during winter when feed is at a premium, and they may be larger in the dryer years. Shelter can also reduce wind erosion of surface soil and its attached nutrients, and reduced wind speed leads to less abrasion and tearing of pasture plant leaves. Overall, through a modest contribution to pasture production (and perhaps quality), especially in winter, when combined with the reduced stress on animals, windbreaks can make a significant contribution to carrying capacity and animal productivity (Bird, 2003).

Overall, through a modest contribution to pasture production (and perhaps quality), especially in winter, when combined with the reduced stress on animals, windbreaks can make a significant contribution to carrying capacity and animal productivity (Bird, 2003).

Healthy vegetated riparian land not only benefits crops, pastures and livestock by acting as a windbreak, but also by providing habitat for pollinators. For some plants like grasses and cereal crops, the movement of pollen by wind is sufficient to pollinate flowers, but much of our food comes from those that require animals to visit their flowers to help move pollen, and so produce seeds. Birds, bats and even small possums can pollinate some flowers, but the most important pollinators are insects, with the most significant being bees. Lucerne, an important pasture species, is a pollinator-dependent species. These pollinators are declining due to loss of habitat and pesticide use. Farmers in many parts of the world now have to purchase the services of bee keepers to pollinate their crops.



This woodlot windbreak has been placed to provide a range of benefits, including stock shade and shelter, habitat for beneficial insects and a source of firewood. A riparian woodlot, providing it is harvested with care, can provide benefits to the wool enterprise as well as diversifying farm income. Photo courtesy RIRDC.

Riparian vegetation also provides habitat for insect-eating birds and insect parasites that can help protect pastures and crops from damage. Virtually all bird species feed on insects and, in so doing, can suppress plant-eating insects. Christmas beetle adults are eaten by cuckoo-shrikes, kingfishers and the larger honeyeaters as well as many other species, while whistlers snatch leaf beetles and caterpillars from eucalypt foliage. Magpies can consume many scarab larvae per hectare each year. Ibis also eat large number of insects, particularly grasshoppers and larvae. Losing even a small number of birds can allow significantly more below ground grubs to survive and become adults. Small mammals, like sugar gliders and bats, and predatory insects and spiders can take a significant proportion of insects that are not eaten by birds. Insect predators of pasture pests, including many wasp species, may also be important in controlling pest numbers and preventing a build-up of pest populations. These species are more likely to be found in native vegetation. Predation of crop and pasture insects is greatest next to intact riparian areas, native vegetation and forested land, with these findings providing further evidence of the benefits to agricultural productivity in maintaining and protecting these parts of the farm.

On-farm management practices

The agricultural productivity gains that can be made by providing shelter belts means that it makes sense to protect and maintain any native vegetation or riparian area on the property. As well, remember that in many situations the riparian pastures are especially productive (deeper soil, retained moisture, higher fertility), so woolgrowers should give priority to optimising the feed produced and used on these areas. The key to this is to identify streams and riparian areas, and to plan for their specialised use and management, as part of a whole property plan (see page 16 on property management planning).

As well, remember that in many situations the riparian pastures are especially productive (deeper soil, retained moisture, higher fertility), so woolgrowers should give priority to optimising the feed produced and used on these areas.



This wide open floodplain is exposed, with little shelter for sheep. Several woolgrowers along this stretch of river are now joining together to fence out the river and replant the riparian area so that both environmental and economic gains can be made. Photo Rae Glazik.



1. In riparian areas, try to maintain or establish a strip at least 10 metres wide with a mix of native trees, shrubs and grasses to provide maximum shelter from wind for stock and crops in adjoining paddocks. Fence the area to prevent livestock eating foliage and increasing porosity, especially if the riparian area is a narrow strip where every tree counts.

2. If starting from scratch, plant at least one row of trees or shrubs that give good coverage down to the ground in multi-row plantings, so that other rows can include tall trees that lose their foliage near ground level, or can be pruned to improve the value of their timber. Use mixed, local species in multiple rows to maximise beneficial animals, especially native pollinators like bees and birds. Achieve the maximum possible height as soon as possible by choosing fast growing tree-species — if the trees are short-lived, ensure that you supplement the area with slower growing trees to replace those that die.

3. Replace young trees that die as soon as possible and control weeds during the establishment phase. The aim is to reduce gaps so that the riparian area forms an effective windbreak for livestock in adjoining paddocks. To estimate the porosity of the riparian windbreak, using your naked eye simply stand directly in front of, but some distance away from the windbreak, and estimate the proportion of ‘open’ versus ‘closed’ areas. It is even more accurate if you use a photograph. Once you have identified the ‘open’ areas, try to plant trees and shrubs to fill the gaps.



A teatree seedling planted deep so its roots can quickly reach the fresh groundwater next to the stream. Photo Michael Askey-Doran.



Photo Michael Askey-Doran.





Rip lines are prepared on the contour across whole paddocks and, providing there is no risk of flood, adjacent to the riparian zone — this promotes rapid establishment. Ripping and mounding may be necessary where there is surface salinity present. Photo Nick Reid.

4. The longer the windbreak, the more effective it is in providing shelter. The wind can change direction by up to 30° and result in only small reductions in the distance sheltered if the windbreak is long enough (i.e. more than 20 times its average height). Even when the wind is blowing along the line of trees, a small area is sheltered because of the ‘drag’ effect of the trees on the wind. If the riparian area is short in length, try to continue the windbreak at adjoining ends into the paddock so that maximum shelter effects can be gained. Consult your local vegetation or Greening Australia expert for advice on the right mix of native species for the riparian area to gain maximum shelter effects for livestock.



Photo Michael Askey-Doran.

5. Weed control is a key issue when replanting riparian areas. It is good to start work on weed control the year before the planned planting. Ripping can be used to open up the subsoil to speed establishment, and to temporarily reduce competition from nearby established trees. Direct seeding, where it is feasible, is much cheaper than planting tubestock, and avoids the possible need for supplementary watering during the first year. Again, use your local agencies and Greening Australia staff to get advice about the best preparation and planning approach as they have a wealth of experience in revegetation methods.





Case study

Mark Wootton and Eve Kantor, 'Jigsaw Farms'

Location: Hamilton, Western Victoria

Average annual rainfall: 675 millimetres

Property size: 4900 hectares (all grazing) comprising 11 holdings

Enterprises: 50,000 merino sheep for fine wool production (18.5 micron); 3000 cattle, including 1200 breeders

Stocking rate: 18–20 dse/hectare

Pasture base: phalaris/fescue and clover

Soil types: country at Hensley Park (40% of the farm land) is predominantly flat to gently undulating heavy basalt country, commonly known as “crab holey”. The remaining 60% of land at Melville Forest ranges from lighter sandy country on the edge of Mount Dundas to undulating loamy clays

River management: 500 kilometres of waterways and creek fencing

Trees and the re-vegetation of creeks and waterways play just as an important role as the 50,000 sheep and 3000 cattle run at Jigsaw Farms, south-west of Hamilton in Victoria's Western District. Owners Mark Wootton and Eve Kantor say that while Jigsaw Farms (a group of 11 properties comprising 4900 hectares) is focussed on high inputs and maximum production from modern pastures, strict environmental guidelines are adhered to, to ensure the properties remain healthy and sustainable.

That means since Jigsaw Farms started about a decade ago, more than 930 hectares have been planted out to re-vegetation or agroforestry. And that figure will continue to grow as Mark and Eve believe they still have much more to do. “The trees and re-vegetation fulfil several roles,” Mark said. “Not only do they provide a valuable source of off-farm income, they are instrumental in building biodiversity, controlling salinity and increasing productivity by, for example, providing shelter for stock. “We also know that the trees and revegetation help lift winter pasture dry matter levels by 6–8%. This is paramount to our bottom line, so we have no qualms taking farmland out of production and planting it out to trees or shrubs. We may soon see up to 30% of our property planted out to trees and revegetation.”

Another important benefit of fencing off and planting out all access to waterways involves Ovine Johnes Disease (OJD) and its control. Mark says that “with the re-growth and plantings along the waterways, we now have a boundary to protect others and ourselves against spreading or receiving OJD as it, and other water-borne diseases can be carried along creeks and rivers.”



Mark Wootton and Eve Kantor inspect the progress of one of their plantations which is part of 900 hectares of re-vegetation and agroforestry at Jigsaw Farms. Photo Mark Saunders.



Mark and Eve are obviously acutely aware of the productive potential of Jigsaw Farms. The stocking rate is 18–20 dse/hectare, nearly double the district average. The average rainfall is 675 millimetres and the pasture base is a phalaris/fescue/clover mix.

They are also obviously not afraid of change. Not being from a farming background (both Mark and Eve are trained secondary school teachers), the couple enjoy the challenge of doing things ‘a little differently’. “At the end of the day, we are grass growers” Mark said. “We generate 60–70% of our production in about three months, so we do all we can to ensure the maximum amount of dry matter per hectare is available to stock. But we love the bush and its native animals so we are encouraging as much biodiversity as possible.”

The tree planting and re-vegetation at Jigsaw Farms was inspired by the work of several individuals and various groups according Mark and Eve. One of the first properties purchased under the Jigsaw Farms’ banner was Helm View — a property owned by the Milne family — and renowned for its sustainable approach to farming and involvement in the Potter Farmland Plan. “Helm View was a great inspiration and played a big part in shaping our land management philosophy” Mark says. “We have had advice and learnt from Landcare and the RIST program and the tree planting involves a number of organisations and schemes such as the Australian Greenhouse Office, the Trees for Greenhouse program, Greenfleet and Trust for Nature grants as where possible, we offset the cost of planting.”

Jigsaw Farms also employs a specialist to monitor bird numbers throughout the properties, which is a great indicator of species diversity and growth, according to Eve. Literally every creek and waterway on Jigsaw Farms is fenced off and has been planted for re-vegetation or agroforestry.

In removing stock access to the riparian areas, Mark and Eve have installed new water management systems, which are based on large, deep dams that are filled by natural drainage which in turn feed turkey nests that are placed strategically around the properties. The turkey nests supply troughs via gravity for stock watering.

Fencing has had to change as well, and Jigsaw Farms has installed more than 500 kilometres of 7-wire electric fencing to fit in with the re-planting and re-vegetation. Mark says the approach to fencing for plantations is basically ‘the wider the better’. “We aim to provide a 50 metre corridor, but in

Some of the 50,000 merino sheep run at Jigsaw Farms in Victoria’s Western District. Photo Mark Saunders.





This eroded creek bed has been fenced off and planted out to native trees and shrubs at Jigsaw Farms in Victoria's Western District. Photo Mark Saunders.

practice, the tree and shrub re-growth is much broader than that. For example, in re-charge areas, the plantations will be much wider. In any case, we have a minimum of six rows of trees either side of the waterway. Everything is direct-seeded and sourced locally. There is no specific mix, but most corridors include eucalyptus, callistemon, melaleuca and hakea varieties.”

The direct seeding involves two controlled sprays for weed management, and then a rip line is put in to a depth of one metre. Seed is then placed directly into the rip line. And while Mark and Eve are not fans of the traditional long rows of cypress pine trees (as featured on many Western District properties) they are very protective of red gum tree remnants, as they believe they provide a fantastic habitat for birds and other wildlife.

“We have four kids and when we decided to start farming we thought it would be great to have a place where we can demonstrate how to farm productively while working in with nature at the same time,” Mark says. “We’ve got more work to do, but we believe that Jigsaw Farms is a great work place where the stock are content and healthy — and so are the people that work here.”



Looking back on the work to date, Mark and Eve say the results have been inspiring. “Anyone thinking about planting trees and revegetation should just get on with it and have a go. Get the plants in the ground and once it starts happening, the results can be quite amazing.”

Eve Kantor and Mark Wootton believe biodiversity is a big part of today's farming practices. They have planted more than 900 hectares of trees and shrubs on their 4900-hectare group of properties known as Jigsaw Farms in Western Victoria. Photo Mark Saunders.

This case study was prepared by Currie Communications.

Section E

Using riparian areas
to water stock:
do's and don'ts



Purpose

To ensure that stock have access to an adequate supply of drinking water all year round.



Using riparian areas to water stock: do's and don'ts

Principles

Sheep need access to adequate supplies of good-quality water for optimal weight gain and wool production. The amount of water required varies according to the type of animal (e.g. lactating ewe versus wether), the type and quality of pasture (green versus dry), and the ambient weather conditions. Water consumption decreases when on green feed, during the cooler months and following rain. In hot weather, animals use more water for evaporative cooling. Shearing can increase the heat stress on sheep because the insulation formerly provided by the fleece is lost.



Above: Unrestricted stock access to this stream has resulted in a muddy, unstable surface, limited riparian vegetation and deep tracks that are channelling nutrient and sediment into the unprotected stream. As a result, water quality in this stream would be poor. Photo Siwan Lovett.

Right: This photo shows the left side of the stream with healthy riparian vegetation, and the right side at the start of rehabilitation (a fence has been put in and trees planted). Although there are still big improvements that could be made, this stream would have significantly better water quality than the one shown above. Photo Phil Price.



Water consumption can increase by 78% under extreme, hot conditions. The provision of shade decreases this requirement (see also section D). In normal conditions and with good water quality, consumption in summer is about 40% higher than in winter, but can be 50–80% higher if the supplied water is above 2000 ppm total dissolved salts. The table below indicates the likely range of water required by different animals under normal conditions, with the lower amounts being for winter and the higher for summer.

	Average daily requirement litres per head	Approximate annual volume required in kilolitres per head
Weaners, average all feeds	2.0–4.0	0.7–1.5
Fattening lambs, dry feed	2.5	0.90
Fattening lambs, irrigated pasture	1.2	0.45
Lactating ewes, dry feed	4.0–10.0	1.5–3.7
Mature sheep, dry pasture	2.0–9.0	0.7–3.3
Mature sheep, irrigated pasture	3.0–4.0	1.1–1.5
Mature sheep, saltbush	4.0–12.0	1.5–4.4

Sources: NSW Department of Primary Industry 2004, Queensland Department of Natural Resources, Victorian Department of Primary Industry, and Wilson (1975).



The “ecotrough” developed by woolgrowers David and Ruth Read showing (inset) reeds planted in a restricting container, and (above) reeds growing to provide shade and keeping the water temperature down, keeping the water highly palatable for sheep. Photos David and Ruth Read.





This riparian area has been fenced, and stock allowed access only when other feed is exhausted or when shelter is required. Photo Phil Price.

In the better-watered parts of Australia, generally the higher rainfall and tableland zones, many woolgrowers allow stock open access to creeks or streams as their main source of drinking water. In those cases where the stream flows all year round, this is a cheap watering option, with the added advantage that stock can graze along the river. However, although the use of streams to water stock is cheap economically, there are disadvantages. In some areas winter flows are high, with riparian areas difficult to access and stock at risk from being lost in floods. The stream may dry up altogether in the summer months, or the water may be too salty for stock to drink, necessitating alternative water supplies.

Uncontrolled stock access to riparian areas compromises water quality by both natural and induced changes. Erosion from upstream can result in muddy or turbid water, while excessive nutrients may lead to blooms of algae (including toxic blue-green species). Stock do not like to drink poor quality water, and this reduces their consumption which can lead to a loss of productivity in the warmer months. Transmission of animal diseases that compromise health and productivity is another risk where streams are intensively used by stock. Intensive grazing of riparian areas can also lead to flushing of dung into the stream following heavy rainfall, further reducing water quality downstream. Stock often camp around water, especially during hot weather, and this makes mustering and checking sheep for problems such as fly strike difficult as they can be down in the river and hard to see, or in inaccessible parts of the riverbank.

The potential for overgrazing can occur in riparian areas, particularly where a small section of stream is the main source of stock water. Removal of palatable species and their replacement by weeds, loss of feed and quality grazing, as well as damage from stock tracks by compaction and pugging of moist soil, all contribute to a decline in water quality and riparian health. Over time, if stock are allowed continued access to riparian areas water quality declines, as does in-stream health and adjoining riparian vegetation. These areas may also carry a high disease burden if used continuously by stock. Further risks include stock becoming bogged in streams and creeks, as well as a reduction in wool quality if it is dirty and muddy.



Stock having unrestricted access to a stream such as this one require constant monitoring to ensure they do not become bogged, drown, or go through the stream to neighbouring properties. It is for these reasons that the woolgrowers on either side of this stream have fenced it out. Photo Phil Price.

The key to better management and more profit for woolgrowers is fencing or other means of controlling stock access, together with alternate systems that deliver good, clean water to stock on demand.

Opportunities and benefits from off-stream watering

In response to the problems of uncontrolled stock access to streams and creeks, an increasing number of woolgrowers are using alternative methods of watering their stock. Whilst this involves initial capital expenditure and ongoing maintenance costs, woolgrowers also report the following benefits:

- installing a watering system is often the trigger to change paddock layout and fencing so that grazing units better reflect land capability for grazing (e.g. hillslopes versus flats), and seasonal pasture availability, leading to improved utilisation and increased carrying capacity;
- once a watering system is installed woolgrowers have a greater ability to match their grazing management system (set stocked, rotational or cell) with animal needs (e.g. pregnant ewes versus wethers) according to season and amount of feed on offer;
- there is better overall utilisation of feed on offer through improved grazing and pasture management, especially where there is a mix of native and improved pastures;
- the increased flexibility in grazing management supports the use of integrated pest and disease control methods;
- the use of watering points enables better control over stock and grazing patterns (even in the absence of fencing);

- sheep prefer water that is clean and fresh and some woolgrowers report noticeable improvements in animal health, growth rates and wool production as a result of a continuous source of clean and uncontaminated water;
- stock are not lost in floods or accidents within the stream channel;
- there is reduced mustering time as stock are not hidden within the channel or surrounding vegetation;
- the condition of riparian areas improves significantly, with natural regeneration able to occur once stock are removed from the stream;
- important ecosystem functions (see section J) are maintained; and
- there is better integration of riparian areas into whole-of-property grazing management plan that aims to optimise pasture growth and wool production.

The pay-back period to recoup the costs and ongoing maintenance of alternative watering systems will vary according to the system used and the particular property and flock size. Improvement in pasture quality, plant growth rate and feed utilisation, all the result of greater flexibility in rotating mobs through grazing management, are considered by woolgrowers to be the main sources of increased economic return. Increased carrying capacity, animal growth rate and wool production have also been reported.

Water quality and the condition of riparian areas are key components of most catchment and water management plans (see Appendix C), with targets being set in most regions for in-stream nutrient and salt levels and the proportion of riparian areas with native vegetation. The use of off-stream watering systems for stock is an important tool that catchment management agencies will be encouraging, and woolgrowers may be able to receive support and possibly financial assistance from these agencies if they establish an off-stream watering system.

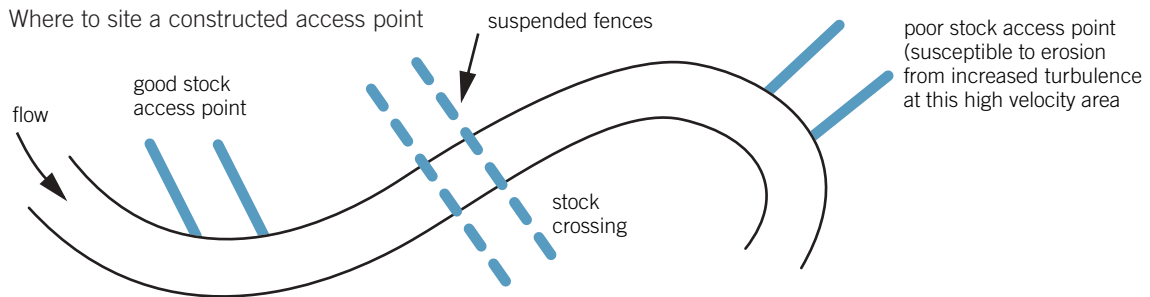
On-farm management practices

Restricting stock access to streams

Where water supply is adequate and maintained year-round, it is likely that many woolgrowers will continue to use creeks and streams as the only, or at least a major, source of stock water. There are still several good management practices worth considering so that environmental and productivity gains can be made.

1. Examine the stream to be used and decide whether stock need access to the whole length, or whether it would be better to control the number and size of access points. Stock access at the outer bends of streams should be avoided where possible, as this is a region of high flow *velocity*. Inside *meander bends* and reaches adjacent to pools between *rock riffles* are areas of generally low velocity, making them safer for stock access (see diagram overleaf). With a limited access point, it is possible to make the movement of stock into the stream safer by providing a gravelled or log-reinforced access point, with fencing on each side to prevent animals wandering along the streambank. Depending on the materials available on-farm, the cost of a constructed access point would be a few hundred dollars at most.





“Velocity”

Velocity refers to the speed of the flow in the stream.

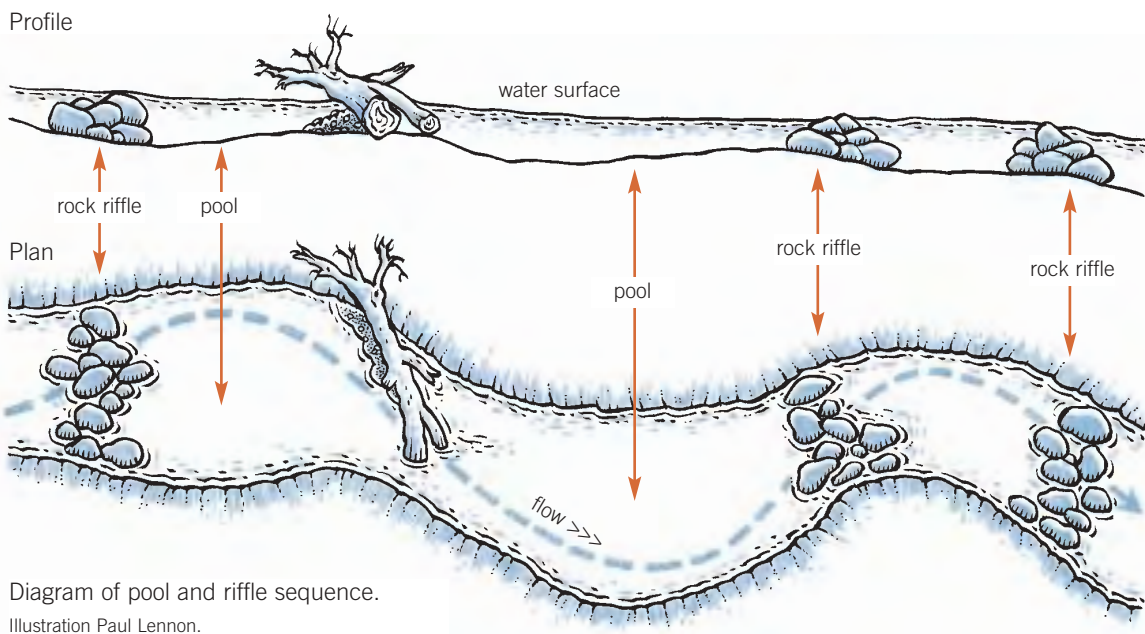


Diagram of pool and riffle sequence.

Illustration Paul Lennon.

2. Another option is to block off the stream during those parts of the year when stock do not need access to the water, for example, when they are getting sufficient moisture from pasture or have access to clean water in dams. This may help to prevent stock losses during flood events, and the riparian areas can be grazed in the warmer months as hill slope pastures begin to dry out. Restricted access to the stream and riparian areas during the warm and wet months can be incorporated into a control program for fluke and other animal parasites.
3. Monitor the effect that stock are having on the stream and the surrounding areas so that the woolgrower adjusts access to riparian areas accordingly. A simple way to do this is to establish fixed photo points using steel droppers or plates. Their approximate location can also be tagged using a hand-held Global Positioning System (GPS) location finder. A series of photos taken from the fixed point up and downstream during each main season of the year will, over time, provide a good record of changes in pasture and other riparian vegetation, as well as changes to the amount of bare soil or eroding banks, or changes in the size and position of the stream channel. This record is particularly useful to assess trends over time following a change in management — for example, restriction of stock access to the stream for some period of the year.

Alternative stock watering options

There are two basic approaches to providing an alternative, off-stream water supply for stock.

1. Capture run-off higher in the landscape through construction of a dam, and then gravity-feed or, if necessary pump, this to other parts of the property so that all paddocks can be watered. The dam must be able to store enough water to provide for both evaporative losses and stock needs throughout the year. Ideally, its capacity should be sufficient for 2–3 years of stock needs to take account of rainfall variability. Some properties may require several smaller dams to meet their needs, although one large, deep dam will lose less water by evaporation than several small, shallow ones. There are regulations in all States that govern dam construction and the amount or proportion of run-off that can be captured and stored for future use (see Appendix B). Cost varies according to the site and soil suitability, but \$2–\$6 per cubic metre (1 KL) of storage space is common. Some natural resource management funding schemes will contribute to the cost of dam construction.
2. In cases where the landscape does not lend itself to construction of one or more dams at a high level, and/or there may be insufficient run-off to provide the amount or seasonal availability of water required, pump water from the stream (or from a groundwater resource) to a high storage point from where it can be gravity fed, or use a pressurised system with one or more storage tanks. Pumping is obviously a more expensive process than gravity feeding, but it too can be cost-effective in many situations when linked with improvements to pasture and grazing management. Capital and operating costs vary widely within a range of \$1000–\$5000 for an installed electric pump or windmill, with daily running costs of between \$2–\$20 depending on the equipment being used.
3. If using a pump, there are many different options available.
 - An electric or petrol-/diesel-powered pump is an obvious choice, but may require personal attention to start, stop and ensure adequate water supplies are maintained. An electrically-powered pump can be set up with automatic sensing of pressure or water levels telemetered to the motor so the particular water level or pressure is maintained constantly. Both systems are quite expensive to purchase, but can be expected to operate over many years so the capital cost can be amortised.
 - An alternative to a mains electric-powered pump is a solar-powered system. These are being used successfully by many woolgrowers, and although the capital costs can sometimes be higher than a mains system, the operating costs should be significantly less. Solar-powered pumps are generally less powerful and hence move smaller volumes over lower height differences. They may require battery support to ensure there is power necessary on sunless days. They can also be operated over long periods during winter when stock do not need access to large volumes of water, so it is possible to pump over long periods into a storage system which is then gradually depleted during the warmer months.

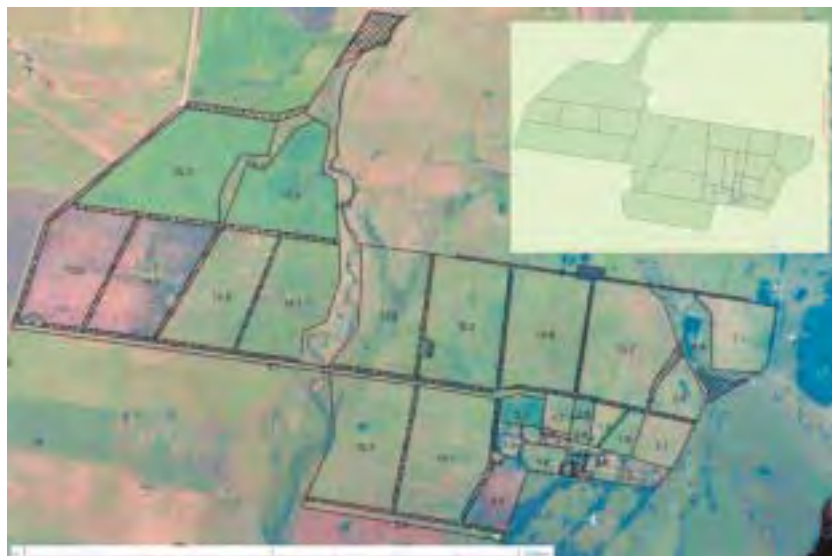


- Another approach to pumping water from the stream to a storage area is the ram pump. This pump uses the streamflow to operate a ram that pumps a smaller volume of water up to a storage tank or dam. These are relatively cheap to purchase and install, however, they do require adequate flow and a fall of at least 1m for their operation. Cost of the pump is around \$1000–\$2000 depending on capacity. As with the solar pumps, they can be used during the high-flow winter and spring to fill storages that will then supply stock over the warmer months.
 - A further method to pump water uses “air displacement”, in which compressed air is piped to the source and used to displace and then transfer water from a sealed container (the pump housing). This method can be used to transfer water from a bore, stream, dam or sump to troughs. The system requires an air compressor (can be remote from the water source) and an electronic pump controller attached to the pump itself (this can be solar powered). Air-driven pumps are especially suited for situations requiring continuous operation at low volumes per hour, and where the water supply is intermittent (e.g. low-producing bores), where they can be very cost-effective.
4. Off-stream systems provide woolgrowers with greater flexibility to move water around the property as well as better control over animal behaviour and grazing patterns. To gain the full benefits of an alternative watering system, it is necessary to plan paddock layout and grazing management at a whole-property scale. This should take into account land capability and the productivity of different parts of the property (for example, hills with shallow soils versus flats in lower-lying areas with greater soil depth that often retain moisture and green growth for longer). Changing fencing according to land class and capability can provide increased pasture productivity and quality, as well as substantially improve utilisation of feed on offer; both are important drivers of profitability.

In addition to the need to achieve commercial benefits and to make alternative watering systems cost-effective over time, there are also likely to be significant benefits to environmental management from controlling or removing stock access to streams and their adjacent riparian areas.

Rob and Annabel Dulhunty have redeveloped their farm and revised the paddock layout of their property. The new farm layout shows paddock areas (hectares), tree plantings and windbreaks (cross-hatching), and the riparian area fenced out (meandering line through middle of the property).

Aerial photography courtesy NSW Land and Property Information, Bathurst. Datum GDA Geocentric Datum of Australia. Grid: MGA94 (GDA94) Map Grid of Australia. The paddock overlays were developed in Practical Systems' *FarmMap* software.



Information courtesy Rob and Annabel Dulhunty, Nant Lodge, Glen Innes.



Case study

Rob and Annabel Dulhunty, 'Nant Lodge', 'Hillside' and 'White Rock'

Location: Glen Innes, New South Wales

Average annual rainfall: 865–915 millimetres

Property size: 'Nant Lodge' 247 hectares, 'Hillside' 630 hectares, 'White Rock' 420 hectares

Enterprises: stud and commercial fine wool merino (17.5–19.3 micron) 15,000 dse, beef cattle fattening

Stocking rate: 11.6 dse/hectare (overall)

Pasture base: phalaris, clover seed, native pastures

Soil types: 'Nant Lodge' — heavy black/brown basalt cracking clay flats with low slopes of red/brown basalt loams and ironstone ridges; 'Hillside' and 'White Rock' — red/brown stony basalt hill country and black/brown basalt clay flats

River management: Furracabad Creek, Reddestone Creek

In a few short years, Rob and Annabel have transformed Nant Lodge into an award-winning farm. Many people talk about trying to balance production with natural resource management, or about production versus conservation. For Rob and Annabel, however, natural resource management and productivity are inextricably linked because production depends on the resource base. “You can’t have one without the other,” says Rob. “Our principal environmental aim is to maintain groundcover and achieve productive outcomes. Biodiversity is one indicator of the health of our resource base, and its intrinsic value is the combined production, resilience and stability that it gives our farm ecosystem.”

Nant Lodge is situated on the floor of the Furracabad Valley and is bisected by Furracabad Creek. Heavy black soil flats along the creek are bounded by lighter ironstone basalt and grey clay low slopes and ridges. Different parts of Nant Lodge were once used for dairy, vegetables and an orchard prior to Rob’s father purchasing it in 1968. When Rob returned in 1989, there was not a native tree on the property.

Hillside overlooks Furracabad Valley, with basalt flat-tops, rocky drop-offs, and undulating valleys and hills. Hillside is drained to the north by Reddestone Creek. Rob’s father cleared ‘Hillside’ but left scattered trees and clumps, 35 hectares of yellow box woodland, 125 hectares of white gum open forest, and understory shrubs, such as blackthorn, wattle and occasional dry rainforest elements on the drop-offs. One third of Hillside was sown to pasture when Rob’s father purchased it. He then sowed another third to pasture and fertilised the whole property aerially every year, initially with phalaris and clover, to increase the valuable species in the less accessible areas. There are still good stands of introduced pasture in the uncultivated areas.

White Rock is well-timbered, fertile, basalt hill country, and a lot more native than the other two blocks: 45% is uncleared and most of the remainder is native pasture, topdressed over the years with annual aerial applications of fertiliser, phalaris and clover seed. In Rob’s mind, the property was cleared well, with timber retained on the steeper country. There are about 125 hectares of sown pasture, and the dominant tree species is white gum, with patches of shrubs on the steeper country.



Rob and Annabel manage an unregistered merino stud of 500 ewes of Nerstane bloodline. Nant Lodge wool is lustrous, stylish and soft, with a long staple. Last shearing, the reserve rams averaged 17.4 microns and cut between 8–10 kilograms of wool. The hoggets average about 16.5 microns and cut 4 kilograms, while the ewes average 19 microns and cut 5 kilogram fleeces.

When Rob bought into the family business after his father’s long illness, the infrastructure at both properties, and the pastures at Nant Lodge were very run-down. There were only a handful of willows and poplars on Nant Lodge, the pastures had not been renovated in a while, and the cropping soils had a long history of being ‘farmed to death’. Furracabad Creek used to be the main source of water for livestock, so many of the main paddocks were fenced onto the creek, leading to overgrazing of the riparian zone. There were lots of floodgates, meaning lots of repair work after each flood.

The sticky basalt soils of the farm dams that watered the other paddocks were death traps for livestock in dry times as the water levels dropped. On one morning alone, Rob found 10 dead stud lambs bogged in a dam, each one worth \$400–\$500.

“In many ways, Nant Lodge and Hillside are opposites. Nant Lodge was run into the ground by 150 years of farming. Meanwhile, Hillside demonstrated the productive capacity of a healthy resource base, and was my inspiration to address resource base decline,” says Rob. A major capital works program was required to bring Nant Lodge back into full production, so Rob and Annabel took the opportunity to study property planning with Landcare, Farming for the Future.

Rob and Annabel re-designed the infrastructure and livestock enterprises from scratch. After seven years, they have completed the major part of the redevelopment of Nant Lodge and have made a start on Hillside. On Nant Lodge, they have re-fenced the entire property to accommodate rotational grazing, fenced out the riparian zone, introduced a laneway and planted shelterbelts and tree lots. They turned problems into assets. An eroding gully system full of rubbish was converted into a drought-proof farmwater supply doubling as an on-farm wetland for biodiversity. Clean water is reticulated to troughs in a move away from using farm dams and the creek.



Left: Losing prime animals is expensive, and can be prevented by fencing the stream and providing safe access points or an alternative source of water.

Right: Hillside has some special natural values that the Dulhunty's are confident contribute to better production outcomes. Photos throughout this case study courtesy Karen Forge.

They have developed a latticework of native tree and shrub shelterbelts across the whole property for shade, shelter and biodiversity, and they have provided block plantings to protect the farm water supply and a section of the riparian zone along Furracabad Creek. On Hillside, the farm water supply/ wetland has been constructed, and the pipelines installed. Rob is currently drawing up the re-fencing plan.

Grazing management

Once the Dulhuntys had drawn up their re-development plan for Nant Lodge, they realised they would need 100 new gates, 16 new troughs, 6.5 kilometres of underground pipe, and 26 kilometres of new fencing. It was a huge opportunity to come up with more efficient designs. Rob's father was one of the pioneers of rotational grazing in the district, and Rob now adapts his grazing management according to the situation, using the advantages of rest and brief periods of intensive grazing. The re-fencing of Nant Lodge into 15 hectare paddocks with a laneway has facilitated rotational grazing, so Hillside and White Rock will receive the same treatment.

Where possible, Rob grazes different mobs in a short-duration, high-density grazing rotation with long rests. He avoids grazing by the calendar or to a set pattern, varying the rotation according to season, pasture growth and livestock needs. When pasture growth is at a maximum, the rotation is sped up. In dry times, it is slowed down. Different enterprises and classes of livestock have different nutritional and management needs at certain times, so for the Dulhuntys, it is impractical to adhere to the rotational grazing plan across all the properties all of the time. For example, the 3000 commercial ewes on Hillside are rotated in one mob for most of the year, but are set-stocked for lambing between late July and October.

On Nant Lodge, the young stud sheep are sometimes divided into 10–15 different mobs for breeding and selection purposes, so they have to be set-stocked. “However, when there’s an opportunity to run bigger mobs and rotate them, we do it. The ram lambs can be put in one mob and rotated, but closer to sale time, we have to divide them into sale and reserve mobs, maybe up to five or six little mobs and set-stock them,” says Rob. “Until this year, I had been using a leader-follower system with the cattle ahead of the sheep. On Hillside and White Rock, we are still reliant on farm dams and the paddocks vary in size from 12–60 hectares. Since big mobs of cattle foul the water, and the feed grows so quickly, we found the leader-follower system was always compromising either the sheep or the cattle. Now we leave the cattle in small mobs in each paddock and rotate the sheep, moving them on earlier than we might have to leave something for the cattle. The cattle keep on top of the pasture so when the sheep come back, it’s more ideal for them. “We may be able to go back to a leader-follower system once we install troughs and re-fence both blocks,” says Rob. The value of rotational grazing became clear in the late 1990s when Rob was pushed for time and tried set-stocking. After 2–3 years, he saw a marked deterioration in pasture health and went back to rotational grazing.



Merino rams penned up and on show at the Nant Lodge woolshed.



Strategies for water and drought

Rotational grazing with large mobs means demand for water is high. This, coupled with two major droughts since 1994, motivated Rob to implement water and drought strategies as part of his farm plan. Along with livestock bogging problems, Rob has observed that sheep and cattle behave very differently around dams, and that cattle foul dams rapidly. “Cattle lose the bloom in their coats when they are drinking bad water. I think the production losses are significant. They will walk past two dams to drink at a trough,” says Rob. “Sheep will trample their own dry pad down to the water’s edge because they hate wet feet. Dam water quality can stay high with sheep only — except after heavy rain when all the dung from the paddock washes in as a result of overland flow.”

Rob and Annabel’s farm water supply and wetland enables them to pump clean water to a tank, and gravitate it from there to troughs, providing high quality water for stock.

Left: One of the many troughs now distributed across Nant Lodge and Hillside and fed by the farm water supply/wetland on each property. The troughs have significantly improved water quality for stock. Photo courtesy Nick Reid.



Right: The wetland end of the Nant Lodge water supply. Photo courtesy Karen Forge.



The water supply and wetland was constructed by damming and fencing out 6.5 hectares of an eroding gully system. The sides were revegetated with native trees and shrubs, and the reservoir was engineered to provide multiple water levels for aquatic fauna and flora in addition to a deep hole for farm water purposes. Livestock were excluded in order to reticulate high quality stock water across the property. Approaching the problem in this way has had a number of advantages:

- The gully is no longer eroding and adding sediment to the creek.
- The farm has a significant supply of clean water for every paddock.
- Wildlife benefit from the wetland features and native plantings.
- Stock production benefits from the high quality water.

Farm dams

The problems of stock bogging and poor water quality have led to a rethink about the farm dams on Nant Lodge. Spending money to destroy rather than create enduring assets doesn’t make sense, so Rob and Annabel plan to fence off and revegetate the surrounds of all the small farm dams to make habitat islands for wildlife. A double gate access into each with basalt rock ‘paved’ stock access points will provide safe ‘emergency’ water supplies should a trough fail or the Dulhuntys spend time away.



Rob and Annabel fenced out Furracabad Creek to manage the riparian zone separately. The 1.5 kilometres of creek frontage used to contain many floodgates; now there are only two to mend after each flood. Adjacent paddocks are watered by troughs from the farm water supply, and the riparian zone is managed for maximum ground cover and water quality using periodic grazing.

“Our original plan was to revegetate the whole creek by planting agroforestry plots above the flood line. We started at the north end with biodiversity plantings around the edge of the agroforestry plantings, which we locked up while the rest of the riparian zone was rotationally grazed. After 5–6 years, pasture density had declined in those areas compared to the grazed areas — there was more bare ground and more blackberry. I concluded that grass needs to be eaten. I’m not a big fan of chemicals, so I now put the sheep and cattle in the riparian areas to periodically control blackberry and maximise grass cover. I restocked the northern planted section for the first time in winter 2002. There was some damage, but the trees are re-shooting.”

The Dulhuntys manage 2.5 km of Reddestone Creek on Hillside. They have decided to also fence this creek into smaller paddocks and use rotational grazing to manage for maximum ground cover and no streambank erosion.

With a background in financial markets, business planning is one of Rob’s strong suits: “I look at the economic or production value of everything we do and how it fits with our goals or vision. Undertaking Landcare works makes financial sense. The tax advantages, coupled with funding assistance, means that maybe only 20% of outlays on improvements are a real cost. The increased capital value of the property alone means I am ahead, even assuming no production gains result. But I think there are production gains from fencing off water storages and reticulating clean water to stock, subdividing into 15 hectare paddocks, grazing rotationally, and establishing shade and shelter belts around every paddock that double as biodiversity corridors across the property. It’s hard to calculate the dollar benefits of all these works because we have changed our livestock enterprises and their management considerably, as well. The bottom line, though, is that I spend money on things that I think are going to improve my productivity. Put simply, investing in improvements to our natural resource base flows through to improvements in productivity,” says Rob.

Environmentally, Rob and Annabel have transformed Nant Lodge by restoring shade, shelter and healthy aquatic ecosystems to the property. All these initiatives have had both productive and beneficial environmental outcomes. Biodiversity is valued and actively managed for across all three properties. All this work has not gone unrecognised. Numerous field days have been held at Nant Lodge in recent years, and Greening Australia selected Nant Lodge as a ‘Best Management Practice Demonstration Site’ for their *Super Solutions* project. Nant Lodge was also the 2004 winner of the GLENRAC Resource Management Competition.



This case study was prepared by Land, Water & Wool Native Vegetation & Biodiversity Sub-program

Northern Tablelands Project. For more information contact Southern New England Landcare, Armidale, NSW 2350. Tel: (02) 6772 9123.



Section F

Maintaining good water quality



Purpose

To maintain or improve the quality of stream water available for use by stock and by downstream neighbours and communities.



Maintaining good water quality

Principles

The quality of water in creeks, streams, rivers and estuaries reflects the type of land use and management throughout the catchment. When water quality is reduced through pollution by soil, sediment, nutrients, pesticides, salt, or other contaminants including animal wastes, all water users suffer. In the higher rainfall zone, the main contaminants affecting water quality are likely to be:

- sediment from eroding streambanks, stock tracks, or from adjacent paddocks under cultivation. In situations where there is low groundcover due to overgrazing or dry conditions, sediment loads increase as there is no vegetation to stop soil eroding and then moving into streams;
- nutrients from natural sources or fertiliser, either attached to soil particles or in soluble forms;
- pesticides from intensive land uses or from treated animals;
- animal wastes, particularly dung washed from the riparian zone and possibly nitrate from urine patches where there are perched water tables;
- dead stock in unfenced waterways; and
- salt from areas where rising groundwater is bringing salt to the surface.

Agriculture is not the only source of contaminants of water within creeks or streams. Urban development and other intensive land uses are often major sources of contaminants, and some background level of soil erosion and nutrient movement is common in most catchments.

“A perched water table”

A perched water table forms in the upper soil layers when the rate of infiltration through the topsoil exceeds the rate at which water can move down through the subsoil. They can be found in duplex soils at the texture contrast horizon, usually for a few weeks over the wet winter period.

Sediment

The clearing of catchments for agricultural land, erosion by unplanned/unmanaged stock access, soil disturbance during forestry operations, urban development and bare areas such as gravel roads and stock tracks, have led to substantial increases in the amounts of sediment (gravel, sand, silt and clay) entering our streams and rivers. This sediment and its associated nutrients and chemicals can contaminate human and stock water supplies, smother breeding sites for fish and other in-stream animals and, by filling up stream pools, deprive these animals of the deeper waters that are vital refuge in dry seasons and prolonged droughts. Whatever the specific impact, the end result is likely to be significantly decreased water quality.





Data from the National Land and Water Resources Audit 2002 show that river sediment loads are 10–15 times higher now than before European settlement in some river basins, and that on average 90% of the sediment reaching estuaries comes from only 20% of the catchments. Large sand deposits moving slowly down river systems are common in the Murray Darling Basin, south-east Queensland and the Glenelg catchment in western Victoria.

Large sand slug in-stream. Photo Ian Prosser.

Nutrients

Under natural conditions, most Australian streams have low levels of nutrients and aquatic plants and animals cannot survive when levels are increased due to contamination. The combination of over-clearing of native riparian vegetation resulting in high light levels, low flow and nutrient enrichment boosts in-stream growth of aquatic plants. Streams in this condition often have massive, choking growth of emergent water plants like rushes and sedges (macrophytes). Algae can also become a problem and may be attached to rocks and grow as long streamers or floating mats in the water. Algal growth may include massive blooms of toxic blue-green algae. When this excessive in-stream vegetation dies during periods of low flow or in winter, the mass of organic material begins to decompose, removing oxygen from the water and often leading to kills of fish and other in-stream life. This means it is important to keep nutrients out of the stream, and back within the paddock where we want them for increased pasture growth.

For more information about managing nutrients see: Bailey, P., Boon, P. & Morris, K. 2002, 'Managing nutrients in floodplain wetlands and shallow lakes', *River Management Technical Update No. 2*, Land & Water Australia, Canberra, www.rivers.gov.au



Applying fertilisers onto paddocks can cause high nutrient runoff into adjoining streams if there is no riparian vegetation to buffer, trap and filter the flow. Photo Cameron Gourley.

Pesticides

Pesticide contaminants can enter streams either directly through inappropriate application, spraydrift or run-off, or indirectly when treated plants begin to decompose, or pesticides are excreted in animal wastes. This form of pollution is generally not a major issue in wool-growing regions, but it can be an issue for mixed farms that include intensive production. Many of these pesticides, and possibly antibiotics and hormonal chemicals, will be in soluble form and it is difficult to keep them out of streams once mobilised.

Animal wastes

Animal wastes must be kept away from streams as they are powerful sources of nutrients (especially nitrogen and phosphorus). Dung also potentially carries disease organisms that may infect other stock downstream. Urine patches are a significant source of nitrate pollution, as this form of nitrogen is mobile and can move through the soil profile and into adjacent streams. The wash-off of dung from sloping riparian land into a stream during heavy rainfall is another potential problem. The risk associated with pollution by animal wastes can be reduced by careful management and timing of grazing in riparian areas to maintain good cover and ensure stock are out of the area before intense rainfall. The use of grass filter strips and strips of natural vegetation along a stream, to retain sediment and attached contaminants, will also help to prevent these pollutants from moving into stream water. Soil organisms within these filters may also help to fix and retain nutrients released from animal wastes.

Salt

In some parts of the tablelands and higher-rainfall areas, salt is becoming a significant pollutant of stream water. Australian soils, due to their age and the arid nature of the continent, often contain quite high quantities of salt. This salt is derived either from salt spray generated from the oceans and moved inland by atmospheric circulation and/or salt derived from decomposition of parent rock. Prior to European settlement, the native vegetation was effective at using nearly all available soil moisture over summer and this meant that salts were generally stored in the deeper layers of the soil profile. With the clearing of catchments for agriculture and the replacement of deep-rooted, perennial vegetation with more shallow-rooted annual crops and pastures, less rainfall is being used by plants and more is available to leach through the soil profile and to raise groundwater levels.

As groundwaters rise, they mobilise the deeper salt stores, and bring that salt to the surface; this is the main underlying cause of dryland (or secondary) salinity. Salt can move laterally from the soil profile into adjacent streams through perched water tables, particularly where different soil horizons join. Salt rising to the surface through capillary action and then left as a surface crust due to evaporation can be washed off in the next rainfall and into the adjacent waterway. As this salt is in a soluble form, it is also difficult to trap once mobilised and prevent its movement into streams. Monitoring data shows that many streams in the tablelands areas are becoming more saline with time, and in the Eastern states this may threaten the future viability of large irrigation areas downstream.



Salt affected stream running through the valley floor. Photo Land & Water Australia.

On-farm management practices

There are a number of approaches that can be taken by woolgrowers to help prevent or reduce these potential contaminants from reaching creeks or streams. Preventing contaminants from entering waterways is the most sensible approach as, once in the water, pollutants are difficult, expensive, and sometimes impossible, to remove.

1. Maintain adequate vegetative cover on all sloping land to prevent or slow contaminants from entering streams and creeks. As a general rule, where ground cover is less than 30%, extensive soil erosion through sheet movement or formation of small rills can be expected, especially under intense rainfall. Careful management of grazing to ensure a minimum of 30%, and preferably 70%, cover is always maintained is a key step in preventing this type of erosion from occurring.



Above: Leaf litter groundcover increasing from left to right.



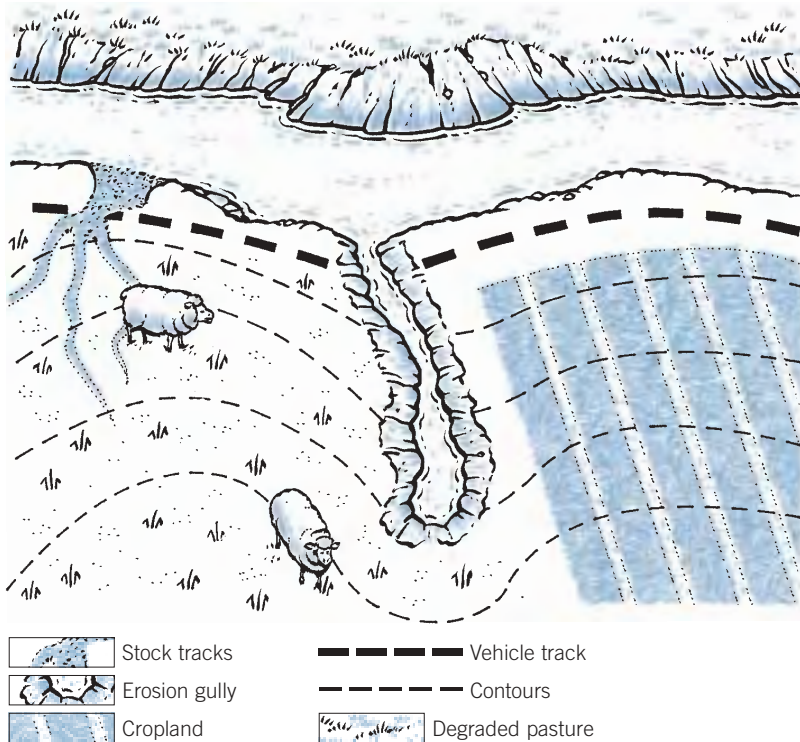
Left: Exotic annual understorey (left) versus native perennial tussock understorey (right).

Photos Amy Jansen, *River Management Technical Guideline No. 4A*, Land & Water Australia, www.rivers.gov.au.

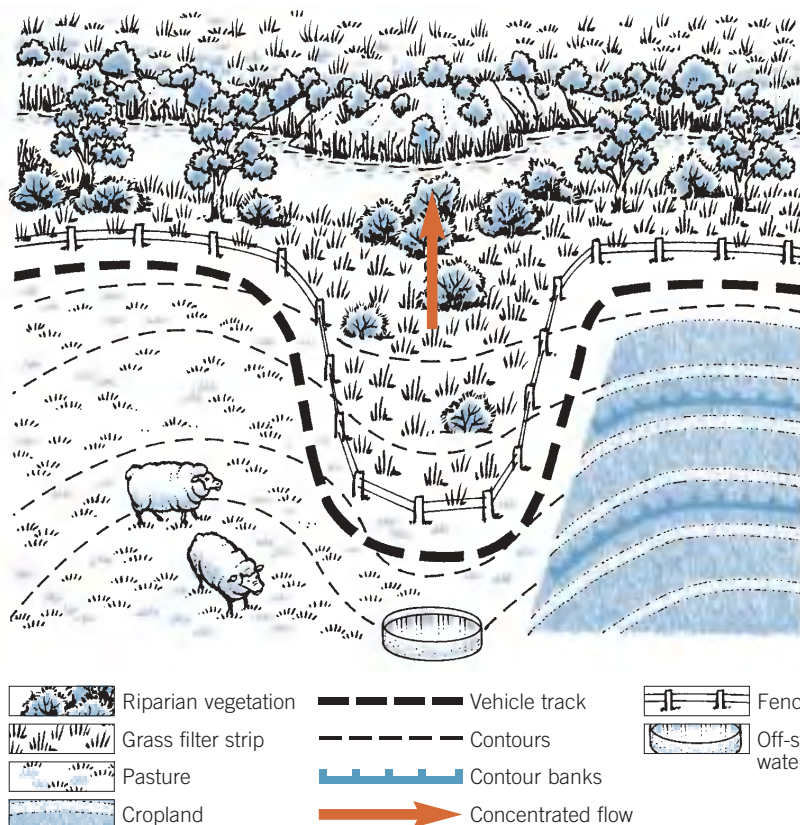


This block of trees form a natural trap for sediment being washed off from the adjoining paddock, as well as providing shade for crops and stock, and habitat for beneficial animals such as bats and owls that eat nuisance crop-damaging insects. Photo Ian Prosser.

- Wherever possible, laneways and tracks for stock movement should go along the contours rather than across them, especially adjacent to a water course. Where tracks must go up and down the slope, use periodic shallow drains and/or levees placed across the track so that drainage water can be taken off into grassed areas. These simple measures can have a large effect on the amount of erosion and sediment generation that takes place on animal tracks during heavy rainfall.

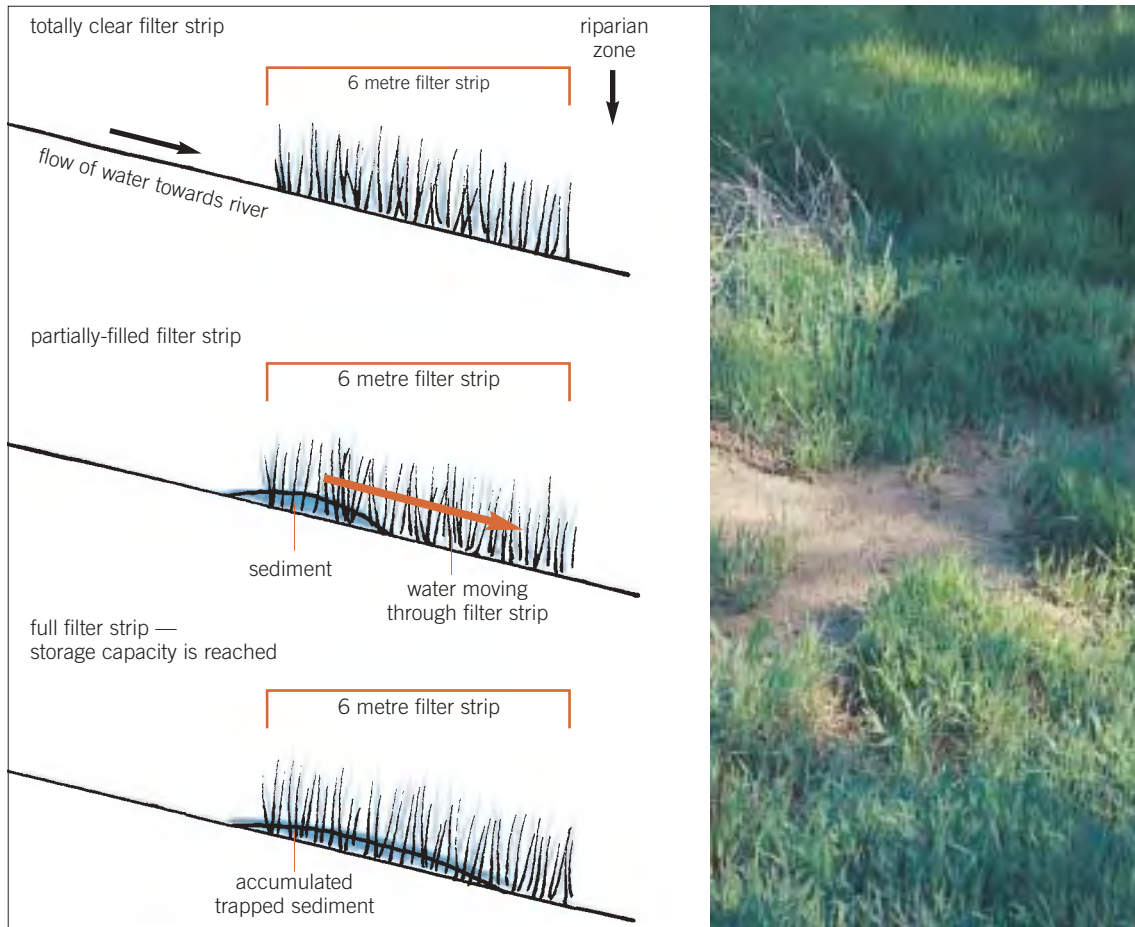


A degraded stream and riparian land. Significant sediment and nutrient is derived from degraded pasture, poor crop layout, unlimited stock access and gully erosion.
Illustrations Paul Lennon.



A riparian filter strip protects water quality by trapping sediment, absorbing nutrients and providing shade over the stream to reduce water temperatures. Crop layout and a vigorous pasture with good cover reduce the potential for soil erosion.





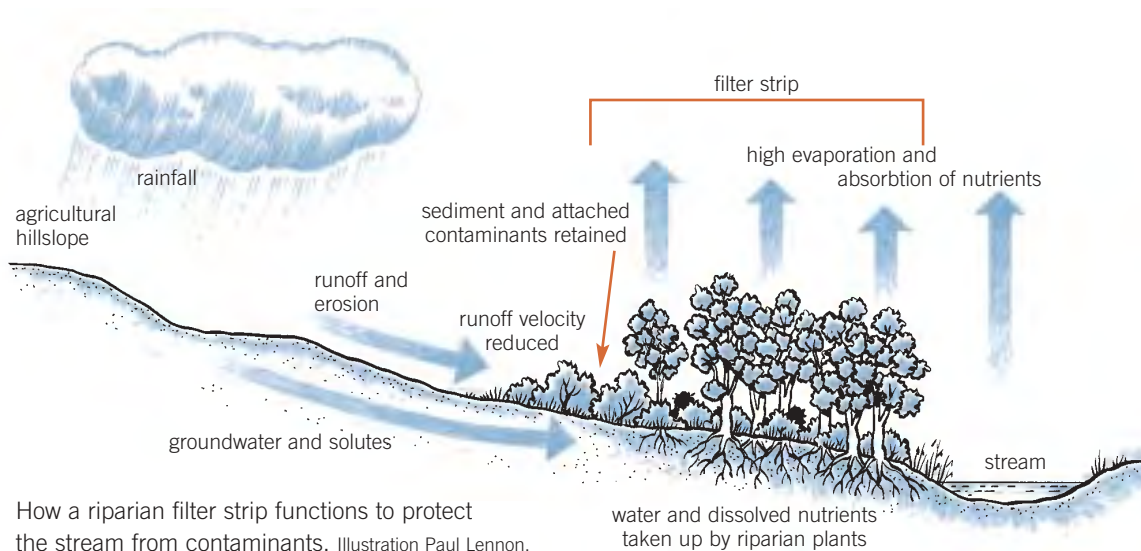
How a filter strip works. Illustration Carolyn Brooks. Photo Ian Prosser.

- Use vegetated filter strips, both within the paddock and near the stream, to trap and retain sediment moving in overland flow. The aim is to slow the flow down sufficiently that the sediment and attached nutrients drop out and are trapped within and among the vegetation, preferably where they can contribute to increased pasture growth. A well-grassed filter strip only 6 metres wide can be very effective in trapping small amounts of sediment where overland flow is shallow. In dips and gullies where flow is concentrated, the filter strip needs to be proportionately wider.



Riparian strips control the delivery of diffuse sources of nutrient by trapping and filtering sediment and stabilising streambanks. Photo Peter Hairsine.





4. Most of the nutrients entering streams, whether naturally occurring or from fertiliser application, are attached to soil particles. The steps taken to reduce soil erosion or to filter and trap sediment described above are also successful in keeping these nutrients in the pasture and not in the stream.
5. To prevent or reduce animal wastes (and parasites and disease organisms) entering streams, it is essential to manage stock access to the water course and its immediate riparian area. A physical barrier (fence) is effective; for more details on riparian fencing see section B. Best management practice could also include managing the timing and duration of stock access to riparian areas to ensure these are not overgrazed, removing sheep well before a season of potential intense rainfall events such as summer storms, and providing a restricted number of constructed watering points on the stream. If a reticulated system is in place for providing stock water, management of watering points can be a cost-effective way of altering animal access and grazing patterns.

For more information on the use of filter strips, see: Prosser, I. & Karssies, L. 2001, 'Designing filter strips to trap sediment and attached nutrient', *Riparian Land Management Technical Guideline No. 1*, Land & Water Australia, Canberra, www.rivers.gov.au



Soil and fertiliser runoff from cultivated paddocks are diffuse sources of phosphorus. Photo Peter Hairsine.



Case study

Trevor Sprigg, 'Boyup Brook'

Location: Boyup Brook, Western Australia

Average annual rainfall: 600 millimetres

Property size: 300 hectares (mostly for grazing, 60 hectares still uncleared)

Enterprises: 2000–2500 peppin merino sheep for fine wool production. Numbers on the low side at present (2005) following two dry years

Pasture base: improved pasture with trikkala sub-clover

Soil types: red soil, gravel and sandy banks near river

River management: 1 kilometre frontage to the Blackwood River, now fenced off

Trevor Sprigg came to live 10 kilometres east of Boyup Brook on the banks of the Blackwood, Western Australia's longest river, as a young boy, when the largely uncleared property was used as a dairy farm and orchard. More than 50 years on, he fondly remembers milking cows before school and scooping marron (WA freshwater crayfish) from the bank by the light of a tilly lamp with his father and brothers. But marron, dairy cows and good quality water in the river are now all distant memories. By the early 1960s, following extensive clearing upstream, the Blackwood River was becoming increasingly saline. Cattle deaths on the property were mystifying even the local vets until a post-mortem revealed the cause — salt poisoning from the only available water source.

Because sheep can tolerate more saline water, the Spriggs got rid of their cattle. Trevor now runs between 2000 and 2500 fine-wool Peppin Merino sheep, depending on the season. His wool averages about 18 microns, some of it down to 15 microns, which is sold at auction in Newcastle and Fremantle. A history of dairy cattle accessing the river bank for water, up to four or five times a day in summer, later followed by equally thirsty mobs of sheep, caused considerable erosion along the Sprigg bank of the Blackwood River. Crown land on the opposite bank near Asplin Bridge provides a marked contrast — vegetation down to the water's edge on a gradual slope and no gullies or siltation.

Trevor was conscious of the erosion problem for many years. He recalled trying to fill one gully with countless truckloads of sand and seeding it with veldt grass, but ultimately achieving almost nothing, as the sheep continually came up and down the steep slopes to drink. In the hottest weather they would even burrow into the banks in search of shade and coolness, tending to camp on the river and eating off any plants as they germinated. "You didn't have to be a rocket scientist to see what needed to be done" Trevor said.

An opportunity to overcome the problem came in 1995 through the Boyup Brook Landcare District Committee (LCDC) and a four-year restoration project. Funding was provided for a solar pump, solar panels, pipes and fittings, a 22,500 litre tank and troughs, plus materials to fence off about a kilometre of river frontage at the high water mark.

Trevor had realised that keeping the stock from the river was essential for its rehabilitation, so fencing combined with a tank and troughs as an alternative water supply, was obvious. The main question was power for the system: mains, diesel or solar? Weighing up the options with other LCDC members, diesel was soon eliminated — too expensive in terms of on-going fuel costs and maintenance. For establishment, comparison of mains (Western Power) versus solar power favoured



Above: Freshly shorn sheep near the tank that has replaced direct river access to supply water. Photos Currie Communications.

Right: Trevor indicates the position for the solar pump, until it is removed over winter when flooding is possible. Removing it in the middle of a flood in its first winter was a salutary lesson!



mains power slightly, but would have required removal of at least four mature trees — two for posts and two for line access (not an easy decision). Wiring and a meter box plus on-going charges would have been part of the package. By contrast, although solar was slightly more expensive to install, over four years the maintenance was minimal and no meters had to be read with on-going charges. In addition, as this was a demonstration site, lack of access to mains power was more realistic for other potential adaptors. Hence, solar won the day!

Following winter rains, river salt levels fall in the Blackwood River but then rise steadily each summer as water levels drop and the river recedes to large unconnected pools. The combination of fencing and a solar-powered pump on the river bank, piping up to 5000 litres of water a day to a tank near the homestead enables sheep on Trevor Sprigg's home block of 52 hectares to carry-on drinking without damaging the river bank. Fencing was completed over winter when succulent grass and sub-clover pastures meant that sheep had little need to access the river, so did not miss it. Lures of lupin seed near the troughs then helped them to readily accept and adjust to their new water source. A double ball valve ensures the pump cuts out when the tank is full and troughs are gravity-fed. As required, the solar pump starts automatically.

Each year in late autumn Trevor removes the pump and solar panels from the river bank to ensure they are not swept away by heavy rains and likely flooding. They are placed back in position in late spring. Maintenance has been minimal (replacement of only two nylon buckets in more than eight years) and he is enthusiastic about the technology.

Because the river water becomes increasingly saline each summer Trevor Sprigg shears in late May to early June and lambs in July (late for this area). This ensures that the ewes don't face too much salt in the river water in late pregnancy. Lambs are weaned in November and then moved to other blocks on the farm with alternative water supplies as they have much lower tolerance of high levels of salt.



Similarly, while Trevor rotates sheep among paddocks on his 'home block' he retains the same group there overall, enabling them to adjust to increasing salt levels over the summer, which a fresh mob of sheep would find hard to tolerate.

It is now 10 years since stock were quarantined from the river bank, but natural regeneration has been slower than expected. New growth of melaleucas, flooded gums and reeds is obvious along parts of the bank, but in other areas regrowth has been minimal, although erosion has ceased. "I expected to see more regeneration on the higher slopes rather than close to the river," Trevor said. "But it seems that the competition from the barley grass, spear grass, wild oats and others has been too much for the native species on those sandy areas."

Local gurus reckoned all would be put right by fire, but a bushfire in 1997 still failed to bring regeneration of trees and shrubs on the upper slopes. Pressure of other work has prevented Trevor from active replanting, which would require spraying to remove grasses, followed by ripping and furrowing in an inaccessible area complicated by fallen trees. Even in two areas fenced off as part of a research project, nothing is growing except grass. Natural regeneration here appears to be a very long-term process.

By fencing off nearly a kilometre of river front at the high water mark, Trevor has lost grazing access to about 10 hectares of land. This is a significant area, but there is potential to use it in other ways. Carob trees have been planted near the river, aiming to produce pods for sheep feed during the autumn feed-gap. However their growth to date has been disappointing, particularly when compared with those planted at the same time near the shearing shed. Other crops or trees could be planted in the future.

Another advantage of fencing off the river is greater safety for the sheep. Losses of at least a few head, stuck in mud, were typical each autumn. Fencing of the danger stretches was usually washed away each winter, this problem and associated losses no longer exists.

Trevor is delighted that erosion has been stopped on his stretch of river, but disappointed that a neighbour declined the opportunity to participate. The contrast between the two properties is notable, with steep bare banks and on-going erosion across a boundary fence. "The river bank has stabilised beautifully in eight to ten years," Trevor commented. "Reeds are colonising the bare ground, and the flooded gums and melaleucas are gradually returning. But it is a long process, and may take 40 years before it is complete. I just hope that when I move on, any new owners will continue the process."

This case study was prepared by Currie Communications.



Trevor Sprigg points out a very young Flooded Gum that has regenerated since stock access to the Blackwood River was closed off. Photo Currie Communications.

Section G

Preventing soil and bank erosion



Purpose

To prevent erosion of soil from stream or creek beds, banks and adjoining riparian land.



Preventing soil and bank erosion

Principles

Erosion is a natural process in most landscapes. However, erosion rates are dramatically increased by human activity such as agricultural production, urban development and the building of infrastructure like roads. Erosion of soil by water during intense rainfall or flood events can move large quantities of sand, silt and clay into adjacent streams, making the water muddy (turbid) and reducing water quality for stock and for downstream users. The depth of pools can be significantly reduced as sediment builds up, to the extent that they may disappear altogether, and this removes essential habitat for aquatic life. Soil particles can carry nutrients and other pollutants into the stream, further compromising water quality; these pollutants can also move as fine (colloidal) particles or in fully-dissolved form.

Once sediment and pollutants get into a creek or stream, they may be flushed through the system into the estuary and eventually out to sea where they can smother sea-grass beds and promote the excessive growth of algae within in-shore fisheries or around reefs. If the material stays within the stream, channel capacity can be reduced and further erosion of the streambank and adjoining land can occur.

The key principle in preventing or reducing erosion on riparian land is to maintain good vegetative cover of the soil surface. This reduces contact between falling raindrops or floodwaters and the soil surface, decreasing the amount of soil eroded into the stream or creek. Vegetation can also slow overland flow and trap sediment particles.

In the case of bank erosion, there are three broad processes at work — sub-aerial erosion, scour and slumping. They may occur singly or in combination, in different parts of the stream or creek. It is important to identify which one is causing the bank to erode so that the appropriate management strategy can be implemented.



A riverbank with no riparian vegetation to protect it from erosion. Photo Guy Roth.



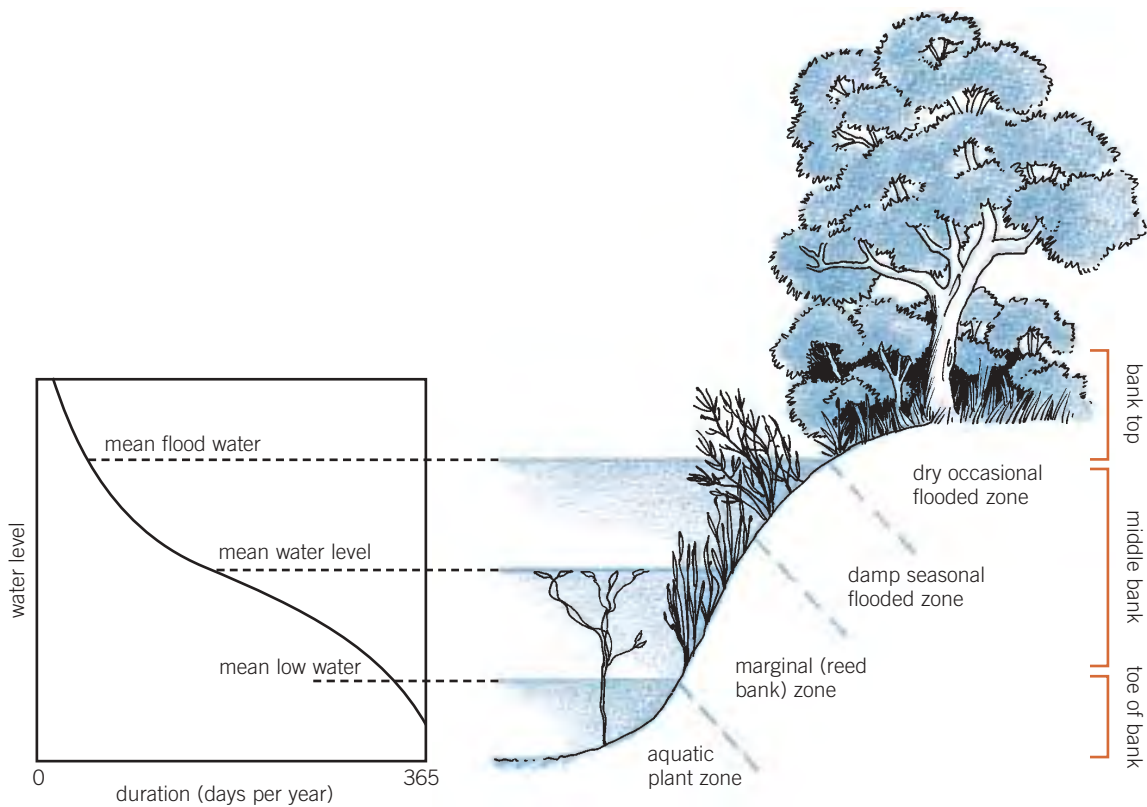


Figure of channel, type of vegetation, and associated mean water levels. Source: Adapted from Seibert (1968).

Sub-aerial erosion

This involves processes that loosen streambank soil, making it vulnerable to being carried away by the water flowing past. Loosening processes include frost heave, where moisture in the soil freezes and expands at night, flaking off the soil surface; trampling by stock; and the impact of wind and rain. The key to preventing this type of erosion is to ensure there is good vegetative cover over the whole of the bank. Cracking clay soils found in some wool-producing regions are particularly prone to this type of erosion.

Scour

Scour occurs when a force applied to the bank by flowing water exceeds the resistance to erosion of the bank surface. On outer bends of a stream meander, water flow is fast and there is strong contact between the flow and the bank itself. Scouring tends to take place in the area known as the toe of the bank, that is, at the water's edge. Repeated scour at this point can undercut the bank, which then topples into the water when its weight can no longer be supported. For this form of erosion too, the key to management is to ensure the bank is vegetated and protected against the scour mechanism.

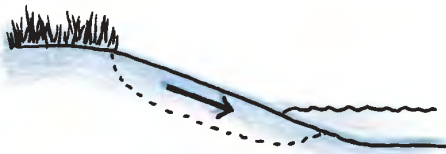
Slumping

Slumping can occur anywhere along a stream, and often follows undercutting by scour. It can occur when the bank soil itself has been saturated, for example by heavy rainfall or from a flood peak, and when the level of flow in the stream drops quickly, leaving the heavy, saturated soil of the bank unsupported. Slumping can often be seen in the middle part of a river network where the bank height exceeds the rooting depth of riparian vegetation, and anywhere where native vegetation has been cleared or lost from the banks. Some soils have natural planes of weakness shown by cracks or gravel bands resulting from past deposition. These are natural places where banks can slump into the stream or creek. Vegetation can be used to prevent slumping by drying out the soil as well as providing networks of roots that reinforce and strengthen the bank soil.

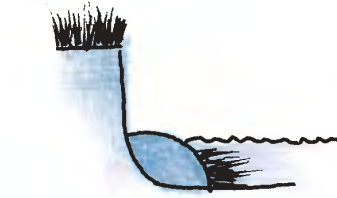
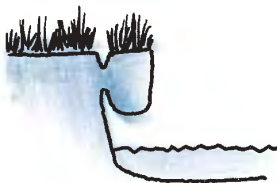
Different forms of erosion by slumping

Before

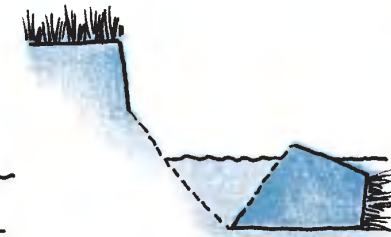
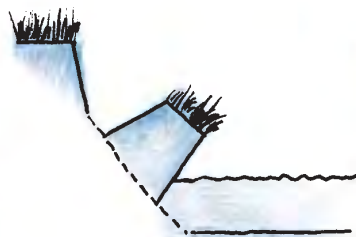
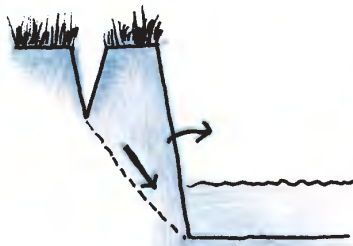
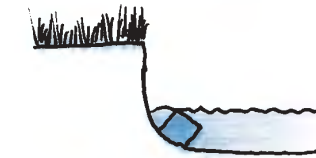
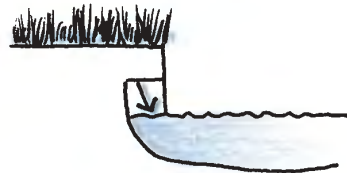
After



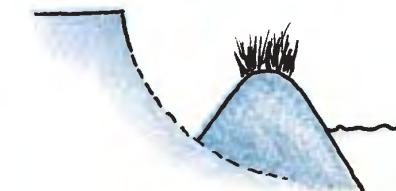
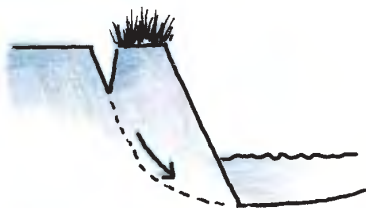
a. Shallow planar-slide failure



b. Scour failure (above and below)



c. Slumping failure (slide → topple)



d. Slumping failure (slope failure → toe failure → base failure)

Broken lines indicate failure planes

Illustration The Idea to Here.

On-farm management practices

Maintaining good vegetative cover is the key to preventing soil erosion. Riparian vegetation buttresses river banks, with roots acting like reinforcing rods holding the soil together. Plants also help to dry the streambank after extensive rainfall or flood events, further reducing the risk of erosion. Research data shows tree roots can extend for 10–15 metres from the trunk and to a depth of at least 1.5 metres (and sometimes more depending on the depth to stream water level), so that even quite widely-spaced trees can be effective at reducing erosion from bank slumping.

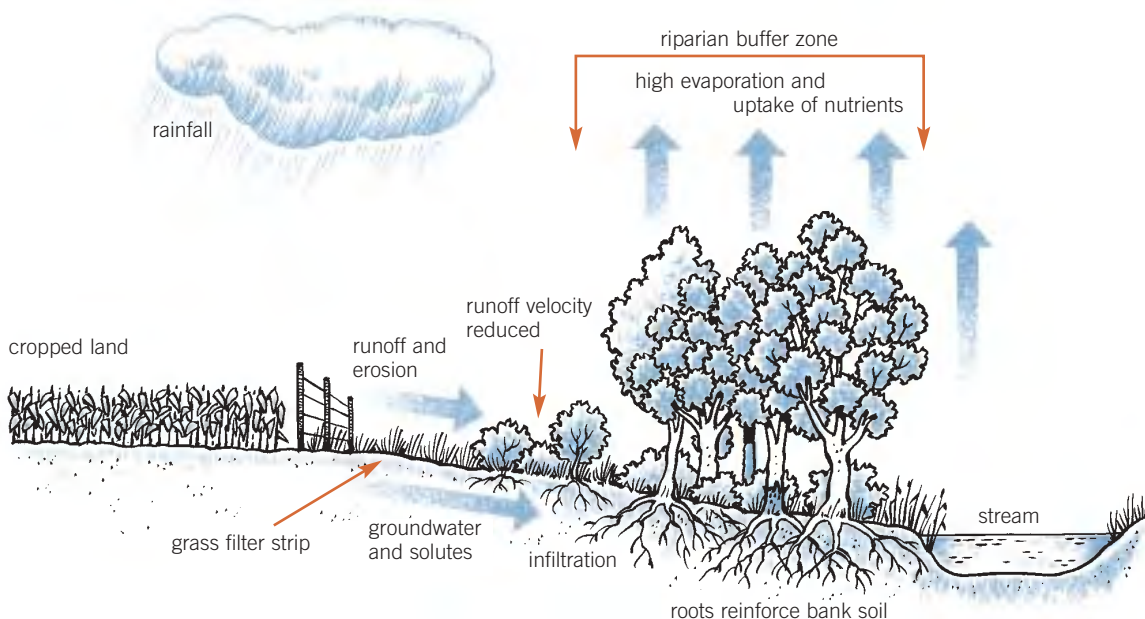


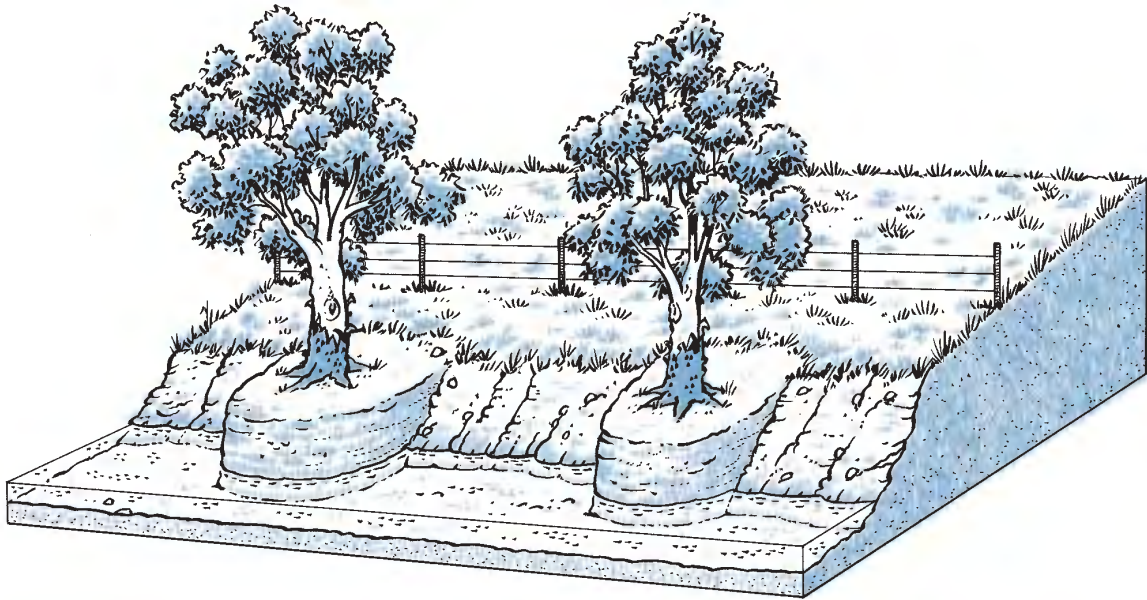


Erosion has resulted in deep gullies that are hazardous for stock and present an on-going threat to valuable grazing land as they continue to expand. Photo Gary Caitcheon.

1. Maintain vegetative cover of at least 30% (preferably 70%) along the top of the bank and on adjacent riparian land to prevent soil loss through erosion. Stock access to, and grazing management of riparian paddocks should aim to maintain at least this minimum level throughout the year, with a higher level of cover (70%) required during seasons when intense rainfall and floods are anticipated.
2. Maintain a well-grassed filter strip adjacent to the stream. Research has shown that a 6 metre wide strip can be effective at trapping and retaining sediment from an adjoining paddock when the depth of surface run-off flow is small. In dips and gullies next to the creek where surface flow collects naturally, and its depth and flow velocity are higher, the filter strip will need to be proportionately wider (see section F for more details).
3. When dealing with sub-aerial and scour erosion, aim to have complete cover of the bank down to the water's edge. Natural vegetation should be retained wherever possible along the bank and for at least 5 metres from the high flood bench or flood level. If there is no vegetation present, encourage natural revegetation of this area. By removing stock from the channel and adjacent

Processes that occur in the riparian zone to assist streambank stabilisation. Illustration Paul Lennon.





Trees buttressing the soil. Illustration Paul Lennon.

riparian strip either permanently, or for at least long enough to allow seeding and regeneration to take place, vegetation cover can be quickly established. In some situations re-colonisation from upstream riparian vegetation may be possible, although care is needed to prevent the establishment of weeds from this source. In situations where there are no sources of seed present for regeneration, revegetate using direct seeding or tubestock. Low-growing native species, including sedges and grasses, as well as species that can bend with water flow, will be most successful at protecting the toe and lower bank areas along a stream or creek.

4. Regeneration or replanting of larger native species of trees and shrubs should be considered on the upper level of the bank, especially where slumping is a problem. Use a mixture of native riparian species to protect the bank and channel and try to match compositions and structure to what is likely to have been there originally. A strip along the top of the bank (minimum 5 metres or one tree width, 25 metres preferred to enable natural regeneration) will also provide important shade for the stream, helping to reduce water temperature and light levels and prevent the growth of in-stream nuisance plants, including algae.

See the Greening Australia website (www.greeningaustralia.org.au) for more information.



This riparian area has been fenced out to protect existing native vegetation and to allow regeneration to occur so that a wider corridor can be established for wildlife. Photo CSIRO Sustainable Ecosystems.



Case study

Scott and Desnee Schlunke, 'Hillgrove'

Location: Bowning, near Yass, New South Wales

Average annual rainfall: 700 millimetres

Property size: 400 hectares (exclusively grazing)

Enterprise: 3200 merino sheep for fine wool production shorn once a year, and averaging 5 kilograms wool cut per head per annum

Pasture base: 40% improved pasture with fescue, phalaris and clover, with the balance native grasses including *Microlaena*, *Danthonia* and native clovers

Soil types: pipe clay soil predominantly, with some granite areas on gently undulating country

River management: 900 metres of the Limestone Creek, which feeds into the Murrumbidgee River, and part of the Murrumbidgee Catchment Area

A proud family tradition of caring for the land today continues with persistence and vigour by the Schlunke family at Hillgrove near Yass in the NSW Southern Tablelands, about 60 kilometres north-west of Canberra. Ten years ago, Scott Schlunke and his father Clarrie, who represent the second and third generations of a family that have farmed the area for more than 60 years, became genuinely concerned for the health and sustainability of the Limestone Creek which ran through Hillgrove, and which had become seriously clogged with woody bushes and fallen trees.

On the basis that the best method of beginning the task of restoring the creek to its former healthy state was to clear the creek banks of a variety of unwanted invaders, including Hawthorne and Briar bushes, the Schlunke family undertook a concerted spraying campaign which, in very short order, managed to return the banks of the almost kilometre long stretch of the creek back to bare soil. Until then, their fine-wool merino sheep had been routinely crossing the creek at various points along the creek, but in the absence of the fallen trees and woody bushes, they had free rein to degrade the entire length of the creek frontage. Seeking guidance from the then NSW Department of Land, Water and Conservation (DLWC), Scott and Clarrie were directed to the Rivercare initiative which was providing funding for riparian projects, provided that part of the funds were applied to local volunteer community organisations.



Sheep are completely excluded from the Hillgrove section of Limestone Creek, allowing significant regeneration and newly established native vegetation to thrive. Photo Currie Communications.



Clarrie Schlunke admires the recovery of Limestone Creek inside the confines of the fenced-out section of the waterway that traverses their property. Photo Currie Communications.

The 10-month project to rejuvenate this high profile section of the Limestone Creek, which is adjacent to the Lachlan Valley Way, the very busy road from Yass to Cowra, included the support of the members of the Limestone–Kangiarra Rural Fire Brigade, who arrived en masse one weekend with equipment at the ready to remove all the exotic trees and other unwanted items from the creek. Using the \$17,000 grant made available by the DLWC, Scott and Clarrie then sought the advice of Greening Australia, the community, government and business to tackle environmental degradation in a practical but scientific way. The project was allocated a further sum of \$7000 in return for fire brigade labour on the project.

A revegetation strategy was developed and in September of 1995 the work began with direct drill planting of eucalypts, wattles and a wide variety of smaller native shrubs including river, swamp and drooping she-oak, crimson bottlebrush, tea tree and swamp paperbark. The first row along the banks were planted with the native shrubs, then came the wattles, and the eucalypts formed the third row, the furthest from the river banks.

Ten years down the track, the Schlunke's riparian restoration project has attracted significant attention both locally, and from as far away as Sydney and Canberra, with Greening Australia and its long-term sponsor, the NSW electricity supplier TransGrid, choosing the site for a high-profile launch of a series of brochures entitled 'Easement Planting with Birds in Mind', an initiative by TransGrid aimed at encouraging landholders to revegetate power line easements. The launch of the brochures promoted the Greening Australia/TransGrid partnership to protect and connect habitat for threatened woodland birds, manage salinity through targeted revegetation, and improve water quality by fencing-off and restoring the health of degraded waterways. The revegetation and restoration of their section of the Limestone Creek at Hillgrove gave Scott and Clarrie Schlunke a great deal of pride and satisfaction, especially to see the return of birdlife to the area, and the pleasure it gives to local folk and those driving past this very special riparian zone.

This case study was prepared by Currie Communications.





Section H

Getting ready for floods



Purpose

To ensure that valuable assets, including stock, buildings and fencing are not lost in periodic flood events.



Getting ready for floods

Principles

Flooding is a natural event in most catchments in Australia, particularly given our variable climate and potential for storms. In the southern part of the country, flooding normally results from an extended wet period during winter that results in saturated soils, being followed by further intense rain from either depressions or storms. When the soil is unable to absorb further rain, or the rainfall intensity exceeds the infiltration rate, overland flow commences and, if it occurs over an extended area, large flow volumes can occur in streams. In the north, where summer rainfall predominates, floods are more likely to be the result of cyclones and rain-bearing depressions where intensity overwhelms infiltration rates, leading to large volumes of water in streams.

Flood flows are important, as they determine the shape, location and size of a stream or creek channel. Under normal flow conditions a creek or stream tends to occupy only a small part of a much larger channel. The channel will often have one or more obvious benches that show the full channel capacity required to convey flood peaks. This is a valuable observation to make, as it provides the basis for siting important infrastructure beyond the highest benches (or flow marks) so that it is protected from flood peaks. Flood flows are also important ecologically as they can be the trigger for particular growth or reproductive phases of aquatic plants and animals.

“Benches”

Benches show as a small level area or floodplain, or as an obvious change in bank slope, within the larger channel. They show the channel size (capacity) required to carry a particular and recurring flood peak, for example the one in two year flood flow.



A recent flood has knocked down the fence and it has now become a trap for debris washed down the stream.
Photo Michael Askey-Doran.



In the past, attempts were made to straighten some stream channels in the belief that this would reduce the frequency and duration of flooding by enabling water to move more quickly down the stream. Whilst this is sometimes effective locally, it usually creates much bigger problems downstream, where flood effects are often much more damaging due to the increased volume and velocity of the water in the system. It is now generally accepted that it is better to temporarily store and slow smaller flood flows in the headwaters of many small streams rather than risk a much larger combined peak flow lower in the river system. This can be done by replanting native riparian vegetation and allowing streams and creeks to maintain their natural meander pattern.

When the flow velocity is increased as a result of stream straightening, the erosive power of the water is stronger and this enables it to undercut banks and erode streambeds. There are many examples of streams where channel straightening and removal of in-stream logs and branches, have resulted in deepening and/or widening streambeds through erosion. This can lead to large volumes of sediment being ‘dumped’ into downstream reaches of the river, while the erosion upstream has also reduced in-stream habitat and the environmental quality of the stream itself. In recognition of these problems, most States and Territories now require any works in, or adjacent to a defined watercourse, to be licensed (see Appendix B for further detail).

Flooding affects all those who live along a stream or creek. When getting ready for floods it is important to work with others so that actions taken on one property don’t cause problems for others. In many wool-producing regions, floods are thought to have become more frequent since European



Left: A track has been built across this small stream with no attempt to stabilise the banks. As a result, the water is highly turbid and in the event of a flood, will erode the loose soil banks. Over time, this channel is likely to deepen as the sides and bed are scoured away. Photos Phil Price.

Below: Activities that impact on streams such as this road, require permits and approval from State and Territory authorities to minimise the damage that can be caused to riparian areas.





River with little riparian vegetation except for a few exotic willows. By replanting (as inset) and fencing, natural regeneration could transform this into a thriving ecosystem. Photos Michael Askey-Doran.

settlement, and are considered to be larger and more damaging than previously experienced. This may reflect the unintended consequences of the clearing of deep-rooted, native vegetation for agricultural development. Without vegetation to trap and slow water, a greater proportion of rainfall now runs off the land surface quickly, making floods bigger and more intense. Streams and creeks in cleared catchments tend to be deeper and wider as a result, and many woolgrowers believe that flooding causes weeds and other nuisance plants to be spread throughout the catchment. These issues make it sensible for woolgrowers to work together to manage floods so that optimum outcomes can be achieved.

On-farm management practices

1. Ensure that farm assets, including stock, buildings, tracks and fencing, are managed to reduce the risk of loss or damage during flood events. Look at the stream or creek channel using past photographs or by talking to people who have lived in the area for a long time, to identify the areas affected by different flood peaks. Many creek or stream channels have one or more benches as part of the bank, indicating how wide the channel becomes to convey particular flood peaks. Place tracks, buildings and fences well away from these points to avoid them being washed away in peak flood events (say 1 in 5 year events).
2. When building streamside fencing to optimise production in riparian areas, use fences designed to cope with floods and which will suffer minimum damage, or can be easily re-erected following passage of the flood (see section B for further information on riparian fencing).



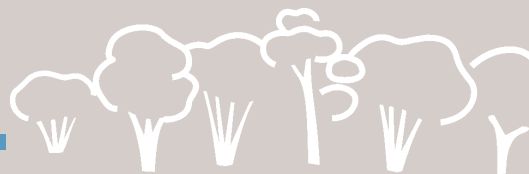
Wood in streams is important as it slows down floods as well as providing important habitat for birds and fish.

Photo Phil Price.

3. For maximum protection against floods, shield eroding areas of creek channels by maintaining vegetative cover and restricting stock access. Vegetation, especially when it includes native riparian species, will help to hold up and slow flood waters, thereby decreasing the risk of greater peak flows and damage downstream. There are significant advantages in groups of woolgrowers working together to plan and manage a stream reach, or even a whole stream or river, as the benefits of this work can be undone if parts are left untreated and at risk of flood damage. Other sections of this guide provide more-detailed information on preventing bank erosion or maintaining riparian pasture and vegetation (see sections B, C and G).
4. Where possible, leave branches and even whole trees within the stream channel as this will help to reduce the effects of flooding. In the past, it was believed that this large, woody material, sometimes known as snags, exacerbated flooding and pushed flood flows out onto the surrounding land. However, research has shown that this material would need to occupy at least 10% of the cross-section of the full channel before it has any appreciable effect on channel capacity to convey flood flow. Large woody material actually helps to protect the streambed from erosion and deepening during flood flows, as well as being an essential component of in-stream habitat for plants and animals.

For more information on managing wood in streams, see: Cottingham, P., Bunn, S., Price, P. & Lovett, S. (eds), 2003, 'Managing wood in streams', *River Management Technical Update No. 3*, Land & Water Australia, Canberra, www.rivers.gov.au





Case study

Brendon Lunney, 'Bogolara'

Location: 50 kilometres west of Yass, New South Wales

Average annual rainfall: 700 millimetres

Property size: 1627 hectares

Enterprises: 10,000 sheep for fine wool production

Stocking rate: 6.15 dse/hectare

Soil types: granite, pipe clay on wetter flats

River management: Ponds Creek

For a committed conservationist such as Brendon Lunney, the quick and easy solution to combat gully erosion on his property at Yass, NSW, would be to remove all stock from affected areas. But as a fine wool grower dedicated to producing wool profitably and equally committed to the sustainability and profitability of the nation's wool industry, the idea of removing stock is impractical and costly. Brendon passionately believes in sustaining the land for the next generation — so long as it's not at the cost of profitability and productivity. "The easy option to counter erosion is to just take stock off... but that's not a practical solution," Brendon said.

Brendon, who owns two properties in the Yass district, Bogolara and Illiliwa, was one of the first farmers locally to join Landcare in the early 1990s. Now, he and his manager, Kevin Schofield, are participating in a research initiative to combat gully erosion within the context of a commercial wool enterprise.

Bogolara is now part of a major research demonstration site for Land, Water & Wool (LWW), a joint initiative between the wool industry's peak research and development body, Australian Wool Innovation Limited, and the Australian Government research body, Land & Water Australia. On Bogolara, LWW are testing the effect of soil erosion on water quality and then determining sustainable, practical ways of controlling gully erosion while maintaining and/or improving water quality.

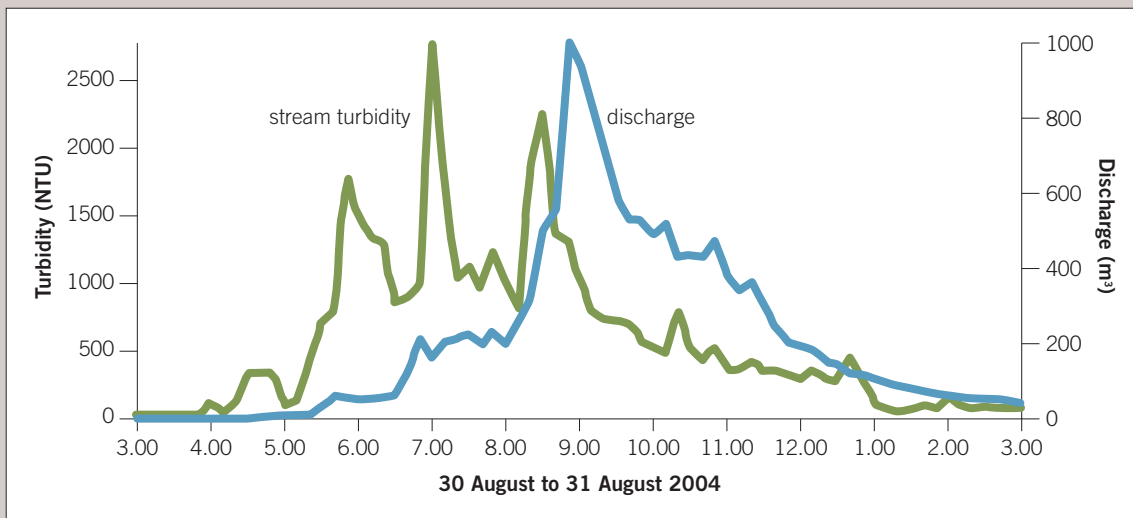


One of the side gullies on Bogolara. A combination of revegetation and 'hard' engineering will be used to address this erosion problem. Photo Gary Caitcheon.



Brendon and Kevin’s decision to participate in LWW two years ago is part of their overall quest to address the problem of gully erosion on Bogolar. Just prior to making the commitment to LWW, Brendon had bought the 1627-hectare property and noticed newly-formed gullies eating up valuable land. “There’s no doubt that gully erosion is becoming worse in this area. I can’t clearly state how much worse it’s become but I’m absolutely certain it’s not getting better,” Brendon said.

Situated 50 kilometres west of Yass, Bogolar has an average annual rainfall of 700 millimetres and runs 10,000 fine wool merinos at a stocking rate of 6.15 dse/hectare. The main creek on the property is Ponds Creek, which feeds into the Murrumbidgee River. Land, Water & Wool has installed equipment to monitor the run-off from the gully, as well as water quality and its turbidity. The results of some of this research are alarming with the impact of a small runoff shown in the graph.



Relationship between discharge, and in-stream and flow-cell turbidity during the largest flood recorded during the monitoring period at the Bogolar gully site.

The largest recorded event (to date) occurred on 30 August 2004 when approximately 13 millimetres of rain fell on the 29th, followed by 37 millimetres on the 30th. This resulted in an estimated 15,300 m³ (15.3 ML) of runoff through the gully. The blue line on the graph shows discharge, or the flow of water through the gully during the rainfall event. It was quite a short event, starting at 4.30 pm, peaking at around 8.00 pm and then tailing off around midnight. The green line shows the concentration of sediment, or the turbidity measurements. The concentration of sediment in the water peaked before the peak of the flood. This is because of the dilution effect of the flow, but also because when flow starts it immediately washes all the unstable surface of the gully downstream, and this happens very quickly. After this initial peak the amount of sediment being released through the gully does not stay consistent with the water flow, rather, it remains at quite a high constant level with the dominant process at work being scour. This is when “new” soil is eroded and explains why these gullies continue to expand in the landscape.

The readings from the monitoring equipment showed the following statistics:

Rainfall	50 millimetres
Gully discharge	15,000 m ³ (15 ML)

Estimated loads

Suspended sediment	75 tonnes (40 m ³ or 2–3 millimetres off gully surface)
Phosphorus	20 kilograms
Nitrogen	75 kilograms



These photographs show a 'V notch' weir that has been installed on the main gully at Bogolara so that accurate measurements can be made of sediment, flow and nutrients. Measurements will be made before and after the restoration treatments are applied so that an assessment can be made of the most cost effective approach woolgrowers can use to manage these gullies on their properties. Photos Gary Caitcheon.



Although a small rainfall event, there was a significant amount of runoff in the gully on Bogolara, and it is typical of hundreds of gullies in the area. Brendon believes that having this sort of information will enable woolgrowers with gullies on their properties to better understand the damage to water quality and loss of land that these areas contribute and consider improving management practices to address the problem. Clearly, gully erosion has a major impact on water quality and is a major source of fine sediment and associated nutrients delivered to streams. Gullies also result in rapid water loss from valley bottoms that previously supported valuable pasture.

The next step on Bogolará is to trial three alternate land management strategies which include:

- minimal involvement, which simply involves fencing off the affected area;
- moderate involvement, which involves a combination of fencing off and planting; and
- major intervention, which involves earthworks.

On a personal level, Brendon is hoping the research will identify practical, sustainable and productive solutions for managing gully erosion and improving water quality that he can incorporate into his whole farm planning. However, he hopes the impact of the research will be far reaching, with benefits flowing to his neighbours, farmers in the district, in the State and even across Australia. With more environmentally-friendly farming practices, Brendon also believes the wool industry will become more sustainable. “Sustainability is a key issue for us. We need to know how we are going to manage for the next generations,” he said.

Although the full results of the trial won't be known for six years, Brendon already believes the program has been successful in terms of drawing wool growers' attention to the problem, the possible solutions and the work that Land, Water & Wool is doing. “Do we have success? Do we have the interest of other farmers? The answer is ‘yes’ and that's a strong benefit from Land, Water & Wool — it has engaged the interest of other land holders and it has engaged State and Federal Government bodies,” Brendon said.

Brendon's ultimate goal is to vegetate the gullies and stabilise erosion by slowing the rate at which gullies are forming and creeping into the paddock. Success in managing gully erosion will dovetail well with Brendon and Kevin's long-term commitment to natural resource management and the environmental dividends they have already received. Over the past 10 years, Brendon and Kevin have planted many thousands of trees on Illiliwa, as part of Landcare's *Webs of Green* program, whereby areas of native vegetation are connected to maintain and enhance biodiversity. Brendon was concerned about the significant amount of degradation in the area and become involved in *Webs of Green* to preserve native bush on Illiliwa.

Although it was hard to accurately pinpoint how successful the tree planting had been, Brendon believes there have been clear benefits for stock as well as wildlife. “I think there's been an improvement — there seems to be more bird life, a greater range of flora in terms of age, nature and size, more shelter and shade for stock and aesthetically it looks better,” he said.

In addition to extensive tree planting, Brendon has made a commitment to exclude 400 hectares of native vegetation from grazing and signed a contract with NSW Department of Land, Water and Conservation two years ago to formalise this agreement. “In reality, we have excluded this portion of the property from grazing for almost 30 years and really we have just formalised this by signing an agreement two years ago,” he said.



This case study was prepared by Currie Communications.

Section I

Managing weeds, pest animals and fire



Purpose

To prevent the establishment of weeds and pest animals in riparian areas, as well as reducing the risk of fire.



Managing weeds, pest animals and fire

Principles

For many woolgrowers, an important deterrent to changing stock management in riparian areas is the fear that they will become havens for weeds and pest animals, as well as posing a fire risk. These are issues that must be taken into account in planning the management of riparian areas, as the aim is to lift production and environmental condition, not to see these parts of the farm become a harbour for pests and a problem that requires a lot of time and effort to fix. Fortunately, many woolgrowers have found ways to improve their management of riparian areas without significant invasion or establishment by weeds and without them becoming harbours or movement zones for pest animals (both native and feral). There are also a number of things that can be done to reduce the risk of fire in riparian areas.

The most important principle of weed management is that most weed species find it difficult to invade and establish into intact riparian vegetation. In general, if vigorous pasture and healthy native vegetation is maintained or established in riparian areas, weeds will find it harder to compete and establish. Managing grazing so that plant cover of established pasture and native vegetation is maintained is the key management practice for woolgrowers to follow to prevent weeds becoming a problem on their farm.



The riparian area has been fenced off from stock but is wide enough to allow access by farm vehicles for weed management. Photo Mike Wagg.



On riparian land that has become degraded by past land use and management, and on areas that are affected by flood, frost, or wildfire, it is vital to promote natural regeneration or to deliberately revegetate as soon as possible after the disturbance, otherwise weed invasion is almost certain and it will be much harder to bring the area back to a natural condition.

However, even with this careful approach to management, some aggressive weed species especially suited to riparian areas may become established. Weeds can be brought in through wind dispersal of seeds, seeds passing through the droppings of birds and other animals, or seeds and pieces of vegetation transported by the stream. Where these invaders are successful, carefully-managed and selective grazing in the riparian area can be used to control some of them, for example palatable annuals may be eaten first by sheep. If stock are allowed access to fenced-off areas to eat weeds before they flower and set seed, it is important that any damage to surrounding native vegetation or the riparian pasture is minimised. Generally, access by sheep to riparian areas should be for short periods only, and timed to achieve good weed control, preferably when the soil is not wet.

If tactical grazing is not possible or sufficient to control weeds, selective control through spraying or hand-weeding can also be considered. Selective spraying using a backpack or with a wiper wand can be very effective if the area to be treated is not large. Particular care must be taken when spraying over or near a creek or stream. For example *Roundup Biactive* and *Weedmaster* contain a special formulation that is less harmful to aquatic life than the standard formulation of glyphosate. Pulling individual weeds out by hand or grubbing out with a hoe can be highly effective when numbers are low.

The problem with willows in riparian areas

In many areas, willows have been used extensively to help stabilise streambanks. Willows establish easily, grow rapidly, produce fine matted roots ideal for stabilising soil, and require little attention after planting. However, over time the consistent use of willows (and the planting of male and female plants of most species that successfully spread by seed), has caused changes to the ecology and flows of rivers and streams. Some southern rivers are now completely choked by invasive willows. Willows have displaced native riparian species and colonised streambanks, sand and gravel bars in streams, diverting flow and causing erosion on vulnerable banks. The soft textured leaves that are all dropped at the same time do not provide a year-round food source for native in-stream animals. This, together with the deep shade provided by willows has reduced biodiversity wherever willows dominate riparian areas. Willows are also prodigious users of water, and *en masse* can reduce natural water flow. Since 1998 willows have been declared a noxious weed in New South Wales. Some of these features also apply to other invasive species found in the higher-rainfall zone including poplars, she-oaks, olives and desert ash.

Willows are now listed as a weed of national significance. Text source: Department of Land & Water Conservation.

Right: Crack willow.
Below: Fragilis root mat. Photos Lizzie Pope.



In many wool-producing regions, riparian areas have already been invaded by woody weeds. These plants, which might include willows, blackberries, poplars, olives, desert ash, privet and other species, may provide some benefits (for example, they may shade the stream or help strengthen banks against erosion), but overall their influence is negative, and in the long run they should be replaced with local native species. Willows, for example, will gradually grow into the stream, blocking the channel, and causing additional flooding. They can be highly aggressive, and now that both sexes in some species are present in Australia there have been some huge seeding events, with millions of seedlings becoming established downstream, completely choking the channel. Willows also use a lot of water, and are harmful to native in-stream animals as they drop all their leaves at once into the stream where they slowly decompose and create anoxic (no oxygen) conditions.

On-farm management practices

Weeds

Riparian environments are subject to natural disturbances, such as flooding, fire or severe frost, as well as the impacts of stock grazing, drift of pesticides and access by machinery. These disturbances provide opportunities for weed species to invade riparian vegetation. Most weed species are much more likely to invade riparian vegetation that has been disturbed and is unhealthy. The recommended management approaches below, aim to reduce weed invasion into riparian vegetation.

1. Maintain a mix of different native vegetation types and layers in riparian areas, so that there are trees, shrub understorey and ground layers of grasses. This will prevent many weeds from finding places to invade.
2. Maintain native riparian vegetation so that it is wide enough to resist drying winds, nutrient movement, and the transport of weed seeds in bird droppings, as these factors assist weeds to invade streams. The ideal width is at least 25–50 metres of native riparian vegetation. The smaller width will assist animal species to move across the landscape, but greater widths are required for species to remain resident in the area.
3. Avoid excessive human disturbance in riparian vegetation, for example from repeated vehicle and equipment access, timber gathering or other clearing. Remember, however, that occasional access may be required to allow spraying, or ripping of rabbit warrens and laying baits.
4. Exclude stock from riparian lands or use fencing to control the timing and season of grazing activity — this includes exclusion of feral or native animals where possible if they exist in large numbers. Stock can spread weeds through their wastes and on their wool, while dung and urine also provide the elevated nutrient levels that many weed species need to establish. It is also a good idea to keep stock in a holding yard for 12–24 hours so that they can void any faeces that might carry seeds into riparian areas.
5. In situations where weeds have already invaded riparian vegetation, control them by regular spot-spraying, stem injection treatment of trees, or by hand removal where this is feasible. In many districts, there are community organisations able and willing to assist in such work (for example, Green Corps). There are some noxious weeds that have a legislative requirement for control. Periodic monitoring and weed control will need to be continued each year (for example, during the non-cropping seasons) until the problem can be overcome.



Green Corps



Green Corps gives young people the opportunity to participate in projects designed to preserve and restore Australia's natural environment and heritage. Green Corps participants also gain improved career and employment prospects through accredited training, structured work activities and work experience. They receive assistance in preparation for employment, personal development opportunities and also provide an opportunity to contribute to the well being of the community. Contacting the local Green Corps group in your region may result in work such as weed management on wool properties becoming part of a Green Corps project.



Photo courtesy Greening Australia ACT & SE NSW.

6. When controlling weeds using herbicides, only those registered for use in riparian lands and near water courses should be used. Seek advice from local government agencies about what you can use. Care must be taken not to disturb the surrounding natural vegetation unnecessarily, as this will only encourage further weed invasion.
7. Work with neighbours to prevent re-infestation of the areas being rehabilitated. Most weed invasions of relatively intact riparian vegetation have come from adjacent and upstream lands, where there may be agricultural or urban weeds. This will often require work in upstream regions first and then gradually moving downstream. If this approach is not followed, unattended lands upstream may continue to provide a source of infestation.

Pest animals

There is a risk that unmanaged or revegetated riparian areas may provide harbour for pest animals, which can include both native and feral species. Wallabies, kangaroos and possums, can cause significant damage to native vegetation and compete with stock for riparian pasture. Feral species, including pigs, foxes, rabbits, deer, wild dogs and cats, are also deleterious to native plants and wildlife, can be predators of lambs and may pose a disease risk. In closely-settled areas, where riparian areas are likely to include grazed pasture and small areas of native vegetation, the eradication of these pests is normally not a problem. However, when larger areas are available, particularly in association with bush runs, this is an issue that woolgrowers will need to consider.





Foxes are a major threat to livestock and to wildlife. Photo Jan and Neville Lubke.

Methods of preventing or controlling pest animals are specific for each type of animal and for certain situations. These details are beyond the scope of this Guide, but readers seeking further information are referred to the series of publications available from the Department of Agriculture, Forestry and Fisheries, including “PESTPLAN: a guide to setting priorities and developing a management plan for pest animals”, and the series of guides for control of vertebrate pests including rabbits, feral goats, feral horses, rodents, feral pigs and wild dogs and dingoes (<http://affashop.gov.au/product.asp?prodid=12598>).



Fire

Fire is a natural phenomenon over much of the Australian continent, but under bad weather conditions it can threaten stock and property, as well as lives. Reducing fire risk is best achieved by managing the amount of fuel available and/or ensuring in fire-prone areas, that adequate firebreaks have been prepared prior to the fire season. In high-rainfall regions, the riparian zone is often less prone to fire than the drier surrounding hillslopes. Fenced-off riparian areas will not necessarily present a much greater fire hazard, particularly where native trees shade out understorey species and where riparian pastures are grazed occasionally to assist weed control or to cover seasonal feed droughts. A track between the fenced area and the adjacent grazing paddock may provide a firebreak to reduce the likelihood of fire moving into or from a riparian area. Grazing of adjacent riparian paddocks prior to the start of the fire season can provide an additional measure of safety.

Some woolgrowers grazing native pastures use periodic fire to help maintain composition and pasture quality, and carefully-managed control burns can be used in the same way in riparian areas. However, it must be remembered that opening up the canopy and the soil surface invites weed invasion, so there is a trade-off to be considered between reducing fire risk and possible weed invasion.





Case study

Mike and Cathy Wagg, 'Jarrapool'

Location: Hamilton, Victoria

Average annual rainfall: 650 millimetres

Property size: 200 hectares

Enterprises: wool, 19 micron average, meat — export wethers, some prime lambs out of merinos, used to have cattle but no longer

Stocking rate: 15 dse/hectare

Pasture base: pastures mainly a mixture of phalaris, perennial ryegrass, leura and trikkala sub clover

Soil types: clay loams and sandy loams over heavy clay

River management: Wannon River

Mike and Cathy Wagg have run a wool and meat sheep enterprise near Hamilton, Victoria, since 1983. The property comprises rolling redgum country with a 650 millimetre average annual rainfall. In 1989 they purchased Jarrapool a 200 hectare block adjoining their main farm with 2 kilometre frontage to the Wannon River. When the property was surveyed for soldier settlement in the late 1940s the title was extended to the edge of the river in places as there was no other water supply, so the frontage is a mixture of private and crown land.

“When we purchased Jarrapool the river frontage formed the boundary of a 50 hectare paddock, nearly half of which was native vegetation full of rabbits and prickly acacia (*Acacia paradoxa*)” said Mike. “Stock from the neighbouring property would often cross the river into our place and visa versa. It was a management headache with significant implications for disease control. In addition, the wool became contaminated with prickly acacia and the classer had to wear gloves when classing wool off the sheep from the river paddock. Controlling the rabbits was difficult as we couldn't bait during the autumn unless we took the sheep out of the paddock, right when our feed reserves were lowest.”





This page and opposite: Some of the special spots along the Wannan River as it meanders through Mike and Cathy's property. Photos in this case study Mike Wagg.

“We put up with this situation for four years as the wool industry was going through another downturn and the issue wasn’t at the top of our priority list. In 1993, we applied to the Natural Heritage Trust for funding to fence out the river frontage along with 23 hectares of native vegetation. We also applied for assistance to extend our reticulated water supply to replace the river for watering stock. The funding pretty much covered the materials and we provided the labour and machinery needed. At the same time we got a 50% subsidy for ripping rabbit warrens and the State government ripped the warrens on the crown land area.”

“We are very lucky that there aren’t many weed issues in the native vegetation (no blackberries but some phalaris in the more fertile areas) and regeneration of redgums and tea tree has been good. When we fenced the area out we were careful to leave vehicle access for laying rabbit bait which we do every autumn. This has kept rabbit numbers very low and even the casurinas are getting a chance to regenerate. A condition of the Natural Heritage Trust funding was not to graze the area for 10 years which we have complied with, however, I now feel that intermittent grazing may be beneficial and would like more information on the best time of year to do this. We put 180 tail end prime lambs in there off shears this year, straight out of the shed so that they wouldn’t carry weed seeds in. While they were in there we had a 125 millimetre thunderstorm and didn’t lose a single lamb.”



“We have now pretty much addressed the management problems that the river was causing and get a tremendous amount of enjoyment as a family from the area including camping, fishing, swimming and horse riding. The local field naturalist and bird observer clubs have both had excursions along the river and a local nursery uses the area for seed collection.”

This case study was prepared by
Mike Wagg.

Trees provide vital habitat for birds, insects and other animals.

Section J

Maintaining in-stream health



Purpose

To manage riparian lands so that in-stream life is healthy and diverse.



Maintaining in-stream health

Principles

Riparian areas support high levels of natural biodiversity. The combination of water, vegetation and connection to other parts of the landscape make riparian areas biological ‘hotspots’ for plants, animals, birds and fish. This section of the Guide describes how riparian areas influence and support in-stream life, and shows the close relationship between how riparian land is managed and the impacts it has on in-stream life. This means that the two must be considered together when making management decisions.

“Biodiversity”

Biodiversity describes the variety of life on earth. Variety (or diversity) is not only the spice of life, it is essential to life. The diversity of biological life (biodiversity) exists at three scales. These range from genes to species to ecosystems. Loss at any point in the scale affects the other scales of biodiversity. A common measurement of biodiversity is the total number of species found in an area.

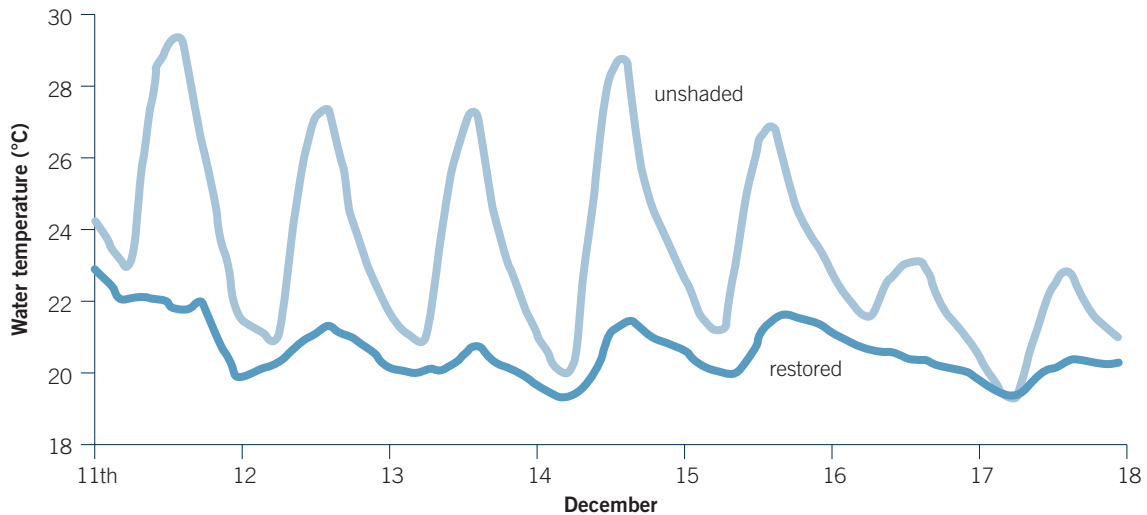


Photo Mike Wagg.



Stream temperature

Under natural conditions, streams were shaded by native riparian vegetation, decreasing the amount of direct and dappled sunlight reaching the water surface, and reducing daily and seasonal extremes of water temperature. Research in Australia has found that the temperature of water in streams where there is no riparian vegetation is 3–5°C warmer than in nearby vegetated sites, and the daily fluctuation in temperature is at least three times greater. The diagram below shows data on fluctuations in water temperature for a stream in south-east Queensland in summer, and shows the difference between grazed (few trees or shrubs) and restored (fully vegetated) sites.



Temperature increases of 3–5°C may seem small, but they can have large effects on the health of in-stream plant and animal communities. The growth and development of most in-stream organisms, such as algae, fish, reptiles and frogs, are in part temperature-dependent, and high temperatures can slow or halt development and result in death. Hatching of eggs, larvae and other stages in an animal's life-cycle, including determination of sex, are often triggered by precise temperature sequences, and research has shown that many in-stream plants and animals have specific temperature requirements for survival. In addition, oxygen concentrations decrease as water temperature increases, and this can limit plant and animal life and possibly contribute to fish deaths. Increased water temperature also elevates rates of bacterial breakdown of plant material and this further decreases the amount of available oxygen. High temperature also increases evaporation from the stream, and this is important in times of low natural flow.

Shade over creeks and streams is a key ingredient in improving or maintaining the health of in-stream life.

Below, canopy shade = 4% and
right, canopy shade = 51%



Photos Peter Davies.

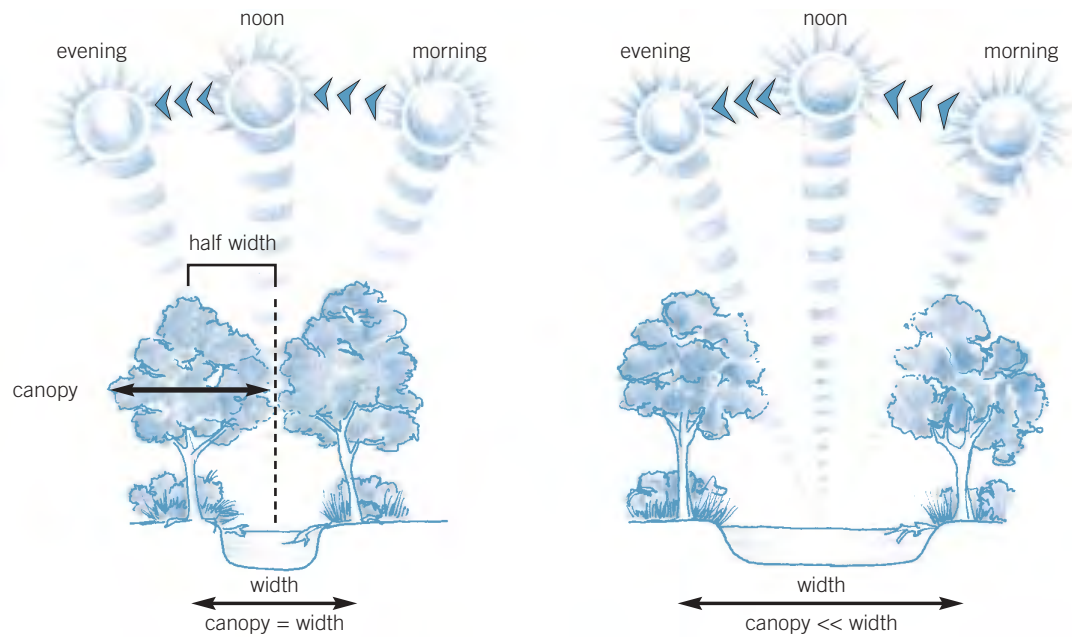


Illustration The Idea to Here.

Influence of channel width on cover. A small stream can be completely shaded if the active channel width is equal to or less than the width of the tree canopy. As channel dimensions increase, and vegetation height and width remain relatively uniform, riparian shading of the channel becomes less effective. Photos below show canopy cover increasing from left to right. Photos Amy Jansen.



Riparian shade is required to maintain the natural water temperatures that are essential for healthy and productive streams. The temperature within a stream is directly related to its orientation to the sun’s trajectory as well as to the thickness and mix of riparian vegetation. Riparian vegetation has a greater shading effect in the infrared/red end of the solar spectrum, which is responsible for most of the heating of surface water. Several factors are involved in this process — for example, canopy height, vegetation thickness, channel width, channel orientation, valley topography, latitude and season. The diagram above shows how riparian vegetation can work to shade the stream from the sun at different orientations.

For more information about in-stream temperature and the importance of shading see: Davies, P., Cook, B., Rutherford, K. & Walshe, T., 2004. ‘Managing high in-stream temperatures using riparian vegetation’, *River Management Technical Guideline No. 5*, Land & Water Australia, Canberra, www.rivers.gov.au

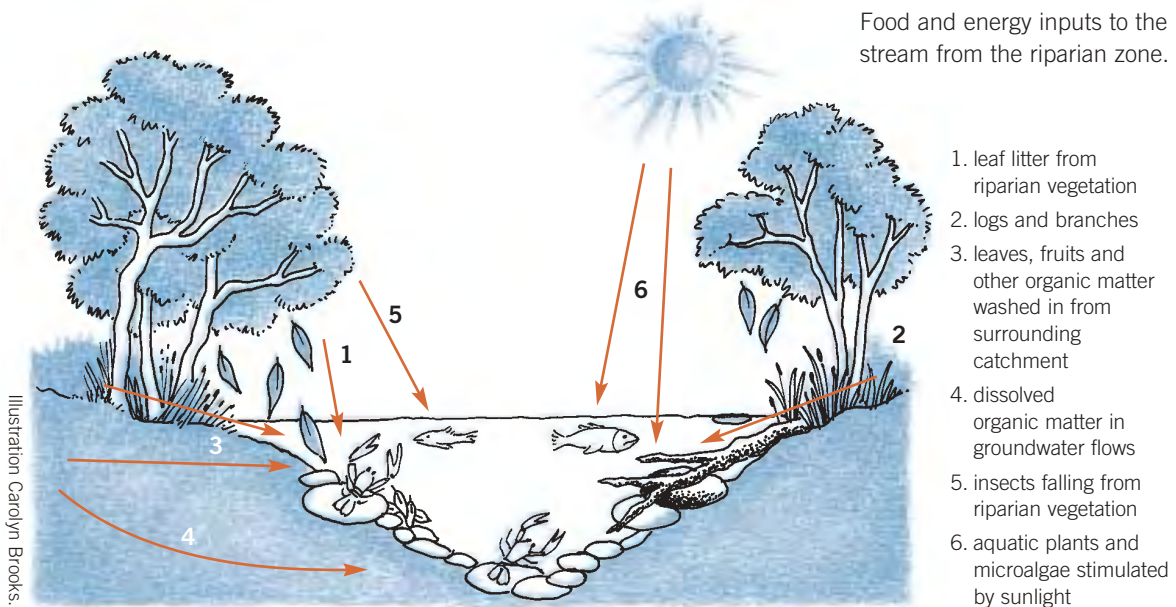
Shade from riparian vegetation is also essential to keep natural light levels in streams. Some nuisance in-stream plants, including algae, need higher light levels before they can flourish and dominate in-stream systems. Under natural conditions, with shading from native riparian vegetation, their growth is restricted by lack of light.



Food webs and habitat

Native riparian vegetation provides the leaves, fruits and insects that support in-stream food webs. Tree roots in the water and undercut banks provide important habitat, access to food sources, and protection from predators. Woody material, such as branches and whole trunks that fall in from riparian land, are important for in-stream bacteria, fungi and some specialised animals which, in turn, are an essential food source for other in-stream life.

Food and energy inputs to the stream from the riparian zone.



Wood forms complex three-dimensional structures in the water column that provide a number of different-sized spaces or habitats. The small spaces formed by sticks, twigs and other debris trapped against larger material provide refuge and feeding areas for small and juvenile fish, as well as invertebrates such as yabbies. The larger branches and logs provide space for larger species. Hollow logs provide essential habitat for such fish, and branches that extend into the water column and above its surface provide habitat at different water levels. Woody material also influences water flow, producing a range of flow speeds used by different animals to feed or rest. It has been thought that woody material in streams reduces flow capacity and increases flooding and, as a result, many streams have been 'de-snagged'. However, research has shown that woody material would need to occupy at least 10% of the cross-section of the channel before having much effect on flooding.

In undisturbed river systems woody material protects the river bank as well as providing vital habitat for instream plants and animals. Photo Ian Rutherford.





This weir has had a rock ramp fishway built alongside so that native fish can continue to move up and down the river, something which many of the diversions and barriers along our rivers has prevented. Photo Stuart Blanch.

In-stream health is also strongly influenced by water flow which includes; the total annual volume, flow levels at critical seasons, and the rate of change in flow and water levels. Together, these factors make up the flow regime. There have been significant changes to the flow regime of many rivers and streams across Australia, many of which are now regulated. The construction of dams and storages, both public and private, has changed the total annual river flow in many cases. Water that previously moved through the river system is now extracted, with seasonal flows disrupted as releases are timed in late summer or autumn in order to meet irrigation requirements. Under natural conditions peak flow in southern Australia was in spring.

An important aim of catchment and water-sharing plans is to try to reduce these negative in-stream impacts. Providing environmental flows at critical times of year (e.g. to support breeding cycles of native fish) is one example of the measures that can be used to improve conditions for in-stream plants and animals. Minimising the impacts of storage, diversion and pump structures through careful siting and operation, better management of river flow and storage volumes, monitoring and reporting of water quality, and removal of barriers to fish passage, are other actions that may be included in catchment plans. Landholders, including woolgrowers, have a vital role to play in determining catchment priorities for water management.

On-farm management practices

Assessment of streams, creeks, and riparian lands in most catchments shows that in-stream health has suffered as a result of past land and water management practices. The following recommended management approaches will assist woolgrowers to improve in-stream life on wool properties.

1. Map all streams and wetlands, including gullies that run only intermittently, on the property plan. Ensure that natural riparian vegetation is kept in these areas during farm or paddock development. The aim should be to retain full natural shade along the stream. Depending on the type of vegetation, a 25–50 metre strip will usually be sufficient to ensure that tall trees can be replaced through natural regeneration. Native species that grow down along the bank and have a spreading but dense habit, are especially valuable in providing stream shade. Where the natural riparian vegetation has been disturbed and the canopy opened up, replanting can be used to regain natural shade levels, and should include shrubs, grasses and reeds as well as trees.

2. When rehabilitating a stretch of stream, visit undeveloped and natural areas in the local district, and compare the mix of riparian vegetation there with what is present on the farm. Information on revegetation of riparian areas is provided in section C of this Guide. For smaller streams, up to 10 metres wide and oriented east–west, the northern bank is particularly important for vegetation retention or replanting, as it will provide the maximum amount of shade for the stream.
3. If the woolgrower is interested, link them into the local Waterwatch network as these groups can assist with regular water quality monitoring so that changes over time can be tracked in streams, creeks and wetlands on the property.
4. Keep wood in streams so that it can provide habitat for in-stream life. In situations where large pieces of wood are a problem, they can be dragged back against the banks at an angle of 40°, where they have little effect in diverting water flow onto the banks.



Large snags repositioned if necessary to minimise their possible effects on flow downstream or onto the bank (flow is from upper left to lower right). Illustration Paul Lennon.

Best management practice is to only shift or remove logs in streams when a thorough channel survey has demonstrated that they are having a significant effect on flood level or frequency — in summary, let sleeping logs lie.



5. Make sure works on streams, e.g. for diversions or pumping stations, are approved or licensed by the relevant agency. The siting and design of these structures must take into account potential consequences on riverine systems.
6. As part of property management planning ensure that the woolgrower is aware of the natural values (for example, vegetation communities, threatened species, wildlife etc.) that the rivers and streams on their properties possess. This can then assist the woolgrower to work out how to achieve multiple benefits from developing a management strategy that maintains, enhances or protected these values.
7. Be aware of the catchment and water-sharing plans being developed in the local region and contribute to them. Many of these plans will include targets that woolgrowers will need to meet as part of wider catchment land and water management strategies (see Appendix B for more details).

Waterwatch — community based water quality monitoring

Waterwatch is a national community water quality monitoring program that has been operating since 1993. Through Waterwatch, groups and landholders can link with each other, share discoveries, compare findings and build a picture of the health of waterways across Australia.

To achieve these goals, the Waterwatch programs have chosen stream habitat, macro-invertebrate and algae surveys to monitor the biological health of the water body and surrounding land. The physical and chemical conditions of the water can be monitored using stream flow, turbidity, temperature, pH, salinity, dissolved oxygen, nitrates, phosphorus and *E. coli* tests. Just which chemical and physical conditions are measured may vary between catchments and the goal of the monitoring program.

Waterwatch Coordinators are employed in each State and Territory and can provide you with access to water quality monitoring kits, information about how to get started on your own creek or stream, and who to go to for on-ground assistance in your region. The website below provides links to all State and Territory Waterwatch Programs.

<http://www.waterwatch.org.au/>



Photo David Kelly.

For more information about wood in streams see: Cottingham, P., Bunn, S., Price, P. & Lovett, S. (eds), 2003. 'Managing wood in streams', *River Management Technical Update No. 3*, Land & Water Australia, Canberra, www.rivers.gov.au



Case study

Jon and Vicki Taylor, 'The Hill' and 'East Oaks'

Location: Uralla, New England tablelands, New South Wales

Average annual rainfall: 711 millimetres

Property size: 'The Hill' 650 hectares and 'East Oaks' 400 hectares

Enterprises: fine wool (17.5–18 micron), 5500 merino sheep (7250 dse). Up to 150 cattle (2100 dse). Radiata pine

Stocking rate: 6–8 dse/hectare

Soil types: 'The Hill' traprock and 'East Oaks' 50% traprock, 40% basalt, 10% granite

River management: Terrible Vale Creek

Like many landholders, Jon and Vicki Taylor's philosophy is one of land stewardship. "Our philosophy is that the property is our 'tools in trade' to make a living from, but to be passed on in as good or better shape to the next generation," said Jon. The Taylor's goal is to increase biodiversity for a healthier ecosystem, avoid overgrazing and reduce the land's exposure to sun, wind, rain and frosts, so that they can maintain a milder microclimate. And they are achieving it.

Jon and Vicki's chief enterprise is fine wool and they join with three other Taylor families in the district to supply an Italian mill with a uniform style of 17.5–18.0 micron wool. Across their two blocks, Jon and Vicki run about 3000 dry sheep (half wethers, half weaners) and join 2500 ewes. Jon and Vicki have stocked their country at a rate varying between 4.6 and 6.1 sheep/hectare over the past 12 years, according to the seasons and carrying capacity. Wool clip has fluctuated between 12,600 and 17,800 kilograms largely in response to seasons and fluctuating numbers of sheep over this period. Wool cut per sheep has consistently averaged around 2.9–3.2 kilograms per head.

The Taylor's conservative stocking rate means that they have been buffered from the worst droughts on record (1994, 2002), and have maintained a consistent level of production over the past decade. Jon and Vicki's wool gross margins have exceeded \$200 per hectare in recent years (except in 2002 due to the drought), and as testimony to the quality of their production, The Hill won 8th place in the 2002 Zegna International Wool Competition. Cross-bred lambs have come and gone as an additional enterprise a couple of times during the past 20 years (1986–88 and 1995–99).

In good seasons, cattle constitute about a quarter of the livestock (by dry sheep equivalent or dse). Cattle complement the fine wool enterprise because they eat the long grass ahead of the sheep. Normally Jon runs 150 breeders, but in poor seasons he is prepared to sell all the cattle, if necessary.

In addition to stock, since the late 1970s, the Taylors have invested in tree planting on The Hill. With time, this has developed into a radiata pine softwood enterprise based on harvesting about 1.5 hectares each year. Jon says, "Each year, we like to plant one to two hectares non-commercially, thin one to two hectares, prune one to two hectares, commercially thin one to two hectares, and eventually harvest one to two hectares".



Pines that Jon and Vicki planted in 1979–80 have already been commercially thinned and will be ready for final harvest in the next 10 years, with a continuous supply coming on-stream thereafter. The benefit of having timber is that successive crops can be harvested when the price is right, or income from the timber is required. The Taylors' plantations were accredited under a Forest Harvest Plan prepared in accordance with NSW legislation.



Riparian zones are revegetated to create sheltered areas for stock and wildlife.

Photo Nick Reid.

Riparian zones

Jon and Vicki were concerned about the condition of Terrible Vale Creek, which runs through The Hill. The riparian zone was an area of high livestock impact and hence overgrazing. “We did a planting right near the creek, and fenced off a boggy patch. The trees grew so well in three years, that we decided we should fence out more of the creek and expand the planting to follow the creek right down,” said Vicki.

They’d already started their whole paddock plantings by then, so they decided to manage the creek as a separate paddock. Watering livestock was simple: they extended the off-creek trough program they’d already begun. Fencing out the riparian zone to create Long Frog paddock had some dramatic impacts, as Jon explains:

“The creek is disappearing! A long time ago, there were no banks or waterholes, but once the grass was taken away, the flow scoured out a gravel bed with a string of bare-sided waterholes along it with no vegetation due to heavy stock pressure. Since we fenced out the riparian zone and starting managing it separately, the banks have grassed up, reeds have come back, and the vegetation retains sediment. After we fenced out the riparian zone and the grass was about one metre tall, we got a big flood. The flood water slowed down, depositing a lot of silt and spreading flood rubbish along 1.5 kilometres of fence: we had to pitch fork it off. So we shifted the fences further back, using a temporary electric fence to start with. Now, in each flood, silt is deposited on the plant surfaces in the riparian zone. This has a filtering effect on the water and the silt is free fertiliser!”

“The pools used to be quite muddy and there used to be a lot more algal blooms, but most of the time now, the water is quite clear,” said Jon. “Stock prefer water if it’s clean, but I don’t think we have seen a detectable increase in production. There’s a lot of feel-good with this, because you know it’s an indicator of better system health and it probably means you have a greater diversity of biota,” he said. “Long Frog paddock is very good for grazing, especially with weaners because it grows a lot of the best grasses and it’s well sheltered by the trees we have planted. It’s also a wonderful spot to go for a walk. The little bird population is tremendous there.”



Jon and Vicki list the following benefits from fencing riparian areas:

- It allows them to be managed as separate units.
- It allows the grass to regenerate, providing good feed reserves and reduces stream bank erosion.
- It slows down flood waters, and allows sediment (free fertiliser) to be deposited on creek flats.
- Reticulating water to troughs — from fenced farm dams and riparian zones provides stock with clean water, which they prefer.

The Taylors have been reticulating water since the 1965 drought: “My father had lots of problems with stock bogging in dams. The water quality drops off badly and stock will bog in virtually any dam, once it’s down to the last foot of water. So we sub-divided paddocks, added a tank and troughs with polypipe, and pumped water with a windmill. Only in the last three years have we gone to a motorised pump — it’s more reliable.”

Water reticulation is important at The Hill because it ensures clean water for livestock, avoids stock bogging in dams, and affords Jon and Vicki the flexibility to redesign paddocks and supply water easily.

Jon and Vicki have fenced off four newly constructed dams in recent years. They gravity feed clean water from the fenced dams to troughs for livestock drinking water. “The dams we fenced off were new dams which we took the trouble to fence from the start, before they had an opportunity to be polluted by stock. We are not sure of the benefits of fencing the older dams — we are not sure how long the advantage of removing stock would take to kick in, in terms of water quality,” said Jon. The permanently fenced dams provide ‘niche areas’ for planting trees and shrubs for biodiversity, protected from livestock, and to reduce evaporation from the dams.

Jon and Vicki are cautious but positive about the financial benefits they have achieved from their transformation of The Hill and East Oaks. “We believe our properties are capable of the same level of production as they were before we started tree planting. In other words, at the very least, the extra grazing production resulting from the shade, shelter, biodiversity and cleaner water compensates for the land taken out of production with trees.”

For their impressive work in the wool industry, environmental repair, and plantation development, Jon and Vicki have won industry recognition in every field:

- they were placed 8th in the 2002 International Zegna Wool Award;
- they won the 1996 Royal Agricultural Society of NSW’s Regional Ibis Award for good conservation practice; and
- they won the 2002 Biennial Australian Forest Growers’ National Farm Forestry Award.



This case study was prepared by Land, Water & Wool Native Vegetation & Biodiversity Sub-program Northern Tablelands Project. For more information contact Southern New England Landcare, Armidale, NSW 2350. Tel: (02) 6772 9123.



Section K

Managing riparian areas for wildlife



Purpose

To provide habitat and passage for wildlife within and along riparian land, and thereby encourage natural control of pasture and stock pests.



Managing riparian areas for wildlife

Principles

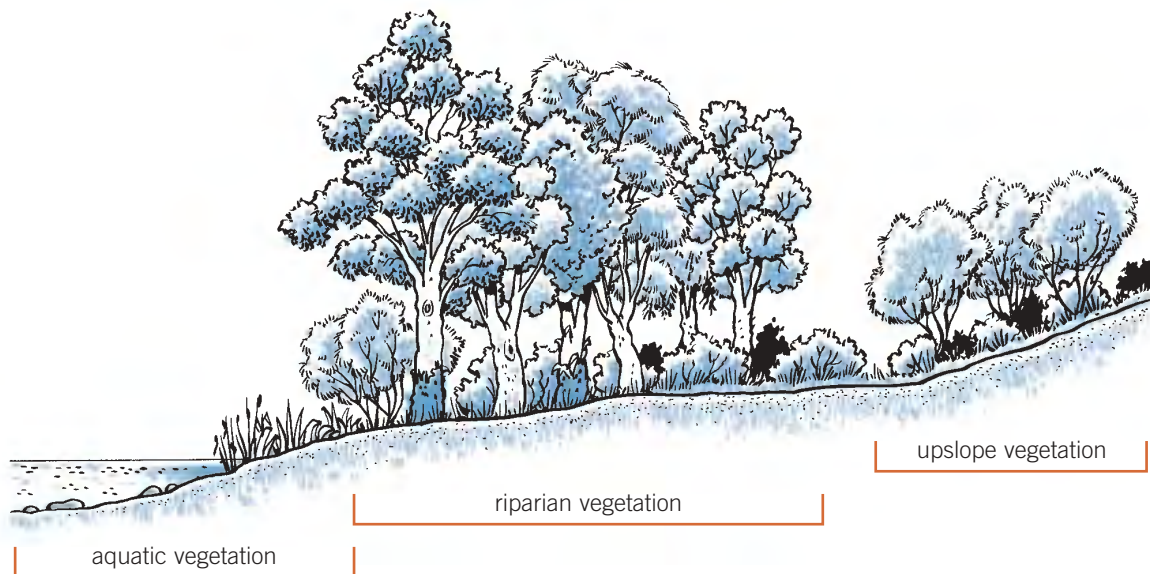
Riparian land provides habitat, as well as a pathway (or corridor) for wildlife moving from one patch or type of vegetation to another, in both cleared and uncleared landscapes. The greater the linkages (connectivity) between these patches, the easier it is for animals to move between habitats. This helps to sustain wildlife populations in adjacent forest and woodland patches as well as within riparian areas. Areas of native vegetation should not be too widely dispersed or isolated. A distance of more than 500 metres may act as a barrier to many of the less mobile species like small mammals and tree-dwelling marsupials moving between patches, compared to some birds which regularly travel 1000 metres or more. Other species are unable to cross even smaller distances, for example squirrel gliders may be able to cross gaps of only 75 metres or so (Van der Rees et al., 2003). The value of riparian lands as a corridor for wildlife is an important consideration in deciding how to manage it.

The width of natural riparian vegetation needed for habitat or movement depends on the wildlife species, habitat type and landscape setting. Research provides estimates of preferred corridor widths, but not the exact corridor width in any particular case. It is known that wider is certainly better, but even narrow corridors are useful to some species. Narrow corridors in cleared landscapes have significantly more edge relative to their area, and so tend to experience negative edge effects, such as temperature changes and weed invasion. This can reduce the ecological value of the corridor itself.

The width of the riparian corridor is only one consideration in the overall context of habitat requirements. For example, breeding birds require nesting sites, suitable vegetation height and structure, and tree hollows (or substitutes), together with adequate corridor width. As some riparian land acts as a temporary refuge or pathway for threatened, endangered or locally significant land or in-stream species, their specific habitat requirements need special consideration. There are likely to be local experts in your region who can assist you in determining the plant species and habitat requirement of particular wildlife you may be trying to protect or maintain on the farm.

It is important to remember that if one aim of riparian management is to maintain wildlife corridors and habitat within an otherwise largely cleared catchment, the width, composition and continuity of the natural riparian vegetation is critical. Riparian plant communities often have greater plant species diversity than those of adjacent upland areas, as there is a variation in the types of vegetation because the area ranges from aquatic through to upslope trees, shrubs and grasses. It is proposed, based on ecological principles and field data, that to maintain crucial ecosystem functions and optimise pasture production, grazing properties based on grassy woodlands should maintain “a minimum of 30% woodland or forest” with woodland patches a minimum of 5–10 hectares to be viable in the long term (McIntyre et al., 2002). Retained or revegetated riparian areas should be a core part of this property-wide 30% target.





Vegetation changes as distance from the water increases. Often there is a band of taller, denser vegetation in the riparian zone and shorter, sparser vegetation further away. Illustration Paul Lennon.

Grazing sheep on riparian lands may be compatible with maintenance of wildlife habitat, providing that grazing is planned and managed with care. Many landholders have found that the feed on riparian lands can be carefully and strategically used to improve enterprise margins and profitability. Careful grazing can also be used to reduce weed infestation and risk of fire during the early years after fencing. The key is good planning, careful monitoring of grazing impacts and prompt removal of stock at the first sign of over-grazing or damage. Section B in this Guide provides more information on managing stock access to riparian areas.

Providing on-farm habitat for wildlife can also offer direct benefits to the wool enterprise. These are in addition to the benefits of shade and shelter from native vegetation in reduced lamb losses, increased animal growth and wool production, and increased pasture growth (see section D). Native vegetation retained or established as wildlife habitat can also make a significant contribution to integrated pest management for both pastures and sheep.

It has been estimated that in New Zealand, the cost of controlling pasture scarab (Christmas Beetles) is between \$NZ48–\$200 per hectare, mainly because in pasture areas there is little vegetation left to support birds and other predators that control the scarabs. These costs would be similar in Australia for farms where the natural predators of scarabs, mainly native birds and small mammals, have been lost due to lack of habitat and alternative foods. Where no control of scarabs and other pasture pests is used, it would be expected that feed production is reduced when pest numbers are high.

There are at least 20 insect species that are pests of pastures in Australia. Some have a restricted distribution while others are more widespread throughout wool-growing regions, but most are only a major problem in improved pastures of the cooler areas of southern Australia. They include scarabs, webworm and heliothus caterpillars. These insects feed on the roots or above-ground parts of pasture plants. Losses of actual or potential dry matter can exceed 25% in clover-ryegrass pastures, so the economic effect of a bad infestation can be significant (Allen, 1987). In the New England area for example, the pruinose scarab (*Sericesthis geminata*), and the dusky pruinose scarab (*S. nigrolineata*) are the most numerous and the most damaging. *S. nigrolineata* is also a pest in the southern highlands of New South Wales, in parts of Victoria and Tasmania. *Sericesthis* species have a one year life cycles and the adult Christmas Beetles feed on eucalypt foliage. The larvae damage the roots of ryegrass,





Trees with hollows like this provide important habitat for wildlife. Photo Guy Roth.

clovers and other plants. Damage is frequently patchy but in severely affected patches, the roots can be entirely removed. Less severe damage can cause water stress resulting from root loss and inability to recover from grazing (Ridsdill-Smith, 1977).

Damage to pastures in the Tasmanian midlands caused by Corbie grubs was severe in the 2004 spring. The direct costs to woolgrowers included loss of summer feed and the need to buy in grain to cover the feed gap, as well as the loss of perennial pasture plants and the need for re-sowing at \$150–250 per hectare. For properties with an infestation over large areas of pasture, the only feasible option in the short-term was to reduce stocking rate and sell sheep. The opportunity cost of this, assuming 10,000 sheep on a 10 dse per hectare and 10% fall in stocking rate with five years required for full recover, would be around \$100,000 based on a gross margin of \$20/dse (data taken from Tasmanian 8X5 Wool Profit Program newsletter, November 2004).

There have been only a few studies in Australia to estimate the impact and value of predators of pasture pests — this is a topic where more quantitative data is badly needed. It is known that magpies can take many scarab larvae per hectare of pasture, and can vary their diet through the year to eat the most common insects. Magpies relish underground larvae which they can hear and pick out of the soil. A single bird may catch up to 42 grubs (about 35 grams) a day, and in summer a large percentage of magpies make Christmas Beetles and grasshoppers a large part of their diet. They have a territory of about 10 hectares and generally do not nest in isolated trees (because of exposure to predators). Kookaburras are also valuable pest controllers, with almost a third of their diet being insects. They are territorial, occupying at least 2.5 hectares, and require tree hollows for nesting.



Photos left to right: Land & Water Australia, Richard Weatherly, Land & Water Australia.

Ibis consume large numbers of insects from pastures, particularly grasshoppers, larvae, crickets and caterpillars. They also eat mice. Ibis need a water source with sites for safe roosting, and will fly 25 kilometres or more to feed on insects in pastures or lucerne, or in new turned soil. Each ibis can eat over 200 insects per day — so a large flock could exert significant control on insect pests of pasture (Davidson & Davidson, 1992).

Arboreal mammals (possums and gliders) are known to be voracious predators of adult Christmas Beetles, and can reduce the population significantly, thereby reducing egg-laying and the number of scarab larvae in surrounding pastures. However, they need access to native vegetation for both alternate food sources (especially in winter) and for shelter.

Studies suggest that in healthy eucalypt woodlands birds may take about half of the insects produced (of the order of 30 kilograms per hectare per year), and more pasture insects are likely to be eaten by birds or native mammals in areas where woodland is adjacent to pasture. Woodland birds like choughs and some flycatchers, robins and wrens, as well as many species of bat, may venture into pastures to forage, where pastures are close to woodland areas. Birds and bats also take the adult stages of pasture insects like scarab larvae and grass grubs when they are in flight or feeding or resting on trees.

There are also many insect predators of pasture pests, but little direct evidence of their impact in controlling pest numbers, enabling maximum feed production, or about their habitat and food requirements. There are also insect predators of sheep pests, including blowfly. Anecdotal evidence suggests that blowfly predators, such as dragonflies, can be found in greater numbers and hunt more effectively when natural wetlands and native vegetation are retained on-farm, but as yet there is no hard data on the benefits to stock health.

Despite the lack of complete data sets relating extent or proportion of native vegetation to benefits in pasture production or animal health, it makes sense for woolgrowers to actively manage trees to encourage pest predators in just the same way that they actively manage their pastures. When all the benefits that can be gained from carefully planned integration of native vegetation into the farm (many described in earlier sections) are added, it seems clear that retaining or establishing up to the 30% level (recommended by McIntyre et al., 2002), especially in riparian areas, can be very cost-effective.

On-farm management practices

The management of riparian lands to maintain land-based ecosystems and to conserve biodiversity must incorporate the protection of native riparian vegetation, with factors such as width, composition and continuity of vegetation vital to supporting wildlife communities. In many cases, improving riparian lands for wildlife is likely to be a secondary consequence of actions taken for other goals (for example, to improve streambank stability). However, with careful planning, riparian management undertaken to achieve other goals can be of substantial benefit to wildlife at little or no additional cost.



The riparian fence has been set back so that the riparian area can perform multiple functions, including habitat for wildlife. Photo Mike Wagg.

Protecting, maintaining and restoring riparian areas is most likely to be effective for wildlife where both the total habitat area and its links with other areas are maximised. Corridor widths suggested as suitable for wildlife habitat range from a minimum of 50 metres to several hundred metres. Whilst some broad guides are possible, the appropriate width of a riparian buffer for the farm will depend on the specific ecosystem, climate and type of wildlife to be maintained. Within cleared areas, negative edge effects are greater, so target widths for riparian rehabilitation need to be wider than in landscapes with retained native vegetation cover. On stream meander bends it may be cheaper to fence out the whole bend than to attempt to follow the bank curves, and this may provide important wildlife habitat.

Revegetation planning needs to consider the specific requirements of the in-stream (see section J) and land based species being catered for. Vegetation diversity both vertical structure and floristic composition are important as they allow a number of different species to use the area. It is important to plant or protect the full range of plant life-forms typical to the area. Reference sites that contain relatively undisturbed native vegetation should be visited, and the typical distances that separate all plants at the sites (including trees, saplings and shrubs) used as a guide for revegetation. Getting advice from wildlife experts, ornithologists (bird experts) and others familiar with local plants and animals is recommended to assist in the development of a plan for managing riparian areas for wildlife on the farm.

In general, it is recommended that at least 50 metres either side of the stream is protected or revegetated for wildlife, but even the narrowest vegetation strips are preferable to none. Restoring wider strips of riparian habitat (100 metres or more) is much more desirable if the available area and resources are sufficient. Fencing or protecting a wider area may allow natural regeneration processes to revegetate these areas. The habitat value of replanted areas can be greatly enhanced by retaining ground litter, especially logs and other plant material. Provision of nest boxes on preferred tree species can also provide additional habitat for birds and other tree dwelling species.



Case study

Richard and Jenny Weatherly, 'Connewarran'

Location: Mortlake, Western Victoria

Average annual rainfall: 600 millimetres

Property size: 1680 hectares (1000 hectares grazing, balance cropping)

Enterprises: 10,000 merino sheep for fine wool production, shorn every 8 months and averaging 5.9 kilograms wool cut per head/annum; 280 hereford-simmental cross cows for beef production; and annual cropping program comprising raised bed farming of wheat, barley and canola using a 3-year rotation

Stocking rate: 14 dse/hectare

Pasture base: phalaris and sub-clover. Heavier country has fescues and lighter country has cocksfoot; balance comprises areas of native pasture

Soil types: tertiary sediments, gravels and sands, some black clay and basalt

River management: 16 kilometres of Hopkins River frontage

On any given day at Connewarran in Victoria's Western District, you could find Richard Weatherly in the middle of a paddock on his hands and knees. There is no problem. It's just Richard keeping an eye on the status of the soil and its surrounds, peering into one of his many 'windows of sustainability'. He could be counting insect species or the number of plants per square metre, or even how many earthworms are in that particular patch of soil. This is how things are done on this remarkable property.

He also keeps a close eye on the 10,000 merino sheep and 280 hereford-simmental cattle that call the 1680 hectares of Connewarran home. And by any standards, it is a pretty good home. Pastures are improved and productive, the property is virtually drought proof and there are more than 40 kilometres of shelterbelts. It is a thriving farming ecosystem that includes livestock, trees, shrubs, wetlands, insects, birds and native wildlife with 16 kilometres of river frontage.

But it has not always been that way. When Richard took over Connewarran 20 years ago, he described it as: "basically 11 paddocks that were historically swamp land and large areas that had not seen superphosphate. There were no yards, no homestead and very little infrastructure. When we started farming, the district standard was a 'bag to the acre' of fertiliser and most calving and lambing was in the autumn," Richard says. "Under those practices, there were many farms in Western Victoria that you could have made a few minor changes, such as the provision of shade and shelter and made a huge difference to the bottom line." Dramatic changes at Connewarran are thanks to Richard's responsible approach to the land and the diversity of life that inhabits it. A world-renowned artist of landscapes and wildlife and respected authority on birds, Richard's philosophy of farming is "that you are managing an open plan ecosystem to harvest the excess production".

An important part of the ecosystem at Connewarran is the Hopkins River and like many other parts of Connewarran, its role in the property's management has changed over the years. The river is now all but fenced off from stock, so while it is no longer a watering point, it is a valuable resource that can be utilised to improve the biodiversity and sustainability of the property, according to Richard.





Richard has fenced off his river to provide a range of benefits on-farm. Photo Richard Weatherly.

“River and waterway management should be a part of the whole farm ecosystem and not a separate issue,” Richard argues. “For example, we had noted a rise in the salinity of the river water, so to water the stock efficiently and provide the stock with clean water, the best thing we could do was to shut them away from the river altogether and water them from another source. There is a strong correlation between water quality and livestock productivity. “But while the river is not utilised for stock watering any more, it’s a vital ingredient to the property’s increase in overall biodiversity.” Richard fenced off the entire length of the Hopkins River on Connewarran to address the increasing levels of salinity in the river and degradation of the riparian zone. The fencing he used was basic 6-strand wire fence. The fenced area varies in width, from the top of the river bank to much wider, up to hundreds of metres. Fencing both banks helps wildlife corridors and a series of wetlands that link various regions of the property (in conjunction with shelter belts and tree plantations). Stock watering is now from concrete troughs or dams (troughs are fed from reticulated water, sourced from dams or underground bores).

Since fencing off the river — an ongoing process for the past 15 years or so — Richard says the re-growth of native trees, including red gums has been impressive. “We direct-seeded some river banks, but thought we were better to just fence it off and let nature sort itself out. To date this appears to be working. The river and its banks today provide a vast habitat that fits into the many wildlife corridors on the property.”

However, there is a social disadvantage from the river being fenced off in that Richard says it has limited human access. The downside could be that people become less aware of river systems. “It is a big difference from when we were kids, as the fishing holes and swimming spots have become more removed. I still want to be able to access some of the river so I can understand what’s happening in the environment. I guess I will have to just clamber over all the new re-growth!” It’s a small concession for Richard. “We have to remember that water quality is a very important factor in livestock productivity and also that the water quality in the river is a result of what happens on the property as a whole,” he says.



Older trees provide seed for areas fenced off to allow regeneration to occur. Photo Richard Weatherly.

Other whole-property changes according to Richard include a very noticeable species ‘flow’ back onto Connewarran in terms of mammals, amphibians, reptiles, birds and beneficial insects. “This all adds to the diversity. An example is the increase in dragon fly numbers — while I don’t understand a great deal about them, dragon flies are a tremendous predator of blowflies and as such a very valuable asset on a wool-growing property. There are other more subtle benefits, such as the increased number of predatory insect species like wasps, which help control the pasture grubs or saw flies. All these small signals are part of a much grander pattern.”

The ‘grander pattern’ of course includes running a profitable farm and while some may struggle to see the benefits of the changes introduced to a diverse property like Connewarran, Richard says they are very obvious. “There is no doubt in my mind that a fundamental way to make money is by improving your asset, for example, by providing protection from wind and sun for the stock. A bare shorn sheep in a 5 kilometre per hour wind will use double the energy to stay alive than in still conditions. And it’s the same for the pastures. Less wind means less evaporation and less stress on grasses, so there are big production gains there. It’s not being a greenie, it’s just good business management.”

Richard’s sentiments are supported by Connewarran’s manager, Leon Watt. “Having been on properties in the Western District for most of my life, I would much rather be here, where there are trees and shelter, as opposed to typical Western Plains farms that can be quite barren,” Leon says. “The Weatherly’s property is so much easier to manage and so much more productive,” he says. “It’s a great environment.”

Just recently this was demonstrated when a run of atrocious weather (very cold, wet and windy) blasted the property. The cold snap was during shearing at Connewarran and there were 6500 sheep bare shorn. “We lost just 13 head where other properties lost hundreds and in some cases, thousands of sheep. It’s inspiring to see Richard’s forethought of more than a decade ago to plant trees and shelter belts making a real difference,” says Leon. Richard has examples where shelter for the stock and paddocks has lifted lambing percentages by 11%. He also cites recent research that shows up to 30% increases in production (wool grown) from sheep that were protected from windy conditions.



The 45 kilometres of shelterbelts on the property contain anywhere from 65 to 120 species of plants — almost all native, and indigenous to the area where possible. Richard plans to one day have every one of the 60 or so paddocks on the property bound on all sides by some form of shelter.

If there are any lessons to be learnt to date from Richard’s waterway, river and property management, he says with a laugh, that he “would have done it all a generation ago!” Richard urges anyone looking to make similar changes to be confident and not afraid to have a go. “A lot of what we have done is experimental and that always attracts nay-sayers. Don’t be afraid to plan big, but don’t try to do everything in one go. Each season gives you a different result, so leave some room for error or variation. We have found that we can put a lot of land under some form of vegetation (non-grazing) and still generate an increased income.”

Richard says the inspiration behind his farm management is due to a number of factors. “My father and family encouraged us as kids to be curious and to question why things happen. My family in general had a responsible attitude to the environment, so we were encouraged to be observant and inquisitive. My wife Jenny has been a driving force in our habitat development from the beginning. I also really enjoy getting near to animals and to nature by stalking things, and to do that, I had to learn to understand them well. I have a genuine interest in knowledge and, I hope, the capacity to listen. That, combined with the terrific generosity and patience of a lot of people that have put their time into helping me, plus a great deal of reading and research, has developed me to what I am.”



This case study was prepared by Currie Communications.



Section L

Is my riparian land in good condition, what is the trend over time?



Purpose

To assess the condition of riparian areas on-farm so that appropriate strategies can be developed to maintain or rehabilitate them, and the effects of changed management can be monitored over time.



Is my riparian land in good condition, what is the trend over time?

Principles

Riparian areas that are in good ecological condition can perform many vital functions and provide a wide range of environmental services that support wool production and maintain the integrity of the wool industry's natural resource base. To help woolgrowers decide what are the priorities for management of the streams or creeks and associated riparian areas on their property, some type of condition assessment method is required. This should be able to provide a comparison of areas on-farm and with local areas considered to be in natural condition; it will help to pinpoint problems where management intervention is required. The method should also be suitable for periodic repeats of the assessment of the same area, so that changes can be tracked over time and management fine-tuned if necessary (an adaptive management approach).

Many different assessment methods are available to evaluate the health of riparian areas. The following assessment method (Jansen et al. 2004) has been developed for people with some technical knowledge of riparian area functions and condition; some prior training would be beneficial before using it on-farm. The method has been checked against a range of other indicators of environmental condition and its assessments shown to reflect differences in those indicators. It has proved in testing over several different regions to be robust and repeatable, with low levels on inter-operator variability (after initial training). There are details on the Land, Water & Wool website about training courses being offered and contact numbers for further details.

The RARC method described in this section was developed by Amy Jansen, Alistar Robertson, Leigh Thomson and Andrea Wilson, Charles Sturt University. It is also available as a stand alone *River and Riparian Technical Update No. 4A* from Land & Water Australia. See the www.rivers.gov.au website.



Photo Amy Jansen.

This Rapid Appraisal of Riparian Condition (RARC) index uses five important characteristics of riparian land, and indicators by which their condition can be measured. Table 1 shows the relationship between the functions of riparian areas, the components of the riparian area that performs those functions, and how these are measured in the RARC.

Table 1. Summary table showing the relationships between functions, components and indicators assessed in the Rapid Appraisal of Riparian Condition index.

Functions of the riparian zone at different levels of organisation	Components of the riparian ecosystem that perform those functions	Indicators of the functions used in the RARC
Physical:		
Reduction of erosion of banks	Roots, ground cover	Vegetation cover*
Sediment trapping	Roots, fallen logs, ground cover	Canopy cover, fallen logs, ground cover vegetation, leaf litter cover
Controlling stream microclimate/ discharge/water temperatures	Riparian forest	Canopy cover
Filtering of nutrients from upslope	Vegetation, leaf litter	Ground cover vegetation, leaf litter cover
Community:		
Provision of organic matter to aquatic food chains	Vegetation	Vegetation cover*, leaf litter cover
Retention of seeds, bulbs, stems and other sources of natural plant regeneration	Fallen logs, leaf litter	Fallen logs, leaf litter cover
Maintenance of plant diversity	Regeneration of dominant species, presence of important species, dominance of natives versus exotics	Native canopy and shrub regeneration, grazing damage to regeneration, reeds, native vegetation cover*
Provision of habitat for aquatic and terrestrial fauna	Fallen logs, leaf litter, standing dead trees/hollows, riparian forest, habitat complexity	Fallen logs, leaf litter cover, standing dead trees, vegetation cover*, number of vegetation layers
Landscape:		
Provision of biological connections in the landscape	Riparian forest (cover, width, connectedness)	Vegetation cover*, width of riparian vegetation, longitudinal continuity of riparian vegetation
Provision of refuge in droughts	Riparian forest	Vegetation cover*

* Vegetation cover = canopy, understorey and ground cover

Table 1 can then be distilled into five RARC components, with each having a number of indicators by which it can be measured (scored) visually (see Table 2). In summary they cover:

1. Habitat continuity and extent (HABITAT).
2. Vegetation cover and structural complexity (COVER).
3. Dominance of native versus exotic plants (NATIVES).
4. Standing dead trees, fallen logs and leaf litter (DEBRIS).
5. Special indicative features (FEATURES).

Table 2. Sub-indices and indicators of the Rapid Appraisal of Riparian Condition, the range within which each is scored, the method of scoring for each indicator, and the maximum possible total for each sub-index.

Sub-index	Indicator	Range	Method of scoring	Total
HABITAT				11
	Longitudinal continuity of riparian vegetation (≥ 5 m wide)	0–4	0 = < 50%, 1 = 50–64%, 2 = 65–79%, 3 = 80–94%, 4 = $\geq 95\%$ vegetated bank; with 1/2 point subtracted for each significant discontinuity (≥ 50 m long)	
	Width of riparian vegetation (scored differently for channels < or ≥ 10 m wide)	0–4	<i>Channel ≤ 10 m wide:</i> 0 = VW < 5 m, 1 = VW 5–9 m, 2 = VW 10–29 m, 3 = VW 30–39 m, 4 = VW ≥ 40 m <i>Channel > 10 m wide:</i> 0 = VW/CW < 0.5, 1 = VW/CW 0.5–0.9, 2 = VW/CW 1–1.9, 3 = VW/CW 2–3.9, 4 = VW/CW ≥ 4 , where CW = channel width and VW = vegetation width	
	Proximity to nearest patch of intact native vegetation > 10 ha	0–3	0 = > 1 km, 1 = 200 m–1 km, 2 = contiguous, 3 = contiguous with patch > 50 ha	
COVER				12
	Canopy (> 5 m tall)	0–3	0 = absent, 1 = 1–30%, 2 = 31–60%, 3 = > 60% cover	
	Understorey (1–5 m tall)	0–3	0 = absent, 1 = 1–5%, 2 = 6–30%, 3 = > 30% cover	
	Ground (< 1 m tall)	0–3	0 = absent, 1 = 1–30%, 2 = 31–60%, 3 = > 60% cover	
	Number of layers	0–3	0 = no vegetation layers to 3 = ground cover, understorey and canopy layers	

dbh = diameter at breast height, < less than, \leq less than or equal to, > greater than, \geq greater than or equal to.

continued over



Sub-index	Indicator	Range	Method of scoring	Total
NATIVES				9
	Canopy (> 5 m tall)	0–3	0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60% cover	
	Understorey (1–5 m tall)	0–3	0 = absent, 1 = 1–5%, 2 = 6–30%, 3 = > 30% cover	
	Ground (< 1 m tall)	0–3	0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60% cover	
DEBRIS				10
	Leaf litter	0–3	0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60% cover	
	Native leaf litter	0–3	0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60% cover	
	Standing dead trees (> 20 cm dbh)	0–1	0 = absent, 1 = present	
	Hollow-bearing trees	0–1	0 = absent, 1 = present	
	Fallen logs (> 10 cm diameter)	0–2	0 = none, 1 = small quantities, 2 = abundant	
FEATURES				8
	Native canopy species regeneration (< 1 m tall)	0–2	0 = none, 1 = scattered, 2 = abundant; with 1/2 point subtracted for grazing damage	
	Native understorey regeneration	0–2	0 = none, 1 = scattered, 2 = abundant; with 1/2 point subtracted for grazing damage	
	Large native tussock grasses	0–2	0 = none, 1 = scattered, 2 = abundant	
	Reeds	0–2	0 = none, 1 = scattered, 2 = abundant	

dbh = diameter at breast height, < less than, ≤ less than or equal to, > greater than, ≥ greater than or equal to.



Photo 1. A site in excellent condition on the Edward River (RARC Score = 50; note continuous canopy of native trees, standing dead trees and fallen logs, native shrub understorey, reeds and regeneration of canopy trees).



Photo 2. A site in very poor condition on the Murrumbidgee River (RARC Score = 14; note discontinuous canopy, lack of shrubs, small amounts of leaf litter, lack of native ground cover and reeds, little regeneration of canopy trees).

Photos 1 and 2 show contrasting sites in excellent and very poor condition. Details of the scoring for these sites can be found in the box below.

Example of scoring indicators for the sites shown in Photos 1 and 2 (see Table 2 for indicators and details)

Sub-index	Excellent condition site (Photo 1)	Very poor condition site (Photo 2)
Habitat	4 + 4 + 3 = 11	0 + 0 + 0 = 0
Cover	3 + 3 + 3 + 3 = 12	1 + 0 + 3 + 2 = 6
Natives	3 + 3 + 3 = 9	1 + 0 + 1 = 2
Debris	3 + 3 + 1 + 1 + 2 = 10	1 + 1 + 1 + 1 + 1 = 5
Features	2 + 2 + 2 + 2 = 8	1 + 0 + 0 + 0 = 1
Total	50	14

Applying the RARC: Steps in assessing riparian condition

The Rapid Appraisal of Riparian Condition index can be used for a variety of applications. Examples include determining relationships between riparian condition and management practices, as in the studies mentioned in this Guide, or surveying overall condition within a catchment to determine priorities for future rehabilitation works in the catchment. Whatever the application, care should be taken to clearly define the question to be answered, determine the sampling design and select sites appropriately to answer the question. This may require help from a consultant with experience in experimental design and data analysis. In general, sampling of sites should be *random**, rather than only sampling sites which are easily accessible by road.

* If you were interested in surveying overall catchment condition, you could choose sites randomly by laying a grid over a map of the catchment, locating and numbering all squares which contain a riparian zone, then putting these numbers in a hat and pulling out as many sites as you wish to sample.

A single observer should conduct all assessments, and they should undertake some training beforehand, to ensure consistency of data collection. The observer will need to have some experience in discriminating native and exotic plant species, and may benefit from previous experience in habitat surveys.

All sites should be surveyed at a similar time of year. Use a separate scoring sheet for each site. Allow 20–60 minutes per site, depending on size and accessibility.

1. Determine site size

Site size must be determined according to the size of the management unit of interest. For example, our studies have examined impacts of grazing management on riparian condition, so management units have been individual paddocks. On the Murrumbidgee River, where paddocks are relatively large, a 1 kilometre length of the riparian zone was defined as a 'site', while in Gippsland, where paddocks are much smaller, a 150 metre length was used. Ideally, sites should be at least 200 metres long, with 500 metres being the preferred length where practicable. On larger rivers, only one side of the river is surveyed, while at smaller sites where it is practicable to do so, both sides may be surveyed (provided they are subject to the same management regime).



The transects at each site should ideally traverse the width of the riparian zone. However, this is not always easy to determine in the field. To simplify this, we use a transect length determined by the width of the river channel — 40 metres long for channels less than 10 metres wide, and four times the channel width for larger rivers. A minimum width of 40 metres should be assessed, unless there is a very clear distinction between riparian and non-riparian areas. Where the riparian zone is clearly narrower than 40 metres or four times the channel width (for example, in a gorge), the transect length should be adjusted accordingly. Where the riparian zone is much wider than this (for example, on a lowland floodplain river), four times the channel width should be adequate to represent the riparian zone. Figure 1 illustrates a hypothetical river with the layout of the survey area and the transects indicated.

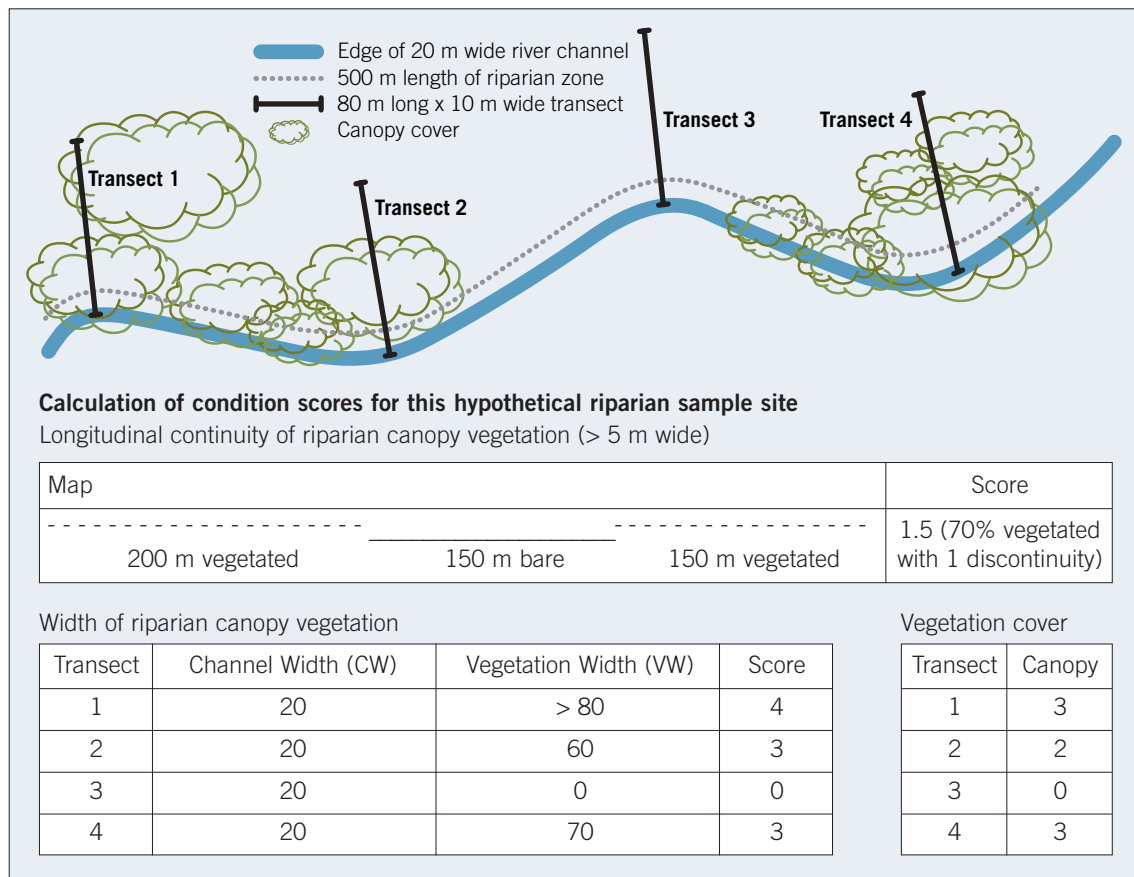
2. Score indicators

A sample scoring sheet can be found on page 163 of this Guide. The complete scoring system is summarised in Table 2. Longitudinal continuity and proximity are given single values for the whole site. All other indicators are scored along four transects (10 metres wide; perpendicular to the direction of river flow) evenly spaced along the bank.

HABITAT

Longitudinal continuity of riparian canopy vegetation: at each site, canopy vegetation along the bank is mapped to show the length and number of any discontinuities (gaps of more than 50 metres) in canopy cover (the bank is considered to be vegetated if the riparian canopy vegetation is at least 5 metres wide). Longitudinal continuity is then scored as follows:

Figure 1. Hypothetical river with length and transects marked. The scoring for the indicators shown in this diagram is shown (see page 163 for full score sheet).



0 = < 50%, 1 = 50–64%, 2 = 65–79%, 3 = 80–94%, 4 = ≥ 95% vegetated bank; with 1/2 point subtracted for each significant discontinuity (> 50m long)

Proximity: an assessment is made of the shortest distance to the nearest patch of at least 10 hectares of relatively intact native vegetation (with an extra point if the area being assessed is within a patch of at least 50 hectares of relatively intact native vegetation). This can be assessed on-site or later using aerial photographs. Proximity is then scored as follows:

0 = > 1 kilometre, 1 = 200 metres–1 kilometre, 2 = contiguous, 3 = contiguous with patch > 50 hectares

A patch of relatively intact native vegetation should have at least the dominant overstorey vegetation remaining. This may not be trees, if the area is a natural grassland or shrubland.

Width of riparian vegetation: The channel width is defined by the area normally lacking any terrestrial or bankside vegetation. The width of the riparian canopy vegetation is the distance from the bank to the first gap of > 50 metres in the canopy vegetation. Channel width (CW) and width of the riparian vegetation (VW) are estimated to the nearest 5 metres in the field. For channels less than 10 metres wide, the vegetation width is converted directly to a score, while for channels more than 10 metres wide, the vegetation width is divided by the channel width to obtain the score as follows:

Channel ≤ 10 metres wide: 0 = VW < 5 metres, 1 = VW 5–9 metres, 2 = VW 10–19 metres, 3 = VW 20–39 metres, 4 = VW ≥ 40 metres

Channel > 10 metres wide: 0 = VW/CW < 0.5, 1 = VW/CW 0.5–0.9, 2 = VW/CW 1–1.9, 3 = VW/CW 2–3.9, 4 = VW/CW ≥ 4

For example, for a channel 12 metres wide and a vegetation width of 30 metres, VW/CW = 2.5, giving a score of 3.

COVER

Vegetation cover within each layer is scored as follows:

Ground cover (lichens, mosses, grasses, herbs, reeds and sedges to 1 metre tall): 0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60%

Understorey cover (herbs, reeds, shrubs and saplings 1–5 metre tall): 0 = none, 1 = 1–5%, 2 = 6–30%, 3 = > 30%

(Note that understorey cover is scored on a different scale to the others, since it is normally less dense.)

Canopy cover (trees > 5 metres tall): 0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60%



Photo 3. Canopy cover increasing from 1–3 (left to right). Photos Amy Jansen.

The number of layers of vegetation is scored as follows:

0 = no vegetation layers to 3 = ground cover, understorey and canopy layers

Tussocky perennial (long-lived) grasses tend to be native species while annual (short-lived) grasses tend to be exotic species (with a few obvious exceptions such as *Phalaris* which is a perennial exotic species).

NATIVES

Native vegetation cover within each layer is scored as for cover, but excluding the contribution of exotic species (to estimate cover of native species, imagine removing all exotic species and re-estimating vegetation cover with only the native species):

Ground cover (lichens, mosses, grasses, herbs, reeds and sedges to 1 metre tall): 0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60%

Understorey cover (herbs, reeds, shrubs and saplings 1–5 metres tall): 0 = none, 1 = 1–5%, 2 = 6–30%, 3 = > 30%

Canopy cover (trees >5 metres tall): 0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60%



Photo 4. Exotic annual ground cover (left) versus native perennial tussock ground cover (right). Photos Amy Jansen.

DEBRIS

Cover of leaf litter on the ground, and cover of native leaf litter are scored as follows:

0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60% cover



Photo 5. Leaf litter cover increasing from 1–3 (left to right). Photos Amy Jansen.

Standing dead trees > 20 centimetres diameter at breast height, and hollow-bearing trees (look for dead branches and broken-off branch stubs in large trees which may have developed hollows) are scored as follows:

0 = absent, 1 = present

Fallen logs (> 10 centimetres diameter) are scored as follows:

0 = none, 1 = small quantities, 2 = abundant (where small quantities = one or two logs, and abundant = three or more logs)

FEATURES

The abundances of native canopy species regeneration (< 1 metre tall) and native understorey regeneration are scored as follows:

0 = none, 1 = scattered, and 2 = abundant, with 1/2 point subtracted for grazing damage (where scattered = one or two seedlings, and abundant = three or more seedlings; grazing damage is evidence that any of the seedlings have been browsed by grazing animals such as domestic livestock or kangaroos)

The abundances of large native tussock grasses (species such as *Poa labillardieri*) and reeds (species such as *Phragmites*, *Typha* (Cumbungi) and *Carex* which are normally only found on riverbanks or in swampy areas) are scored as follows:

0 = none, 1 = scattered, and 2 = abundant (where scattered = one or two plants, and abundant = three or more plants)



Photo 6. *Poa labillardieri*, an example of a large native tussock grass found in riparian zones. Photo Amy Jansen.

3. Analyse data

The indicators are averaged across transects, then summed into sub-indices. The final index score is then the sum of the sub-indices, with a possible maximum of 50 indicating best condition. To examine the results, it is helpful to categorise the index scores, e.g. less than 25 very poor, 25–30 poor, 30–35 average, 35–40 good and more than 40 excellent. It is also helpful to examine sub-index scores, and to determine which sub-indices contribute most to the final condition score. This can be done by regression of sub-index scores on the total index score.

4. Benchmarking

The scoring system given here has been developed for a generalised riparian area in south-eastern Australia, and may need to be adjusted for particular situations. Ideally, a number of relatively pristine sites in the region should be surveyed to provide a benchmark for the scoring system. The scores for each indicator can then be checked to ensure that all indicators are present, and that the maximum score can be achieved for each indicator. For example, in wet forests with a dense canopy, there may be no large tussock grasses but ferns could be used as an indicator instead. Also, ground cover may never reach > 60% due to shading, so this indicator may need to be adjusted accordingly (for example, the scores given for different levels of ground cover could be rescaled similarly to those given for understorey cover). Benchmarking against relatively pristine sites is not always possible in highly modified catchments. In these situations, we can only make a ‘best guess’, based on local knowledge and historical information, about the appropriate scoring for each indicator in these catchments.

Limitations of the RARC

While the condition index outlined in this Guide has been tested in a number of catchments and situations, it has some limitations:

- The RARC has been designed and tested on creeks and rivers in south-eastern Australia. Its usefulness in other regions is yet to be explored.
- The RARC is designed for riparian zones that are naturally dominated by trees, with at least 60% canopy cover.
- The RARC is intended as an indicator of *current* condition. Thus for restored areas, it will not indicate the potential for recovery of ecosystem function.

Further information

We will be continuing to refine and update the RARC so to get the most recent version check the website www.rivers.gov.au and www.landwaterwool.gov.au. There is an Excel spread sheet available on these websites which includes a copy of a field data sheet for printing, and a data entry sheet. If you enter the data for a site, it will automatically calculate the averages for each transect and the final sub-index and total scores for you. If you have a number of sites, you will need to save a separate copy of the worksheet for each site. There is also a field calculation sheet which you can print on the reverse of the field data sheet if you wish to calculate scores as you go in the field (you may need a calculator to take the averages across the transects).

The method was developed by Amy Jansen, Alistar Robertson, Leigh Thomson and Andrea Wilson. It is also available as a stand alone *River and Riparian Technical Update No. 4A* from Land & Water Australia. See the www.rivers.gov.au website for details.



Sample scoring sheet for the Rapid Appraisal of Riparian Condition

Site: _____ Site number: _____
 Observer: _____ GPS start: _____
 Date: _____ GPS end: _____

Longitudinal continuity of riparian canopy vegetation (> 5 m wide)

Map	Score

0 = < 50%, 1 = 50–64%, 2 = 65–79%, 3 = 80–94%, 4 = ≥ 95% vegetated bank, with 1/2 point subtracted for each significant discontinuity (> 50 m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1			
2			
3			
4			
Average			

Proximity

Score

Nearest patch of native vegetation > 10 ha:
 0 = > 1 km, 1 = 200 m–1 km,
 2 = contiguous, 3 = contiguous with patch > 50 ha

Channel ≤ 10 m wide: 0 = VW < 5 m, 1 = VW 5–9 m, 2 = VW 10–19 m, 3 = VW 20–39 m, 4 = VW ≥ 40 m

Channel > 10 m wide: 0 = VW/CW < 0.5, 1 = VW/CW 0.5–0.9, 2 = VW/CW 1–1.9, 3 = VW/CW 2–3.9, 4 = VW/CW ≥ 4

Vegetation cover: Canopy > 5 m, Understorey 1–5 m, Ground cover < 1 m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	Number of layers
1							
2							
3							
4							
Average							

Canopy and ground cover: 0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60%

Understorey cover: 0 = none, 1 = 1–5%, 2 = 6–30%, 3 = > 30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1					
2					
3					
4					
Average					

Leaf litter and native leaf litter cover: 0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60%

Standing dead trees (> 20 cm dbh) and hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (> 10 cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1				
2				
3				
4				
Average				

Regeneration < 1 m tall: 0 = none, 1 = scattered, 2 = abundant with 1/2 point subtracted for grazing damage.

Reeds and large tussock grasses: 0 = none, 1 = scattered, 2 = abundant



Calculation of scores

Site number: _____

Longitudinal continuity of riparian canopy vegetation

Score	A
-------	---

Width of riparian canopy vegetation

Average	B
---------	---

Proximity

Score	C
-------	---

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	Number of layers
Average	D	H	E	I	F	J	G

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	K	L	M	N	O

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	P	Q	R	S

Totals

Site #	Habitat	Cover	Natives	Debris	Features	Total
(out of)	11	12	9	10	8	50
	A+B+C	D+E+F+G	H+I+J	K+L+M+N+O	P+Q+R+S	

Appendix A

Resources



Appendices

A: Resources	165
B: Legislation that governs the management of streams, creeks and riparian land	173
C: Management issues related to streams, creeks and riparian areas, as listed in regional catchment management plans	193
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Resources

When working with wool growers there are a number of organisations that produce useful information. For river and riparian management the most comprehensive range of fact sheets, technical guidelines and manuals can be accessed at www.rivers.gov.au. This website also has a number of interactive catchment diagrams that show well managed and poorly managed riparian areas in relation to a particular topic. The diagram below relates to water quality and agriculture and can be downloaded from the website for use in PowerPoint presentations.



www.rivers.gov.au

Other useful contacts at the National and State level are listed below:

National contacts

Organisation	Telephone	Website
Australian Legal Information Institute (free access to Australian legal documents)		www.austlii.edu.au
Australian Wool Innovation	1800 070 099	www.wool.com.au
Birds Australia		www.birdsaustralia.com.au
Bureau of Rural Sciences	(02) 6272 4282	www.affa.gov.au/brs/
Department of Agriculture, Fisheries and Forestry	(02) 6272 3983	www.affa.gov.au
Department of the Environment and Heritage	(02) 6274 1111	www.deh.gov.au
Environmental Defenders Office	State contacts provided	www.edo.org.au
Greening Australia	(02) 6281 8585	www.greeningaustralia.org.au
Land & Water Australia	(02) 6263 6000	www.rivers.gov.au www.lwa.gov.au
Land, Water & Wool		www.landwaterwool.gov.au
Murray-Darling Basin Commission	(02) 6279 0100	www.mdbc.gov.au
National Farmers Federation	(02) 6273 3855	www.nff.org.au
National Land and Water Resources Audit	(02) 6263 6000	www.nlwra.gov.au
National Plan for Salinity and Water Quality	State contacts provided	www.napswq.gov.au
National Resource Management	1800 552 008	www.nrm.gov.au
Natural Heritage Trust	1800 065 823	www.nht.gov.au
Waterwatch	State contacts provided	www.waterwatch.org.au
Weeds Australia	(03) 6344 9657	www.weeds.org.au



New South Wales

Department of Infrastructure, Planning and Natural Resources (DIPNR)

Tel: (02) 9762 8044

DIPNR have produced a number of fact sheets covering natural resource management issues, that can be accessed at the website.

Website: www.dipnr.nsw.gov.au

New South Wales Agriculture

Tel: (02) 9372 0100

Website: www.agric.nsw.gov.au

Catchment Management Authorities

- Central West Catchment Management Authority, Tel: (02) 6721 9810, Website: www.cw.cma.nsw.gov.au
- Border Rivers-Gwydir Catchment Management Authority, Tel: (02) 6339 4900, Website: www.brg.cma.nsw.gov.au
- Hunter-Central Rivers Catchment Management Authority, Tel: (02) 4930 1030, Website: www.hcr.cma.nsw.gov.au
- Lachlan Catchment Management Authority, Tel: (02) 6341 1600 and 1800 885 747 (freecall), Website: www.lachlan.cma.nsw.gov.au
- Murray Catchment Management Authority, Tel: (03) 5881 9200, Website: www.murray.cma.nsw.gov.au
- Murrumbidgee Catchment Management Authority, Tel: (02) 6923 0479, Website: www.murrumbidgee.cma.nsw.gov.au
- Namoi Catchment Management Authority, Tel: (02) 6742 9220, Website: www.namoi.cma.nsw.gov.au
- Lower Murray Darling Catchment Management Authority, Tel: (03) 5021 9460, Website: www.lmd.cma.nsw.gov.au

Environment Protection Authority

Tel: 131 555

Website: www.epa.nsw.gov.au

NSW Fisheries

Tel: (02) 9527 8411

www.fisheries.nsw.gov.au

NSW Parks and Wildlife Service

Tel: (02) 9585 6444

Website: www.npws.nsw.gov.au

Greening Australia

Tel: (02) 9560 9144

Website: www.greeningaustralia.org.au

NSW legislation can also be viewed at the website: www.legislation.nsw.gov.au

Streamwatch

Tel: (02) 9228 6111

Website: www.streamwatch.org.au

Atlas of NSW Wildlife (contains sightings of plants and animals, not fish, on a regional basis)

Website: www.nationalparks.nsw.gov.au/wildlifeatlas

New South Wales Farmers' Association

Tel: (02) 8251 1700

Information sheets entitled 'Legislation relevant to NSW Landholders' and 'NSW Landholders and Environmental Planning Instruments'.

Website: www.nswfarmers.org.au/policy/conservation/legislation

Queensland

Department of Natural Resources, Mines and Energy (DNRME)

Tel: (07) 3896 3111

DNRME has a number of fact sheets covering natural resources management issues that can be accessed via the website.

Website: www.nrme.qld.gov.au

Department of Primary Industries

Tel: 132 523

Website: www.dpi.qld.gov.au

Regional Natural Resources Management Groups

For more information on regional NRM groups group visit the website: www.regionalnrm.qld.gov.au

- Burnett Mary Regional Group for NRM Inc, Tel: (07) 4132 8333, Website: www.burnettmarynrm.org.au
- Condamine Alliance, Tel: 1800 181 101, Website: www.condaminealliance.com.au
- Fitzroy Basin Association, Tel: (07) 4999 2800, Website: www.fba.org.au
- Natural Resource Management South East Queensland Inc, Tel: (07) 3211 4404, Website: www.nrmseq.com
- Queensland Murray Darling Committee, Tel: (07) 4637 6270, Website: www.qmdc.org.au
- South East Queensland Western Catchments Group, Tel: (07) 3816 9700
- South West Natural Resource Management Group; Tel: (07) 4654 7382.

Environment Protection Agency

Tel: (07) 3227 7111

Website: www.env.qld.gov.au

Greening Australia

Tel: (07) 3902 4444

Website: www.greeningaustralia.org.au

Queensland Landcare and Catchment Management

Regional contacts are provided on the website of those involved in Landcare activities

Website: www.landcareqld.org.au

Waterwatch

Tel: (07) 3896 9625

Website: www.qld.waterwatch.org.au

Environmental Defenders Office

Tel: (07) 4031 4766

Website: www.edo.org.au/edonq.html

Queensland Farmers Federation

QFF has put out Fact Sheets covering the implications of the *Vegetation Management Act 1999*, and it can be accessed via the website.

Website www.qff.org.au/Policies/Environment

Agforce

Tel: (07) 3236 3100

Website: www.agforceqld.org.au



South Australia

Department of Water, Land and Biodiversity Conservation (DWLBC)

Tel: (08) 8463 6800

Website: www.dwlbc.sa.gov.au

Department for Environment, Heritage and Aboriginal Affairs

Tel: (08) 8204 9000

Website: www.dehaa.sa.gov.au

Department of Primary Industries and Resources South Australia

Tel: (08) 8226 0222

Website: www.pir.sa.gov.au

Integrated Natural Resources Management Groups

- Northern and Yorke Agricultural District Integrated Natural Resources Management Group, Tel: (08) 8260 1266, Website: www.dwlbc.sa.gov.au/nrm/delivery/plans/yorke.html
- Adelaide and Mount Lofty Ranges Integrated Natural Resources Management Group, Tel: (08) 8303 9712, Website: www.dwlbc.sa.gov.au/nrm/delivery/plans/mtlofty.html
- Eyre Peninsula Integrated Natural Resources Management Group, Tel: (08) 8688 3400, Website: www.dwlbc.sa.gov.au/nrm/delivery/plans/eyre.html
- Kangaroo Island Natural Resources Board, Tel: (08) 8553 4940, Website: www.dwlbc.sa.gov.au/nrm/delivery/plans/ki.html
- Arid Lands (formerly Rangelands) Integrated Natural Resource Management Group, Tel: (08) 8648 5173, Website: www.dwlbc.sa.gov.au/nrm/delivery/plans/arid_lands.html
- SA Murray Darling Basin Integrated Natural Resources Management Group, Tel: (08) 8536 4809, Website: www.dwlbc.sa.gov.au/nrm/delivery/plans/murray.html
- South East Natural Resources Consultative Committee, Tel: (08) 8762 9120, Website: www.dwlbc.sa.gov.au/nrm/delivery/plans/southeast.html

Environment Protection Authority

Tel: (08) 8204 2004

Freecall: (country) 1800 623 445

Website: www.epa.sa.gov.au

Government Information Centre

Tel: (08) 8204 1900

Freecall (country): 1800 182 234

Legislation may be viewed on www.parliament.sa.gov.au

Environmental Defenders Office (SA) Inc

Tel: (08) 8232 7599 for advisory service

Freecall: (country) 1800 337 566

Website: www.edo.org.au

Legal Services Commission of South Australia

'The Law Handbook' contains information on environmental law and can be accessed via the website

Website: www.lawhandbook.sa.gov.au

South Australian Farmers Federation

Tel: (08) 8232 5555

Website: www.saff.com.au

Tasmania

Department of Primary Industries, Water and the Environment (DPIWE)

Tel: (03) 6233 8011

Wetlands and Waterways Works Manual covers works on waterways and methods often undertaken by farmers and community groups. Can be accessed along with other information on river management from the website by clicking on 'water' and then via the A–Z Guide.

Website: www.dpiwe.tas.gov.au

Regional Natural Resources Management Committees

- Cradle Coast NRM Committee, Tel: (03) 6431 6285, Website: www.nrmtas.com.au
- Northern Tasmania NRM Regional Committee, Tel: (03) 6336 5371, Website: www.nrmtas.com.au
- Southern Regional NRM Committee, Tel: (03) 6234 2248, Website: www.nrmtas.com.au

Environmental Defenders Office

Tel: (03) 6223 2770

Website: www.tased.edu.au/tasonline/edo

Parks and Wildlife Service

Tel: (03) 6233 8011

Website: www.parks.tas.gov.au

Tasmanian Conservation Trust

Tel: (03) 6234 3552

Website: www.tct.org.au

Tasmanian Farmers' and Graziers' Association

Tel: (03) 6332 1800

Website: www.tfga.com.au

Victoria

Department of Sustainability and Environment (DSE)

Tel: 136 186

The DSE website has a list of all the legislation administered by the department. Go to 'About Us' and click on 'legislation'. They also have a series of brochures including: *Changes to riparian vegetation* and *Sedimentation*. Go to 'Plants and Animals' and click on publications.

Website: www.dse.vic.gov.au

Department of Primary Industry

Tel: 136 186

The *Notes Information Series* includes information on a number of relevant topics e.g. willow control and declared noxious weeds.

Website: www.dpi.vic.gov.au

Catchment Management Authorities

- Wimmera Catchment Management Authority, Tel: (03) 5382 1544, Website: www.wcma.vic.gov.au
- Glenelg-Hopkins Catchment Management Authority, Tel: (03) 5571 2526, Website: www.glenelg-hopkins.vic.gov.au
- Corangamite Catchment Management Authority, Tel: (03) 5571 2526, Website: www.ccma.vic.gov.au
- Goulburn Broken Catchment Management Authority, Tel: (03) 5822 2288, Website: www.gbcma.vic.gov.au
- Port Philip and Westernport Catchment Management Authority, Tel: (03) 9785 0183, Website: www.pppwca.vic.gov.au
- North East Catchment Management Authority, Tel: (03) 6043 7600, Website: www.necma.vic.gov.au
- North Central Catchment Management Authority, Tel: (03) 5448 7124, Website: www.nccma.vic.gov.au
- West Gippsland Catchment Management Authority, Tel: (03) 5175 7800 and 5662 4554, Website: www.wgcma.vic.gov.au

Victorian legislation can be accessed on

Website: www.dms.dpc.vic.gov.au



Gateway to environment matters: A–Z guide to Victorian and Commonwealth matters

Website: www.environment.vic.gov.au

Environmental Defenders Office

Tel: (03) 9328 4811

Website: www.edo.org.au/edovic/

Victorian Farmers Federation

Tel: 1300 882 833

Website: www.vff.org.au

Western Australia

Department of Environment

Tel: (08) 9278 0300

Website: www.environment.wa.gov.au

Department of Conservation and Land Management

Tel: (08) 9334 0333

Website: www.calm.wa.gov.au

Department of Agriculture WA

Tel: (08) 9368 3333

Website: www.agric.wa.gov.au

Catchment Councils

- Avon Catchment Council, Tel: (08) 9690 2250, Website: www.avonicm.org.au
- Northern Agricultural Catchment's Council, Tel: (08) 9973 1444, Website: www.nacc.com.au
- South Coast Regional Initiative Planning Team, Tel: (08) 9892 8537, Website: www.script.asn.au
- South West Catchments Council, Tel: (08) 9780 6193, Website: www.swcatchmentscouncil.com
- Swan Catchment Council, Tel: (08) 9374 3333, Website: www.swancatchmentcouncil.org

Department of Environmental Protection

Tel: (08) 9222 7000

Website: www.environ.wa.gov.au

Department of Planning and Infrastructure

Tel: (08) 9264 7777

Website: www.dpi.wa.gov.au

Environmental Protection Authority

Tel: (08) 9222 7000

Website: www.epa.wa.gov.au

Commissioner of Soil and Land Conservation

Tel: (08) 9368 3282

Website: www.agric.wa.gov.au

State Law Publisher (for copies of legislation)

Tel: (08) 9321 7688

Website: www.slp.wa.gov.au

Environmental Defender's Office WA Inc

Tel: (08) 9221 3030

They provide legal advice on environmental issues and has a number of useful Fact Sheets

Website: www.edo.org.au/edowa

Statewide NRM Groups: www.nrm.org.au

Pastoralists' and Graziers' Association of WA

Tel: (08) 9478 4599

Website: www.pgaofwa.org.au



Appendix B

Legislation that governs the management of streams, creeks and riparian land





Legislation that governs the management of streams, creeks and riparian land

This section provides a summary of the key pieces of legislation at the Commonwealth, State and Territory level that governs or affects what woolgrowers can do near a stream, creek or other waterbody. This information has been summarised against particular issues, so some of the multi-purpose acts appear more than once. This is intended to be a general guide only, and woolgrowers are encouraged to check with local agencies for specific information about any intended works or changed management in riparian areas.

Definition of watercourse/riparian zone

Content	Legislation	Comment
<p>New South Wales</p> <p>'River' includes any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved, and any tributary, branch or other watercourse into or from which a watercourse flows.</p> <p>'Lake' includes a wetland, a lagoon, a saltmarsh and any collection of still water, whether perennial or intermittent and whether natural or artificial.</p> <p>'Waterfront land' means the bed of any river together with any land lying between the bed of the river and a line drawn parallel to and 40 metres inland of, the highest bank of the river (or the shore of a lake).</p>	<p><i>Water Management Act 2000</i></p>	<p>NEW SOUTH WALES</p>
<p>New South Wales</p> <p>In this context, 'waterways' means a river, creek or naturally flowing stream of water, whether flowing regularly or intermittently and includes any lagoon or other body of water that is intermittently subject to tidal influence or that intermittently flows into a river, creek or stream.</p>	<p><i>Fisheries Management Act 1994</i></p>	
<p>Queensland</p> <p>The land comprising the bed and banks of a non-tidal boundary watercourse or lake to be the property of the State. A boundary watercourse (or lake) is one that forms part of the boundary of a land parcel irrespective of the ownership of the parcels.</p>	<p><i>Water Act 2000</i></p>	<p>QUEENSLAND</p> <p>As the terms 'bed' and 'bank' are difficult to define, there is debate as to the extent of the State's ownership where the adjoining land is freehold. The State's interpretation of the Act is that it applies to all the land between the high banks of the watercourse or lake. Exactly where the high banks occur is also open to interpretation.</p>



Content	Legislation	Comment
<p>South Australia</p> <p>A watercourse can be a river, creek other natural watercourse (whether modified or not). It can also include a dam or lake or a channel into which water from a watercourse has been diverted.</p> <p>'Lake' means natural lake, pond, lagoon or spring (whether modified or not).</p> <p>'Wetland' means an area that comprises land that is permanently or periodically inundated with water (whether through a natural or artificial process) where the water may be static or flowing.</p> <p>A natural resource can also be designated as a waterway or wetland or a body of water as a lake by an NRM plan.</p>	<p><i>Natural Resource Management Act 2004</i></p>	SOUTH AUSTRALIA
<p>Tasmania</p> <p>'Riparian tenement' means land that adjoins a watercourse or through which a watercourse runs, or that adjoins a lake or on which a lake is situated.</p> <p>'Watercourse' means a river, creek or other natural stream of water (whether modified or not) flowing in a defined channel, or between banks, notwithstanding that the flow may be intermittent or seasonal or the banks not clearly or sharply defined, and includes dams, lakes, channels and floodplains.</p> <p>This does not include drains, or drainage depressions used to relieve land of excess water in times of major precipitation.</p>	<p><i>Water Management Act 1999</i></p>	TASMANIA
<p>Victoria</p> <p>A waterway includes a river, creek, stream or a watercourse and a water channel where water regularly flows, whether or not the flow is continuous.</p>	<p><i>The Water Act 1989</i></p>	VICTORIA
<p>Victoria</p> <p>'Waters' includes any reservoir, tanks, billabong, anabranch, canal, spring, swamp, natural or artificial channel, lake, lagoon, waterway, dam, tidal water, coastal water or groundwater.</p>	<p><i>Environment Protection Act 1970</i></p>	
<p>Victoria</p> <p>Riparian land is defined as the area of land that adjoins, regularly influences or is influenced by, a river.</p> <p>Past administrative definition of riparian land is the land within some fixed width (generally between 20 and 60 metres) running alongside specific rivers). Under the Strategy, widths will be determined at the local level to reflect the ecological functions of that particular riparian land.</p>	<p><i>Victorian River Health Strategy 2002</i></p>	
<p>Western Australia</p> <p>'Watercourse' means:</p> <ul style="list-style-type: none"> any river, creek, stream or brook in which water flows (regularly or intermittently); any collection of water (including a reservoir); and any place where water flows that is prescribed by local by-laws to be a watercourse. <p>The definition includes the bed and banks of the above whether natural or artificially improved or altered.</p>	<p><i>Rights in Water and Irrigation 1914</i></p>	WESTERN AUSTRALIA



Duty of care

Content	Legislation	Comment
<p>Queensland</p> <p>The Act imposes a general duty of care on all persons requiring them to take all reasonable care to prevent or minimise likely environmental harm.</p>	<p><i>Environment Protection Act 1994</i></p>	QUEENSLAND
<p>Queensland</p> <p>The purpose of the Act is the preservation of the natural values of rivers that have all, or nearly all of their natural values intact. The Act regulates activities which could impact on declared rivers. It affects activities regulated by other Acts, for example development applications for the material change of use of premises for agricultural activities and operational work under the <i>Integrated Planning Act 1997</i> as well as activities regulated by the <i>Environment Protection Act 1994</i> (see above).</p>	<p><i>Wild Rivers Act 2005</i></p>	
<p>South Australia</p> <p>The Act places a General Environmental Duty on individuals not to harm the environment and imposes severe penalties for causing serious environmental harm either intentionally or unintentionally. See also 'Water Quality Issues'.</p>	<p><i>Environment Protection Act 1993</i></p>	SOUTH AUSTRALIA
<p>South Australia</p> <p>The owner of land has a statutory duty to employ land management practices that will not result in unreasonable degradation or risk unreasonable degradation of land.</p> <p>It is the duty of the owner and occupier of land on which a watercourse is situated, or that adjoins a watercourse, to take reasonable steps to prevent damage to the bed and banks of that watercourse and to prevent contamination of the waterway. Failure to maintain a watercourse in good condition may result in penalties.</p>	<p><i>Natural Resources Management Act 2004</i></p>	
<p>Tasmania</p> <p>Recent amendments to the Act place a general environmental duty on everyone to take reasonable steps to prevent environmental harm.</p>	<p><i>Environmental Management and Pollution Control Act 1994</i></p>	TASMANIA
<p>Tasmania</p> <p>In taking water as provided by this Act, it is the duty of the owner and occupier of land on which a watercourse or lake is situated, or that adjoins a watercourse or lake, and any other person permitted to take water on or from that land, to take reasonable steps to prevent damage to the bed and banks of the watercourse or the bed, banks or shores of the lake and to the exosystems that depend on the watercourse or lake.</p>	<p><i>Water Management Act 1999</i></p>	
<p>Tasmania</p> <p>The protection of vulnerable land is regarded as a duty of care. Vulnerable land includes land that is within a streamside reserve and the Forest Practices Code prescribes the following buffer widths:</p> <p>Class 1 river: 40 metres either side of stream channel Class 2 stream: 30 metres either side of stream channel Class 3 stream: 20 metres either side of stream channel Class 4 stream: 10 metres either side of stream channel</p>	<p><i>Forest Practices Act 1985</i></p>	



Content	Legislation	Comment
<p>Victoria</p> <p>Under this Act, Catchment Management Authorities (CMA) are responsible for developing regional catchment strategies that set out how the catchment in the region is to be managed.</p> <p>The Act sets out the general duty of land owners which includes:</p> <ul style="list-style-type: none"> • to avoid causing land degradation; • to conserve soil; • to protect water resources; • to eradicate and prevent the spread of regionally prohibited weeds; and • to prevent the spread of, and as far as possible eradicate, established pest animals. 	<p><i>Catchment and Land Protection Act 1994</i></p>	<p>Where a landowner is not complying with the Act, a CMA may issue a land management notice requiring certain activities to be undertaken. If negotiations are not successful and the landowner fails to comply with a notice, the landowner may be penalised.</p>
<p>Victoria</p> <p>Catchment Management Authorities are the caretakers of river health, responsible for regional and catchment planning and coordination, and waterway, floodplain, salinity and water quality management.</p>		<p><i>Securing our Water Future Together</i>, Victorian Government White Paper, published by the Victorian Department of Sustainability and Environment, June 2004.</p>

Access to water, riparian rights

Content	Legislation	Comment
<p>New South Wales</p> <p>The Act specifies:</p> <ul style="list-style-type: none"> • that water must be provided for the fundamental health of a water source or dependent ecosystems as a first priority; • secure property rights including the framework for trading rights and compensation for change; • licensing of water users; and • a planning process with locally representative water management committees and community input. <p>Water Sharing Plans set out the rules for water management on a river valley basis.</p> <p>Water can be taken for domestic consumptive use and for stock without a licence.</p>	<p><i>Water Management Act 2000</i> and <i>Water Management Amendment Bill 2003</i></p>	<p>The Department of Infrastructure, Planning and Natural Resources has developed a series of publications on how surface and groundwater resources are managed and allocated to users in the State's river valleys. Website: www.dipnr.nsw.gov.au/care/water/</p>
<p>Queensland</p> <p>The Act grants the owner or occupier of lands adjoining non-tidal boundary water course or lake, certain rights over the lands within the watercourse or lake to the water's edge. These include the right of access over the land for the person, family, agents and stock, and the right of grazing for that person's stock.</p> <p>Water allocations are separated from the land and entitlements and are established under a Resource Operations Plan. Allocations can be traded. Licenses specify the conditions under which water may be taken.</p>	<p><i>Water Act 2000</i></p>	

Content	Legislation	Comment	
<p>South Australia</p> <p>The Act controls water entitlements, licensing and permits. Water entitlements are issued in 22 prescribed areas (and other areas where the resource is under stress) of the State and specify the quantity of water that can be taken from surface water, a watercourse or groundwater. Licenses are required to take water from these areas other than for stock and domestic purposes although licenses are required for stock water in some areas.</p>	<p><i>Natural Resources Management Act 2004</i></p>	SOUTH AUSTRALIA	
<p>Tasmania</p> <p>Some of the key elements of the Act are to:</p> <ul style="list-style-type: none"> • guarantee minimum water allocation for the environment; • provide for water allocations (that are tradeable); • issue licences to water users; • provide a charging system; and • enable the community to be involved in the management of the resource. <p>Enforceable <i>Water Management Plans</i> are progressively being drawn up for each catchment. These set out the rules by which water will be managed in that catchment including meeting the needs of the environment. Wetlands are also protected.</p> <p>A licence must be obtained from the Department of Primary Industries, Water and Environment (DPIWE) before water can be taken from a river or stream or stored in a farm dam for commercial purposes. An allocation may be attached to the licence.</p> <p>Rights to water are predominantly for riparian landholders wishing to take water for stock, domestic house and garden purposes.</p>	<p><i>Water Management Act 1999</i></p>	TASMANIA	
<p>Victoria</p> <p>This Act:</p> <ul style="list-style-type: none"> • establishes rights and obligations in relation to water resources; • provides mechanisms for the allocation of water resources; • governs the statutory powers and functions of all water authorities outside the metropolitan area; • and provides for integrated management of the water resource and for environmental and consumer protection. <p>The Victorian water allocation framework is set out in the Strategy and includes providing users with entitlements to water that are explicit, exclusive, enforceable and tradable.</p> <p>A person has the right to take water, free of charge, for domestic and stock use from a waterway that flows through the property or is adjacent to the property.</p>	<p><i>Water Act 1989 and the Victorian River Health Strategy 2000</i></p>	VICTORIA	
<p>Western Australia</p> <p>The Act was amended in 2001 to include major reform in the system of water allocation.</p> <p>The management of water resources is guided by statutory plans made at a regional, sub-regional and local level.</p> <p>It is an offence to take water from a watercourse in a 'proclaimed area', 'irrigation district' or 'prescribed area' unless taken in accordance with a riparian right, public right or licence issued by the Department of Environment (formerly 'Water and Rivers Commission'). Many of the State's major rivers are within one of these areas and details are available from the Department.</p> <p>Water licences and entitlements can be traded.</p> <p>Riparian rights allow water to be taken for domestic use and for watering stock (other than those being raised under intensive conditions) from a waterway or wetland that is on, or contiguous to the property.</p>	<p><i>Rights in Water and Irrigation Act 1914</i></p>	<p>Brochures on the changes to the Act can be accessed on the Water and Rivers Commission website: www.wrc.wa.gov.au/using/law_reform_brochures.htm, or via the Department of Environment website.</p>	WESTERN AUSTRALIA



Activities for which permits are required

Content	Legislation	Comment
<p>New South Wales</p> <p>Approvals are necessary for any water supply work (such as construction of banks or levees that have the effect of diverting water from the water source), drainage work or flood work in or in the vicinity of a river or lake, or within a floodplain.</p> <p>Approvals are also required for a 'controlled activity' proposed in waterfront land.</p> <p>Controlled activities are:</p> <ul style="list-style-type: none"> • the construction of buildings or carrying out of works; • the removal of material or vegetation; • the deposition of material on land; or • any activity that affects the quantity or flow of water. 	<p><i>Water Management Act 2000</i></p>	<p>NEW SOUTH WALES</p>
<p>New South Wales</p> <p>A permit is required for any dredging or reclamation work and fishways must be provided in the construction, alteration or modification of a dam, weir or reservoir on a waterway.</p> <p>See also 'Definition of watercourse/riparian zone.'</p>	<p><i>Fisheries Management Act 1994</i></p>	
<p>Queensland</p> <p>Examples of developments for which a permit application has to be made are:</p> <ul style="list-style-type: none"> • artesian bore/subartesian bore; • watercourse pump; • weir, barrage, dam or excavation in a watercourse; • gravity diversion; • referable dam; • stream diversion; and • removal of sand and gravel. <p>Installation of watercourse pumps or gravity diversions used to supply stock or domestic water are self assessable but must be completed in accordance with the relevant development code.</p>	<p><i>Water Act 2000 and Integrated Planning Act 1997</i></p>	<p>Recent changes to the <i>Water Act 2000</i> mean that most water related developments now require assessment and approval by local authorities under the <i>Integrated Planning Act 1997</i>. Many of these developments will also require a Water Licence under the <i>Water Act</i>.</p> <p>QUEENSLAND</p>
<p>Queensland</p> <p>A permit is generally required for clearing riparian vegetation apart from essential management (e.g. maintaining a fire break), routine management in areas other than those protected by the Act (e.g. construction of a necessary fence) or regrowth.</p> <p>See also 'Vegetation Management Near Watercourses'</p>	<p><i>Integrated Planning Act 1997</i></p>	
<p>Queensland</p> <p>The Act controls a wide range of activities (called environmentally relevant activities) by way of licence or permit, many of which could impact on riparian lands, for example releasing a contaminant into a waterway.</p> <p>See also 'Water Quality Issues'</p>	<p><i>Environment Protection Act 1994</i></p>	

Content	Legislation	Comment
<p>South Australia</p> <p>Some of the activities that may require a permit are:</p> <ul style="list-style-type: none"> the erection, construction or enlargement of a dam, wall or other structure that will collect or divert water flowing in a watercourse. <p>All the other activities come under:</p> <p>A person must not undertake any of the following activities contrary to an NRM plan applying in the region in which the activity is undertaken:</p> <ul style="list-style-type: none"> depositing or placing an object or solid material on the floodplain of a watercourse or near the bank or shore of a lake to control flooding from the watercourse or lake; excavating or removing rock, sand or soil from a watercourse or lake or the floodplain of a watercourse or an area near to the banks of a lake so as to damage, or create the likelihood of damage to, the banks of the lake. 	<p><i>Natural Resources Management Act 2004</i></p>	<p>SOUTH AUSTRALIA</p>
<p>South Australia</p> <p>A person wanting to clear native vegetation must apply to the Native Vegetation Council for permission unless he/she is engaged in certain activities e.g. clearing for the construction of buildings or a dam or clearing to prevent or reduce the risk of injury to people or damage to property, including fire.</p> <p>The Council will rarely consent to the clearing of wetlands.</p>	<p><i>Native Vegetation Act 1991</i></p>	<p>Woolgrowers need to consult the legislation and/or the Department of the Environment, Heritage, and Aboriginal Affairs before commencing any clearing</p>
<p>Tasmania</p> <p>Local government regulates land use and development through planning schemes and a planning permit system. Examples of uses and developments that may require a planning permit include works in wetlands and waterways that involve:</p> <ul style="list-style-type: none"> stormwater and erosion control; clearing of debris and vegetation from streams and banks; development of drainage and river works schemes (not routine maintenance); stream channel modification; structures such as pump stations; road and pipeline crossings; off-stream storages less than 1 megalitre; and works ancillary to dam construction (not dams themselves). 	<p><i>Land Use Planning and Approvals Act 1993</i></p>	<p>TASMANIA</p> <p>Planning schemes must be prepared in accordance with the <i>State Policy on Water Quality Management 1997</i>. These requirements are achieved in some recent planning schemes through incorporation of a <i>Wetlands and Waterway Schedule</i></p>
<p>Tasmania</p> <p>Building a dam, weir or levee across a natural watercourse or if it will hold more than 1 megalitre of water, requires approval from the Water Resources Branch of the Department of Primary Industries, Water and the Environment (DPWIE).</p>	<p><i>Water Management Act 1999</i></p>	<p>Where a dam is placed across a river, the Inland Fisheries Commission may require a 'fish-pass' to be constructed if fish passage will be impeded.</p>



Content	Legislation	Comment
<p>Victoria</p> <p>Examples of activities for which a planning permit is required:</p> <ul style="list-style-type: none"> • sub-dividing land; • clearing native vegetation; and • changing the use of a property. <p>However, even minor matters may need a planning permit and woolgrowers need to check with their local council before proceeding with a development or activity that might have an effect on the riparian zone</p>	<i>Planning and Environment Act 1987</i>	VICTORIA
<p>Western Australia</p> <p>Permits are needed for the construction or alteration of a dam on private land in irrigation districts, proclaimed or prescribed areas and on Crown land. The Department requires the adoption of good resource management practices such as causing minimal impact on riparian vegetation, allowing minimal flows to bypass the dam and making every effort to ensure that sediments do not enter the watercourse as a result of the construction.</p>	<i>Rights in Water and Irrigation Act 1914</i>	WESTERN AUSTRALIA
<p>Western Australia</p> <p>Clearing of native vegetation requires a permit unless clearing is for an exempt purpose. When assessing application consideration will be given to the impact of clearing on biodiversity, water and soil resources, salinity and other environmental issues. Some activities, for example, day-to-day activities involving clearing and situations where other statutory approvals have been granted such as works approval, do not require a permit.</p>	<i>Environment Protection Act 1986</i>	

Works in or adjacent to a watercourse

Content	Legislation	Comments
<p>Queensland</p> <p>Specifically, this Act provides for protection against disturbances that may adversely affect the stability of the bed or banks of streams or lakes, for example, the clearing of native vegetation, excavation, and placement of fill. It also relates to activities outside of these features that may adversely impact on water quality, for example, the dumping of waste that may wash into a watercourse or lake and degrade water quality or cause and obstruction to flow. Protection of these areas is managed through a permitting system that has powers to issue 'stop work' notices.</p>	<i>Water Act 2000</i>	QUEENSLAND
<p>Queensland</p> <p>This gives River Trusts the power to impose a notice on woolgrowers or other persons to prevent them from undertaking work or activity that may be detrimental to the condition of the stream or may adversely affect the works of the River Trust.</p>	<i>River Improvement Trust 1940</i>	
<p>Tasmania</p> <p>Local by-laws may have control over the execution of works in wetlands, waterways or riparian zones. There may be a requirement that the works be undertaken by a qualified person and in the manner specified by the Council.</p>	<i>Local Government Act 1993</i>	Wetlands and Waterways Works Manual can be downloaded from the DPIWE website
<p>Tasmania</p> <p>This Act aims to maintain fish passage and protect fish habitat. A person may not place or use in any inland waters any equipment or object likely to hinder or obstruct free passage of fish in that water, without the consent of the Director of Inland Fisheries.</p>	<i>Inland Fisheries Act 1995</i>	



Content	Legislation	Comment
<p>Tasmania</p> <p>A license is required to construct a dam or levee. If banks are lines with rock and that rock raises the height of the streambank above floodplain level this could be regarded as a levee.</p>	<i>Water Management Act 1999</i>	TASMANIA
<p>Tasmania</p> <p>Local government can require a development application to be lodged for a range of activities, including installing structures and the removal of woody weeds such as willows.</p>	<i>Local Government Planning Schemes</i>	
<p>Victoria</p> <p>Catchment Management Authorities may make recommendations, based on their regional catchment management strategies, to a planning authority and parts of the strategy may be incorporated in a State environment protection policy. This may include riparian zone management.</p>	<i>Catchment and Land Protection Act 1994</i>	VICTORIA
<p>Western Australia</p> <p>A person needs approval from the Department of Environment (or authority under another Act) before interfering with a water course (including wetlands):</p> <ul style="list-style-type: none"> • on land within a proclaimed area; • on land prescribed by local by-laws to be subject to this provision; and • on Crown land outside a proclaimed area. <p>'Interfering' would include such activities as undertaking earthworks, dumping material in a watercourse, damaging vegetation or destabilising the banks of watercourse.</p>	<i>Rights in Water and Irrigation Act 1914</i>	WESTERN AUSTRALIA

Water quality issues

Content	Legislation	Comments
<p>New South Wales</p> <p>This is the central piece of environment protection legislation in NSW. The Act provides a single licensing system to regulate activities that generate air, water or noise pollution and enables the government to make 'protection of the environment' policies through which it can set environmental goals, standards and guidelines. Offences under the Act include to:</p> <ul style="list-style-type: none"> • cause any substance to spill or leak in a way that harms or is likely to harm environment; • pollute waters or permit waters to be polluted; • dispose of waste in a way that harms, or is likely to harm the environment • transport waste to an unauthorised disposal site; and • the unauthorised use of land as a waste facility. 	<i>Protection of the Environment Operations Act 1997</i>	NEW SOUTH WALES
<p>New South Wales</p> <p>This Act aims to protect human health, the environment, property and trade in relation to the use of pesticides. It is an offence to pollute waters — e.g. by runoff or drift. Polluting waters is identified very widely to include that of placing of any matter in a position such that it ends up in any natural or man-made waters. Recirculation of tailwater is a condition of surface water irrigation licences in the State.</p>	<i>Pesticides Act 1999</i>	There are new mandatory requirements for recording information about pesticide applications. From September 2005, pesticide users will also have to undergo mandatory pesticide training.



Content	Legislation	Comment
<p>Queensland</p> <p>In assessing an application to undertake an activity, the Department of Natural Resources, Mining and Energy will consider the possible effects of the activity on water quality.</p>	<i>Water Act 2000</i>	QUEENSLAND
<p>Queensland</p> <p>The following substances must not be deposited or released into a roadside gutter, stormwater drain or a water; or in a place where it could reasonably be expected to move or be washed into a roadside gutter, stormwater drain or a water:</p> <ul style="list-style-type: none"> • rubbish; • scrap metal, motor vehicle parts, motor vehicle bodies or tyres; • building waste; • sawdust; • solid or liquid waste from an on-site domestic waste water treatment system; • cement or concrete; • a degreasing agent, paint, varnish or paint thinner; • any manufactured product, or any by-product or waste from a manufacturing process, that has a pH less than 6 or greater than 9; • an insecticide, herbicide, fungicide or other biocide; or • oil. <p>Sand, silt or mud should not be deposited in a roadside gutter, stormwater drain or water</p>	<p><i>Environment Protection Act 1994, Environmental Protection (Water) Policy 1997 and Environmental Code of Practice for Agriculture</i></p>	
<p>Queensland</p> <p>The Act requires pesticide users to follow label direction, to dispose of pesticides and pesticide containers in a way that does not harm people, property or the environment. There are particular responsibilities if using aerial sprays. The Queensland Code of Practice for Agriculture includes a list of sensitive place (includes waterways) and how nearby agricultural activities should be managed.</p>	<p><i>Chemical Usage (Agriculture and Veterinary) Control Act 1988</i></p>	
<p>South Australia</p> <p>The policy establishes water quality objectives and sets down general obligations, such as the obligation to avoid discharges to water, to not contravene the water quality criteria set down in the policy and to not cause environmental harm.</p> <p>A person must not, by discharging or depositing a pollutant into any waters, cause any of the following:</p> <ul style="list-style-type: none"> • loss of seagrass or other native aquatic vegetation; • a reduction in numbers of any native species of aquatic animal or insect; • an increase in numbers of any non-native species of aquatic animal or insect; • a reduction in numbers of aquatic organisms necessary to the health of aquatic organism; • an increase in algal or aquatic plant growth; • the water to become toxic to vegetation on land; • the water to become harmful or offensive to humans, livestock or native animal; or • an increase in turbidity or sediment levels. <p>Certain listed pollutants must not be discharged into any waters or onto land from which it is reasonably likely to enter any water.</p>	<p><i>Environment Protection (Water Quality) Policy 2003</i> is one of a number of policies that come under the <i>Environment Protection Act 1993</i></p>	SOUTH AUSTRALIA



Content	Legislation	Comment
<p>South Australia</p> <p>Releasing wastewater from drilling into a watercourse (even if it is temporarily dry), a wetland channel or well or close to the bank of a watercourse may be causing environmental harm, which is an offence under the Act.</p>	EPA Guidelines-Pollutant management for water well drilling (reissued September 2003) are linked to the <i>Environment Protection (Water Quality) Policy 2003</i>	The Guidelines lists a number of mitigation measures that could be adopted and also deals with exemptions and permits to discharge.
<p>South Australia</p> <p>Failure to maintain a watercourse in good condition may result in penalties. It is the duty of the landholder to prevent contamination of the waterway by soil sediments, nutrients such as phosphorus and nitrogen, plant material such as leaf litter, animal manure and chemicals, fertilisers and pesticides.</p>	<i>Water Resources Act 1997</i>	Fact Sheet 27, <i>Watercourses Section 9 Permits</i> — <i>Water Resources Act 1997</i> is available on the DWLBC website and it outlines obligations in relation to protecting the riparian zone.
<p>Tasmania</p> <p>This Act is the central piece of legislation that deals with pollution. Its aim is to prevent, reduce and undo harm to the environment. Causing serious environmental harm is an offence and involves having an adverse effect on the health or safety of human beings that is of a high impact or on a wide scale, or on the environment that is of a high impact or on a wide scale or resulting in actual loss of, or property damage exceeding a threshold amount. Local government authorities are responsible for environmental regulation of smaller scale activities.</p>	<i>Environmental Management and Pollution Control Act 1994</i>	
<p>Tasmania</p> <p>The Policy assigns protected environmental values to each water body and appropriate water quality objectives can be set according to this designation. Codes of Practice for activities, such as minimising the impact of runoff from agricultural land, that can affect riparian areas are developed under the Policy. The implementation of the Code of Practice could be used as a means of showing compliance with the regulation of <i>Environmental Management and Pollution Control Act 1994</i></p>	<i>State Policy on Water Quality Management</i>	
<p>Tasmania</p> <p>The Act prohibits the flow into inland waters containing fish, any substance likely to harm fish or spawning grounds or food — this includes sediment.</p>	<i>Inland Fisheries Act 1995</i>	

SOUTH AUSTRALIA

TASMANIA



Content	Legislation	Comment
<p>Victoria</p> <p>A person is not allowed to pollute waters so that the condition of the water is changed to make it:</p> <ul style="list-style-type: none"> • noxious or poisonous; • harmful to human beings; • harmful to animals, birds, wildlife, fish or other aquatic life; • harmful to plant or other vegetation; or • detrimental to any beneficial use made of those waters. <p>It is an offence to cause or permit a pollutant to be placed in any waters or in a place where it may gain access to waters. It is also an offence to cause or permit waste to be placed in a position from which it could reasonably be expected to gain access to a waterway or the dry bed of a waterway.</p>	<p><i>Environment Protection Act 1970</i></p>	<p>The <i>State Environment Policy (Waters of Victoria) 1988</i> (SEPP) is the statewide statutory policy framework for water quality protection in Victoria. It has been updated to take account of the recent regional catchment management arrangements.</p>
<p>Western Australia</p> <p>Two levels of offences are created by the Act.</p> <ul style="list-style-type: none"> • Material environmental harm is harm that is not trivial or negligible or results in loss or damages that exceed \$20,000; • Serious environmental harm refers to high impact, irreversible damage in an area of significant conservation value or where the cost of damage or losses exceeds \$100,000 — such as demolishing a wetland. <p>Both are subject to heavy penalties with the more serious offence being treated like a pollution offence.</p>	<p><i>Environmental Protection Act 1986</i></p>	<p>When the <i>State Water Quality Management Strategy</i> is implemented, environmental values for water quality will be assigned to each significant water resource. These values will be linked to appropriate water quality objectives and benchmarks and will be incorporated into policies and conditions for activities regulated by the <i>Environment Protection Act</i>.</p>
<p>Western Australia</p> <p>Waste must be at least 100 metres from a waterbody and all waste must be retained on site and not allowed to enter a waterbody.</p>	<p>Environmental Protection (Rural Landfill) Regulation</p>	
<p>Western Australia</p> <p>The Act is concerned with controlling land degradation in agricultural and pastoral land and correcting any such problems.</p> <p>Land degradation includes soil erosion, salinity, eutrophication (deterioration of water quality resulting from the accumulation of nutrients), flooding, and detriment to present or future use of land due to the removal or deterioration of natural or introduced vegetation.</p> <p>Failure to comply with the Act may result in a Soil Conservation Order being issued.</p> <p>Proposals to build drains or discharge saline water directly into a watercourse or a wetland are subject to a notification process.</p>	<p><i>Soil and Land Conservation Act 1945</i></p>	

VICTORIA

WESTERN AUSTRALIA

In-stream health and wildlife

Content	Legislation	Comment
<p>Commonwealth</p> <p>This Act is the main Commonwealth environmental law. It protects matters of national environmental significance and Commonwealth land. It also covers actions taken by the Commonwealth.</p> <p>There are seven matters of national environmental significance that are triggers for Commonwealth assessment and approval. The ones of greatest relevance to rural landholders are:</p> <ul style="list-style-type: none"> • World Heritage properties; • National Heritage places; • Ramsar wetlands of international importance; • Nationally listed threatened species and communities; and listed migratory species. 	<p><i>Environment Protection and Biodiversity Act 1999</i></p>	<p>The National Farmers' Federation has produced Fact Sheets on the Act and also has an Information Officer who will provide assistance. E-mail: vhodges@nff.org.au</p> <p>Website: http://www.nff.org.au/pages/EPBC.html</p> <p>The Department of the Environment and Heritage has a number of Fact Sheets available on line as well as a page showing relevant links to make is to work with the Act. http://www.deh.gov.au/epbc/industrylinks/farming/index.html</p>
<p>New South Wales</p> <p>A licence is required to carry out activities that may have significant effect on threatened species, populations, ecological communities or their habitats. A licence is not generally required to carry out routine agricultural activities.</p>	<p><i>Threatened Species Conservation Act 1995</i></p>	
<p>New South Wales</p> <p>Of particular relevance to farmers is the part dealing with the conservation of threatened species, populations and ecological communities of fish. The Act includes nominations and listing of threatened and vulnerable species. See also 'Activities for which permits are required'</p>	<p><i>Fisheries Management Act 1994</i></p>	
<p>Queensland</p> <p>The Act gives full protection to:</p> <ul style="list-style-type: none"> • endangered regional ecosystems; • declared areas of high nature conservation value; and • declared areas vulnerable to land degradation (e.g. soil erosion, salinity, stream bank instability etc). <p>The Act also requires the protection of 30% of remnant vegetation across a bioregion.</p> <p>See also 'Vegetation management near watercourses'</p>	<p><i>Vegetation Management Act 1999</i></p>	



Content	Legislation	Comment
<p>Queensland</p> <p>The aim of this Act is the conservation and management of the State's native flora and wildlife. Under this Act, areas can be declared 'protected' with management of these subject to approval. The Queensland Environment Protection Agency administers this Act. Where woolgrowers adjoin declared parts of reserves or other protected areas, property plans and management practices should take account of the need to maintain the ecological health of these areas.</p>	<p><i>Nature Conservation Act 1992</i></p>	<p>QUEENSLAND</p>
<p>Tasmania</p> <p>In Tasmania there are 14 species of freshwater plants, over 30 riparian plant species and 76 species of freshwater fauna listed under the Act. The Minister can also make an interim protection order to conserve the habitat, or part of the habitat of a listed species on both private or crown land. The Act makes it an offence to knowingly take, destroy, injure, trade, keep or disturb listed flors or fauna without a permit</p>	<p><i>Threatened Species Act 1995</i></p>	<p>TASMANIA</p> <p>The presence of threatened flora or fauna can be determined by contacting the Threatened Species Unit, Parks and Wildlife Service or by electronically accessing GT Spot (www.gisparks.tas.gov.au)</p>
<p>Tasmania</p> <p>The Act enables the creation of fauna reserves within inland waters and the placement of restrictions upon activities within such reserves.</p>	<p><i>Inland Fisheries Act 1995</i></p>	<p>For further information contact the Inland Fisheries Service</p>
<p>Tasmania</p> <p>Any person taking water is required to take reasonable steps to prevent damage to the relevant water resource or associated ecosystems. A person may be directed to rectify any damage caused. The Act also protects wetlands.</p>	<p><i>Water Management Act 1999</i></p>	
<p>Tasmania</p> <p>This Act makes provision for the creation of conservation covenants for the protection of biodiversity on private land. Covenanted land is not subject to land tax and landowners may be eligible for certain compensation payments when they enter the covenant.</p>	<p><i>National Parks and Wildlife Act 1970</i></p>	
<p>Victoria</p> <p>The Act is concerned with the conservation of Victoria's communities of flora and fauna and the management of potentially threatening processes. The degradation of native riparian vegetation is listed as a potential threatening process under the Act. The Act also provides a list of threatened species.</p> <p>If an area is considered to be critical to the survival of a particular species it may be the subject of an interim conservation order. A landholder is entitled to compensation for financial loss suffered as a result of the interim conservation order.</p>	<p><i>Flora and Fauna Guarantee Act 1988</i></p>	<p>VICTORIA</p>
<p>Victoria</p> <p>The Act makes it possible for landowners to enter into land management co-operative agreements for the conservation of particular areas on their farm.</p>	<p><i>Conservation, Forests and Lands Act 1987</i></p>	<p>Grants, loans and rate relief may be provided in return for specified conservation land management practices.</p>

Content	Legislation	Comment
<p>Western Australia</p> <p>The 2003 amendments to the Act use the concept of 'environmental harm' to cover acts of unauthorised environmental vandalism that are more than trivial or negligible, but not considered to be pollution. 'Environmental harm' includes the direct or indirect harm to the environment involving removal or destruction of, or damage to:</p> <ul style="list-style-type: none"> • the habitat of native vegetation or indigenous aquatic or terrestrial animals; • alteration of the environment to the detriment or potential detriment of an 'environmental value'; and • alteration to the environment of a prescribed kind. 	<p><i>Environmental Protection Act 1986</i></p>	<p>The 'environmental value' terminology includes the ecosystem health condition and thus gives protection to the environment itself. This will come into effect through Environmental Protection Policies</p>
<p>Western Australia</p> <p>There are two Environment Protection Policies (EPP) directed towards protecting the environmental values of wetlands in the Swan coastal plan and within the south west agricultural zone. These EPPs are legally enforceable and include penalties for an offence. See also 'Water Quality issues'.</p>	<p><i>Environmental Protection Act 1986</i></p>	
<p>Western Australia</p> <p>Under this Act, individual species of plants and animals are protected with the level of protection varying depending on whether the species is rare or endangered. Aquatic species may also be protected by the <i>Fish Resources Management Act 1994</i>. However, ecological communities and their habitats are not protected under this Act.</p>	<p><i>Wildlife Conservation Act 1970</i></p>	<p>This Act will be replaced with a new Act. Submissions on a consultation paper entitled <i>A Biodiversity Conservation Act for Western Australia</i> closed in 2003.</p>

WESTERN AUSTRALIA

Vegetation management near watercourses

Content	Legislation	Comments
<p>New South Wales</p> <p>The Act sets a framework for the:</p> <ul style="list-style-type: none"> • management of native vegetation on a regional basis; • prevention of broadscale clearing unless it improves or maintains environmental outcomes; • protection of high conservation value native vegetation; and • encouragement of revegetation and rehabilitation of land with appropriate native vegetation. <p>The Act provides clear definitions of different classes of native vegetation and what constitutes broadscale clearing. Landholders will also be supported to voluntarily develop individual or group Property Vegetation Plans that will have a 15 year tenure.</p>	<p><i>Native Vegetation Act 2003</i></p>	<p>A set of supporting Regulations is currently being developed and until these come into effect, existing arrangements under the <i>Native Vegetation Conservation Act 1997</i> will remain in place.</p>
<p>New South Wales</p> <p>The authorities engage regional communities in key natural resource management issues facing their catchment. Their duties include funding catchment activities. In 2005, Catchment Management Authorities will have the powers to assess clearing applications and make consent decisions for on-farm activities.</p>	<p><i>Catchment Management Authority Act 2003</i></p>	

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Content	Legislation	Comment
<p>New South Wales</p> <p>This Act is the primary piece of land use and planning legislation in NSW. Local environmental plans, development control plans and codes of practice are developed by local government to control land use and planning in the municipality. These may include stipulations regarding riparian zone management.</p>	<p><i>Environmental Planning and Assessment Act 1997</i></p>	
<p>Queensland</p> <p>This is the principal piece of legislation relating to the State's native vegetation on freehold land. Vegetation clearing comes under the category of 'assessable development' under the <i>Integrated Planning Act 1997</i>. A permit is generally required for clearing apart from essential management (e.g. maintaining a fire break), routine management in areas other than those protected by the Act (e.g. construction of a necessary fence) or regrowth. A <i>Property Vegetation Management Plan</i> is required as a part of the tree clearing permit application. The Plan must be consistent with an approved <i>Regional Vegetation Management Plan</i>. Regional codes should also be checked as they determine the extent of riparian vegetation that should be retained.</p> <p>Clearing should not isolate wetlands, lakes or springs or within a specified distance (depending on the region) of the static high water mark of these water bodies.</p> <p>See also 'Works in or adjacent to a watercourse'</p>	<p><i>Vegetation Management Act 1999 and Integrated Planning Act 1997</i></p>	<p>In this context, 'regrowth' means vegetation that covers less than 50% of the undisturbed canopy, averaging less than 70% of the undisturbed height and composed of species characteristic of the undisturbed predominant canopy.</p>
<p>Queensland</p> <p>This is the principal legislation for the management of State owned (Crown) lands, including leases, reserves etc. A permit is required from the local Department of Natural Resources Mines and Environment office to undertake clearing within a critical area, which includes riparian land, unless the clearing is for isolated trees as part of routine property maintenance, for example, replacement fence posts.</p>	<p><i>Land Act 1994</i></p>	
<p>South Australia</p> <p>Landowners who have native vegetation growing on their properties may enter into a 'heritage agreement' with the government and agree to manage the land in a certain way.</p> <p>See also 'Duty of care' and 'Activities for which a permit is required'.</p>	<p><i>Native Vegetation Act 1991</i></p>	
<p>Tasmania</p> <p>See page 177 under 'duty of care' for definition of vulnerable land as this also relates to vegetation adjacent to watercourses.</p>	<p><i>Forest Practices Act 1985</i></p>	
<p>Victoria</p> <p>The Victorian Healthy Rivers Strategy establishes the CMAs as the 'caretakers' of riparian land, where their role is to be responsible for the coordination of the required planning and implementation of programs for protection and restoration activities.</p> <p>CMAs now undertake Stream Restoration Plans to provide direction for specific work programs on stream erosion control, in-stream and riparian revegetation and habitat restoration. Contact your local CMA for more details.</p>	<p><i>Victorian River Health Strategy 2000 (VRHS) and Catchment and Land Protection Act 1994</i></p>	<p>A Fact Sheet <i>Managing Riparian Land</i> is available on the DSE website www.dse.vic.gov.au</p>

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VICTORIA



Content	Legislation	Comment
<p>Victoria</p> <p>Native Vegetation Retention Controls implemented by local government through the State planning schemes control the removal or destruction of native vegetation.</p>	<p><i>Planning and Environment Act 1987</i></p>	VICTORIA
<p>Western Australia</p> <p>A permit is required for the removal of trees or land clearing on Crown land other than that permitted under the lease.</p>	<p><i>Land Administration Act 1997</i></p>	WESTERN AUSTRALIA

Control of weeds and pests

Content	Legislation	Comment
<p>New South Wales</p> <p>The Act specifies the control measures (according to its control category) that have to be undertaken by public and private landholders. The occupier of the land is responsible for the control of noxious weeds on that land and a local authority may issue the occupier with a weed control notice to carry out specific control measures. Willows are declared noxious weeds in some areas.</p>	<p><i>Noxious Weeds Act 1993</i></p>	<p>Willow clearing in State Protected Land (for riparian land this is 20 metres from the bank or any part of the waterway) requires a pre-application site visit by a local DIPNR officer.</p>
<p>Queensland</p> <p>This is the principal legislation for the management and control of pests and weeds in the State. Certain plant and animals can be declared in various categories under the Act for the purposes of control (destroy, reduce, or contain). The Act requires occupiers of private land to control all declared plants and animals.</p>	<p><i>Rural Lands Protection Act 1985</i></p>	QUEENSLAND
<p>South Australia</p> <p>The purpose of this Act is to deal with pest animals and plants. The Act places restrictions on the movement and sale of pests and also makes the landowner responsible for carrying out the instructions of the local Animal and Plant Control Board in respect of their control or destruction.</p>	<p><i>Animal and Plant Control (agricultural protection and other purposes) Act 1986</i></p>	SOUTH AUSTRALIA
<p>Tasmania</p> <p>A plant considered a serious economic, environmental and/or social risk, is declared under the Act, allowing legally enforceable actions to be undertaken to control it. Examples of declared riparian weeds are willows and blackberries. The Weed Management Plans developed for each weed species contain information on the legally enforceable management of that weed and includes measures to control, eradicate or restrict the spread of the weed.</p> <p>See also 'Works in or adjacent to a watercourse'</p>	<p><i>Weed Management Act 1999</i></p>	TASMANIA
<p>Tasmania</p> <p>Chemicals can only be used for control when it can be demonstrated that chemical control poses less net environmental risk than other means.</p>	<p><i>Agricultural and Veterinary Chemicals (Control of Use) Act 1995</i></p>	<p>See also 'Works on or adjacent to a watercourse'</p>



Content	Legislation	Comment
<p>Victoria</p> <p>The Act establishes the Victorian Catchment and Land Protection Council, Regional Catchment and Land Protection Boards and the Pest Animal Advisory Committee.</p> <p>The Act makes provisions for the classification and control of noxious weeds and pest animals and the enforcement of penalties for non-compliance with a direction.</p> <p>See also 'Duty of Care'</p>	<p><i>Catchment and Land Protection Act 1994</i></p>	<p>A list of declared noxious weeds can be found on the Department of Primary Industry Website under their Notes Information Series (www.dpi.vic.gov.au)</p>
<p>Western Australia</p> <p>The Act is the main legislation dealing with pest plants and animals and it is administered by the Protection Board. Classes of plants and animals may be 'declared' by the Board. If the occupier of any private land finds a declared plant and animal on the land the Protection Board must be notified. The occupier must then take appropriate steps to control it. Local government may also make local laws prescribing as a pest plant any plant that is likely to adversely affect the district or its inhabitants. Where such a plant occurs, a notice may be served on the owner/occupier of the land to control that pest plant. If the owner/occupier does not comply, the local government may take measures to control the pest plant at the expense of the owner/occupier.</p>	<p><i>Agriculture and Related Resources Protection Act 1976</i></p>	

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Appendix C

Management issues related to streams, creeks and riparian areas, as listed in regional catchment management plans





Management issues related to streams, creeks and riparian areas, as listed in regional catchment management plans

In this section we have listed some of the high-priority management issues that have been identified in catchment plans in higher-rainfall or tableland areas where wool production is an important land use. Parts of the Murrumbidgee (NSW) catchment plan are summarised in more detail as one example of how some communities are setting catchment targets. The significance of the priority issues and catchment targets listed here, is that woolgrowers who are interested in tackling these problems can access assistance from their local catchment management agency, or regional natural resources management organisation.

Water quality

Actions to address contamination of streams by salt, sediment and nutrients:

- Improve surface water management on farms through graded banks, adopting no till practices, grassed waterways, revegetation, less clearing
- Control in-stream gravel abstraction, dam construction, roads and mining
- Identify location of major contributors to sedimentation
- Ensure better compliance with point source pollution regulations
- Adoption of best management practices in relation to pollution of waterways by agriculture and industry
- Decrease export of phosphorus and nitrogen particularly from over clearing, poor land management, poor use of fertilisers, and change from native to exotic vegetation

Streambank erosion

Actions to address streambank erosion:

- Target bed and banks erosion and implement rehabilitation works
- Protect watercourses and regulate drainage infrastructure to minimise erosion
- Stabilise banks and reduce extent and severity of erosion in priority waterscapes

Acidification

Actions to reduce acidification of water resources to lessen harmful effect on fish and other aquatic organisms:

- Avoid draining of water logged areas

Riparian vegetation

Establish/restore native riparian vegetation to:

- Provide aquatic habitat
- Control strong sunlight, rise in water temperature, infestation by exotic fish and loss of native vegetation
- Protect and rehabilitate riparian vegetation whilst protecting cultural and heritage values
- Develop riparian revegetation program and increase riparian management works

Conservation

- Support and effectively maintain conservation reserves on private land
- Increase the extent of and improve the condition of native riparian vegetation along priority waterways
- Consider voluntary management of priority sites to improve riparian vegetation
- Maintain or increase populations of threatened aquatic flora and fauna and protect key habitats

Weeds and feral animals

- Control nuisance fauna and flora
-



Ground water

Primary concern about increased salinity of water, decline in ground water levels and adverse effect on water dependent ecosystems. Actions to address issue:

- Stabilise aquifers and modify ground water licenses to prevent further decline
-

River health

- Protect assigned environmental values of waterways
 - Ensure achievement of targets for riverine quality meets targets set under NAP
 - Protect and rehabilitate degraded rivers, wetlands and floodplains
 - Protect aquatic biota and maintain or improve overall health of rivers
 - Reverse trend of declining water quality
-

Wetlands

- Maintain current areas of biodiversity of wetlands
 - Assess the condition of wetlands and identify isolated wetlands of high value
 - Modify impeding structures to ensure floods reach important wetlands
 - Minimise off site effects on wetlands
-

Flow regimes

Actions to improve management of flows:

- Identify required allocation for fish passage, floodplain, wetland, and health of in-stream organisms
 - Manage water extraction for irrigation to safeguard riverine ecosystems
 - Set up a system of equitable water use and water trading
 - Provide environmental flow
 - Improve the control of water discharge peaks from dams
-

Floodplain management

- Coordinate flood management by local government and farmers
 - Ensure that management is responsible in terms of the environment, and economic and social development
 - Consider floodplain management plans, and wetland health when assessing flood plans for cropping
-

Water use

- Ensure there is community access to water resources to enhance industry, lifestyle and community benefit
 - Ensure regional water balance is achieved through sustainable management of quantity and quality of water to optimise productive use whilst providing for the needs of aquatic ecosystems
-

Stock management

Better management of stock

- Fence waterways including minor streams
 - Limit stock access
 - Educate community about responsible stock management in the riparian zone
-

Incentives

- Provide incentives for better management of stock including fencing
 - Develop cost sharing packages and incentive schemes to encourage adoption of best management practices
-

Planning, monitoring and assessment

- Develop and implement management plans, water sharing plans
 - Develop and implement monitoring programs
-



Catchment Natural Resource Management Plans consulted, 2004–05

Central West Catchment Management Board, 2002, *Central West Catchment Blueprint*.

Website: www.dipnr.nsw.gov.au/nvrig/cma.html

Fitzroy Basin Association, 2000, *Central Queensland Strategy for Sustainability*.

Website: www.glenelg-hopkins.vic.gov.au

Glenelg Hopkins Catchment Management Authority, 2003, *Glenelg Hopkins Regional Catchment Management Strategy 2003–2007*.

Website: www.fba.org.au

Gwydir Catchment Management Board, 2002, *Catchment Management for the Gwydir catchment*.

Website: www.dipnr.nsw.gov.au/nvrig/cma.html

Mid North Coast Catchment Management Board, 2002, *Integrated Catchment Management Plan for the Mid North Coast Catchment*.

Website: www.dipnr.nsw.gov.au/nvrig/cma.html

Murrumbidgee Catchment Management Board, 2002, *Integrated Catchment Management Plan for the Murrumbidgee Catchment*.

Website: www.dipnr.nsw.gov.au/nvrig/cma.html

Upper North Coast Catchment Management Board, 2002, *Integrated Catchment Management Plan for the Upper North Coast Catchment*.

Website: www.dipnr.nsw.gov.au/nvrig/cma.html

Integrated Catchment Management Plan for the Murrumbidgee Catchment

Catchment Plans are now completed or in the process of being completed for all the major agricultural catchments. Whilst they do not all follow the same format they typically revolve around targets that are specific, measurable and to be achieved within a specified period of time. The Murrumbidgee Plan is given as an example.

The Murrumbidgee Plan consists of a hierarchy of targets and actions from the broad catchment level down to the local action required to achieve the desired outcome. The information provided below relates only to Catchment Targets, Management Targets and examples of actions that have implications for the riparian zone

Water quality and flow targets

The intent of the water quality and flow targets is to improve river and tributary health, particularly through an improvement in riparian and aquatic habitat and ecological process, which will be reflected in an improvement in water quality, including reduced suspended sediment levels and a more natural flow regime. Water Sharing Plans will ensure equity and certainty for landholders and provision for environmental needs. The Plan seeks to achieve:

- Environmental benefits: Improving the quality and diversity of riparian and aquatic habitat and supporting the maintenance of aquatic ecological processes and therefore enhance biodiversity.
- Social benefits: Improved quality of water for industry, recreation, towns and landholders; including clear and equitable water access rules.
- Economic benefits: A viable irrigation industry through improved security of access (quantity) and enhanced water quality. Reduced costs in treating blue-green algae outbreaks, and reduced pump maintenance costs.

Murrumbidgee catchment target

By 2012, in the Murrumbidgee River and its main tributaries, suspended sediment levels will be reduced so that they meet National Standards. Flows and water extractions will be managed to maintain or improve river health consistent with the River Flow Objectives and the Murray-Darling Basin Cap.

Below are a number of Management Targets (MT) together with some of the actions required to meet those targets.



MT 1. Protect and enhance 1500 kilometres of streambank using native riparian vegetation for bank stabilisation and runoff filtration.

- protect, enhance and re-establish existing riparian native vegetation e.g. by developing incentives to encourage land managers to implement riparian zone actions and works;
- manage stock access e.g. by investing in off-stream watering points; and
- manage problem weeds e.g. black willows.

MT 2. Along those stream reaches, which yield the highest sediment and nutrient loads, control streambank and gully erosion using structural control works covering a total length of 50 kilometres.

- construct streambank and gully erosion control works e.g. by prioritising gullies and streambanks for erosion control works and developing and implementing gully control works on a property scale.

MT 3. Improve native vegetation condition in 90% of the floodplain billabongs to restore their natural capacity to filter sediment.

- restore (or improve) the hydrological regime to billabongs e.g. negotiate with land managers the requirements for each priority floodplain billabong;
- manage stock access to billabongs e.g. by developing incentives to encourage land managers to manage floodplain billabongs for water quality outcomes;
- manage problem weeds and pest animals.

MT 4. Reduce pollution from point sources

- ensure appropriate regulation of point sources;
- encourage local government to reduce water quality impacts of rural residential development.

MT 5. Implement Water Sharing Plans for the Murrumbidgee River and each of its subcatchments and priority groundwater systems, which are classified under the Water Management Act 2000 as 'high risk' 'high stress' or "high conservation value" by 2012.

- by 1 December 2007 complete and commence implementation of Water Sharing Plans for the Lower Murrumbidgee Groundwater Management Area, the Murrumbidgee River and Tarcutta and Adelong creeks.

Biodiversity MT

Maintain diversity of indigenous aquatic biota and processes by a reduction in the species diversity ratio of alien to native fish by 25%, a 10% increase in aquatic invertebrate diversity, and establishment and long term maintenance of native aquatic plants for 10 linear kilometres of Murrumbidgee River.

- retain, enhance and revegetate riparian and aquatic native vegetation;
- investigate river flows, seasonality and water quality to optimise suitable locations for aquatic plant establishment in the Murrumbidgee River;
- enhance aquatic connectivity;
- protect sites of relatively intact aquatic biodiversity; and
- manage instream habitat complexity by maintaining and improving channel complexity and instream vegetation.

Salinity Catchment Target

A year 2010 target of less than 245 EC for 50% of the time and less than 320 EC for 80% of the time at Balranald. A salt load of less than 145,000 tonnes per year for 50% of the time and less than 325,000 tonnes per year for 80% of the time by 2010.

This target will be achieved by better land management practices and will result in improved river and wetland ecosystems, and improved water quality for stock and domestic users.



Appendix D

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This River Guide aims to assist Australian woolgrowers and those who work with them to better manage water courses and riparian land on farms. It provides practical advice and examples of how woolgrowers can improve wool production and profit, and at the same time achieve and demonstrate sound environmental management. It is designed primarily for audiences with some technical knowledge of natural resource management, but its contents are also suitable as base materials for local workshops and field days.



HIGH RAINFALL ZONES
including tableland areas