Managing riparian lands in the cotton industry

A RESOURCE FOR PEOPLE IN THE COTTON INDUSTRY TO ASSIST THEM IN IMPROVING RIPARIAN LAND MANAGEMENT ON COTTON FARMS

Cotton Research & Development

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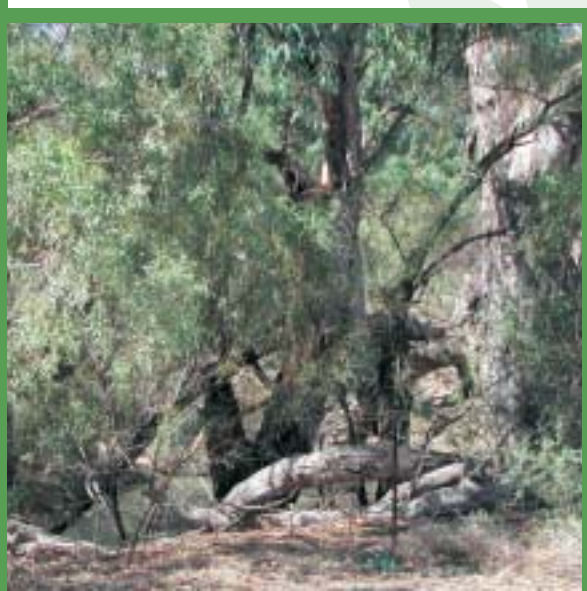

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Disclaimer

The information in this publication has been published by the Cotton Research and Development Corporation (CRDC) and Land & Water Australia (LWA) to assist public knowledge and discussion, and to help improve the sustainable management of land, water and vegetation in the cotton industry. These guidelines have been prepared from research and development studies with specialist input from researchers, practitioners and land managers. However, the guidelines do not purport to address every condition that may exist on riparian land in Australia.

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Consultation trip for cotton guideline, May 2003. From left: Stefan Henggler, Robyn Watson, Mike Logan, Phil Norrie, John Watson, Guy Roth, Ross Brown, Jinnie Lovett and Phil Price, with Morgan at the front.

Abbreviations

ANZECC	Australia and New Zealand Environment and Conservation Council
BMP Manual	Australian Cotton Industry Best Management Practice Manual
Cotton CRC	Australian Cotton Cooperative Research Centre
CRDC	Cotton Research and Development Corporation
DIPNR	Department of Infrastructure, Planning and Natural Resources (NSW)
DLWC	Department of Land & Water Conservation (NSW) (now PIPNR)
EPA	Environment Protection Authority (NSW)
GM	Genetically Modified
LWA	Land & Water Australia
NAP	National Action Plan for Salinity and Water Quality
NHT	Natural Heritage Trust
QEPA	Queensland Environment Protection Agency
QDNRM	Queensland Department of Natural Resources and Mines
QDPI	Queensland Department of Primary Industries

1 Purpose of the guide

chapter one

This guide is a resource for improving riparian land management on cotton farms. Riparian land is important because it is economically and environmentally productive. Intensive agricultural production systems like cotton growing can affect waterways, downstream water users, neighbours and communities. Careful management of riparian land on cotton farms can help minimise these effects, and result in environmental and aesthetic benefits for cotton growers and their families.

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

This guide provides information on how best to manage riparian land. Different management options are provided, with the science underpinning these options described so that on-farm decisions can be made based on the best available information. It is intended that the guide be used to complement existing information on sustainable cotton production, as well as to assist the development of other products and materials. For example, material in the guide could be used by the cotton industry, government agencies and other groups to develop:

- projects and activities to restore and improve riparian land;
- best management practices, codes or plans;
- workshops to increase awareness and skills;
- fact sheets on specific issues of riparian management; and
- presentations to landcare, farming and community groups.

Provided that the original source of the material is acknowledged, reproduction of parts of the guide in other products is encouraged.

The guide has been developed by the Cotton Research & Development Corporation, Australian Cotton Cooperative Research Centre, Land & Water Australia, the New South Wales Department of Infrastructure, Planning and Natural Resources and the Queensland Department of Natural Resources and Mines. It is recognised that today's best practice may not be tomorrow's. As such, it is expected that this guide will be reviewed and further improved from time to time, based on grower experience and new scientific knowledge.

Background

Cotton production has grown to become one of Australia's most important agricultural industries, with several regional economies supported by its development. Growing cotton is an intensive land use, requiring cultivation of the soil, inputs in the form of fertiliser and pesticides, and a reliable supply of water. Cotton is a significant user of arable land and irrigation water in several catchments in New South Wales and Queensland. In recent times, the industry has been proactive in developing production systems that are both profitable and sustainable. For example, it has developed systems of integrated pest management with reduced use of pesticides for dryland and irrigated production, as well as improving water use efficiency for irrigated cotton systems.

The location and extent of cotton-producing districts means that they have the potential to significantly affect water quality and river flow, with impacts on down stream neighbours and communities, as well as on the health of riverine systems. Although cotton farms cover less than 5% of the catchment area, they are generally located adjacent to rivers and riparian areas. Many of the improved practices introduced by the industry over the past decade have had beneficial effects on the health of rivers and waterways. Improving the management of riparian lands is an obvious and necessary next step for the industry.

Recent scientific research has substantially improved the understanding of how riparian land functions in Australia. This guide draws together scientific findings, tools and techniques that can assist cotton growers to better manage the important, yet vulnerable, riparian lands that exist on their farms. The management of riparian land should be incorporated with other aspects of farm operation, and this guide should be considered as a further component of the Australian Cotton Industry Best Management Practices Program. The guide is intended to cover both irrigated and dryland cotton growing, and growers should adapt the recommended management approaches accordingly. It is also important that growers check any regulations that apply (see Appendix B). Although this guide has been prepared specifically for the cotton industry, many of the management approaches described can be applied to the growing of other field crops.

2 The importance of riparian land

chapter two

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. This guide aims to help cotton growers improve and protect the health of riparian land and associated waterways on cotton farms, as well as to minimise the impacts of cotton production on water quality, and river health. As a result, the definition in the flash box below refers to the roles, or functions, that riparian land plays. Using this functional approach, riparian land is defined as:

> 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 rivers, including the riverbank itself;
- gullies and dips, including those adjacent to cropping paddocks that sometimes run with surface water;
- land adjacent to drains and channels that empty into streams or wetlands;
- areas surrounding lakes and dams;
- wetlands, billabongs and floodplains that are linked with the river in times of flood; and,
- vegetation dependent on groundwater supplied by a river.

Any part of the farm that is linked to the local river system by water flow, including parts linked only during storm events, should be considered as covered in these guidelines. This is because what happens on them and how they are managed can have a significant influence on the river's health and its water quality.

Examples of riparian land.

Cudgegong River. Photo Guy Roth.

Cox's Creek. Photo Guy Roth.

Open channel on cotton farm. Photo Guy Roth.

Artificial wetland on cotton property. Photo Mick Rose.

It is important to remember that the width of riparian land will depend on its purpose and management objective. For example, the width required to trap soil from a cultivated paddock (filter strip) may be a fraction of the width required to provide wildlife habitat, yet both are appropriate riparian management objectives. The main aim of this guide is to help cotton growers understand the basic requirements for sustainable management of riparian land. It also provides information about how these requirements can be incorporated into farm design and cotton production operations. At the same time, various legislation contains legal definitions of riparian land that cotton growers must be aware of, and these are described in Appendix B.

'**Filter strip**' means a grassed area established to trap soil and attached contaminants moving in shallow surface flows after rain or irrigation, so that they do not enter adjacent streams (see Section A).

Why is riparian land important?

Riparian land is important because it is usually the most fertile and productive part of the landscape, in terms of both agriculture and natural ecosystems. It often has better quality soils than surrounding hill-slopes and, because of its lower position in the landscape, often retains moisture over a longer period.

The term '**ecosystem**' refers to a community of plants and animals that interact with each other, as well as with the physical and chemical environment in which they live. A lake or a stream with its adjacent riparian lands, may be referred to as an ecosystem.

The meandering line of trees running through the middle of this photograph is a riparian area providing a corridor for wildlife and protecting the river from the impacts of adjoining land uses. Photo CSIRO Sustainable Ecosystems.

Ecosystems are everywhere — in agricultural fields, suburban gardens and national parks — and perform functions that allow humans to live on earth and fulfil our lives in a variety of ways. We call these functions '**ecosystem services**' and they are essential for human health and survival. Examples of the kinds of services we receive from nature include water filtration, regulation of atmospheric composition, maintenance of soil fertility and pollination.

Riparian land often supports a greater diversity of plants and animals than non-riparian land. This is a result of its wide range of habitats and food types, its closeness to water, its microclimate and its ability to provide refuge. Many native plants and animals are found only, or mainly, in riparian lands, and this makes these areas essential to many animals for all or part of their lifecycle. Riparian land also provides a refuge for native plants and animals in times of drought and fire, as well as providing corridors for wildlife in highly-cleared landscapes.

For waterways, vegetation on riparian land regulates in-stream life by: moderating undesirable temperature changes through shading; supplying the energy and nutrients (for example, leaves, twigs, fruits and insects) essential to in-stream food webs; and by providing the logs and branches that fall into the stream to create habitat for fish, plants and animals (see Figure 1). As well as being environmentally productive, riparian land is also a vulnerable part of the landscape. It is at particular risk of damage from over-clearing, cultivation, uncontrolled grazing, weed invasion, spraydrift from chemicals, soil eroded from upslope, and natural events such as floods and fire. This combination of productivity and vulnerability means that careful management of riparian land is vital for the conservation of Australia's unique biodiversity.

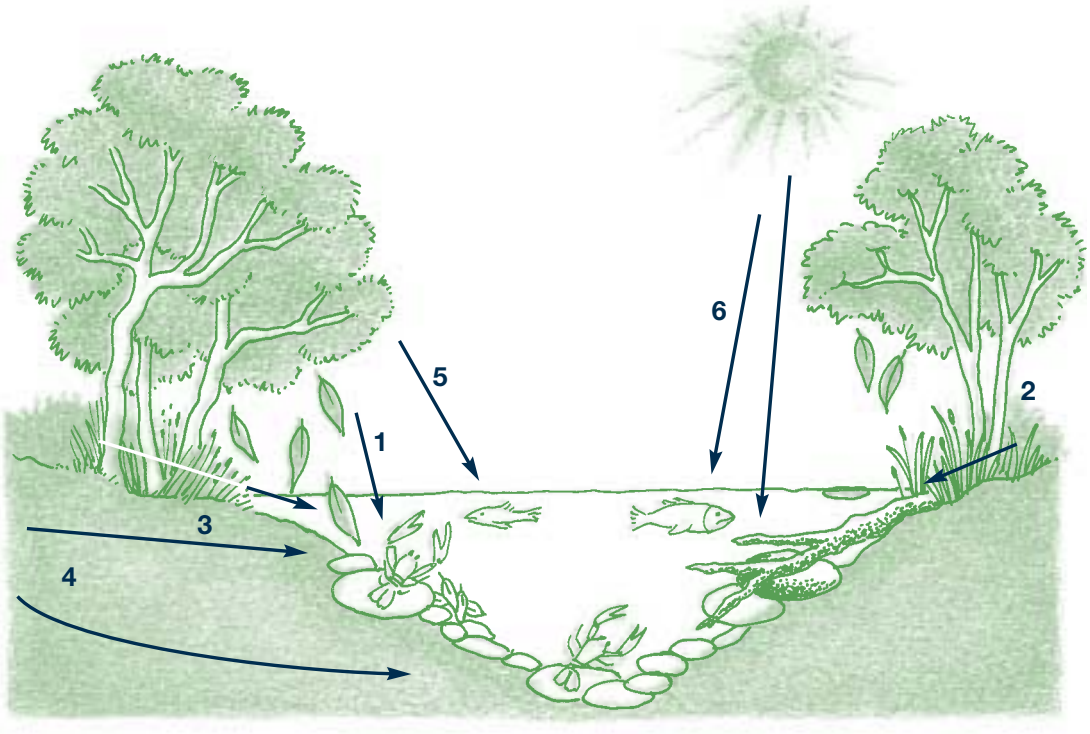


Figure 1: Land and water interactions that occur in riparian lands. Source: S. Bunn 1998.

1. Inputs of leaf litter and fruits from riparian vegetation
2. Inputs of logs and branches that provide habitat for fish and plants
3. Leaves and organic matter washed in from surrounding catchment
4. Sub-surface flow and groundwater
5. Insects falling from riparian vegetation
6. Microalgae and other aquatic plants stimulated by sunlight

The interaction between land and water

There are many types of interaction between riparian land and adjacent waterways. For example, a tree on riparian land may fall into the water creating new in-stream habitat; uncultivated riparian land can 'buffer' streams against sediment and nutrient washing off adjacent cropped land; and native vegetation on riparian land can be a source of litter and insects that fall into a waterway and become food for in-stream animals. The reverse also occurs, for example, insects that spend much of their life in the water may become food for land-based animals when they emerge. Some of the key interactions between riparian land and adjacent streams and rivers are shown in Figure 2.

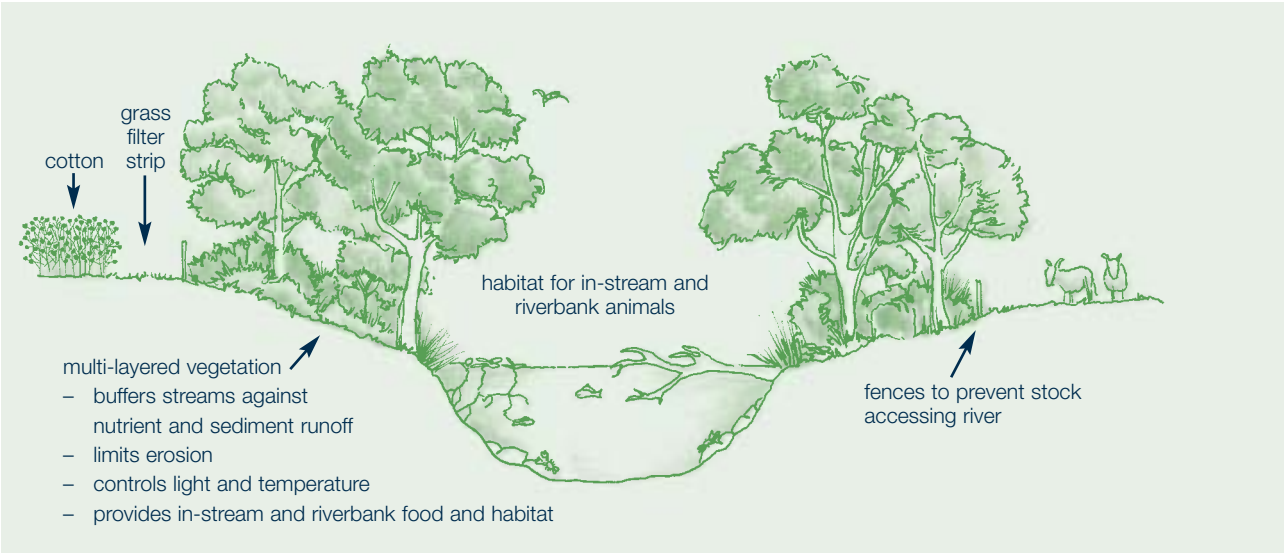


Figure 2: Key interactions between riparian land and adjacent streams and rivers.

For many years, the important linkages between land and water in riparian areas were not well recognised in Australia. There was a commonly held belief that streams and rivers could be used as drains — removing problems from adjacent land. However, research is now showing that rather than being seen as drains, waterways should be thought of as the arteries supporting the land around them. In recognition of the many potential benefits that can be achieved from better management of waterways, growers, community groups and government agencies have become actively involved in improving riparian management. They have recognised that undisturbed riparian land with its natural vegetation can:

- trap sediment (e.g. soil), nutrients and other contaminants (e.g. attached pesticides and herbicides) before they reach the waterway;
- reduce rates of bank erosion and loss of valuable land;
- control nuisance in-stream plants through shading;
- reduce water temperatures and help ensure healthy in-stream life;
- provide a source of food and habitat for stream animals;
- provide an important location for conservation and movement of wildlife;
- connect fragmented habitats for wildlife;
- help to maintain agricultural productivity;

- provide recreation and aesthetically-pleasing landscapes;
- improve water quality for human and stock consumption, as well as the environment; and,
- support beneficial insects and animals that prey on pest species (e.g. bats preying on heliothis moth).

Many of these benefits can only be achieved through careful riparian management at the farm and catchment scale.

> Riverine condition assessments are being developed for most catchments in NSW and Queensland. Chapter 3 of this guide provides information about the priorities identified in plans covering some cotton-growing catchments.

Factors that affect the condition of riparian land

Riparian land changes under the influence of natural factors such as fire, unusual droughts or 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 and eastern Australia. The widespread clearing of riparian vegetation for agricultural or urban development, as well as grazing by domestic stock, have had the biggest impacts. Northern Australia is fortunate in that clearing has been less widespread, although even here there are many areas where much of the natural riparian vegetation has been removed. The major effects of 'catchment development' on riparian land and adjacent waterways are as follows:

- removal of riparian trees increases the amount of light and heat reaching waterways. This favours the growth of nuisance algae and weeds, and can significantly alter the conditions in the waterway 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 waterway and prevent it from carrying floodwaters. When the weeds and algae eventually die and begin to decay, the water is deoxygenated and this can contribute to fish kills downstream.

Waterway with excessive algal growth. Photo Nick Schofield.

- under natural conditions, trees occasionally fall into waterways and provide an important habitat for animals and plants living in the stream. Large tree trunks and branches in the waterway 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.

Woody material in the Namoi River provides habitat for in-stream animals. Photo Guy Roth.

- cropping up to the top of streambanks increases the delivery of sediments and nutrients to waterways. 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.

A poorly managed riparian zone. Almost no trees remaining, bank erosion, cattle grazing along the riverbank, algal blooms and sand slugs that smother in-stream habitat for fish. Photo Ian Prosser.

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

- removal of riparian vegetation and loss of its protective root systems destabilises riverbanks, often resulting in large increases in the width, depth and erosion of waterway channels. This channel erosion can then deliver more sediment to the waterway. Significant areas of valuable agricultural land can be lost as a result of channel erosion, and water turbidity is also increased, leading to loss of water quality for downstream users.

> Turbidity refers to the cloudiness of water bodies 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 fines 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.

- removal of vegetation throughout a catchment can lead to raised water tables and salinisation of land. Salt carried in sub-surface flow, or washed from the surface by runoff, drains into waterways and reduces 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.

The removal of natural vegetation is not the only human activity that adversely affects riparian land:

- altering the streamflow by building dams and weirs, as well as pumping out water during low flows, can severely affect in-stream life and the capacity of waterways to carry flow. These structures block fish passage unless specially constructed fish ladders are provided. 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.

Weirs and dams have altered flows and changed salinity ranges. Photo Stuart Blanch.

- sand and gravel removal, channel straightening, and construction of levee banks and drains can change the waterway channel and result in increased erosion. This can lead to loss of agricultural land as well as damage to infrastructure such as roads, bridges and buildings.

Rock riprap is being used on this part of the Condamine River to protect the toe of the bank which is gradually eroding away and threatening the bridge supports. Photo Guy Roth.

Uncontrolled stock access degrades riparian lands. Photo Guy Roth.

- uncontrolled access by stock 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 (a few days or at critical times of year) can be enough to prevent regeneration of native riparian species; often only the trees are left with no native understorey species and little opportunity for regeneration.

- altered fire regimes and invasion by exotic weeds also degrade riparian land.

Nogoora Burr, castor oils and willows have invaded this cleared patch of riparian vegetation. Inset: Nogoora Burr. Photos Guy Roth.

- urban development influences water quality and the condition of riparian lands.

Stormwater pipe carrying stormwater runoff directly into the river and reducing water quality. Photo Guy Roth.

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, 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, conditions that enable nuisance weeds and algae to flourish in the stream and dominate in-stream life.

Above: Riparian zone that has been cleared and stock allowed access to the river. There would be little in-stream life as a result of limited shade and low quality water. The stream is gradually eroding away the bank. Photo Guy Roth.

Right: Moderately disturbed riparian area with some willows, but overall good vegetation cover, stable banks, shade and woody habitat for in-stream life. Photo Guy Roth.

Current status of riparian land in catchments where cotton is grown

Cotton is now grown over a wide area, from central Queensland to the Lachlan Valley in southern New South Wales, as well as in the north-west of Western Australia (see Figure 3). Typically, cotton uses 5% or less of land in the catchments where it is grown, with the irrigated cotton industry mainly located along rivers and riparian areas (see Figure 4). Riparian catchments in these areas are generally in a degraded state following the widespread opening up of lands for grazing, cropping and urban development. The clearing of riparian vegetation for agricultural development, combined with continuous grazing by cattle (and in some areas sheep) has led to the loss of palatable native grasses and other species unable to cope with continued defoliation. These native grasses have disappeared, to be replaced by less-palatable but more-resistant species, as well as by a range of introduced exotic weeds (for example, Nogoora Burr and more recently Lippia). Native trees are still present in many areas but they are often scattered, nearing the end of their lifespan, and in poor condition.

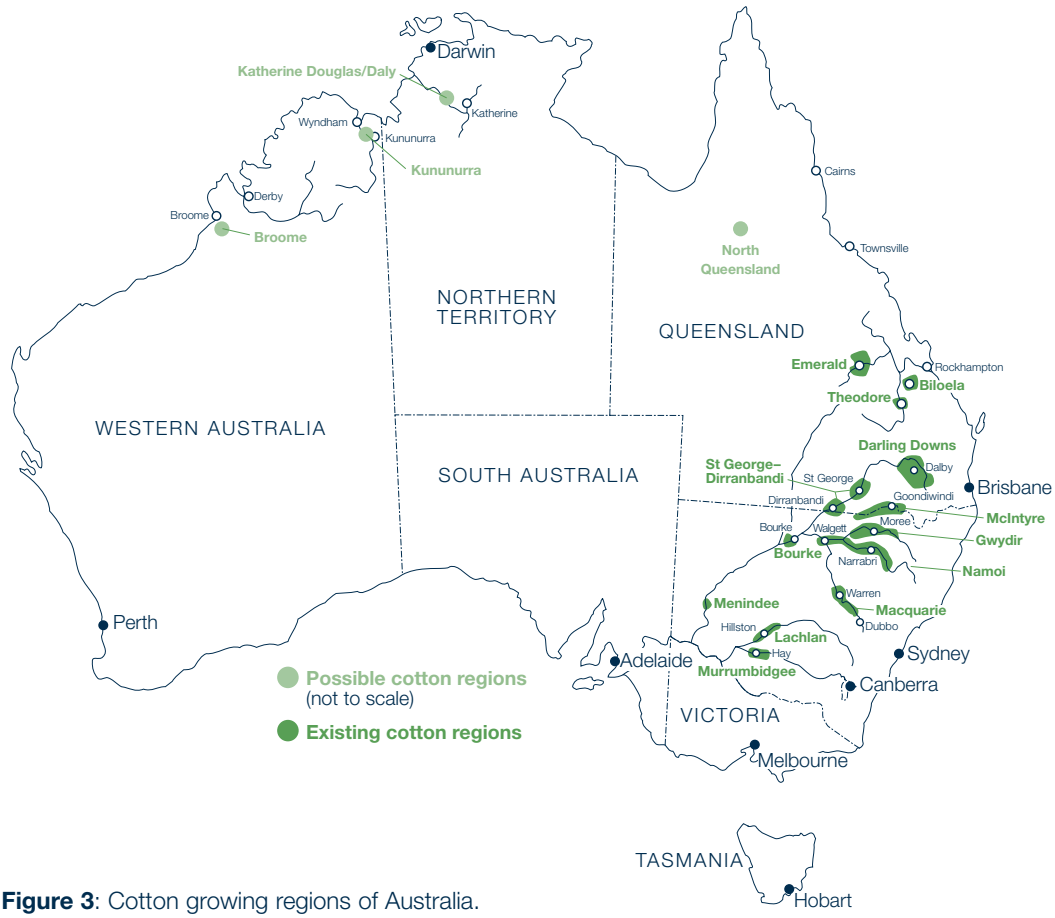
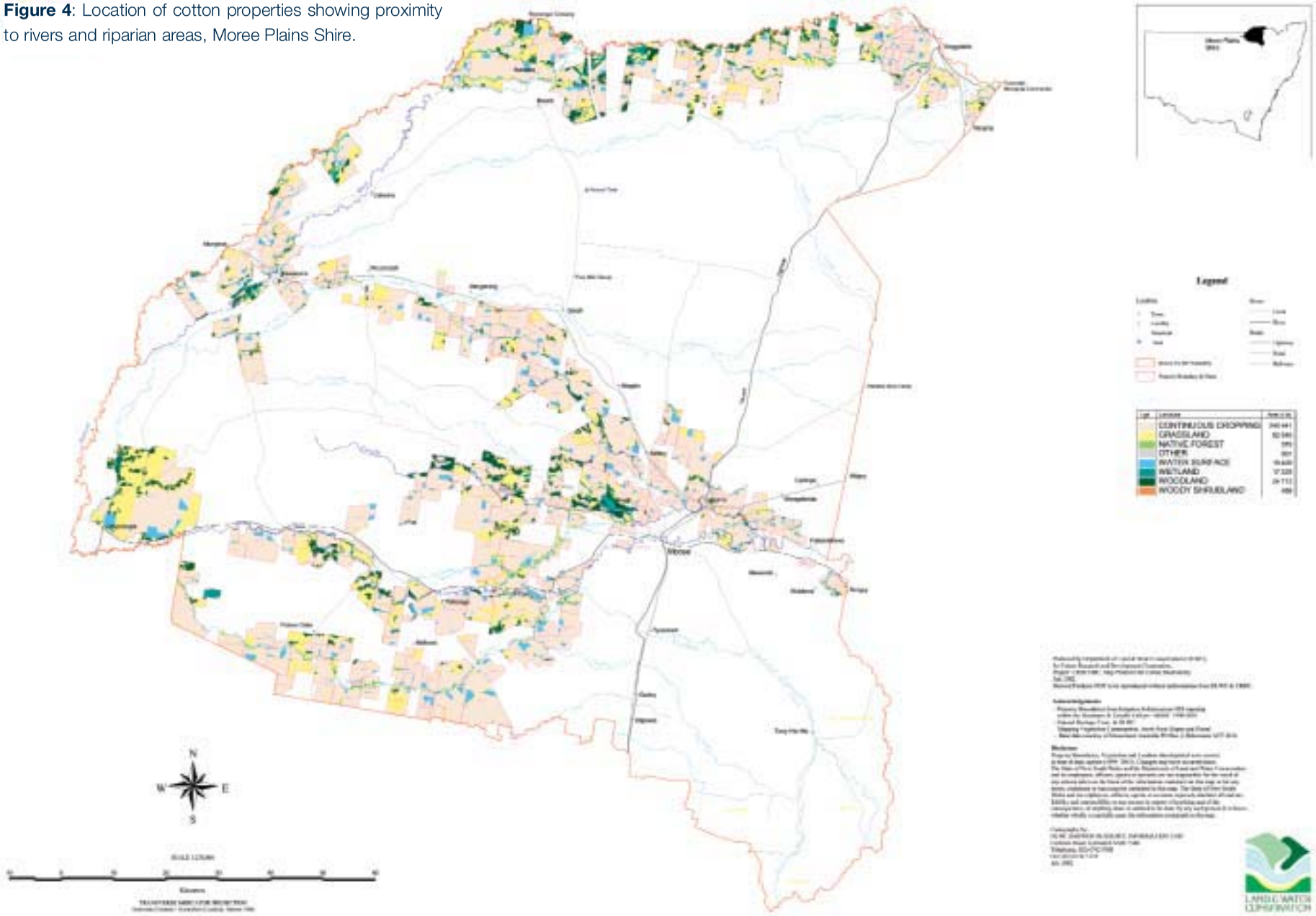


Figure 3: Cotton growing regions of Australia.

Many cotton growers also run cattle operations and see their riparian lands as an important component of feed production for stock. It is important to recognise that improved management of riparian lands does not require the permanent removal of grazing, but rather, that grazing be carefully managed to encourage regeneration of native species and to maintain productive pasture species. Some growers have made an effort to regenerate or replant riparian areas degraded by stock, often with success.

Figure 4: Location of cotton properties showing proximity to rivers and riparian areas, Moree Plains Shire.



Cattle fenced out of riparian area to protect the riverbank and prevent stock losses. Photo Penny Van Dongen.

The motivation of growers to undertake this rehabilitation varies from a wish to control waterway erosion, restrict flooding effects, provide crop shelter belts, or to improve environmental management of sensitive parts of the property. Fencing and revegetation can also prevent stock wandering off the property when river levels are low, causing problems for neighbours and requiring time consuming mustering.

Restoring riparian land can be expensive if past management has led to these areas becoming degraded. This means that it is important to be clear about management objectives and priorities, so that growers who devote time and resources to riparian restoration can be assured of beneficial outcomes. If possible, riparian areas (including wetlands) should be identified prior to development for cotton production so that plans for their integration and ongoing management within the overall farm design can be made. This is a much cheaper alternative than restoration.

Planning as the key to sound riparian management

There are many things that that cotton growers can do to help improve the health of on-farm riparian land and waterways. Careful planning is the key to achieving this. Riparian areas need to be highlighted in farm or Stormwater Management Plans as requiring special management strategies that take account of the mix of land, water, vegetation and wildlife issues. In this way, a plan provides a single document that can be assessed against the requirements of local authorities and catchment plans, as well as providing the basis for environmental management systems or quality certification.

The cotton industry has made considerable progress in developing these guides and checks on the environmental soundness of production systems, and the development of plans underpins the implementation of this guidance material. Plans should be seen as living documents that can be updated and modified as regulations change and new management strategies are developed. Initially, this type of planning needs to be done at the level of individual farms. For other objectives, however, where it is important for neighbours to act together (e.g. in stabilising waterways, controlling exotic weeds or providing wildlife habitat), planning needs to be done at a local and catchment level as well.

The recent development of catchment plans and blueprints in Queensland and New South Wales provides producers with access to information about broader riverine management approaches. Using this broader catchment context, producers can integrate riparian management and property development on-farm. Appendix A in this guideline provides an overview of the catchment plans, water sharing plans and other reports that have been developed for each of the cotton growing regions. This snapshot of cotton regions provides general guidance only, and more information about the documents discussed is available from government agencies and catchment boards. In addition to catchment plans, there are also Acts and regulations that may influence the management of cotton farms with respect to riparian land, waterways and water use (see Appendix B for more information). By developing some form of a farm plan that incorporates these issues with cotton production and applies industry best management practices on-farm, growers can be confident that they are meeting statutory requirements.

3 Principles for sound management of riparian land

The table on the following page, draws together the recommendations that have been made throughout this Chapter for managing riparian lands to meet different objectives.

chapter three

Riparian widths required to meet different management objectives

Pg.	Section objective	Riparian width required	Management practice
19	**A** Trapping soil and nutrients	■ 6 metre minimum grassed filter strip on top of bank. ■ 10 metre minimum natural riparian vegetation filter strip on top of bank. ■ Various width natural or artificial wetland/reed bed.	■ Identify location of filter strips on farm plan — maintain existing strips and establish new filter strips with tough perennial grass species. ■ Manage stock access carefully to maintain full vegetative cover in seasons of likely soil and nutrient runoff. ■ Remove stock altogether from wetland areas.
28	**B** Stabilising banks	■ Entire bank from low water level to high bankfull water level. ■ In addition, a 5–10 metre riparian area along the top of bank.	■ The entire bank needs to be fully vegetated with native species, including trees, shrubs and grasses. ■ Maintain or revegetate strip along top of bank so that it has mixed native tree, shrub and grass species. ■ Manage stock access and grazing (see Section H below).
36	**C** Managing farm drains	■ see Section A (above).	
41	**D** Prevent spraydrift to waterways	■ Requires 20 metres of native vegetation (as a minimum), and this must include trees.	■ Retain or replant native tree species and manage stock access accordingly.
48	**E** River offtake pumps	■ See Australian Cotton Industry BMP and Section A (above).	
52	**F** Healthy riparian vegetation	■ Entire bank from low water level to high bankfull water level. ■ In addition, a 5–10 metre riparian area along the top of bank.	Identify riparian areas in farm plan and develop management strategies that: ■ control stock access and grazing, ■ promote natural regeneration of native species, ■ control weeds and feral and native animals, and ■ replant where necessary using local native species.
69	**G** In-stream health	■ Entire bank from low water level to high bankfull water level. ■ In addition, a 5–10 metre riparian area along the top of bank.	■ Manage as for Section F. Include native trees to provide shade so that water temperatures can be lowered, as well as providing food and habitat for aquatic plants and animals. ■ Do not remove large wood from rivers, streams and other waterways (may reorient position if essential).
77	**H** Managing stock	■ Entire bank from low water level to high bankfull water level. ■ In addition, a 5–10 metre riparian area along the top of bank.	■ Control stock access and manage grazing to retain full ground cover of native species and to promote natural regeneration.

A Trapping soil and nutrients

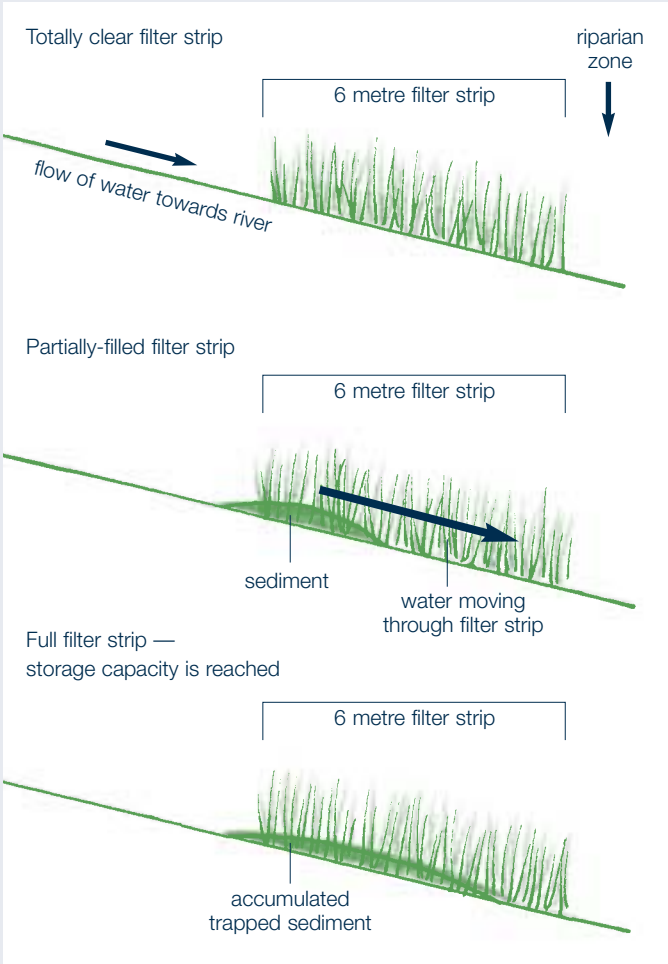
Objective

To keep soil, nutrients and other contaminants on-farm and prevent them from entering waterways where they can reduce water quality and stream health.

Recommended management approach

Soil particles, nutrients and attached pesticides/herbicides, and crop residue can move from cropped land to waterways in runoff or groundwater. The amount of soil and other contaminants reaching waterways can increase dramatically in situations where crop production involves periods of bare soil surface, where the land adjacent to waterways has a significant slope, and where rainfall can be intense (even for short periods). Under these conditions, large quantities of soil, nutrients and other contaminants can enter streams and severely reduce water quality and stream health. This problem is made worse when the flow is concentrated in irrigation furrows, shallow depressions or gullies.

Figure 5: Cross-sections of filter strips.



Carefully maintained riparian vegetation cover can be very effective in trapping soil and nutrients before they enter waterways. The mechanism of trapping is similar to that reported from past work with the cotton industry on the effect of retaining cereal stubble to reduce soil loss from irrigation furrows. This work shows that slowing the speed of surface water is the key to reduced furrow erosion and to trapping and removal of suspended sediment. Recent experimental work has shown that a well-maintained perennial grass filter strip of 6 metres wide can be highly effective at trapping sediment and much of the nitrogen and phosphorus attached to it.

A grass riparian filter strip trapping sediment downslope of a ploughed paddock. Photo Ian Prosser.

Some grass species can grow through and stabilise the trapped sediment, gradually developing a small levee bank along the waterway. In many circumstances wider grass filter strips can be used to accommodate access tracks for cropping machinery and/or a firebreak.

Grass filter strips are most effective when the incoming overland flow is shallow, around 1 centimetre or so in depth (or less). When the overland flow is deeper as a result of high-intensity rainfall, grass filter strips become overloaded and cannot prevent soil and nutrients entering the waterway. By incorporating contour banks and additional filter strips well upslope, this problem can be managed so that the soil and nutrients stay where they belong — on the paddock. For similar reasons, wherever possible, paddock or section blow-out points should be located well away from streams, preferably where runoff will pass through a grassed area before entering a waterway.

Keeping crop residue on the paddock is also important, as the wash-off of, for example cotton stalks and the organic compounds they produce as they decay, can cause severe oxygen depletion in streams and the death of stream animals. A combination of trees and shrubs with grass filter strips along waterways may be an effective way of trapping residues as well as soil and nutrients.

Nutrients (including nitrogen and phosphorus) and other contaminants such as pesticides, can also be carried in sub-surface flows. Sub-surface flow rates are generally slow, except in very open-textured soils. Deep-rooted riparian vegetation can reduce nutrient levels in sub-surface flows by absorbing them for plant growth. The effect of dense riparian vegetation in helping to dry out soils may also help to reduce sub-surface flows (see Figure 6).

The recommended management approaches for using grass filter strips on riparian lands are as follows.

1. Map all waterways on the farm including areas that carry overflows. Where these waterways drain cropping land with slopes of 2% or more (dryland farms), farm layout should be designed so that furrows run parallel to, and not perpendicular to,

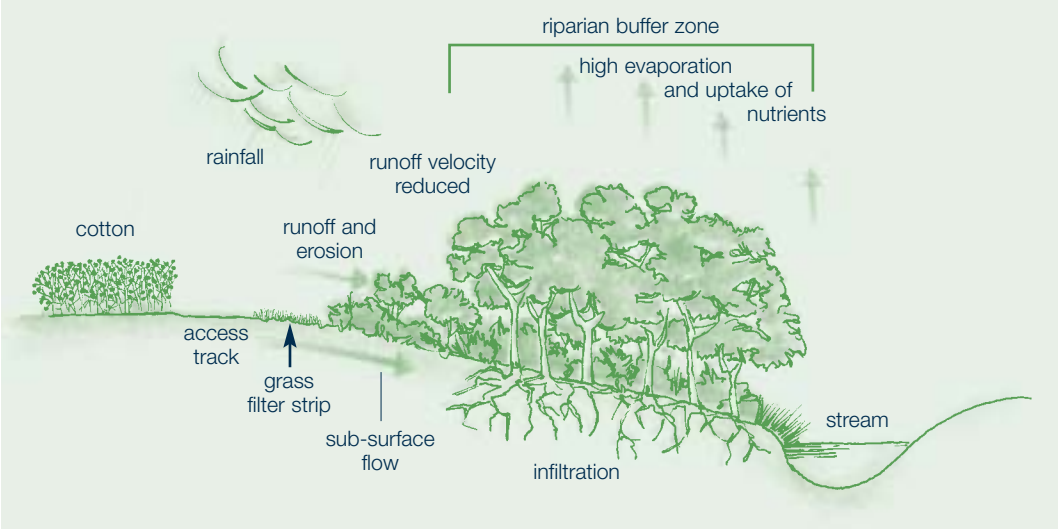


Figure 6: Different functions performed by riparian areas to protect waterways. Illustration Carolyn Brooks.

drains and streams. This is because these areas are often major sources of suspended sediment and nutrients. Once these waterways have been identified, keep natural riparian vegetation along them to a width of at least 10 metres.

2. Identify potential sources of sediment, nutrients and other contaminants, and implement the measures described in the Australian Cotton Industry Best Management Practices (BMP) Manual and SPRAYpak. These include:
   - locating blow out points as far as possible from streams and waterways;
   - maintaining stubble or other cover in the field and on headlands (e.g. through opportunity cropping);
   - limiting furrow length according to slope and soil type;
   - maintaining in-field surface roughness;
   - laser-levelling paddocks;
   - ensuring tail drains are no more than 25 centimetres below the bottom of furrows;
   - designing culverts so that they reduce flow speed and allow sediment to settle;
   - incorporating drop boxes and stilling ponds into tailwater systems;
   - designing return drains with low slope;
   - capturing tailwater for recirculation;
   - ponding and filtering runoff;
   - using low fields to temporarily pond excess stormwater; and,
   - after high intensity rainfall retain at least 15 millimetres of runoff from treated areas (pesticides etc.).

All these methods help to reduce sediment and nutrient loads BEFORE water draining from fields reaches riparian land and waterways.

John and Robyn Watson have moved this cotton field 80 metres back from the river so that a riparian buffer can be maintained, Boggabri. Photo Guy Roth.

3. Work out the best location and width of grass filter strips, based on slope and shape of the land and soil type, so that maximum trapping of sediments and nutrients can occur. Where flow is concentrated in depressions or shallow gullies, the filter strip will need to be proportionately wider. Filter strips may need to be located along each side of drains within paddocks where there is a risk of soil erosion and where the crop itself does not provide an adequate buffering function. For waterways with sloping banks (greater than 5%) a grass filter strip is required along the high bank as vegetation on steep banks is unable to trap sediment and nutrients.

4. Use perennial grass species that are able to grow into and stabilise trapped sediments. Many grasses are able to root from nodes along the stem, and those species with a spreading rather than tussock or bunch growth habit are the most effective. Mowing, or carefully managed grazing of grass filter strips, may be required to keep them functioning effectively. Once they grow higher than 20 centimetres there is little additional benefit (no effect) to sediment trapping. For areas with intense runoff, hedges of upright grasses or similar species can be used to initially slow the surface flow.

5. Avoid disturbing grass filter strips by grazing and cultivation, or when spraying out weeds with herbicides.

6. Use a combination of a grass filter strip with trees directly adjacent to the stream to provide shade, as this will trap sediment as well as providing shade to the waterway (see Section G).

Using grass filter strips within a farm plan provides an opportunity to ensure the best mix of maintaining crop productivity while also practising environmentally sound management.

Self-assessment

Cotton growers can check their progress in better managing sediment and nutrient in runoff by including in their farm plan:

- maps of all waterways on the farm, including floodways, drainage lines and blow out points that run intermittently. These maps would also identify potential source areas for sediment and nutrient that could be transported into waterways. This step is also a requirement in the BMP Manual;
- management strategies designed for each waterway to trap sediment and nutrient runoff (see points 1 and 2, page 21);
- periodic inspection of fields and riparian areas to check for erosion on the field and build-up of sediment within the waterway or drainage line;
- management of riparian vegetation, either retained or replanted, so that it can trap sediment and nutrient and improve the health of the waterway and adjoining land;
- risk assessment using procedures described in the BMP Manual;
- planting native grasses and monitoring their progress; and,
- periodic monitoring of the health and reestablishment of riparian vegetation, and checking that the trapping capacity of filter strips hasn't been exceeded.

CASE STUDY

chapter three A

Using nature to filter stormwater

Glen Whittaker — 'Yahgunyah Partnership', Quambone

By Kirrily Rourke

Five years ago, Yahgunyah Partnership purchased a 2000 acre irrigation farm on the Marthaguy Creek, near Quambone, 90 kilometres north of Warren. A Stormwater Management Plan has been prepared in accordance with the BMP Manual. Even though the first 25 millimetres of stormwater runoff could be contained in accordance with the Plan, additional stormwater would discharge directly onto the neighbours grazing country. To address this issue, the Partnership relocated the blow-out point 700 metres further up the tailwater return channel, and installed a bank so that the water filters through a reed bed to clean it of sediment before any surplus is discharged across the adjacent grazing country.

Above: The new blow-out at bottom right with the constructed bank opposite. The trees in the background line the Marthaguy Creek. Stormwater travels through the reeds to the right. Photos K. Rourke.

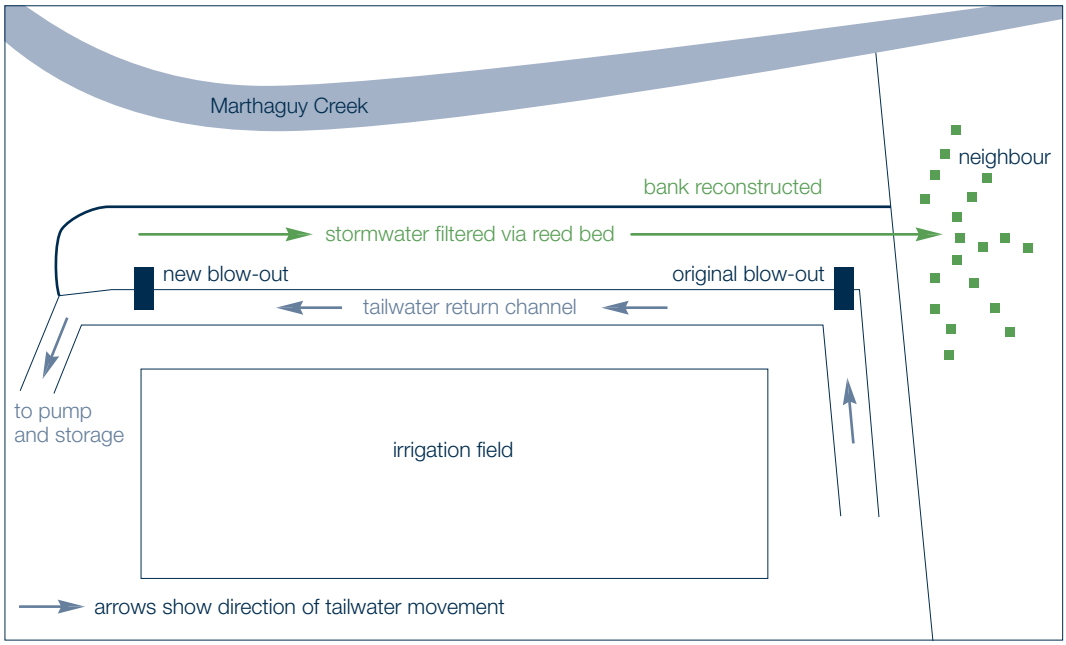
Below: The reed bed filters stormwater before it flows onto the neighbours grazing country. The reeds are regenerating well after a flush of water following the drought.

A bank was constructed that diverted the water from the new blow-out point near the creek, through about 600 metres of reed bed after which it could enter the neighbour's paddock at the original blow out point. This bank cost around $15,000 to construct.

The only concern with this system is that in a large storm event with very high water flows the reed bed may slow the water down too much, causing it to back up unless the reeds bend and allow flow to increase. The system is yet to be tested under these conditions, but it will be modified if needed.

A final word...

The Partnership was more than happy to make these changes as it gave them extra confidence in their stormwater management system. Other benefits include good relations with all neighbouring land holders, and the reed bed functioning as an on-farm wetland that enhances the biodiversity of both the farm and nearby creek ecosystem.



Yahgunyah stormwater blow-out system.

Regenerating riparian areas to achieve multiple benefits

Harvey Gaynor and Terry Haynes — 'Auscott Midkin', Moree

By Julie O'Halloran

Auscott's properties in the Gwydir valley are located along the Carole Creek. About six years ago, Auscott Midkin ceased grazing and farming of their riparian areas to allow for regeneration of native vegetation. Today, a significant portion of Auscott Midkin's creek frontage (about 24% of farm area) is not farmed, with Auscott Midkin's General Manager, Harvey Gaynor and Water Resources Manager, Terry Haynes revealing that there were several prompts for this change in management. Erosion along Carole Creek was a problem, and it was felt that the riparian areas were better left to protect the creek bank, and provide a buffer for pesticides and sediments entering the waterway. Harvey and Terry also felt that farming riparian areas was inefficient as they were often oddly shaped and difficult to access. The riparian areas on the property now form a corridor for wildlife as well as protecting the creek from further erosion. These areas of deep rooted vegetation may also help prevent watertables from rising and guard against salinity problems.

For the first three years, management to regenerate the cleared riparian areas was relatively intensive. This involved slashing and selective spraying of weeds (e.g. Nogoora Burr, Sesbania Pea), and efforts continue to control weeds such as Johnson Grass. Feral animals such as cats and goats were a problem in timbered areas, however, a successful removal program has been implemented to control them. Unfortunately, feral pigs remain a problem.

Pump sites have also been considered in the management of riparian zones. At many sites engines are sitting close to water with fuel storage in close proximity. Fuel storages are now bunded to prevent contamination of Carole Creek in the event of leakage, and only biodegradable drip feed oils are used in pump sites to limit contamination of the waterway.

Part of property being allowed to regenerate and extend width of the riparian zone. Photo Julie O'Halloran.

Riparian area with mix of trees and shrubs regenerating naturally. Photo Julie O'Halloran.

Irrigation areas adjacent to Carole Creek are planted to Genetically Modified Ingard® cotton. This management practice helps to minimise the number of insecticide sprays in close proximity to the waterway. Prior to the release of Genetically Modified cotton, Auscott had a spray management plan in place, as well as guidelines for spraying these areas to minimise the potential for drift. Auscott is currently in the process of formalising and documenting their riparian zone management practices. They hope that this will help identify gaps in their current management and highlight areas that require further attention.

Harvey and Terry believe the main challenge for riparian land management is accurately defining what is natural for riparian areas and determining how to return it to that state. Non-native species are quite prolific along the creek (e.g. willows), as well as species not native to the area. The management of regrowth and controlled thinning are also challenging and require ongoing maintenance. There is also some concern over future flood events if riparian lands become heavily timbered since development of the surrounding area has altered natural flood flows.

A final word...

Harvey and Terry believe that the benefits of allowing riparian lands to revert to a 'natural' state include the value of these areas as effective buffers between different areas of the properties. As cotton growers, these areas are important to Auscott for spray drift management, as they provide a buffer between cropping areas and the creek and different types of cropping. The provision of a continuous corridor along the creek has also increased the diversity of vegetation and wildlife.

Feral animals — useful references

Choquenot, S., McIroy, J. & Korn, T. 1996, *Managing Vertebrate Pests: feral pigs*, Bureau of Resource Sciences, Canberra (series includes feral goats, foxes and rabbits).

Braysher, M. 1993, *Managing Vertebrate Pests: Principles and Strategies*, Bureau of Resource Sciences, Canberra.

The Bureau of Resource Sciences website has useful information about 'agricultural pests and feral animals'. You can find this information by going to the www.affa.gov.au website.

B Stabilising waterways and riverbanks

Objective

To stabilise riverbanks so that erosion and threats to cropping land and infrastructure are reduced.

Recommended management approach

Riverbank erosion is a natural process as waterways slowly meander across the landscape. However, since European settlement of Australia, the rate of streambank erosion has increased dramatically. Two main factors are responsible for this increase. First, extensive clearing of deep-rooted, natural vegetation for agricultural and urban development, and the planting of shallow-rooted crops, means that rainfall tends to move through the catchment at a much faster rate. This causes higher peak flows that waterways can no longer contain. Second, natural riparian vegetation has been disturbed, either through broadscale clearing or through uncontrolled stock grazing, fire or other effects. This has reduced the amount of stabilisation and reinforcement provided by the roots of riparian vegetation.

Problems caused by streambank erosion include:

- loss of productive cropping land;
- flood-outs and cutting in (incision) of new channels;
- stripping of topsoil from the floodplain;
- damage to infrastructure such as farm roads, pump installations and buildings;
- sedimentation, leading to blocked pumps and channels as well as degraded in-stream habitat; and,
- reduced water quality for downstream users.

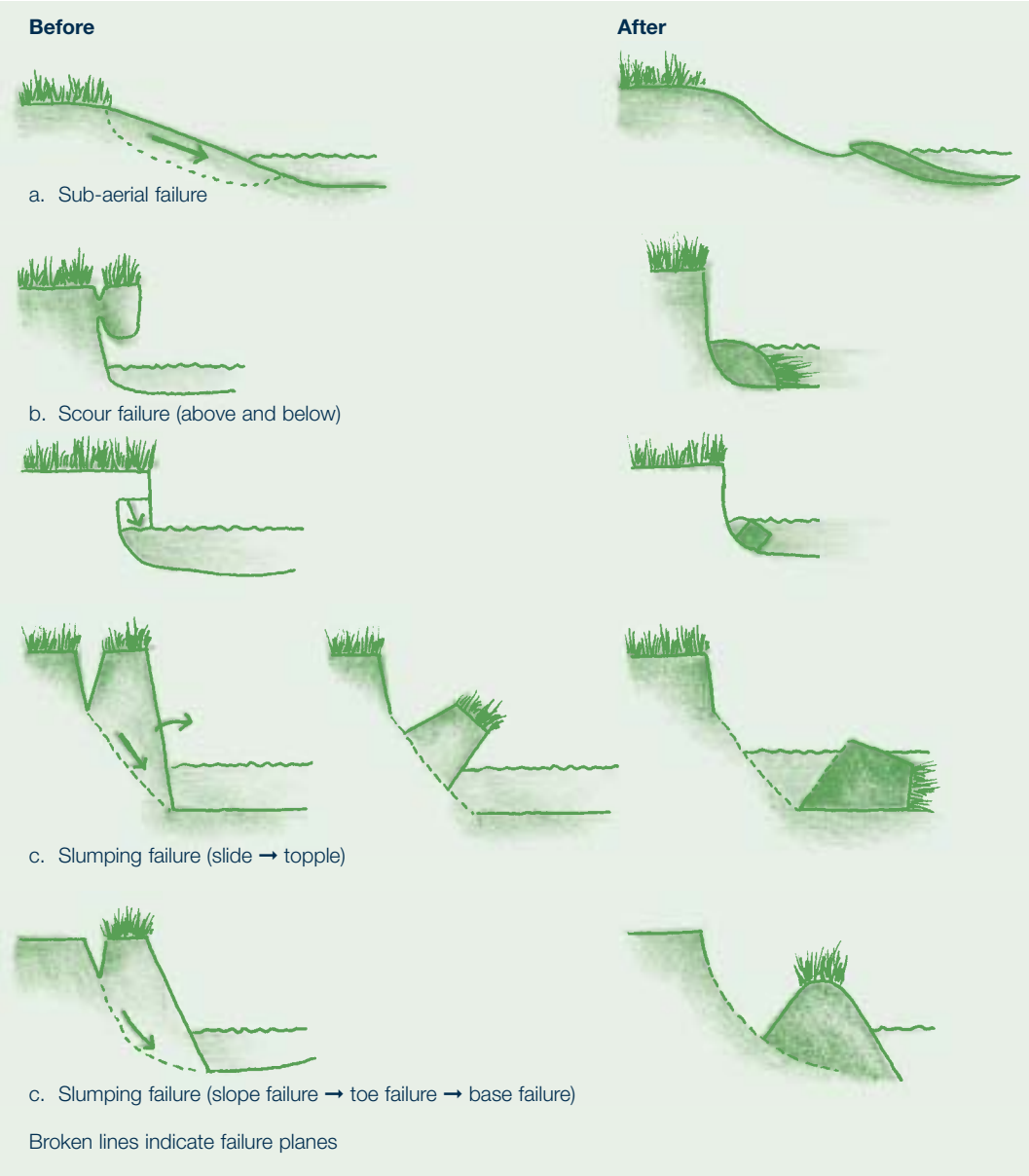
Sedimentation is the process by which the larger sand and silt particles in eroded soil that has washed into a waterway settle out within the channel. How quickly, and where these particles settle, depends mainly upon their size and the water flow rate. This sediment can block and choke stream channels, increasing flood risk, and also filling pools which once provided refuge for fish and other animals in times of low flow.

Sand accumulation and bank erosion has led to willow infestation. Photo Ian Rutherfurd.

Erosion of stream or channel banks occurs in three different ways (see Figure 7):

- *Sub-aerial erosion* — involves processes that loosen the soil of the bank, which is then carried away by the water flowing past. For example, trampling by stock and the impact of wind and rain loosens the surface of the bank, gradually eroding the soil away. The cracking clay soils common in cotton districts are particularly prone to this type of bank erosion.
- *Scour* — occurs when the force applied to a bank by flowing water exceeds the resistance of the bank surface. This often happens at the toe of the bank (at the water's edge) where the flowing water scours away the soil. It is also common on the outside bends of rivers and channels, where the flow is fastest.
- *Slumping* — occurs when blocks of the bank collapse as a result of scour processes. Slumping can also occur when the bank soil is saturated, particularly when a peak flow (e.g. a natural fresh or a dam release to meet irrigation demand) recedes quickly.

Figure 7: Illustrations of how sub-aerial erosion, scour and slumping occurs along riverbanks.



Healthy riparian vegetation can help to reduce all three processes (sub-aerial, scour and slumping) that cause bank erosion. The maintenance of a dense cover of vegetation from the water level to the top of the bank reduces the effect of sub-aerial processes, such as soil loosening by rain. Vegetation protects the bank, and when water levels rise it also works to reduce the effects of scouring. The roots of riparian vegetation bind and reinforce the bank, with recent research finding that tree roots can extend for 10–15 metres from the trunk, and to a depth of at least 1.5 metres, depending on the size of the tree. The trunk or stem of trees and shrubs can also physically buttress the bank against slumping. As well, dense riparian vegetation uses water and dries out bank soils making them less likely to slump.

The weight of trees on a waterway bank is generally not significant in comparison with the weight of the soil beneath and, contrary to popular opinion, is generally not a factor in the slumping of soil blocks into a stream.

This Eucalypt tree on the Namoi River is holding the bank together and providing protection against further erosion. Photo Guy Roth.

In situations where riparian lands need to be restored, it is best to mimic natural conditions. Healthy riparian vegetation contains a range of species — native grasses, reeds and shrubs with flexible branches often occupy the lowest parts of the bank, where they are subject to occasional inundation. Their ability to bind soil and to resist flood flows are highly-prized characteristics. Further up the bank, shrubs and small trees usually predominate, with an understorey of grass species. In many cotton-growing districts, large trees are naturally widely spaced along riverbanks, and this pattern should be followed unless there is a particular management issue to be addressed that requires closer planting.

The recommended management approaches to stabilise waterways are listed below.

1. Determine which dominant erosion process (sub-aerial soil loosening, scour or slumping) is affecting the waterway bank. This may require a simple inspection or survey of the waterway reach, or getting some professional advice. Once the key erosion processes are known, the design and implementation of revegetation works can proceed — matching the type and position of riparian vegetation to the nature of the problem and combining it, if necessary in particularly difficult situations, with structural work such as posts, wire-meshing, rock rip-rap, or groynes.

This bank has been cleared of riparian vegetation and is now slumping into the river. The clearing of riparian vegetation has also provided an opportunity for Lippia to spread along the riverbank. Photo Guy Roth.

2. Where the primary management objective is to stabilise waterway or channel banks, the aim should be to revegetate the bank itself and at least a 5–10 metre strip along its top. Wider areas of riparian vegetation may be needed to stabilise waterways on outer bends that are more susceptible to erosion. There may be statutory requirements in the development of new land for cotton growing that require a particular width of riparian lands to be recognised and managed separately (see Appendix B for details of legislation).

3. If the problem being managed is a bank eroding at its 'toe' followed by slumping, start revegetation work with water-edge grasses, sedges, rushes or similar plants. On the slope and top of the bank, match the rooting depth of the vegetation to be established with the height of the bank. If the roots of the species planted do not cross the potential slump area of the bank, they will have limited ability to reduce this form of erosion. Extending tree, shrub and grass plantings over and beyond the bank top by 10–20 metres will provide additional protection from slumping by reducing the growth of tension cracks on the top of the bank.

The grasses, reeds, logs and branches at the toe of this bank are protecting against further erosion. This site would respond well to rehabilitation as the toe is currently protected and there are some trees remaining on the riverbank to help bind the soil. Photo Guy Roth.

4. If resources are limited and erosion control is the primary aim, do not target a revegetation program at the most unstable section of the waterway (e.g. an outside bend or channel junction). Efforts are better spent targeting a part of the stream or channel where erosion may not be so severe, but where revegetation will be most successful. Once these areas have been stabilised, the more-difficult section can then be tackled with confidence.

5. Keep existing native riparian vegetation on as much of the farm as possible, as this is by far the cheapest option for stabilising waterways and channels. Where this vegetation is substantially degraded through past land uses, it may be possible to regenerate it through fairly simple means. For example, remove stock at a time when mature trees or shrubs carry a good seed-load and conditions are good for regeneration. For cotton growers who also graze cattle and wish to use feed in riparian areas, it may be possible to exclude stock from one section of the bank at a time — say, a 300–500 metre section. Excluding stock from this section for up to two years will give sufficient time for regeneration and establishment of larger shrub and tree species to a height where they are resistant to grazing by stock. The 'regenerating section', where stock are excluded, can gradually be moved along the bank over time.

The riparian area is acting as a buffer between the cotton crop and the river, as well a stabilising the river channel so that erosion does not occur. Photo Guy Roth.

6. Where erosion of banks or beds is a problem on farm irrigation and tailwater channels, apply the recommended management approaches outlined above. Most cotton growers prefer to keep channels bare in order to maintain their designed flow capacity. Where grades are low and erosion minimal, this may be acceptable, although the herbicides used to prevent weed growth may be harmful if transported to waterways by peak flows. Bare channel banks and beds are also likely to become significant sources of sediment (and possibly nutrients and pesticides) during major

Drop box incorporated into farm irrigation system. Photo Guy Roth.

flows. Channel systems should incorporate drop-boxes, stilling ponds or other devices to allow sediment to settle before waters are discharged from the property. The rapid rise and fall of water levels in waterways and delivery channels in response to irrigation demand can cause massive bank slumping when saturated soils cannot support their weight. Revegetation using the principles above can significantly reduce this problem.

Self-assessment

To check the progress of stabilisation techniques you need to measure any physical changes in the bank-slope and position. Detailed surveys of the longitudinal and cross-section of the channel can be made at the time of farm and paddock design. Repeat surveys following major events can be used to show changes in channel location and shape. An alternative (and cheaper method) is to take photographs from the same reference point or benchmark. A tree, fence post or steel peg can be used so that the photographs taken before and after rehabilitation can be compared directly. The benchmark helps to position later surveys or photographs in exactly the same spot so that results can be compared.

Things to measure or include in the photographs include:

- the bank height, slope and channel width;
- the average depth of flow during typical seasonal conditions and how depth varies along the waterway section of interest; and,
- the existence of particular channel features, such as undercuts, rock bars and pools.

Reducing bank slumping and pesticide contamination

John and Robyn Watson — 'Kilmarnock', Boggabri

By Guy Roth

John and Robyn Watson have been growing cotton for over 20 years on the Namoi River near Boggabri. In 1995, they started a program of improving riparian areas as they were concerned about bank slumping and pesticide contamination of the river. They identified the places where action was needed along the seven kilometres of river that runs through their property and worked to rehabilitate these areas. Most of the work involved planting a mix of native grasses, shrubs and trees to stabilise the riverbank and prevent erosion and loss of valuable land. John and Robyn also kept their cattle out of riparian areas as they were causing a lot of damage to the riverbank and increasing erosion. Some of the lessons John and Robyn wanted to share with other cotton growers are:

- do not try to do too much at once — pick your sites and do a little every year as conditions allow;
- exclude stock if you have them. Once the area has been rehabilitated light grazing is okay, but do not let in bulls!;
- do not think that you have to use expensive machinery to restore riverbanks — you can do a lot with plants and repair steep banks without spending a lot of money;
- when there is moisture in the bank, such as from a 'fresh' in the river, this is the ideal time to plant your trees. On steeper banks, use longstem stock for seedlings (up to 1 metre high see page 60 for more details about using longstem tubestock). Bore a hole with a waterjet in the bank and plant the tree so that about 20 centimetres is exposed. This will protect the tree from floods and you shouldn't need to water them as 80 centimetres will be in the ground. The species we have had most success with are River Red Gum, Casuarina and River Cooba;

River Cooba and grasses getting started despite the drought.

- planting native grasses is very important for stabilising the toe of the bank. The grasses we use are Phragmites at water level; Queensland Cane Grass in the middle of the bank and Native Vetivia a bit higher up from the Cane Grass. Once established, other grass species naturalise around them;
- weed management is important — if possible, slash the top of the banks as it encourages native grasses and reduces weeds. Do not plough the native grasses between rows. On the bank, chip out bad weeds like Nogoora Burr and Sesbania, other weeds can provide ground cover while your native species get established. Ground cover is very important, however, Lippia is not good as it dries out the bank, causes slumping and is a weed;
- do not water unless it is really dry;
- grow your own plants by collecting the seeds from those areas along the riverbank and on the property that are regenerating or protected. Use local tree stock as it is native to the area and most likely to survive; and
- use riparian buffers between the riverbank and cotton paddocks as this protects the river from spray drift as well as trapping sediments and nutrients running off the paddocks.

A final word...

'Now we have done some areas along the river and around the farm, we need to develop an overall farm plan to target our future efforts.' John Watson

Robyn Watson in a section of rehabilitated riparian land during the drought. Photo Guy Roth.

Common plant names are used throughout the guide,
for the scientific names see Appendix D.

C Managing farm drains and channels for water quality

Objective

To ensure that farm drains and channels are managed to maintain or improve water quality.

Recommended management approach

The limited availability and cost of irrigation water makes it a valuable resource, and irrigated cotton farms now include a system to capture and reuse tailwater draining from furrows. These systems also provide an opportunity to capture runoff following rainfall. The water captured includes surface flow and water that has drained through the cropped bed profile and into the furrows. This water can carry large quantities of nutrients, particularly nitrogen, as well as herbicides and insecticides. If it is allowed to discharge directly into waterways, it raises nutrient levels and significantly affects water quality by promoting the growth of nuisance aquatic plants and algae. This problem is made worse when there is no riparian vegetation to lower light levels and reduce in-stream growth of nuisance plants or algae. By carefully siting drains, channels and storages for drainage water, cotton growers can minimise these negative in-stream effects.

Many of the recommended management approaches outlined in this guide can be applied to surface channels, drains and tailwater return channels on irrigated farms, as well as to dips, gullies and creeks on dryland farms that sometimes run with water. These are in effect, small streams, and even though they run intermittently, they represent a significant waterway network that has the potential to have large effects on downstream water quality. As a general rule, the battle to maintain water quality is won or lost in these small channels and drainage lines and, as a result, plans for new cotton farms or paddocks should include details about the management, treatment and reuse of drainage waters, both surface and sub-surface. Ideally, plans should also include provision for the capture and recirculation of excess drainage waters from within furrows. Paddock size and layout should be related to the furrow length required to provide adequate, but not excessive sub-soil moisture in the paddock. In this way, over-irrigation and excessive drainage of some parts of the paddock will be avoided, helping to maximise crop production for the irrigation volume available.

The management approaches recommended for farm drains and channels are as follows.

1. Minimise the movement of soil and nutrients into surface channels through the use of grassed filter strips where practical, or by using the crop itself and accumulated surface litter as a trapping mechanism (see Section A).

2. Wherever practical, ensure that surface channels are shaded. This helps to reduce the temperature of water draining into adjacent waterways which, in turn, decreases the growth of in-stream nuisance plants and algae (see graph page 69). If it is not feasible to plant shading vegetation, then it may be necessary to consider an artificial wetland or detention pond to capture and 'polish' the water from drainage channels. For dryland cotton farms, this will apply for all drainage waters (where feasible); for irrigated cotton farms that are required to retain tailwaters, there may be opportunities to also improve the quality of stormwater before it leaves the property. A natural or artificial wetland or detention pond with fringing vegetation and water depth of at least 50 centimetres, will enable water temperatures to drop, cause sediments to sink and enable nutrients to be absorbed by wetland plants. All of these lead to significant improvements in water quality before the drainage water reaches the natural waterway system . This is a particularly important issue for dryland cotton farms. On irrigated farms, the reservoirs or ring tanks used to store tailwater before it is recirculated can perform these very valuable functions, and growers aim to reuse all such water rather than allowing it to discharge from the property.

The term '**polish**' is used to describe actions aimed at improving the quality of water before it leaves the farm. For dryland cotton farms this refers to any water leaving the property; for irrigated farms the emphasis is on storm runoff. Actions to polish water generally involve removal of contaminants such as crop residues, soil particles, or nutrients and pesticides attached to those particles. This may be achieved through the use of grass or artificial filters, or by temporary detention in channels, storages or wetlands, or on paddocks.

3. Use furrow orientation and agronomic practice (e.g. stubble retention, reduced tillage) to minimise any loss of soil, crop residue or drainage waters from paddocks that directly discharge into waterways. Ways of designing on-farm drains and channels to improve water quality are:
   - using contour banks within cropped paddocks;
   - maintaining vegetation within drains and channels;
   - retaining a stand of short grass at the bottom end of gullies and channels;
   - using vegetation filters wherever possible;
   - using drop boxes, stilling ponds and return drains to store water and allow sediment to settle out (periodic removal of sediment will be required);
   - reducing erosion risk by using wider channels of low slope and grassy beds; and,
   - calculating likely flow volumes and velocity before drainage or recirculation channels are designed.

By incorporating these design criteria, the costs associated with improving the quality of water leaving cotton farms can be reduced to a minimum. In areas where captured water is a valuable resource for irrigation, the additional costs incurred may be recouped quickly through increased production.

There are several examples within the industry where growers have incorporated such practices in a way that improves yields (for example, by constructing small levees to establish a wetland and storage for reuse) which more than compensated for the costs.

Self-assessment

Cotton growers can check their progress in better managing farm drains and channels by including in their farm plan:

- design and layout of paddocks to allow for the capture, polishing and reuse of drainage waters;
- practices designed to improve the quality of water leaving the farm, either through active management of surface channels, or through collection and treatment of drainage waters;
- periodic testing of surface and sub-surface waters leaving the farm, to test whether water quality standards are being met;
- keeping all water in-field or on farm. Failing this, runoff should be kept away from sensitive areas, or 'cleaned up' before it reaches sensitive areas. This is a particular issue for dryland farms that do not have the channel infrastructure found on irrigation properties; and,
- using BMP Manual (farm design and stormwater management sections).

The value of artificial wetlands

Wayne Reeves — 'Parker Joint Venture', Emerald

By David Kelly

'Parker Joint Venture' is a mixed farming operation producing an average of 550 hectares of irrigated cotton per season as well as dryland and irrigated cereal and fodder crops. The property takes its irrigation water from the Fairbairn Dam via the Nogoa River. All irrigation water is retained on the farm by using an artificial wetland located in the centre of the property. The wetland is used throughout the year, with all irrigation tailwater passed through it. The area is home to a myriad of wildlife, including many waterbird species. Regular testing is carried out on water quality in the wetland to determine the chemical content and to assess aquatic species diversity.

Since the testing began in 1999, water samples from the wetland have not shown excessive levels of chemicals, and monitoring done as part of the Waterwatch program has shown that the wetland contains freshwater macro invertebrate species that would not be present if the water was polluted.

Parker Joint Venture was winner of the Australian Cotton Grower of the Year and Cotton Achiever of the Year in 2002, with special commendation in both awards for the environmental and irrigation management practices used on-farm. Wayne Reeves, the manager of Parker Joint Venture believes that the contained system working on the property allows much greater water use efficiency as tailwater from irrigation and stormwater events can all be reused. He maintains that the money spent on building the wetland has paid for itself many times over as a result of this improved efficiency.

A final word...

'The wetland is an indicator of our on-farm environmental practices. Maintaining a healthy wetland such as this on a cotton farm demonstrates the industry's environmental awareness and responsibility.' Wayne Reeves

Regular sampling of the wetland areas enables water quality to be monitored. Photo David Kelly.

Containing tailwater on-farm

Millar Farms — 'Trawalla', Emerald

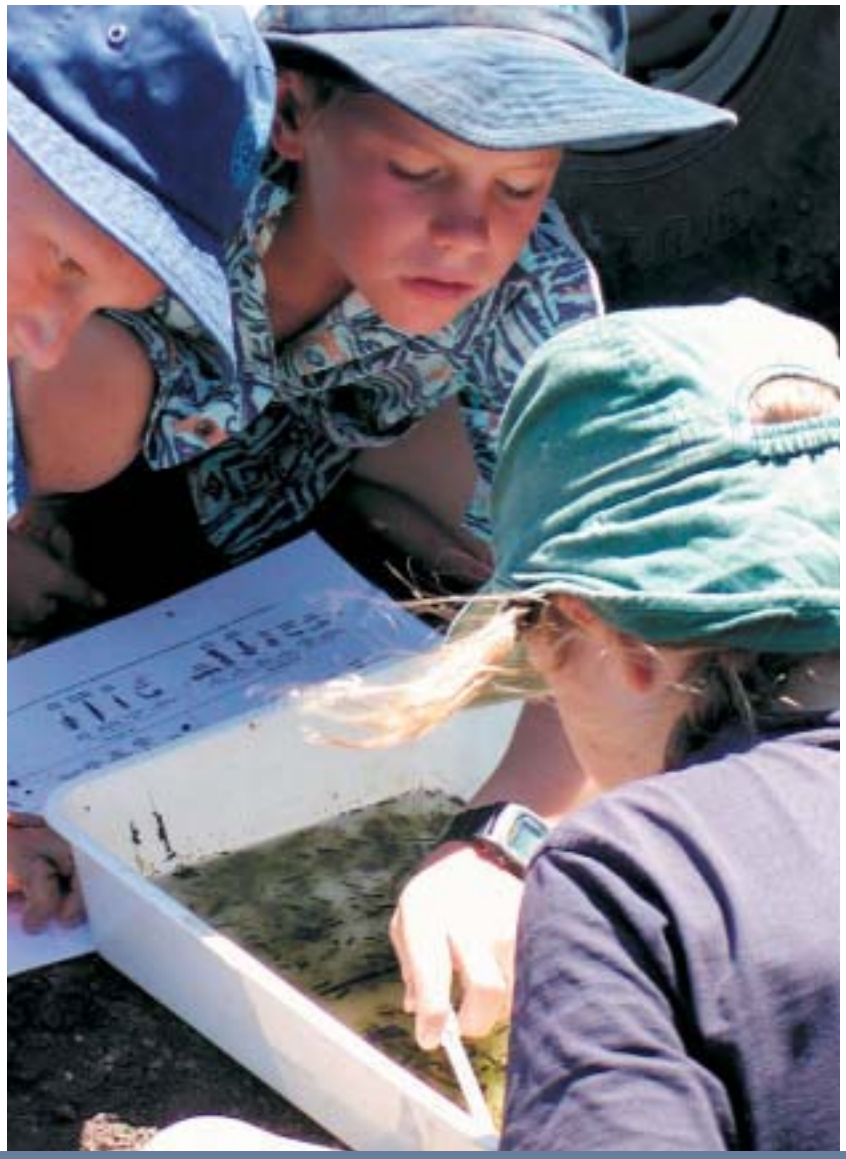
By David Kelly

'Trawalla' is a 280 hectare irrigation farm on the left bank of the Emerald Irrigation Area. Getting its water from Fairbairn dam via the Selma Channel, it produces irrigated cotton and winter rotation crops such as wheat and chickpea.

Trawalla has a fully contained tailwater system that allows all irrigation and stormwater to be kept on farm. The system is all gravity fed except for 40 hectares of the property, this means the ability to catch water is not reliant on pumps. To further assist this, all dams are kept at a relatively low level during the season.

Water quality is monitored regularly through collaboration with the Waterwatch program. Testing up to this point has not found any excessive levels of nutrients of pesticides in the system. The storage dams also play host to a large range of aquatic fauna including small shellfish and insect species that are good indicators of water quality.

Water quality monitoring is an ongoing activity on the farm. From left Daniel Bock, Charles Forsyth, Sala Rankine. Photo Patricia Bock.



D Using agricultural chemicals near streams

Objective

To manage agricultural chemicals so that off-site impacts in waterways and riparian lands are prevented.

Recommended management approach

Pesticides are widely used in cotton-growing districts as an integral component of crop-production systems. Adoption of integrated pest management systems and the use of genetically-modified varieties have reduced pesticide use, but the frequency and total amounts of chemicals used in cotton growing remain high in comparison with many other agricultural industries.

'**Pesticide**' includes insecticides, herbicides, growth regulators, defoliants, conditioners and dessicants.

Many pesticides are highly mobile in the environment, some degrade fairly quickly, but others remain highly toxic — either in their original form or in a different form — over many weeks or months. The four ways pesticides move in the environment are listed below.

1. Through the application process, for example, in spraydrift.
2. Through the soil profile to groundwaters, and then into waterways through sub-surface flow.
3. Through absorption — some pesticides are absorbed onto soil particles, and then move by soil erosion and deposition of sediment into drains and streams.
4. Through uptake by plants and animals and subsequent movement within land or water food-webs (the concentration of some pesticides can increase during this process).

In-stream life is particularly sensitive to some forms of pesticide, wetting agents and boosters that are widely used in the cotton industry. Contamination limits for environmental damage are very low, often in the 1–5 part per million range. Waterways fall under the heading of 'sensitive areas', and there may be statutory requirements regulating what farming operations can be carried out within or adjacent to such areas (refer Appendix B). Particular provisions may relate to actual or potential pollution, for example, the Queensland Code of Practice for Agriculture includes a list of defined sensitive places and how nearby agricultural activities should be managed.

Great care is needed when planning and applying pesticides in cotton growing areas. This includes tailwater drains and channels, and other parts of the farm where chemicals may be moved off-site through break-out points following intense rainfall. An overriding principle for the sound use of agricultural chemicals is to use integrated pest management practices that reduce chemical use to a minimum; these are already widespread within the cotton industry. This may include cropping practices to reduce weed infestation or soil seed stores; the use of agronomic practices to minimise insect pests; and the economic use of chemicals so that minimum amounts are used to achieve crop protection.

Recommended management approaches for agricultural chemicals on cotton farms are as follows.

1. Implementation of the cotton industry BMP Manual. The BMP Manual includes an example of a Pesticide Application Management Plan as well as details about how to manage the storage and handling of chemicals. The Plan should also include:
   - a farm map to identify sensitive areas and potential hazards for pesticide use, including waterways and water bodies, and designated buffer lands around these sensitive areas;
   - measures to ensure good communication between all those involved in planning and applying pesticides, including farm operators, staff and spraying contractors;
   - details about the selection and use of appropriate application methods, as well as use of equipment that will optimise effectiveness while minimising risk;
   - details about the storage, handling and management of pesticides — for example pesticides should be stored at a reasonable distance from any waterway or receiving water body; a container disposal program should be used; and farm disposal pits constructed where there is little risk of seepage into groundwaters;
   - record keeping processes in place that check and report on the use and impact of agricultural chemicals (a legal requirement in NSW). These records also help demonstrate that farm owners and operators are complying with statutory obligations;
   - pesticides only applied during appropriate weather conditions;
   - buffer lands located on the down-wind boundary of fields near sensitive areas;
   - appropriate products are selected for the result required;
   - integrated pest management practices implemented;
   - equipment selected and maintained for different chemicals, property situations and application conditions; and,
   - chemical users are appropriately trained and qualified.

By Rebecca Smith

Jones Air, like many other aerial operators, assists growers to develop their farm Pesticide Application Management Plan so that spray parameters and guidelines protect riparian areas from spray drift. Prior to the season, a member of the Jones Air team meets with growers to discuss the spray parameters and guidelines for each farm. As one of the pilots, Shayne says "This gives us an opportunity to highlight any changes that have been made to the farm from the previous season, such as new water holding bodies or new homes, so our records can be updated accordingly." The pilots are issued a colour-coded map that highlights sensitive areas like waterways, dams and wetlands. The grower is contacted prior to the plane entering the paddock and keeps contact with the pilot via the radio during the job. As Shayne comments "This contact helps to avoid any problems associated with the application, and by having an observer on the ground, growers are complying with the industry Best Management Practice". These efforts have paid off for Jones Air as they are the first Aerial Application company in the world to become ISO14001 certified.

2. Design the farm so that it has the capacity to retain the initial runoff from storms and intense rainfall events on the property. The first flush of this runoff is likely to carry considerable quantities of pesticides with it, particularly when paddocks are bare or the crop is at an early growth stage, and when soils are already saturated from previous rainfall or irrigation. On irrigated farms, the tailwater collection and return system may provide some capacity to store this first-flush runoff, with culverts, drop-boxes and stilling ponds used to hold this water and allow the majority of sediment to settle before it is recirculated. In some situations, holding limited quantities of runoff on the lower paddocks of the farm for up to 24 hours can also be used to 'polish' runoff waters and reduce pesticide concentrations.

Pesticides

Pesticides, including herbicides and insecticides, can find their way into river systems through spraydrift, surface runoff, stormwater escape and sub-surface water movement. Urban stormwater and industrial waste may also contain pesticides. Many insecticides and their decay products are highly toxic to aquatic animals, while some herbicides can damage aquatic plants.

Data for pesticides found in the river system are available for the Namoi catchment for the past decade. Water quality continues to be monitored throughout the Namoi catchment, to assess the impact of current and future land management practices, to collect information for better management of water resources and to monitor change over time (*Water Quality in the Namoi Catchment, NSW DLWC, 2000*). Pesticide residues are regularly detected in the river system between Gunnedah and Walgett. The most frequently detected chemicals in 2000–01 were herbicides. Atrazine was the most commonly found herbicide, followed by Metolachlor, Fluometuron, Prometryn, Diuron and Simazine (though not all of these herbicides are used by the cotton industry). Some samples from the Cox's Creek at Boggabri contained residues of all six herbicides.

The insecticide Endosulfan was detected in the 2000–01 samples at four sites in the lower Namoi Valley. However, as shown by the graph below, the concentration of Endosulfan detected in the lower Namoi has dropped significantly over the last ten years. It is believed that this reflects significant changes in farm and crop management, with less of the insecticide being applied, and growers' success in preventing losses off-site. This provides an excellent example of what can be achieved through development of industry standards for best practice and their rapid adoption by individual growers.

Growers believe that herbicides are now the main issue to be addressed to protect water quality, and this may focus future attention on the chemicals used on-farm and management practices that will help to reduce off-site movement.

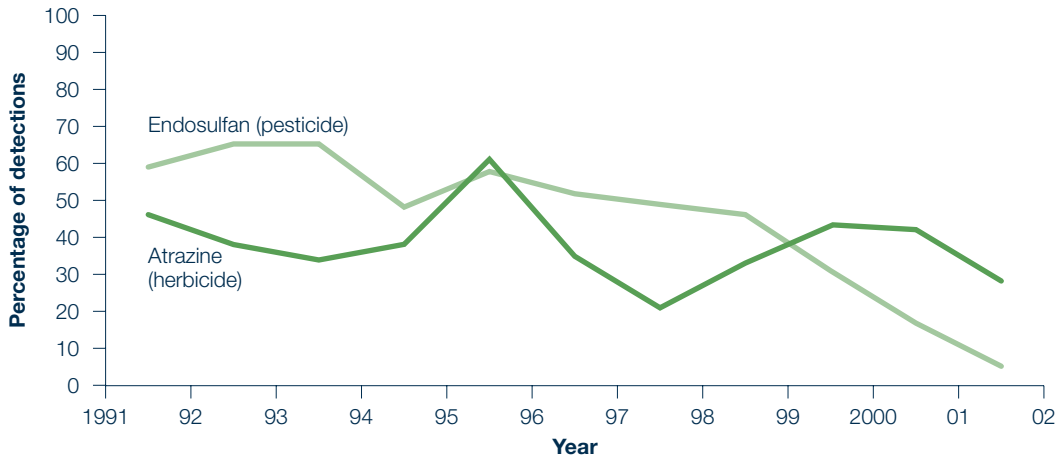


Figure 8: Percentage of detections of common pesticides for all samples collected across sites in the Namoi, Gwydir and Macintyre Valleys from 1991/92 through to 2001/02. Source: Warwick Mahwinney.

Fertilisers

The majority of soils on which cotton is grown in Australia are inherently fertile. However, growing cotton can result in high rates of nutrient removal, and the industry is a significant user of applied fertilisers, particularly nitrogen and phosphorus. Loss of phosphorus to waterways, through either overland flow (e.g. attached with soil particles) or through sub-surface flows, has been implicated in increasing frequency and severity of algal blooms in inland rivers, including blooms of toxic blue-green algae. In the northern hemisphere, management of nitrogen to protect the quality of surface waters and prevent contamination of groundwaters has become a major component of farm and catchment management. There is little information about the movement of nitrogen and phosphorus on cotton farms, or its significance (if any), compared with other land uses.

It is important that nutrient additions be matched with crop requirements, and cotton growers have access to the NUTRIpak and SOILpak decision-support systems to assist them in determining crop requirements and application rates and times. Recent estimates based on field samplings suggest that cotton crops remove only about a third of the total nitrogen applied. Around 20% remains in the soil largely associated with organic matter, while around 40% is assumed to be lost from the system through denitrification, volatilisation or leaching.

Self-assessment

If a Pesticide Application Management Plan is developed and implemented it will contain record keeping processes that will enable cotton growers to check progress and ensure they are achieving best practice in using agricultural chemicals near streams.

Planting trees for multiple on-farm gains

Mike and Robin Logan — 'Oakville Pastoral Company', Narrabri

By Rachel Holloway

Oakville Pastoral Company commenced a tree-planting project in 1996 with a goal to plant 1 kilometre of tree lines per year. Most of the property has been used for grazing and cropping purposes over the years, and a key goal was to increase vegetation on the farm. The trees provide a spray drift buffer, a vegetative corridor from the river to surrounding remnant vegetation, habitat for wildlife, and improve the aesthetics on the farm. Between 1996–2000 over 10,000 seedlings have been planted, with six different tree line sites planted on the property.

The property is divided between a flat black cracking clay soil, which runs parallel with the Namoi River (Narrabri Creek) and graduates to a hill with red ridges. The irrigated cotton and other crops are grown on the flat black soil. Oakville is located 5 kilometres from the edge of residential development, and the property shares a boundary with Narrabri industrial estate, council owned land, travelling stock route, landholders and residential holders. One of the main goals for tree planting was to create a natural buffer zone where possible around the farm due to the sensitive nature of growing cotton among close neighbours.

Site preparation involves deep ripping the soil six months before planting to ensure a good moisture profile for the new trees. At the same time, to keep the area weed free both cultivation and herbicide applications are used. A residual herbicide, Simazine, is applied six weeks before planting; this herbicide is used because it does not affect native trees.

Planting of the tree lines was trialed in spring and autumn. The Logans found that spring plantings have good establishment rates due to good soil moisture availability, whereas autumn plantings can mean the trees are prone to frosts and lack good growth during the winter months. Trees selected for the first planting were sourced from southern NSW, with later tree lines using indigenous trees from north-west NSW. After six months, the trees from the north-west were more established and had a greater tolerance to drought, frost and insect attacks.

As more experience was gained from planting trees, one of the goals was to ensure diversity in the species planted. The initial planting only had four species of Eucalyptus trees compared to the later plantings where trees and shrubs of up to 10 to 30 species were selected. The species that have done exceptionally well are River Red Gums, Yellow Box, Bimble Box, Belah, Bull Oak, Swamp Oak, River Cooba and Cooba.

After experiments with machine and hand planting, hand planting was favoured due to the clay content of the soil inhibiting how well the mechanical planter functioned. Hiko seedlings were used for all plantings, these seedlings are 6–12 months old and are very cost effective (approx. $0.55 per plant). The trees were planted with a 'potti putki' hand-planting implement. Each tree was guarded with a cardboard milk carton and two bamboo stakes. It was important to ensure a good seal between the soil and the tree roots, as well as a good seal between the milk carton and the soil to stop the wind drying the seedling out. The guards were also used to stop hares and rabbits eating the whole tree.

The tree lines range from four to five rows of trees, to a small wood lot with nine rows of trees. The tree lines are 25 metres wide and about 1 kilometre long. Shrubs and trees are mixed and the trees are planted 4 metres apart, the rows are 6 metres apart to allow a slasher to maintain the tree lines once established.

The tree line shown in the photo below is close to a main road and has generated a great deal of interest from the local community. Through the drought these trees have looked extremely healthy. Other benefits have been an increase in birds on the farm, beneficial insects for the cotton crop and a very effective visual barrier.

Trees and shrubs planted in 1996 — Bimble Box, Grey Box, River Red Gum, Yellow Box.

Trees and shrubs planted from 1997 onwards — Belah, Berry Saltbush, Bimble Box, Black Box, Blakley's Red Gum, Blue Mallee, Brigalow, Bull Oak, Butterbush, Carbeen, Cooba, Coolibah, Grey Box, Kurrajong, Mugga Iron Bark, Old Man Saltbush, Red Bottlebrush, River Cooba, River Red Gum, Rough Barked Apple, Silver Leaved Iron Bark, Swamp Oak, Weeping Bottlebrush, Western Golden Wattle, White Box, White Cloud Tree, Whitewood, Yellow Box.

Scientific names for all these plants can be found in Appendix D.

Above, treeline planted 1998 on Oakville boundary near Wee Waa Road, Narrabri. Below and right, same spot and in between rows, April 2003. Photos Rachel Holloway.

E Managing river offtake pumps, ring tanks and storages

Objective

To site and design offtake pumps, ring tanks and storages to maximise efficient management of water supplies and minimise environmental impacts.

Recommended management approach

The BMP Manual includes general principles about the siting of water management structures. Cotton growers should follow these guidelines, as well as implement the following recommended management approaches:

1. Wherever possible, tailwater collection drains, recirculation channels and storage tanks should be sited in the lower part of the property, allowing gravity flow and, where possible, a single pump lift back into the delivery system. In siting this infrastructure, it is important to work out the natural discharge points for the property — these are the points where water will leave the farm during a major rainfall or flood event and re-enter the local waterway system. Problems can occur when farm channels and storage overflows become discharge points as they may be vulnerable to substantial erosion unless they are maintained with a high level of vegetative cover.

2. When designing the size, shape and location of storages and channels, the ability to store first flush runoff should be considered (at least the first 15 millimetres of surface runoff). As noted in earlier sections, this first flush of runoff is likely to carry the highest concentrations of pesticides and nutrients. Once constructed, storages need to be managed so that the designed storage capacity is available at times during the cropping season when there is a high likelihood of storms and runoff. This may require growers to circulate captured tailwater to higher parts of the channel system when there is a threat of storm runoff. The order of pump starts and gate opening/shutting will need to be designed and tested to optimise storage and management of runoff prior to its release.

3. Where the shape or location of the property and cropping paddocks makes it difficult to obtain the required level of storage within recirculation channels, reservoirs and ring tanks, consideration should be given to providing a temporary store for first-flush runoff on the lowest paddocks. Storage of this water on cropped paddocks for 24 hours can result in a substantial improvement in the quality of the water without huge detriment to the crop. A volumetric calculation based on the cropped area and the need to retain the first 15 millimetres of storm runoff can be used, with this volume to be matched by the storage capacity of the 'retention' paddock.

4. On dryland cotton farms, as much as possible, the first flush runoff should be kept on the paddock using crop layout, row direction, stubble retention and other agronomic practices, for example, using filter strips at lower-lying headlands to prevent large loads of sediment and pesticides entering waterways. More details about recommended filter strip widths can be found in Section A.

Lombard Farms, Warren, access their irrigation water directly from the Macquarie River. A 20,000 litre fuel tank supplies their five river pumps. The tank is concrete bunded so spillages do not reach the river, 50 metres away. It slopes to a drain hole allowing the spilt fuel to be returned to the tank. The bunding will hold the tank's capacity.

Concrete bunding was chosen over an earthen one because spillages can be salvaged and it prevents seepage into the river. Matt Seccombe, the farm manager, says if they were to do it again, and the funds did not lean towards concrete, he would have an earthen floor with a plastic lined base and walls of concrete or bessa bricks to prevent seepage into the river.

Bunded fuel tank at Wambandry. Photo Kirrily Rourke.

5. When installing a river offtake pump, disturbance to the waterway bank should be kept to an absolute minimum. This is because rivers flow at their fastest on the outside of waterway bends. This often results in a scour pool forming on these bends, and sometimes an equivalent point bar of sediment building up on the inner bend. Growers often prefer to site pumps at the outer bend because of the deeper water. However, because of the higher flow speed, the outer bend is at most threat of bank erosion. Given the expense involved in most pump installations, growers should consider reinforcing the bank to help reduce the risk of future erosion. Vegetation may be enough to protect the bank from eroding, but engineering solutions are required in some situations. This might involve posts and netting to reduce flow speed immediately adjacent to the bank, groynes to direct flow back towards the centre of the channel, or even rock rip-rap along the toe itself. These sorts of in-stream works generally need to be licensed and should only be undertaken after consultation with the agencies responsible for waterway management.

Rock riprap and meshing is being used here to stabilise the channel bank. This type of engineering solution is sometimes necessary to protect pumps and other infrastructure from high water flows. Australian Cotton Research Institute.

Left: Reverse angle from photo above. Photos Guy Roth.

Self-assessment

Cotton growers can check their progress in better managing river offtake pumps, ring tanks and other water management structures by including in their farm plan:

- stormwater management practices that are integrated with local area Floodplain Management Plans and Stormwater Plans, and which meet BMP Manual requirements; and,
- the capacity to retain at least the first 15 millimetres of runoff from total cropped area, with flows leaving channels and storage overflows directed away from waterways so that they run through vegetated areas before they leave the property.

Using on-farm wetlands to manage runoff

By Mick Rose

Artificial wetlands have been used for a number of decades to clean stormwater and urban wastewater of suspended sediments, pathogenic bacteria and excess nutrients. Wetlands work because they slow the water moving across cotton fields and filter it through the plants and animals that live in these environments. Recent studies at The University of Sydney have now identified a number of plants that can accelerate the removal of pesticides from water, including Water Primrose and Slender Knotweed. A pilot study on Mollee, a cotton property near Narrabri, has shown that by arranging these plants in an artificial wetland, a reduction of up to 40% of some pesticides found in irrigated cotton tailwater (over a 12-day period) can be achieved.

It is anticipated that a sub-surface wetland, that is, one that filters water through vegetated gravel or equivalent, will be able to further reduce pesticides whilst allowing water movement to continue around farms. This is now being researched in a number of treatment channels on Auscott Narrabri, another irrigated cotton farm.

This research is showing that successful integration of artificial wetlands into farming systems can reduce the risk of pesticides toxicity to wildlife, native vegetation and livestock. Treated water may subsequently be used for other purposes, such as irrigation of a different crop, watering livestock or aquaculture. This project was funded by the Australian Cotton Cooperative Research Centre.

A final word...

On-farm wetland systems may also provide a number of other services including reduced evaporation through water-cooling and surface windspeed reduction; refuges for beneficial insects; an increase in on-farm biodiversity and feed for livestock after the cotton-growing season.

An artificial wetland being sampled for water quality. Photo Mick Rose.

F Managing riparian vegetation

Objective

To maintain and improve the health and diversity of riparian vegetation on cotton farms.

Recommended management approach

The vegetation of riparian land is often more diverse and 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 runoff after rain, while nutrients and silt may be deposited along waterways 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 waterway. As a result, riparian vegetation is often complex, with increased species diversity. Some riparian plant species occur only along waterways as they require the better soils and increased moisture for survival and reproduction.

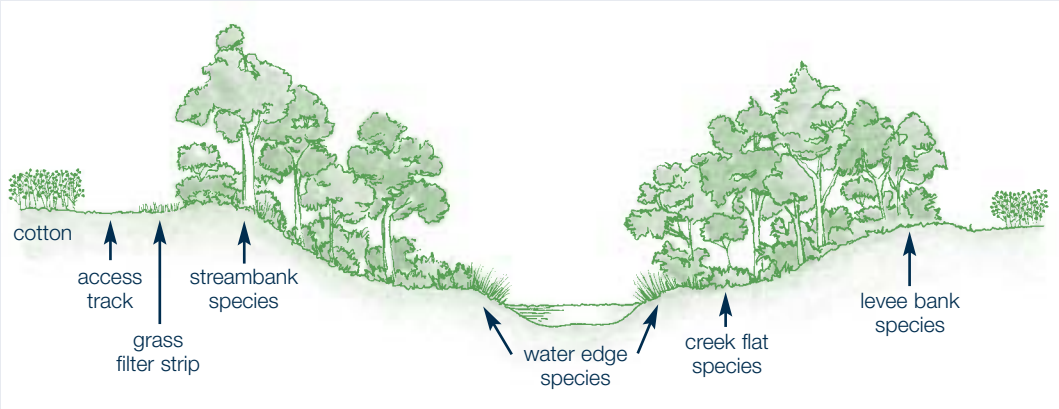


Figure 9: Different vegetation types on a cross section of riverbank. Illustration Carolyn Brooks.

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 (Section B);
- forming windbreaks to prevent cotton lint blowing around cotton gins;
- trapping sediment and nutrients (Section A);

- shading waterways for reduced light and temperature (Section G);
- providing wildlife habitat (Section F);
- 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);
- harvesting of native fruits and seeds; and,
- improving aquatic biodiversity which helps to maintain fish stocks.

For these reasons, the management of riparian lands on cotton farms can be designed to optimise productivity and environmental outcomes. In this section, recommended management approaches are provided to address some of the processes threatening riparian vegetation health on cotton farms.

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

Managing riparian lands as a different, but integrated part of farming operations

Riparian lands on cotton farms require a different set of management strategies to other parts of the property if they are to perform the functions listed above. On established farms, all the waterways running through or adjacent to their property should be surveyed so that their status and condition can be recorded. There are several assessment methods available to help in this, and the list of contacts at the back of this guideline can assist cotton growers to complete this task. This on-site survey will identify opportunities for improved management of existing riparian vegetation or, in many cases, 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 waterway and riparian management, but individual landholders can also plan and implement restoration projects on their own property. Once riparian lands have been identified the following management approaches are recommended.

1. When developing new land for cotton production, riparian lands should be clearly identified and steps taken to protect these areas during paddock development and cropping operations. Consideration should be given to improving the vegetation by planting to fill obvious gaps or to expand the width to gain further benefits. Maintaining or enhancing the degree of connectivity with other native vegetation should be a primary goal.

2. Farm layouts should be planned to keep riparian vegetation in an intact and healthy state. On dryland farms, furrows should not be constructed to drain directly into riparian vegetation, but rather, direct the water through a channel or detention pond system. Irrigated farms are already required to retain tailwaters.

3. Healthy riparian vegetation should not be cleared to provide headlands or turning areas for equipment; these should be established well clear of the riparian land, preferably with a grass filter of at least 6 metres in between.

4. Farming operations should be carried out in a way that minimises any potential for movement of herbicide, other chemicals or nutrients into adjacent riparian vegetation. Maintaining a grass filter strip between the crop paddock and the riparian vegetation will help to achieve this aim.

The grower is rehabilitating the riparian zone as an effective buffer against spray drift, as well as trapping any runoff from cotton paddocks. Photo Guy Roth.

Rehabilitation following over-clearing

In many cotton districts, the natural riparian vegetation has been extensively altered, largely through grazing by domestic stock and clearing. In many places, scattered large trees remain, but there is little natural understorey and native grasses have been replaced by annual and exotic species, including weeds. Many of the native trees are old and where riparian areas are 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 can cause problems, as it 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 waterway. The result is that many waterways in cotton districts are in poor ecological condition. When rehabilitating riparian lands, the following recommended management approaches can be used.

The trees on this stretch of the Namoi River are all of the same age and grazing has prevented any understorey or young trees surviving. When these trees die there will be nothing to replace them and the riverbank will be eroded away. Photo Guy Roth.

1. Determine which part of the waterway 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 waterway each year over several years, beginning in the uppermost reaches and gradually working downstream.

2. Consult local experts, for example Greening Australia, river planners or government agencies, to develop a plan for riparian rehabilitation. Where native species remain on the farm and are in sufficient health to flower and produce viable seed, natural regeneration is the best way to revegetate. Growers should check to see whether seed is present either on plants or in the soil, and then aim to remove grazing for at least two years to give new plants time to establish and grow to a stage where they can survive the return of stock. Some site preparation may be required, for example hand removal or spot-spraying of weeds, or a cool burn to remove dead plant material; these actions should be timed to coincide with seed fall and the greatest likelihood of rains for germination.

A group of young trees growing on the banks of Namoi and protecting against erosion. Photo Guy Roth.

3. 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.

4. 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.

5. Avoid the tendency to 'tidy up' and burn fallen timber in riparian areas as it important habitat for plants and animals. It can make control of weeds and feral animals more difficult, but it should be left wherever possible.

Useful references

Rural Industries Research and Development Corporation, 1999, *Growing Trees on Cotton Farms, A Guide to Assist Cotton Farmers to Decide How, When, Where and Why to Plant Trees*, Canberra.

Carr, D. & Curtis, D. 2000, *Plants in Your Pants 2: A Pocket Guide to the Trees and Shrubs of the North-West Plains of NSW* (available through Greening Australia, NSW).

Andrews, S. 2000, *Optimising the Growth of Trees Planted on Farms: A survey of farm tree and shrub plantings of the north-west slopes and plains and northern tablelands of NSW*, Greening Australia, NSW.

Greening Australia NSW has available a range of booklets and species lists for particular locations in the north-west of New South Wales, for example "The Trees and Shrubs of the Wee Waa/Merah North Area" and "Native Plants of the Boggabilla Area". A wide range of Fact Sheets are also available, and cover how to collect and grow seeds of native trees and shrubs, selecting species for farm forestry, bush food plants and plants for attracting particular animals, as well as brochures on native plant species suitable for riparian zone revegetation. These are available through the Greening Australia North-West NSW Regional Office in Armidale, tel: 02 6772 3248.

Weed management

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. Lippia is an example of a recent invader of both disturbed and healthy riparian lands in cotton districts. Most weed species, however, are much more likely to invade riparian vegetation that has been disturbed and is unhealthy. The recommended management approaches that follow, aim to reduce weed invasion into riparian vegetation.

1. Maintain a mix of different vegetation types and levels 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 natural 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 waterways. The ideal width is at least 30 to 50 metres of riparian vegetation. The smaller width will assist animal species to move and disperse across the landscape, but greater widths are required for species to remain resident in the area.
3. Avoid human disturbance in riparian vegetation, for example, from fires, vehicle and equipment access, timber gathering or other clearing.
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.
5. In situations where weeds have already invaded riparian vegetation, control them by regular spot-spraying, stem injection treatment, or by hand removal where this is feasible. In many districts, there are community organisations able and willing to assist in such work. There are some noxious weeds that have a legislative requirement for control. Periodic monitoring and weed control will need to be continued each year (e.g. during the non-cropping seasons) until the problem can be overcome. When controlling weeds using herbicides near riparian land, ensure label directions are read and followed. Care must be taken not to disturb the surrounding natural vegetation unnecessarily, as this will only encourage further weed invasion.
6. Work with neighbours to prevent reinfestation 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 downhill. If this approach is not followed, unattended lands upstream may continue to provide a source of infestation.

This riparian zone has been fenced out to restrict stock access. Once the area has been rehabilitated, stock may be permitted access for drought refuge or shelter in times of severe weather events. Photo Siwan Lovett.

Above: This riparian zone has been cleared and Lippia has invaded the whole area right down to the water's edge.
Right: Lippia. Photos Guy Roth.

Lippia

Lippia is a serious weed of inland river systems of New South Wales and Queensland. It is estimated that at least 800,000 hectares of floodplain grazing, riverbanks and watercourse country is infested by Lippia.

Lippia is a perennial, broadleaf, flat growing plant, with numerous branched stems of up to 1 metre long. It has the ability to root at nodes along the stems, providing a solid mat-like ground cover. The stout central taproot (80 centimetres long) has fibrous secondary roots. Leaves arise in pairs from stem nodes; they are 2–5 centimetres long and covered in minute hairs. The flowers are white and look similar to lantana weed flowers. It spreads both vegetatively and by seed. Plants break up during flooding and can quickly reestablish as the water subsides. The plant tolerates frost and drought and can survive inundation for at least three months.

Lippia invasion can result in increased soil erosion, especially along riverbanks. The plant's dense mat of stems and leaves prevent the growth of other species. Under the dense mat the soil is bare and at high risk of erosion should the Lippia die back in drought, or when flooding causes water levels to rise. There are many examples in cotton districts of Lippia invasion along riverbanks being followed by bank slumping and accelerated erosion. Lippia also prevents regeneration of native vegetation leading to a further loss of biodiversity. Lippia is well adapted to floodplain situations and is extremely difficult to control. It is rapidly spreading, not only within the floodplain regions, but also on adjacent higher ground.

Cultivation and herbicides can be used to provide short-term Lippia suppression in the process of establishing a pasture. Farmer experience has shown that cultivation of dry soil in hot weather prevents transplants and gives the best Lippia kill. There are cultivation restrictions in riparian areas and growers should check with State agencies about native vegetation legislation and riparian zone regulations. With good soil moisture and actively growing Lippia, apply a herbicide prior to cultivation to give better results. Several herbicides are registered for suppression of Lippia (Refer to New South Wales Agriculture Agnote DPI-384, *Herbicides for Lippia control*). Glyphosate, 2-4-D amine and Lantana DP 600 are options. Restrictions exist concerning the use of products near waterways and 24D should not be used during the cotton season. Results vary from region to region, as does the best time of year to spray. Spot spraying can be used for keeping a check on Lippia in a relatively uninfested area. Lippia can invade very quickly and vigilant spot spraying is needed.

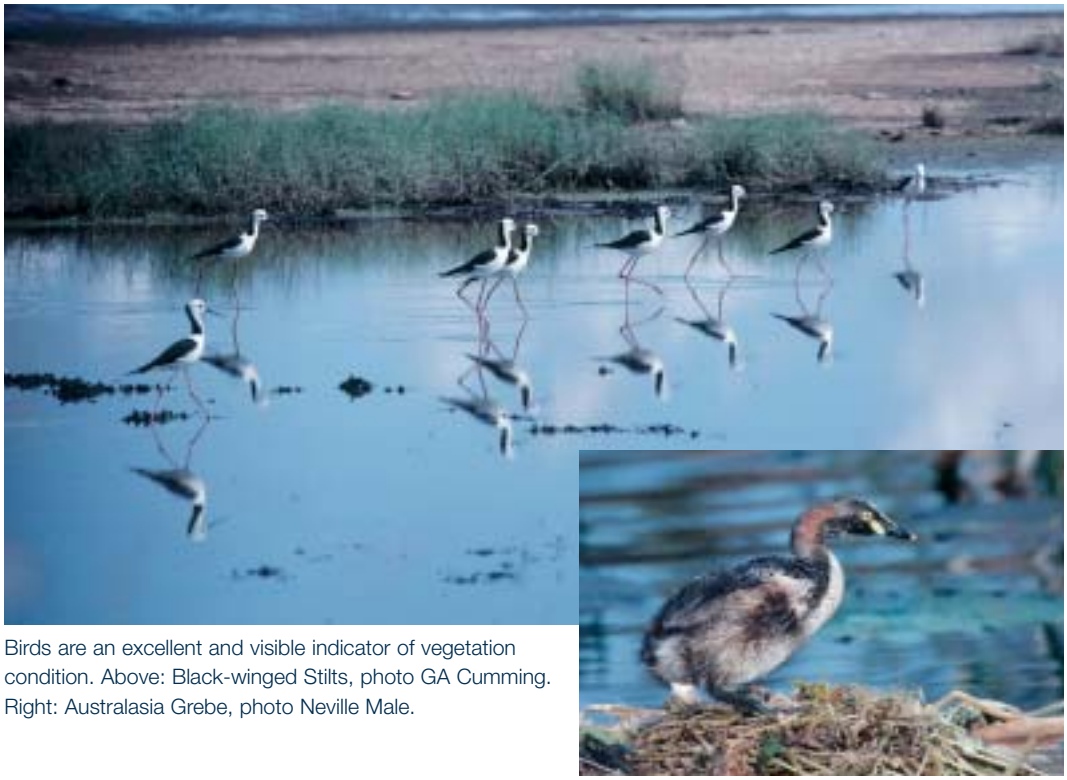
Fire

Fire is an important natural component of many Australian landscapes and is often used as a tool in vegetation management. In the past, fires escaping from cropping operations have been an important force in degrading riparian vegetation in cotton districts. This has become less of an issue with the adoption of stubble retention and direct drilling of cereal crops (where other crops are grown on cotton farms), but care should still be exercised whenever fire is used. Carefully managed fire, generally a low intensity burn, can be used to help reduce weed infestation along waterways, or to provide conditions for reestablishment of native species. However, the season and exact timing of the burn needs to be planned carefully to ensure that it is beneficial and not damaging. It may also be necessary to get local council consent and notify neighbours.

Self-assessment

Cotton growers will be able to check the progress of their riparian rehabilitation projects by assessing some of the following indicators:

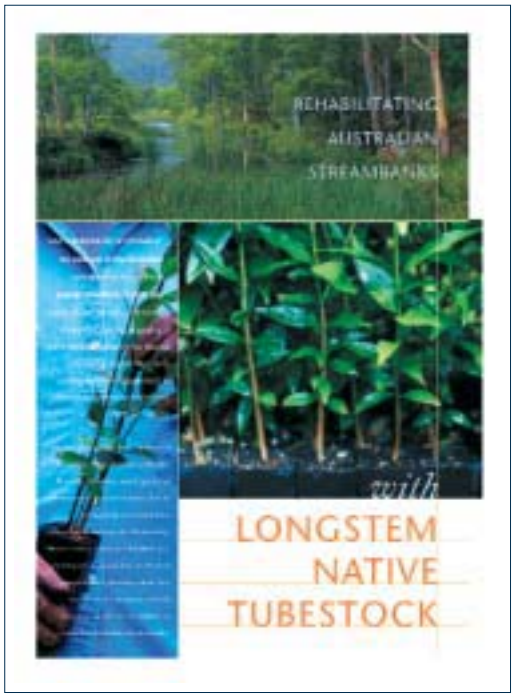
- riparian vegetation along on-farm waterways is intact and healthy with a diverse mix of local native plant species;
- there is a low level of weed infestation;
- there is no evidence of damage to riparian vegetation through drift of pesticides, fire, uncontrolled grazing by stock, or through vehicle/equipment access; and,
- bird lists that grow with the number of species present as the rehabilitated area develops (compare with local list for natural areas — see Bird Atlas of Australia to assess progress).



Birds are an excellent and visible indicator of vegetation condition. Above: Black-winged Stilts, photo GA Cumming. Right: Australasia Grebe, photo Neville Male.

Using longstem native tubestock to restore riparian lands

Modified from Department of Land & Water Conservation fact sheet



The problem with willows

Since the 1950s, willows have been used extensively to help stabilise many streambanks. Willows establish easily, grow rapidly, produce fine matted roots ideal for stabilising soils, 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) which 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 sand and gravel bars in streams, diverting floods 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 extreme shade provided by willows, has reduced biodiversity wherever willows dominate riparian areas. Since 1998, willows have been declared a noxious weed in New South Wales.

Using longstem tubestock as an alternative to willows

Bill Hicks, a Hunter Valley Landcarer, 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;
- longstems achieve rapid erosion control; and,
- longstems require minimal follow-up care, with the need for watering and weeding largely eliminated.

Where to use longstems

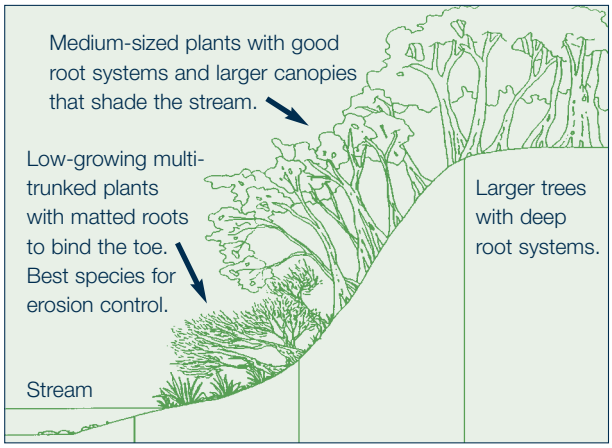
Most species that occur naturally along streams are considered to be suitable for longstem development due to their tolerance to sediment build-up around the stem, although it is always a good idea to trial any untested species before mass plantings take place. Longstems can potentially be planted in 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 below.

More information

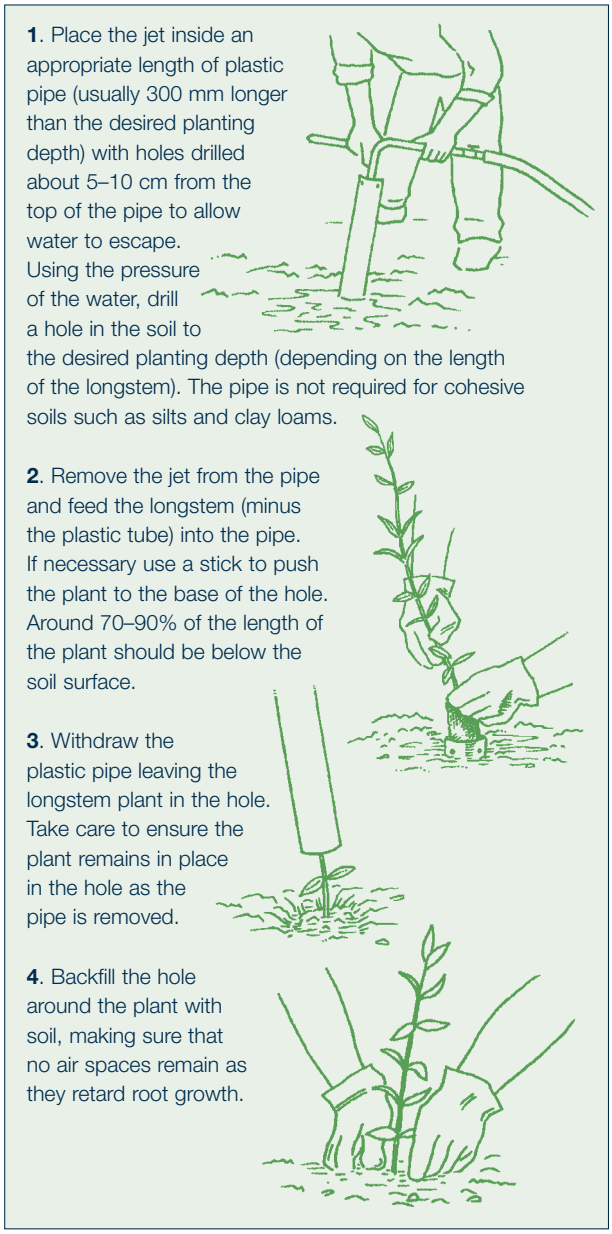
Supplies of longstems are currently limited, however, commercial production is being encouraged through regional workshops and education. A detailed brochure outlining how to grow and plant longstems is available, and the Rivercare Officer at your local office of the New South Wales Department of Infrastructure, Planning and Natural Resources will be able to send you a copy. They will also 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*.

Source: Department of Land & Water Conservation, *Rehabilitating Australian Streambanks with Longstem Native Tubestock*.



Source: Raine and Gardner 1995.



Riparian areas as living 'haystacks'

Bruce Kirkby — 'Koiwon', Bellata

By Nicky Schick

Bruce Kirkby manages a mixed dryland cotton, wheat and grazing enterprise west of Bellata in northern NSW. He has been fencing riparian areas to reduce soil erosion and to provide stock fodder as a form of 'living haystack'. He says "it has proven very handy this year given the recent drought, we have managed to maintain our stock by rotating them on the creeks. Normally, if managed properly, the creeks provide a very good feed source. However, the grazing must be managed to avoid damage to pasture establishment and ground cover".

"We had been farming right up to the creek bank. However, we found that if runoff from the cropped area coincided with a sizeable flow in the creek, this resulted in erosion of the creek bank with potential to wash back into the paddock." To avoid this, Bruce moved "...right back off the creeks and planted oats and lucerne to gain some establishment on the past farming country, in time we hope natural pasture will regenerate. Another thing we did was to use rocks where there were fresh areas of erosion to prevent further cut back while we are trying to get the pasture to establish. There is always the risk of small washes becoming big washes on these friable soils, particularly when it has been so dry and windy. This recent drought just emphasises the need for good vegetation in your riparian areas".

Bruce says he has a few more areas where they will be looking at shifting the fence lines back off the creek in the future. The highest flood line determines the location of the fence. He hopes to get quick establishment of ground cover to prevent weed problems from developing. Large floods can result in a weed seed bank becoming established right alongside the cropped area, which is another reason for getting native vegetation established quickly. Reducing weed growth is another reason for spot grazing when circumstances permit.

A final word...

"Walking through the creek the last time I moved the weaners out, I was happy to see the number of little River Gums rather than Black Wattle coming up through the grass." Bruce is pleased that he has found an economic management strategy for his creeks that has a definite environmental benefit and leaves natural habitat for the next generation.

The photo at right shows the trees in one of the creeks and the fence line moved back to the high flood line. The area planted to oats and lucerne on either side of the creek should eventually reestablish to natural pasture. Photos Nicky Schick.

Using riparian areas as wildlife corridors

Bobbie and Lyn Brazil — 'Anchorfield' and 'Bemarng', Brookstead

By Ingrid Christiansen

Bobbie and Lyn Brazil's properties at Brookstead lie along the Condamine River. Along most of the river frontage they have retained, replanted and regenerated riparian corridors that are up to 250 metres wide. With natural billabongs and open Eucalypt forest, riparian lands provide habitat for a range of animal life. Bobbie and Lyn believe that native vegetation areas need to be at least 30–50 metres wide to be of enough value to wildlife, and they exclude cattle, as stock prevent plants from regenerating naturally.

Working by the philosophy 'only do what you can manage' the Brazils have revegetated small areas each year when there has been sufficient moisture. Along one stretch of their part of the Condamine River, the Brazils established over 1500 trees in a planting coordinated with five other farms in the district. Each of these farms planted similar trees along the river to supplement native trees along a 12 kilometre reach of the river. On 'Anchorfield' and 'Bemarng', River Red Gums and Chinchilla White Gums have been the main species planted. They have also taken out a few rows of cropping county to provide a wildlife corridor between water sources.

In planning revegetation projects, Lyn comments that you need to be practical and provides the following advice:

- look for where you can most practically restore vegetation within your farming system;
- use areas of the farm that are not highly productive;
- use little corners and shapes of field that are not easy to farm;
- use areas around ring tanks to plant trees and gain aesthetic benefits;
- look to where a revegetation program will enhance what is already there;
- excluding stock from some areas may be enough to encourage natural regeneration;
- do your tree planting at the right time — make use of soil moisture when it is there and fits in with your work planning;
- make sure you prepare your areas carefully — just like you would for other crops; and,
- read books, talk to people and look at what is being done around you.

A final word...

"There are outstanding people out there who are putting in a tremendous effort, planting large areas of trees. Don't be put off just because you can't do something of this scale. Do what you can — every little bit counts." Bobbie and Lyn Brazil

Photos Ingrid Christiansen.

Improving biodiversity on cotton farms

Summarised from material prepared by Leah MacKinnon and Martin Dillon, Ingrid Rencken, and Peter Jarman and Janelle Montgomery

Areas of land used for intensive agriculture, such as crop production, generally have low levels of biodiversity compared with adjacent natural areas. The frequent disturbance and other activities associated with crop production, such as soil tillage, bed preparation, planting a monoculture crop, application of fertilisers and pesticides, and eventual harvest, results in a simplified system with a low diversity of plants and animals. These systems can be highly productive and profitable, but they also tend to have low resilience in the face of climate changes, pest or disease, or other unusual events such as flood or fire. Below are three stories that outline some of the benefits that may be achieved by managing cotton farms deliberately to increase the level of biodiversity adjacent to cropped paddocks. These are drawn from work supported by the Australian Cotton CRC, by the CRDC, and from other sources.

1. Bats — natural pest controllers

Retaining or replanting native vegetation around cotton fields provides habitat for plants and animals that can assist in the control of pest species. Recent research has shown that many small, insectivorous bats that have been found in and around cotton crops, feed on the pest moth *Helicoverpa spp*, amongst other species. As well as directly catching and eating the pest species, the presence of bats can disturb flight patterns and egg-laying, another means of helping to control pest populations. Bats use different frequencies of ultrasound to search for and locate their insect prey. Many insect species can detect the bat sonar and immediately adopt avoidance behaviour of fast or erratic flight away from the approaching bat. For the important pest of cotton crops, *Helicoverpa spp*, this means interruptions to normal nightly activities of mating and egg-laying in cotton fields.

Bats, even though they are voracious feeders and may consume something approaching their own bodyweight in insects each night, need to be present in large numbers to have a significant impact on pest populations. However, it is possible that even a small population of bats at the beginning of the cropping season may have a significant impact on how quickly pest populations increase. This can potentially limit the damage caused and the level of crop protection measures required later in the season.

Studies in Texas, USA, of large maternity Mexican Freetail bat populations have shown that each female needs to eat around 70% of her body weight each night, estimated to be about 9 grams of insects. It has been estimated that the large recorded populations of this bat may consume 1000 tons of insects in a single night!

Trees are needed to provide hollows for birds and bats. Photo Guy Roth.

A study is currently underway in northern New South Wales to provide estimates of the potential impact of insectivorous bats on cotton pests. So far, ten bat species have been identified around cotton crops in the Narrabri area, with more species found in cotton fields that are near native vegetation than in those without. The table below lists the different bat species so far identified, and shows the type of habitat they prefer for hunting.

Table of insectivorous bat species identified around cotton fields in the Narrabri area

Species of bats detected with an Anabat ultrasound recorder*, Narrabri, Lower Namoi Valley, 1999/2000 and 2000/2001 cotton seasons	Woodland next to water storage (Richards)	Cotton next to remnant vegetation (Richards)	Cotton isolated from vegetation (MacKinnon)
Inland Freetail (*Mormopterus planiceps* Sp.3)*	✓	✓	✓
Inland Broadnosed (*Scotorepens balstoni*)*	✓	✓	✓
Little Broadnosed (*Scotorepens greyii*)*	✓		✓
White-striped Freetail (*Tadarida australis*)*	✓	✓	
Southern Freetail (*Mormopterus planiceps* Sp.4)*	✓	✓	
Chocolate Wattled (*Chalinolobus morio*)*	✓	✓	
Gould's Wattled (*Chalinolobus gouldii*)*	✓		
Little Forest (*Vespadelus vulturnus*)*	✓		
Yellow-bellied Sheathtail (*Saccolaimus flaviventris*)*		✓	
Lesser Longeared (*Nyctophilus geoffroyi*) (dead in *Helicoverpa armigera* feramone trap — trapped while chasing prey)		✓	
Total species	**8**	**7**	**3**

This data is from work done by Richards and MacKinnon 2002, as yet unpublished.

All these bat species require tree hollows for roosting sites, with the type of hollow most preferred varying between species. For example, Gould's Wattled bats use the dead limbs of River Red Gums, whilst Lesser Longeared bats roost only in cracks of dead trees. Trees are very important habitat for bats, with studies of riparian trees (mainly River Red Gum) on the cotton property 'Little Mollee', Mike Carberry's 'Cardale', and Phil Norrie's 'Mollee', revealing that single trees can contain from 2–29 roosting hollows. The trees surveyed were a mix of dead and living, with the dead trees averaging 22 hollows and 8 cracks, and the living trees 11 hollows. Not all hollows are suitable for bats, and unfortunately most of the trees in the survey are extremely old and in decline, which means that habitat for bats is becoming increasingly scarce. At the same time, Eucalypts do not develop hollows suitable for bats until they are around 120–180 years old. In many riparian areas within cotton districts there is little natural recruitment of trees occurring due to continuous access by stock to riverbanks and adjacent areas.

A final word...

The many species of bats now known to be present in cotton districts that may be able to provide a useful service to growers in helping to reduce pest insect populations at certain times of year. It is important that they be conserved as an important part of the natural ecosystem.

Strips of vegetation provide habitat for bats, insects and other predators that can assist cotton farmers to control pest populations. Photo Guy Roth.

2. Providing habitat for insect predators and pollinators

Windbreaks around cotton properties offer a unique opportunity to reintroduce biodiversity into the agricultural landscape. Greening Australia and other organisations can provide information on the effectiveness of different types of windbreaks and their height and orientation, as well as on suitable species and planting techniques. In addition to the direct benefits of reduced wind speed, these windbreaks can provide habitat for a range of pollinators and predators of insect pests that are then able to forage in adjacent paddocks.

Two windbreaks on a cotton property west of Narrabri were sampled to investigate whether insect predators were using them. The trees were a mix of Eucalypts, Casuarinas, Acacias and Melaleuca. The results showed that a wide range of insect predators were in the windbreaks, including lacewings, ladybirds, damsel bugs and assassin bugs. The presence of larvae indicated that the lacewings also use the windbreaks for egg-laying. Within the windbreaks, different predators seemed to favour different trees. An interesting observation from this study was that all predator species seemed to prefer windbreaks offering north–south aspects rather than those oriented east–west; the former possibly provides a better microclimate for insects. These are initial results and it is yet to be seen whether windbreaks and the predators they contain can have a significant effect on insect pest populations or through assisting pollination of crops.

A final word...

The research being undertaken is encouraging as it clearly show that windbreaks can be a valuable way of reintroducing or retaining biodiversity on cotton farms.

3. Water birds and irrigation storages

On-farm storages in the Lower Gwydir Valley in northern New South Wales now cover around 120 square kilometres in total, equivalent to more than 1% of the landscape and representing around 45% of the total area of natural and artificial wetlands in the region. During the period 1999–2001, several surveys were undertaken of on-farm storages and wetlands on nine cotton farms. Over 45 species of water birds were recorded, including several rare species and four that are listed under the NSW *Threatened Species Conservation Act 1995*.

The water bird communities recorded on the on-farm storages were dominated by ducks, geese and swans, followed by pelicans, darters and cormorants. The four most abundant individual species were all ducks. Variations in the number and species recorded during repeat surveys suggested that the water birds were highly mobile, using on-farm storages as part of the dispersed system of wetlands in the Lower Gwydir.

The study found consistent and significant differences in the number, density and composition of water bird communities on different types of on-farm storage. The five most bird-rich storages carried 10–30 times as many birds as the five most bird-poor. There was also a significant difference between bird species in the frequency at which they were recorded on the on-farm storages. Some species, such as Whistle-Ducks, were very numerous but occurred only irregularly, whereas Black Duck were present on most storages. The water birds were, in general, more numerous and more frequently present on storages:

- that included trees in the water, beds of aquatic vegetation, and shallow areas that formed mud islands as water level fell; and,
- that had soil species-rich seedbanks with high total seed numbers.

Very few water birds were observed to breed on the on-farm water storages. The study also concluded that although the on-farm storages in the Lower Gwydir constitute nearly half of its mapped wetland areas, they probably support, on average, only 1–5% of the Valley's water bird community and less than 0.5% of water bird nesting numbers. The study has also suggested ways in which the characteristics of on-farm storages could be modified without unacceptably reducing their usefulness in water management on irrigated cotton farms. Modifications might be made to existing storages when they are drawn down, or incorporated in new designs, to include areas of shallow slopes, aquatic vegetation and trees and standing dead timber. This would significantly increase the value of these storages for use by water birds, and enable growers and the industry in general to maintain and enhance its existing contribution to water bird biodiversity in cotton regions.

Pelicans are commonly found living in and around cotton farm storages. Photo Guy Roth.

G Maintaining in-stream health

Objective

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

Recommended management approach

Native riparian vegetation shades waterways, decreasing the amount of direct and dappled sunlight reaching the water surface, and reducing daily and seasonal extremes of water temperature. Research has found that the temperature in waterways 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. Figure 10 presents data on fluctuations in water temperature and shows the difference between grazed unshaded sites and restored protected sites.

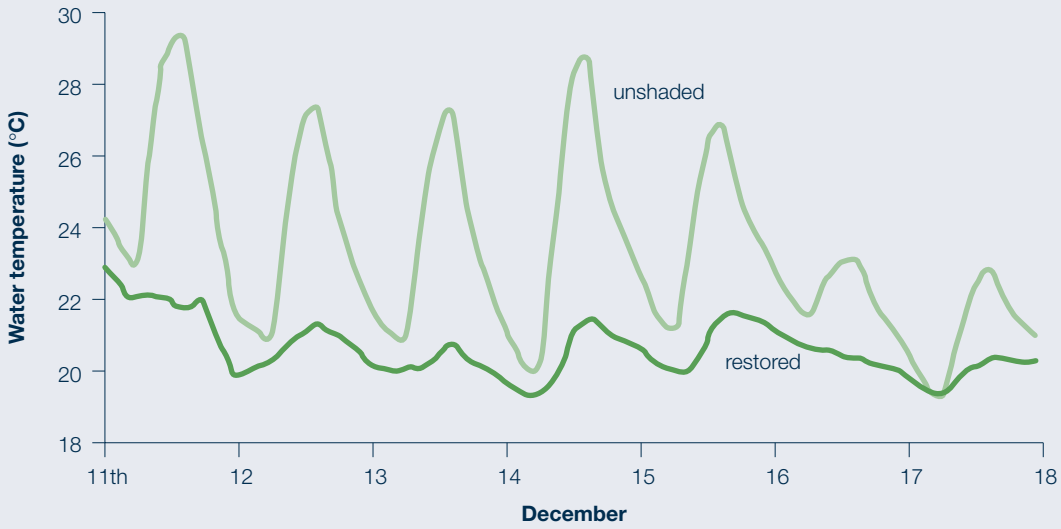


Figure 10: Predicted temperatures in Echidna Creek, south-east Queensland. Predictions assume average flow. Source: Rutherford unpublished data.

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 are often triggered by precise temperature sequences, and research has shown that many in-stream plants and animals need specific temperature requirements to survive. 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.

Shade is required to maintain the natural water temperatures that are essential for healthy and productive streams. The temperature within a waterway 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. Figure 11 shows how riparian vegetation can work to shade the stream from the sun at different orientations.

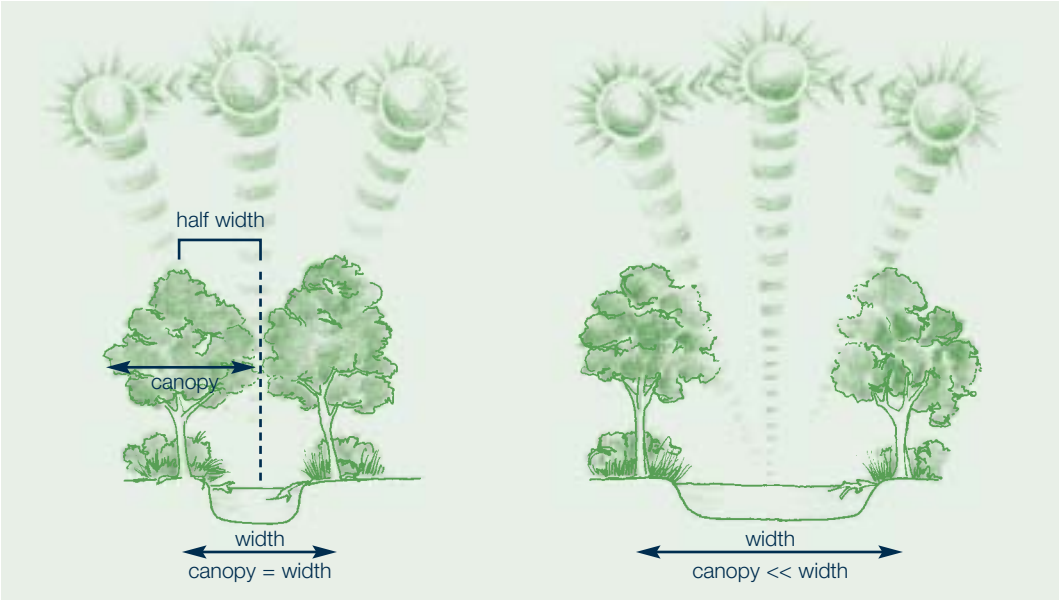


Figure 11: Influence of channel width on cover. A small stream could be completely shaded if the active channel width was equal to or less than the width of the tree canopy. As channel dimensions increase, and vegetation height and width remain relatively uniform, riparian shading of the channel becomes less effective.

Shade from riparian vegetation is also essential to keep natural light levels in waterways. 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.

Riparian vegetation also 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 the riparian land, are important for in-stream bacteria, fungi and some specialised animals which, in turn, are a valuable food source for other in-stream life. 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 bigger 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.

Namoi River with healthy riparian vegetation on right hand side and disturbed with erosion on left hand side of river. Photo Guy Roth.

It has been thought that woody material in waterways reduces flow capacity and increases flooding and, as a result, many waterways 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 riverbank as well as providing vital habitat for instream plants and animals. Photo Ian Rutherfurd.

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 rivers in cotton-growing districts, many of which are now regulated. The construction of dams and storages, both public and private, have changed the total annual river flow in many cases. Water that previously moved through the river system is now lost, with seasonal flows disrupted as releases are timed in late summer or autumn in order to meet irrigation requirements.

A further problem is that water released from the bottom of large dams is usually cold and lacks oxygen, and this places further stress on in-stream life. The map below shows the location and scale of probable cold water (thermal pollution) impacts within the Murray-Darling Basin. It is generally very expensive to re-engineer large storage dams for multi-level offtakes; an alternative is to construct a detention pond near the water release site so that deep water can be retained and provide an opportunity for it to warm up and become re-oxygenated. This is an important issue for further consideration by public and private water agencies and storage managers.

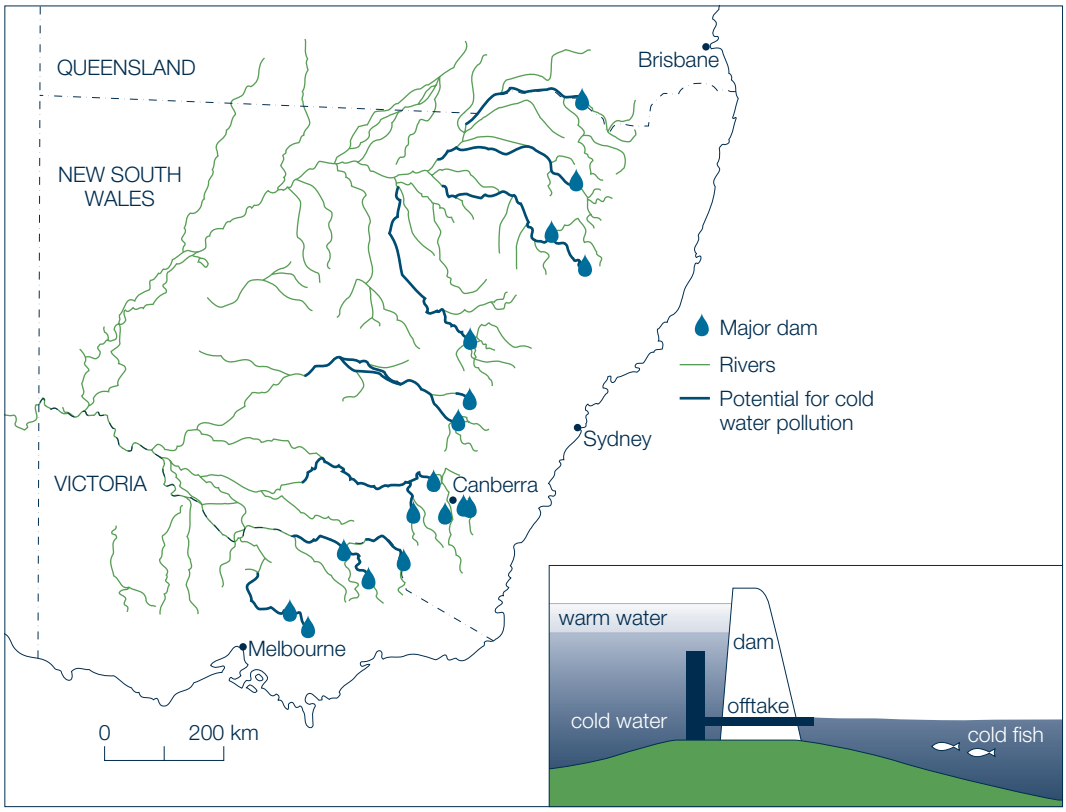


Figure 12: Cold water pollution is caused by bottom release of water from dams.
Source: NSW Fisheries.

An important aim of the catchment and water-sharing plans being developed in cotton districts in both NSW and Queensland 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.

Assessment of riparian lands in most catchments shows that riparian lands and in-stream health have suffered as a result of land and water management practices. The following recommended management approaches will assist cotton growers to improve in-stream life on their farms.

1. Map all waterways and wetlands, even intermittent ephemeral creeks on the farm 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 waterway. Depending on the type of vegetation, a 25 metre strip will usually be sufficient to ensure that tall trees can survive through natural regeneration. Native species that grow down as well as 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 should be undertaken to return to natural shade levels.

2. When rehabilitating a stretch of waterway, 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 F of this guide. For smaller waterways, 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 waterway.

3. Keep wood in waterways 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.

Figure 13: The best location to position snags is on the outside and downstream of bends. Illustration Carolyn Brooks.

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

4. Make sure works on waterways, 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.

5. 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 cotton growers will need to meet, for example 'by 2012 key water quality indicators meet the requirements of the *New South Wales Interim Water Quality and River Flow Objectives, 1999*'.

Self-assessment

Cotton growers can check progress in improving in-stream health by using some of the following techniques:

- visiting the rehabilitation site and using photographs to monitor the success of revegetation and the degree of shade being provided to the waterway;
- comparing the revegetated site with an area of natural vegetation to see how shading is affecting the stream. This can be done by visual comparison or use of light meters; and,
- participating in community-based monitoring programs (Waterwatch in Queensland and Streamwatch in NSW) to detect changes in water quality in waterways. Catchment coordinators can provide advice on the use of meters to measure changes in salinity and pH, as well as information sheets that will help in the identification of in-stream insects and other animals that are indicators of water quality.

The Gwydir River being tested for water quality and in-stream life. Photo Guy Roth.

Protecting and promoting biodiversity on-farm

Betsy and David Turner — 'Macintyre Downs', Goondiwindi

By Anne Sullivan

Betsy and David Turner of Macintyre Downs have lived on the banks of the Macintyre River for the past 21 years. In this time, they have fenced off the river and provided off-river watering points for stock so that they do not require access to the riparian zone. In total, 37 kilometres of fencing has been completed and this has protected the heavily timbered riparian zones and the native plants that thrive within them. Because David and Betsy protected their riparian zone from stock, they have focused tree planting efforts on other parts of their farm. Buffer zones have been planted to capture spray drift, protect crops from wind and create habitat for wildlife.

The riparian areas on the property include wetlands that fill after heavy rainfall and flood events. David and Betsy regard these areas as highly sensitive and manage them prudently to protect the birds, animals and plants that live in them. Evan Cleland conducts Bird Atlas surveys on three sites in the Macintyre Downs riparian corridor. Evan comments that the vegetation in the fenced riparian area is remarkable for its natural integrity and absence of exotic weeds, and that the bird life is rated 'normal' (of high conservation value). In the conditions imposed by survey rules, the area has a species rich strike rate with 68 species recorded in seven surveys averaging 21 species each. He reports that after two decades of careful management, the Macintyre Downs riparian zone is "in pristine condition, vegetatively superior than at any previous time of human occupation".

One of the riparian areas on-farm that has been protected for its biodiversity and aesthetic values. Photos Anne Sullivan.

Above: Natural regeneration since stock has been excluded.
Right: Betsy and David Turner. Photos Anne Sullivan.

Betsy and David have worked with their neighbours to protect their riparian areas, and there is an informal 'No Spray' policy between Macintyre Downs and the properties around it when the wind is blowing towards the river. This policy was initially implemented to protect the homesteads but it is now expanded to include riparian lands. Macintyre Downs also has a farm plan that contains all tail water on farm surge areas so that none of it leaves the property.

Buffer paddocks have also been developed between riparian areas and cropping country, with stock grazing these areas. These paddocks have no chemical inputs, and on the farming country, David and Betsy have begun trailing a biological farming program that seeks to further minimise chemical inputs. Employees on Macintyre Downs are required to undertake Farm Safe and Chemical Accreditation courses so that they understand how to safely use pesticides.

A final word...

"Everyone here on Macintyre Downs loves the river, loves fishing — it is their environment, their home — and they are very protective of it. We are all much better off in the long run by looking after our riparian zones." David and Betsy Turner

H Managing stock

Objective

To manage access and grazing of domestic stock in riparian land so that production is maintained without damage to the waterway.

Recommended management approach

Domestic stock, particularly cattle, favour riparian lands and if not managed carefully, will spend much of their time along streambanks and in the water. This results in the following problems:

- manure and urine going directly into the waterway. This contributes large quantities of phosphorus and nitrogen to streams. Under conditions of sufficient light, and increased temperatures (i.e. where riparian vegetation has been substantially cleared), this can lead to excessive growth of nuisance water plants and algae, including toxic blue-green algae;
- animal wastes are an important source of disease-causing bacteria and viruses. These may have significant effects on other animals that drink downstream. There is growing evidence from overseas studies that livestock drinking contaminated water show significantly decreased growth rates and lower productivity than those that have access to clean, uncontaminated drinking water. In addition, animal wastes fouling waterways above the catchments for dams and reservoirs, can significantly increase treatment costs for downstream users;
- over-grazing removes vegetation cover from the banks of waterways. This contributes large amounts of soil and nutrients to the stream during heavy rainfall as well as increasing streambank erosion and the consequent loss of productive land. Section B in this guide discusses the issue of bank erosion in more detail;

Stock reserve on Namoi River, riparian areas degraded and active erosion occurring as a result of continuous stock access. Photo Guy Roth.

- stock selectively graze the seedlings of some native species, preventing the establishment of new plants and resulting in the eventual loss of the species. This also increases the potential for weed invasion and accelerates the loss of habitat for wildlife. Ground covers, such as herbs, tufted grasses and tussock species, which help to slow overland flow and to trap sediments, can all be damaged or removed through trampling and excessive grazing; and,

- the disturbance created by livestock through grazing of plants and opening up of bare ground, together with increased nutrient levels from animal dung and urine, creates an ideal situation for the establishment of weeds. Weeds may also be spread directly by the animals, either through attachment to hair or skin, or through their manure. Troublesome weeds can also spread in the other direction, from riparian lands onto adjacent farmland.

These problems can be tackled without permanently excluding animals from riparian lands. Controlled access of stock in riparian lands takes a bit of planning and effort, but many landholders are discovering that significant payoffs can be gained by the increased production, improved water quality, stable streambanks and healthy riparian vegetation that results. There are three key approaches for dealing with stock, and these are grouped under fencing, watering points and managing grazing pressure.

Fencing

Fencing can be used to regulate animal access and grazing pressure on riparian land. It enables stock access to be managed according to need and available feed, and opens up opportunities for additional or alternative productive use of riparian lands, for example for forage production or agroforestry. The use of fenced riparian land as a living haystack is gaining acceptance as more and more landholders report that carefully-planned, strategic use of the feed available on riparian lands can have a significant benefit to profitability.

The type and location of fencing that best suits your needs will depend on your type of stock, when and how much you want to use the riparian land, the size and shape of the stream channel, flood frequency, and size of the flood peak. Riparian fencing needs careful planning, as flooding is a continual threat to conventional fence lines. Landholders and researchers have come up with several alternative methods to cope with these problems. Some of these are discussed below, and more-detailed information is available from government agencies, catchment management authorities, farm advisers and retailers.

1. When positioning the fence it is important not to place it too close to the stream. This makes the fence vulnerable to frequent flood damage, and the fence line may be lost if the waterway channel changes. It is better to place the fence line some distance from the current bank, generally at least 10–20 metres, as this means the riparian land can be used as a 'paddock' for stock. It also means the bends and curves of the stream can be cut out and this reduces the number of end-assemblies that may be required if you are going for a conventional fencing option.

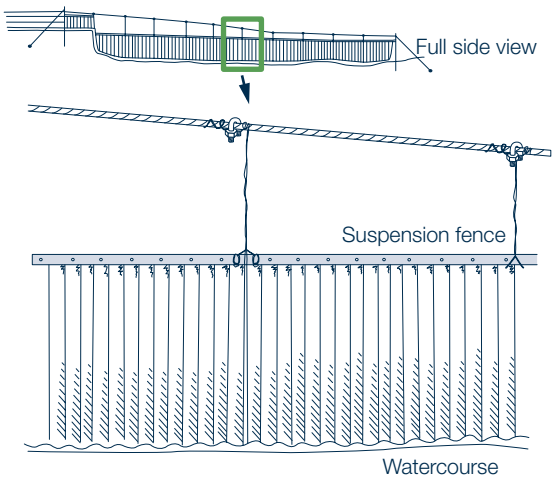
> There are many local government and community riparian fencing schemes that help to defray the capital cost faced by landholders.

2. Consider using different fence types depending on the section of riparian land being fenced.

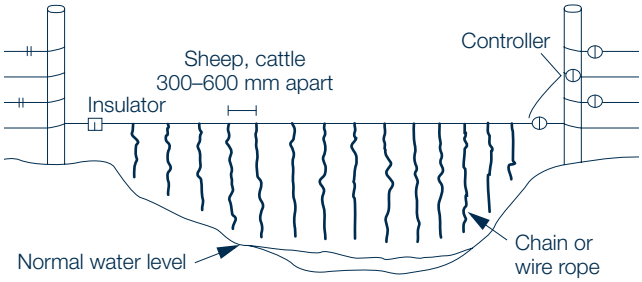
   - Hanging fences can be built across narrow streams so that animals cannot walk along the stream to bypass fence lines. Hanging fences are usually suspended from steel cable or multi-stranded, high-tensile fencing wire strung across the waterway. In order to prevent them being damaged or destroyed during floods, they have hanging panels which are designed to ride up with heavy flows and return to their normal position once the peak flow has passed. The hanging panels are usually galvanised iron or ringlock hinged across the cable. They may be damaged by debris coming down in a big flood, but the damage is usually not severe and the panels can cheaply and easily be repaired or replaced.

   - Electric fences can be used along and across waterways. An electric fence is not only much cheaper to construct, but it is much cheaper to repair following an unexpectedly large flood. Steel droppers will usually survive a flood unless hit by large debris, so it is often only the cost of a length of electric fencing wire that has to be covered. When placed across the stream a steel cable is used as a horizontal support, from which steel chains or hinged panels are hung. The chains and/or panels are separated electrically from the grounded cable, and all are electrified and able to move independently, allowing floodwater and debris to pass underneath. Portable electric fences are another option that allow landholders to control stock movement along streamsides, and have the added advantage that they can be quickly moved if there is advance notice of a likely flood peak.

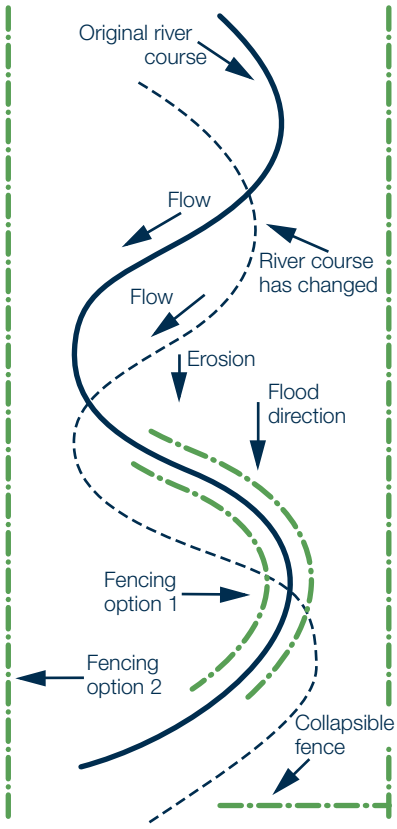
Design for hanging fence

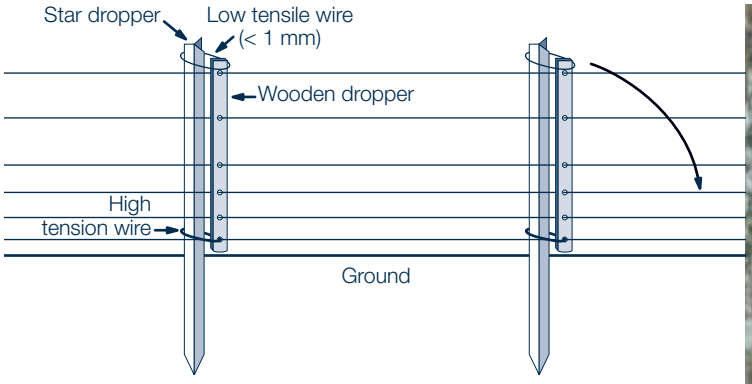


Electrified flood gate



What to consider when positioning a riparian fence line





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

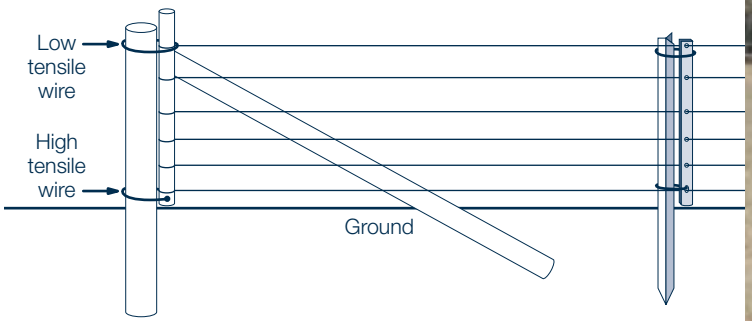
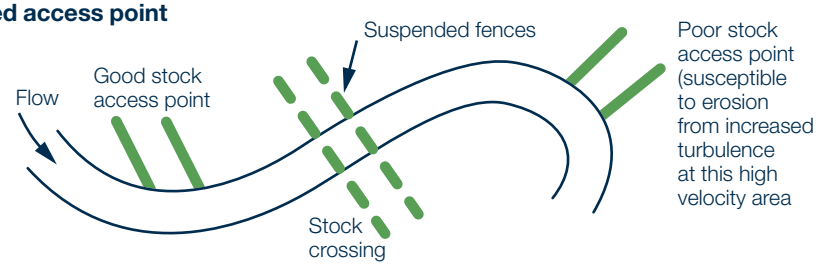


Photo Penny Van Dongen.

- Drop fences are designed to be either manually operated (dropped) before a flood, or to drop from their anchor points under the pressure of floodwater and debris. Once the floodwaters have receded, these fences are quick and simple to pull back up and reattach to their anchor points. They can also be dropped to allow stock or vehicle movement from one paddock to another without the need for expensive gateways.
- Electronic fencing has been developed overseas as an alternative to fixed fencing, particularly for cattle. The stock wear a receiver initially developed in the form of an ear-tag, and transmitter boxes are located to form a boundary between the riparian area and the rest of the paddock. The transmitters emit a continuous signal which defines the boundary. The ear-tags respond by producing firstly an audio signal, followed by an electric stimulus to the animal's ear if it attempts to enter the exclusion land. Tests have shown that cattle quickly get used to this form of fencing, which is cheaper than conventional fixed fences and can be moved quickly in the event of a flood peak. This type of fencing is under active development in Australia, with the aim of bringing the price down to a level at which it can be adopted widely.
- To minimise cost, and for ease of replacement following a flood, most growers in cotton districts have opted for either a three-strand electric or barbed wire fence. When using barbed wire, it is preferable to make the top strand a plain wire as it is used for perching by birds and bats and this will prevent unnecessary damage to wildlife whilst still controlling stock.

Where to site a formed access point



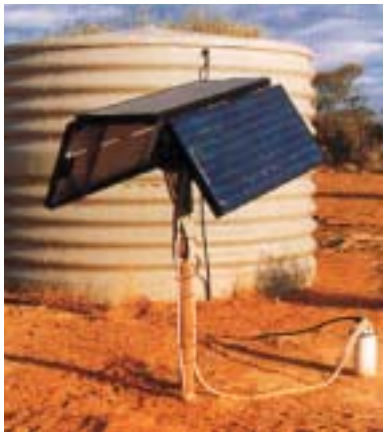
Watering points

Once a streambank has been fenced, you may need to consider providing alternative watering points. The siting of watering points and supplementary feeding stations can be used as an alternative to fencing to help manage stock access to streams. Much depends on the individual situation, but some landholders have demonstrated that by providing a shaded access point to clean water, or by providing a watering point closer to preferred pastures, they have been able to significantly reduce the amount of time stock spend in riparian areas without the need for fences. Some watering systems to consider are listed below.

1. Stock can be watered from a stream or river without undue damage to the bank if a formed access point is built at a carefully selected section of the channel. It is important to avoid boggy areas and the outsides of bends where flow speed is high and streambanks tend to erode. Cross-stream fencing may be required to prevent animals wandering along the streambank. A formed access point requires a graded slope into the stream. The surface of the waterway access point is then protected by using concrete, compacted gravel, logs or similar materials to form a walkway. It is important to consider likely changes in the depth of flow in order to make sure that access to water is available for as much of the year as possible.

2. Provide a water trough connected to a permanent water supply from a dam upslope, or through a reticulated water scheme. In the more-intensive industries, such as dairying, the number and layout of watering points is an important consideration in enabling and encouraging stock to maximise the use of available feed. In these situations, the time taken to walk down to the stream for a drink and back is considered by some landholders to be 'unproductive' time, with the cost of a reticulated water supply and better-sited watering points more than paying for itself through increased production.

3. Use an electric pump or windmill to access groundwater aquifers and water stock away from riparian lands. Such aquifers are often not far beneath the land surface, so that even a small-sized pump can provide sufficient water for a large number of animals. A range of pumps has been developed to use the flow of the stream itself to pump a small volume to a header tank and stock trough, with the tank providing a storage buffer. Solar pumps (as shown at right), which are becoming more cost-effective, are ideally suited to watering stock in remote areas.



3. continued.
   Another pump type, that is used more commonly overseas than in Australia, is a nose pump (at right) operated by cattle. As the animals drink from the pump bowl, they push against a lever, which in turn operates a piston and diaphragm and pumps more water from the stream. Their low cost and small number of moving parts has made this type of pump an attractive option.

Managing grazing pressure

When managing stock grazing on riparian lands, the aim is to maintain continuous ground cover, with enough vegetation to protect the soil surface from heavy rain and provide filtering and trapping of sediment. Vegetation also assists in keeping banks stable, as well as providing wildlife habitat. Your particular management objectives have an important bearing on how you manage grazing pressure on the riparian land. In general, timing, intensity and duration of grazing all need to be considered.

1. Grazing should be restricted, or prevented altogether, when plants are starting their annual growth cycle. Heavy grazing during this time can substantially weaken pastures and natural vegetation. Grazing should occur when plants are either dormant, such as in winter, or when there will be less impact upon plant growth, seed and root production. Vegetation should be spelled around the time of flowering and seed production in order to allow for continual replacement and maintenance of good vegetation cover. This is especially important for native species.

2. Grazing on riparian lands should be restricted or removed altogether during that period of the year when maximum rainfall is expected. This will help to ensure maintenance of a complete ground cover when the potential for erosion and soil loss is at its greatest. This is especially important for native species. Some growers have used cell-grazing methods, in which pastures are grazed hard for a short period and then rested for a longer period, to good effect in riparian paddocks. This approach may help to maximise use of the feed on offer, while allowing stock to be removed prior to flowering and seed set, or during the summer storm season when maximum ground cover is required.

3. Monitor the impact of grazing during the period when the animals have access to the riparian area. This will enable you to assess whether grazing intensity is too high or too low, and to move the stock before vegetation degradation becomes a problem. Grazing intensity can also be managed as a tool to reduce weed populations, or to reduce total plant material if fire management is an issue. The key to successful management of intensity is careful inspection and the ability to move stock elsewhere before damage occurs.

4. Do not continuously graze riparian lands as native grasses, herbs and shrubs will eventually die out, and be replaced by unpalatable, weedy species. Ideally, riparian lands need to be maintained so that a mix of species and quality feed is provided.

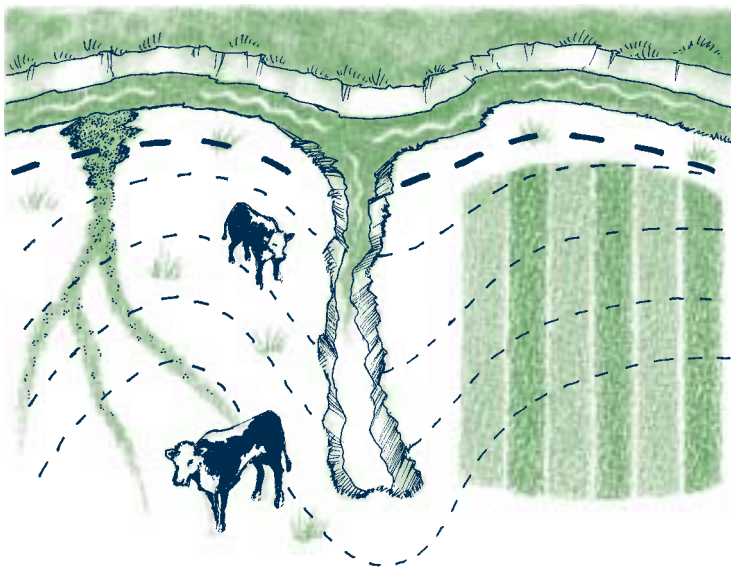
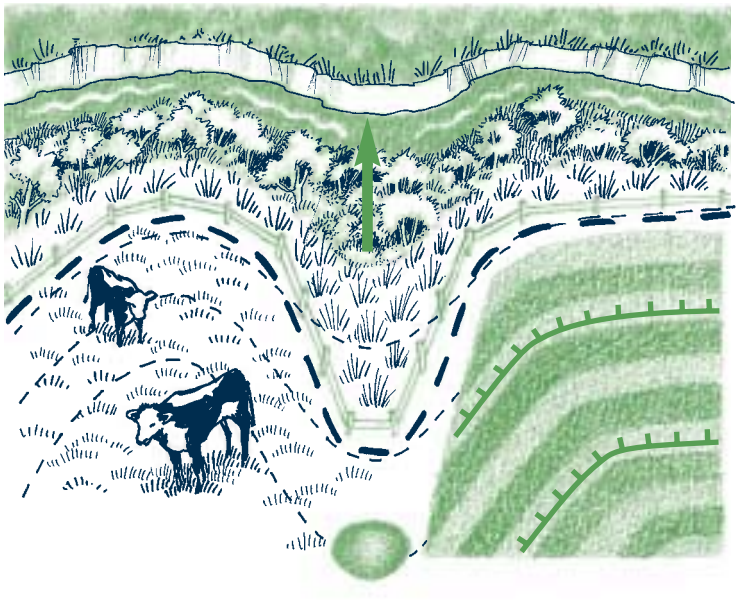


Figure 14: Comparison of poorly managed and well managed stock access to riparian areas.

Poorly managed
A degraded catchment and riparian land. Significant sediment and nutrient is derived from degraded pasture, poor crop management, unlimited stock access and gully erosion. Illustrations Carolyn Brooks.

Degraded pasture
Erosion gully
Cropland
Vehicle track
Contours
Stock tracks



Well managed
A combination of good on-farm management and good riparian land. Riparian forest provides ecological benefits and absorbs nutrients, variable width grass buffers trap sediment and stock access is controlled.

Riparian forest
Riparian grass buffer
Pasture
Cropland
Off-stream watering
Fence
Vehicle track
Contour banks
Contours
Concentrated flow

Self-assessment

Cotton growers can monitor the health of their riparian lands by ensuring that their farm plan includes measures to control stock access. Regular assessment of the riparian lands on-farm will enable cotton growers to time stock grazing so that the minimum damage is done yet productivity outcomes are still gained.

Collaborating to reduce stock access and protect riparian areas

'The Island', Wee Waa

By Annie Spora and Elizabeth Apuli

Forty kilometres west of Wee Waa on the Namoi River, is an area known as 'The Island'. The Duncan Creek branches off the Namoi and rejoins several kilometres later, forming a land structure of around 1200 acres. Until seven years ago, stock grazed this block, however, local landowners realising the damage that this practice was having on the area decided to make some changes.

Five landholders — Allan Radford, Jeff Carolon, Tim Grellman, Warren Hamilton and Gavin Opperman, whose properties border or include the area, collaborated with Landcare Australia to fence off the riparian zone in an attempt to prevent further damage and regenerate vegetation. A four-strand barbed wire fence was erected along both sides of the river and the creek to prevent stock from accessing the area. Landcare Australia sponsored the project by providing the funding and all the fencing materials. The initial labour was provided by a group of volunteers, with the landholders agreeing to maintain parts of the fence for the long-term. The project took three years to complete and resulted in 20 kilometres of fencing. Native tree species were planted in degraded areas and included Melaleucas, Eucalypts, Acacias and Casuarinas.

A final word...

"The fencing has been very effective at keeping the stock off the area and despite unfavourable weather conditions, vegetative regrowth can already be seen along the banks where it was thought to be permanently lost." John and Jenny Grellman

Photos Annie Spora.

Managing cattle, cotton and protecting waterways

Darryl Brooks — 'Elengerah', Warren

By Penny Van Dongen

Darryl Brooks is assistant manager of Elengerah, a property that is part of the Twynam Pastoral Company. He runs cattle in conjunction with his cotton enterprise, with stock grazing the blocks fronting the river. However, the damage being done by the stock led Darryl to start fencing off his riparian areas in an effort to protect the riverbank. So far, five kilometres of river frontage have been fenced, and Darryl plans to do two more paddocks in the future that will see 13 kilometres of the river protected. Landcare has provided the fencing materials through a native vegetation fencing project.

Darryl has used a permanent electric fence with two single wires, as he believes this will withstand flooding and minimise damage; it was also cheap to install and will be easy to replace if there is any flood damage. The electric fence is powered by a solar unit. It keeps the cattle out of the riparian areas, and prevents them crossing the river at low flow to the neighbouring property. Darryl uses a submersible pump with mains power to provide water from the river to troughs. All the riparian paddocks where there is significant risk of high flood flows will be taken out of the cropping program and sown to pasture and lucerne.

Stock fenced out of riparian areas and Darryl showing the solar unit and submersible pump used to water cattle. Photos Penny Van Dongen.

CASE STUDY H chapter three

Preventing stock losses and soil erosion

Vic Melbourne — 'Yarrall', Phil Norrie — 'Mollee'

By Guy Roth

Cotton growers and graziers Vic Melbourne and Phil Norrie manage their enterprises between Narrabri and Wee Waa. Between them they have fenced off 18 kilometres of the Namoi River from stock. They originally set out to prevent stock crossing the river at low flow and wandering on to neighbouring properties, but it didn't take them long to work out that the riparian vegetation improved significantly following the fencing. The country is flood prone, which is why good riparian vegetation coverage is essential to prevent soil erosion.

Vic and Phil generally use a two- or three-barb wire fence which is cheap to install and can be repaired easily if there is any flood damage. Stock get their water from watering points which in some cases are part of the irrigation system. Some supplementary grazing is possible in the riparian area so long as ground cover is maintained and the young trees are big enough.

Vic Melbourne looking at the fences he has built to prevent stock losses in the river. Photos Guy Roth.

CASE STUDY H

chapter three

Appendix A: A snapshot of Australia's cotton districts

Catchment management committees have developed integrated natural resource management plans (Blueprints in NSW) for all catchments in New South Wales and Queensland. They guide natural resources management investment by the community, State and Commonwealth in that region. Priority issues identified in these plans are eligible for funding under the Natural Heritage Trust (NHT), which includes Landcare and Rivercare, and the National Action Plan for Salinity and Water Quality (NAP) Programs.

These snapshots are included to provide growers with the opportunity to practice on-farm management strategies for rivers and riparian areas that are in line with over arching catchment planning in their region. Growers may also be interested in applying for funding under NHT or NAP for collaborative projects to tackle issues that are better addressed across a number of properties. Local catchment management committees will have copies of these plans, as well as information on how they are being applied across each cotton district. Catchment coordinators can also provide assistance with how to apply for funding. Regional vegetation plans may also be useful to refer to in New South Wales.

Area: Macquarie Valley

Catchment Management Plan

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

Points relating to river and riparian land management

Major threats include:

- declining surface water quality; and,
- degraded riparian and wetland ecosystems.

The Plan advocates the need to:

- manage flow regimes to minimise streambank erosion in all regulated river systems;
- establish and maintain perennial vegetated buffers along streams identified as being contributors of high nutrient loads;
- maintain and enhance slightly degraded native riparian vegetation and improve highly-degraded native riparian vegetation;
- reduce the impact of point source pollution;
- maintain the extent and health of nationally-listed and regionally-significant wetlands within the landscape; and,
- implement integrated management plans to increase diversity of native riparian vegetation and manage aquatic and riparian weeds and pests.

Area: Bourke

Catchment Management Plan

Western Catchment Management Plan 2002, Western Catchment Management Board.

Points relating to river and riparian land management

The Plan recognises that native riparian vegetation:

- improves water quality, river health and high productivity values;
- protects water bodies from pollution from overland runoff and strengthens riverbanks against erosion;

- provides food for bugs, habitat for fish and other animals;
- needs to be specifically managed to protect and enhance its values; and,
- needs to be repaired if degraded.

The Plan advocates the need to:

- maintain or improve the overall health of the rivers;
- modify impeding structures (e.g. weirs) to ensure flow of floods reaches important wetlands and floodplains;
- consider relevant floodplain management plan and floodplain and wetlands health when assessing floodplain cropping;
- consider voluntary management of priority sites leading to incremental improvement in riparian vegetation within ten years;
- work towards 100% compliance with regulations relating to point and diffuse source pollution;
- adopt current best management practice relating to pollution of waterways by agriculture and industry;
- manage extraction for irrigation to safeguard riverine ecosystems;
- develop water sharing plans; and,
- develop cost-sharing packages, incentives schemes and other opportunities to encourage adoption of best management practice.

Area: Namoi Valley

Catchment Management Plan

Namoi Catchment: A Blueprint for the Future 2002, Namoi Catchment Management Board.

Points relating to river and riparian land management

The Plan advocates the need to:

- maintain or improve the overall health of the rivers;
- develop water sharing plans;
- establish native riparian vegetation along both banks of rivers and streams in areas of high recovery potential to improve riverine ecosystem health;
- manage native riparian vegetation along all rivers and streams to maintain riverine ecosystem health; and,
- provide investment in on-ground works with cost sharing that improves riverine ecosystem health.

River assessment

Riverine Condition Assessment of the Namoi Catchment 2002, Department of Land and Water Conservation. This document found that:

- all sites located below Gunnedah and on the Liverpool Plains exceed the Electrical Conductivity (Salinity) ANZECC Guidelines for the Protection of Aquatic Ecosystems more than 90% of the time;
- total phosphorus concentrations are high across the catchment;
- turbidity levels increase downstream with changes related to changes in land use from grazing to cropping;
- pesticides are detected regularly in areas that are intensively cropped with herbicides being the most frequently detected; and,
- an average of 30% tree cover exists within riparian zones across the catchment.

Area: Gwydir Valley

Catchment Management Plan

Catchment Blueprint for the Gwydir Catchment 2002. Gwydir Catchment Management Board.

Points relating to river and riparian land management

The Plan advocates the need to:

- improve overall health of the rivers;
- manage river flow to sustain ecological function of riverine environments;
- maintain and improve water quality;
- prevent net increase in the rate of streambank erosion, bed lowering and sedimentation;
- maintain all existing native vegetation within the riparian zone and improve its condition;
- establish and maintain further native vegetation along creeks and rivers to improve extent and connectivity of existing riparian vegetation; and,
- introduce protective mechanisms for ecosystems, including wetlands outside current reserve system.

River assessment

Riverine Condition Assessment of the Gwydir Catchment 2001, Department of Land and Water Conservation. This document found that:

- turbidity levels increase with distance downstream, and these changes relate to changes in land use from grazing to cropping;
- pesticides are detected regularly downstream;
- total phosphorus concentrations are high across the catchment with none meeting ANZECC Guidelines for the Protection of Aquatic Ecosystems; and,
- an average of 30% tree cover exists within riparian zones across the catchment.

Water Quality in the Gwydir Valley Watercourses 2001, Gwydir Valley Irrigators Association.

This study places greater emphasis on the load rather than the concentration of substances that influence water quality and found that:

- flow is significantly higher at upstream sites;
- loads of salts and nutrients tend to be higher upstream of irrigated areas due to higher flows;
- most on-farm storages exceed water quality guidelines for turbidity except where there are high levels of vegetation to filter out particulate matter; and,
- recycling tailwater and containing tailwater and runoff on farms is effective in preventing sediment, salts and nutrients from entering river systems except in exceptional flooding.

Area: Macintyre Valley

Catchment Management Plan (1)

Catchment Blueprint for the NSW Border Rivers 2002, Border Rivers Catchment Management Board.

Points relating to river and riparian land management

The Plan advocates the need to:

- improve the overall health of the rivers;
- develop water-sharing plans;
- improve water quality;
- control streambank erosion, bed lowering and barriers to fish passage to improve water quality, in-stream habitat and in-stream stability;

- adopt a no-loss principle and retain existing native riparian vegetation;
- manage a proportion of native riparian vegetation for conservation and establish further native vegetation to improve extent and connectivity; and,
- provide incentives for work on in-stream requirements.

Catchment Management Plan (2)

'What the Community Wants', Catchment Management in the Border Rivers 2001, Border Rivers Interim Catchment Committee (covers NSW and Qld).

The Plan advocates the need to:

- implement water best management practice and raise awareness;
- ensure equitable water sharing and trading;
- review overland flow harvesting conditions;
- provide clearer understanding of water ownership;
- coordinate floodplain management incorporating responsible environment, economic and social development;
- educate community about benefits of responsible management of stock in riparian zone;
- provide incentives (by the government) for responsible management of riparian zone, including fencing; and,
- manage chemicals (includes pesticides, herbicides and artificial fertilisers) responsibly to minimise impact on catchment ecology and human health.

River assessment results

Riverine Condition Assessment of the Macintyre Catchment 2001, Department of Land and Water Conservation. This document found:

- increases in turbidity as move downstream from grazing to cropping;
- pesticides are detected regularly downstream;
- total phosphorus is high with none meeting ANZECC 2000 Guidelines for the Protection of Aquatic Ecosystems;
- many sections of river have poor flows; and,
- an average of 35% of tree cover exists within riparian zone across catchment.

Area: Darling Downs

Catchment Management Plan

Regional Natural Resource Management Plan, 2003 Draft under negotiation, Prepared by the Queensland Murray-Darling Committee Inc. in partnership with South West NRM and the Border Rivers, Maranoa Balonne, and Bulloo Catchment Management Associations.

This Plan updates the *1997 Queensland Murray-Darling Basin Natural Resources Management Plan* and provides direction for investment for strategic management actions to address the issues identified in the former plan.

In relation to riparian land, investments will be made in actions to:

- ensure target development for riverine and water quality meet community, state and commonwealth requirements defined by the NAP program;
- ensure sustainable production that minimises water impacts;
- stabilise aquifers in productive areas and modify groundwater allocation licences in areas experiencing groundwater decline to prevent further decline associated with over allocation;

- achieve on-going and measurable decrease in the movement of pesticides, nutrients and suspended solids off-site by major contributors in priority sub-catchments;
- identify locations of major contributors of pesticides, nutrients and suspended solids in the Border Rivers and the Warrego Paroo by 2006;
- support the development by local government of water management plans (including stormwater) that incorporate pesticide, nutrient and suspended solid reduction by March 2003 and implement plans by 2005;
- maintain current areas of biodiversity of wetlands;
- establish a comprehensive monitoring framework for water quality, riverine and floodplains from property to regional scale by 2004;
- involve 5% of the community in natural resource monitoring by 2004;
- identify strategic areas and develop coordinated riparian plans (identify good and bad) by 2005;
- identify the required water allocations for maintenance of fish passage, floodplain wetland connectivity (groundwater) and health of in-stream organisms by 2006;
- carry out at least 300 kilometres of riparian management works in priority areas each year from 2003 until 2008; and,
- coordinate floodplain flows that are affected by private and public infrastructure and land management practice by 2010.

Points relating to river and riparian land management

The Plan advocates the need to:

- protect and rehabilitate degraded rivers, wetlands and floodplains;
- conserve in-stream and riparian environments;
- monitor these habitats;
- monitor the various impacts on the biodiversity of riverine habitats;
- develop plans to manage water allocation, river flows and groundwater; and,
- carry out region-wide investigations on sediment; nutrient and pesticide loads and their impacts on floodplain, wetland and riverine environments.

Area: St George-Dirranbandi

As previous.

Area: Dawson-Callide

Catchment Management Plan

Central Queensland Strategy for Sustainability 2000, Fitzroy Basin Association.

Points relating to river and riparian land management

The Plan advocates the need to:

- maintain and enhance regional river health and water quality;
- ensure that management of the region's river systems sustains marine and aquatic resources;
- develop water quality and health targets and management systems that suit central Queensland and maintain the values of instream, riverine, estuarine and marine ecosystems;
- maintain and protect and enhance riverine areas and restore degraded riverine areas; and,
- improve the management of landscapes and land uses which contribute excessively to nutrients and sediment runoff into streams.

Area: Central Highlands

As previous.

Appendix B: Legislation relating to riparian land management on cotton farms

Riparian areas are places where land, water, vegetation and animals interact. This means that they are complex areas to manage, with this complexity reflected in the range of legislation that exists to regulate the management of different aspects of the landscape, including riparian lands. The following section covers the main pieces of legislation in Queensland and NSW that cotton growers need to be aware of when managing riparian areas on their farms, and highlights the implications of each one for day-to-day farm management.

Some Commonwealth legislation, for example, the *Environmental Protection, Conservation and Biodiversity Act 1999*, also applies to the management of riparian areas.

Queensland legislation

Water Act 2000

This is the principal legislation for the protection of the 'physical integrity' of non-tidal rivers, lakes, springs and their riparian environments. 'Physical integrity' relates to bed and bank stability, and associated water quality. The Act applies to all lands (Crown and private) defined as being within the high banks of a stream or lake, as well as imposing limited controls on lands outside of these features. The Queensland Department of Natural Resources and Mines (QDNRM) administers this Act.

The Act declares 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 (a parcel is a standard registered lot of land e.g. Portion XX) irrespective of the tenure or ownership of the parcels. As the terms 'bed' and 'banks' are difficult to define exactly, 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, however Figure 15 shows where the 'high bank' may be located in riparian areas within cotton districts.

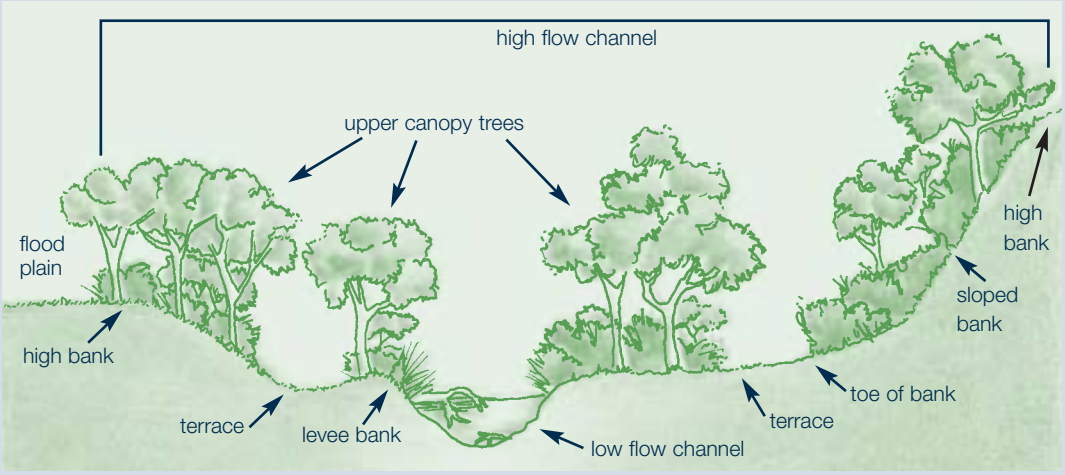


Figure 15: Location of the high bank for the purposes of the *Water Act 2000*.

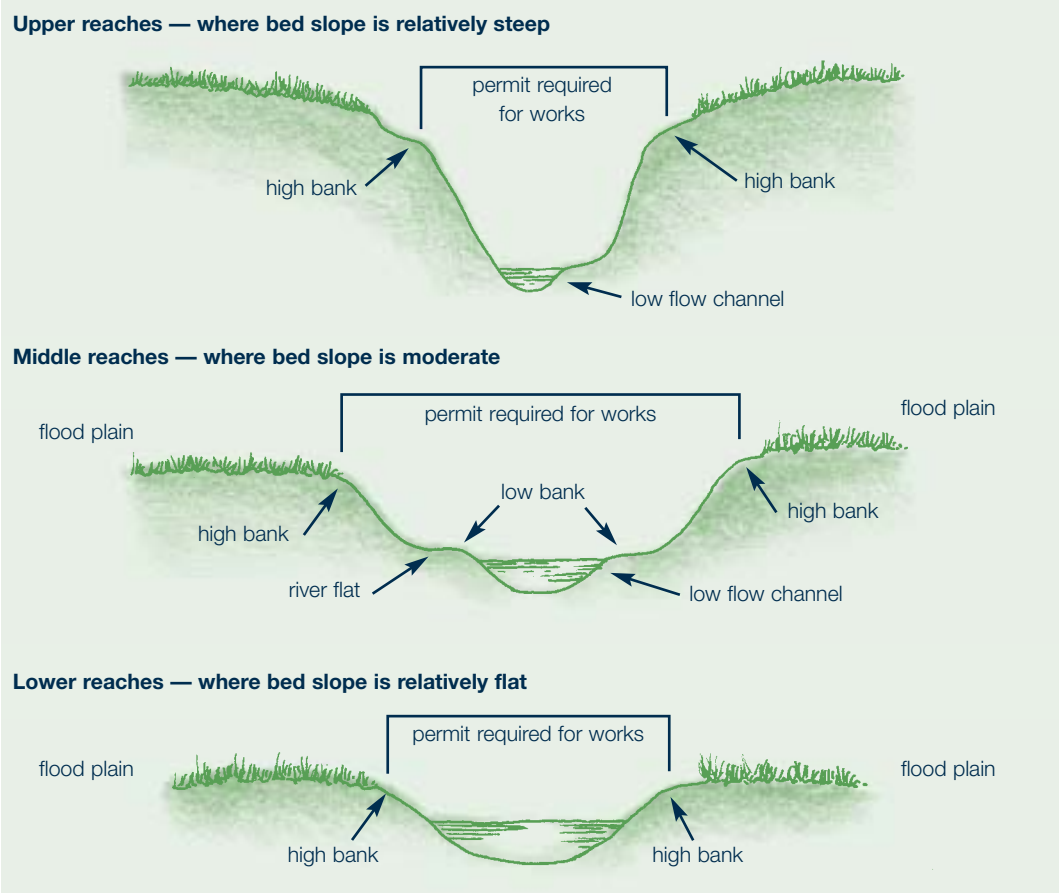


Figure 16: High banks as defined for the purposes of the *Water Act 2000*.

The Act also grants to the owner or occupier of lands adjoining a non-tidal boundary watercourse or lake, certain rights over the lands within the watercourse or lake to the water's edge. These include the right of access over that land for the person (including family, employees, agents and stock), the right of grazing on that land for the person's stock, and the right to bring action against trespassers. Effectively these 'riparian' rights provide exclusive use and enjoyment of these lands. However, the State retains the power to remove these rights by appropriating the lands in whole, or part, for a purpose under the Act (e.g. to construct a weir or other work).

Specifically, this Act provides for protection against disturbances that may adversely affect the stability of bed and banks of streams and 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 create an obstruction to flow. The protection of these areas is managed by QDNRM through a permitting system that has powers to issue 'stop work' notices.

Given the importance of this Act, a cotton grower intending to undertake an activity that will disturb the physical condition of a watercourse or a riparian area is required to first obtain a permit from their local QDNRM office. In assessing applications for permits, the QDNRM will consider:

- the season and how this may affect the impact of the activity on the river system;
- the possible effects of the activity on water quality;
- the reasons behind the grower wanting to undertake the activity;
- the long-term impacts on the sustainable use of the river system; and,
- the likely cumulative impacts on the river system that could accrue as a result of the activity.

These factors combined, will then be assessed by the QDNRM office and a permit issued, or not, depending on the potential impact of the activity on the river/riparian system.

Importantly, the Act also covers a number of situations that do not require a permit to be obtained. For example: riverine disturbances related to works licensed under other sections of the Act (e.g. installing a pump); to approved activities undertaken by River Improvement Trusts and electricity authorities (authorised removal of sand and gravel); and, to clearing undertaken in emergency situations such as fires. A regulation has also exempted authorised mining exploration and development activities, authorised clearing on leasehold lands (see the *Land Act*), and clearing of declared pest plants.

IMPLICATIONS: Before commencing any activity in watercourses or riparian areas that may affect bank and bed stability and associated water quality, contact the local QDNRM office to seek a determination on the location of the 'high bank' boundary. Once this is gained, the grower can apply to the QDNRM office for a permit to cover the activities they wish to undertake.

Vegetation Management Act 1999

This is the principal piece of legislation for the management of the State's native vegetation on freehold land. It seeks to secure the ecologically sustainable use of land, protection of biodiversity and other environmental and social values, as well as the prevention of land degradation and protection of water quality. Vegetation management on State (associated leasehold) lands is covered by the *Land Act 1994* (see below). The QDNRM administers this Act.

The following advice relates to how to work within the Vegetation Management Act and provides some useful steps for a grower to follow if they are seeking to clear a significant area of vegetation:

1. Find out your farm's 'Lot on Plan Number' also known as your RP number, this will be in your Rates Bill.
2. Telephone the local QDNRM office with this number and ask if this area falls within an area designated as 'Remnant Vegetation'.
   (a) Most farms will apparently fall outside of areas designated remnant. If the farm falls outside an area designated remnant, then the grower can proceed to clear the vegetation, as it is regrowth i.e. without the need for an approval.
   (b) Some farms will fall within areas designated as remnant. If the farm falls within an area designated remnant, the grower should request that a 'Vegetation Management Officer' from the QDNRM office visit the farm to verify that the vegetation is indeed remnant. This person may also be able to assist them develop a 'Property Vegetation Management Plan' that will need to be a part of the tree clearing permit application. The application fee will be $250.

This Property Vegetation Management Plan must be consistent with any approved Regional Vegetation Management Plan. In those cases where a Regional Vegetation Management Plan does not exist, policies exist under the Act that set out target objectives that will be used in the assessment of applications to clear native vegetation. The Property Vegetation Management Plan will be assessed against a set of codes that are used by the QDNRM to determine whether clearing can proceed. These codes cover requirements that watercourses and adjacent habitat are protected to maintain bank stability, water quality, aquatic habitat and wildlife habitat.

When preparing a Property Vegetation Management Plan for assessment, the Guides provided by QDNRM suggest that the requirements can be achieved if vegetation is retained in riparian areas of at least:

- 200 metres from each high bank of a river (stream order 5 and above — rivers more than 30 metres wide);
- at least 100 metres from each bank of a creek (stream orders 3 & 4 — streams 5–30 metres wide); and,
- at least 50 metres from each bank of a waterway (stream orders 1 & 2 — creeks or channels up to 5 metres wide).

Source: Queensland State Policy for Vegetation Management on Freehold Land: Explanatory Notes to Code.

The *State Policy for Vegetation Management for Freehold Land* contains information about the performance requirements and acceptable solutions that growers will need to meet when preparing their Property Vegetation Management Plan. This policy is worth having a look at, as it provides details about why the widths outlined above are recommended and what environmental outcomes they are designed to achieve. It can be found in full on the www.dnr.qld.gov.au website in the vegetation management section.

IMPLICATIONS: Before clearing native vegetation on freehold land, apply for a permit from the local QDNRM office. Ensure that your permit is accompanied by a Property Vegetation Management Plan that takes account of the key features of the Guides listed above.

Land Act 1994

This is the principal legislation for the management of State-owned (Crown) lands, including leases, reserves, etc. Over 70% of the land in Queensland is State-owned. The QDNRM administers this Act.

The Act places constraints on the clearing of trees in 'critical areas' on leasehold and other State-owned lands. Importantly, this includes riparian lands. A permit is required from the local QDNRM office to undertake clearing within a critical area, unless the clearing is for isolated trees as part of routine property maintenance, for example, replacement fence posts, etc. Local Tree Clearing Guidelines may also be available to assist in determining whether or not the proposed clearing will be authorised.

These provisions are secondary to the requirements of the *Water Act 2000* with respect to State lands within a boundary watercourse or lake.

IMPLICATIONS: If considering clearing trees or other vegetation on leasehold land within the watercourse or riparian area (as defined above), contact the local QDNRM office for a permit.

River Improvement Trust Act 1940

This Act provides powers for River Trusts, as established under the Act, to undertake works within streams for the purposes of flood mitigation and stream improvement or protection. The QDNRM administers this Act.

The Act does not provide River Trusts with powers to permit or control works undertaken by other bodies or persons. It does, however, give River Trusts the power to impose a notice on growers or other persons to prevent them from undertaking a work or activity that may be detrimental to the condition of a stream or may adversely affect the works of the River Trust. A notice may also be issued by the River Trust that requires a person to rectify damage caused by an activity. The notice binds successive growers. If the grower fails to comply with the notice, the Rivers Trust can undertaken the work and recover costs from the grower.

IMPLICATIONS: Prior to undertaking works in streams or river/riparian areas, check with any local River Trust that the activity is assessed as not being detrimental to the stream or operations of the River Trust.

Rural Lands Protection Act 1985

This is the principal legislation for (among other things) the management and control of certain pests and weeds in the State. Certain animals and plants can be declared in various categories under the Act for the purposes of control (destroy, reduce or contain). The QDNRM administers this Act.

For the control of declared plants and animals on private lands (freehold and leasehold), the bed and banks of a non-tidal watercourse forming the boundary of a land parcel are deemed to be part of that private land. The Act requires occupiers of private lands to control all declared plants and animals. A person failing to do so may be served a notice by the local government authority or State to control particular plants or animals, in specified areas and by a set time. If the notice is not complied with, the local government authority or State may carry out the work listed in the notice and recover costs from the person. A notice binds successors in title.

IMPLICATIONS: Ensure that farm plans cover the management of declared plants and animals, and that the management strategies proposed are approved of by the grower's local QDNRM office.

Fisheries Act 1994

This is the principal legislation for the protection and management of the State's fresh and marine fishery resources, including habitat areas. The Queensland Department of Primary Industries (QDPI) administers this Act.

A Fish Habitat Guides FHG 003 *Fish Habitat Buffer Zones* has been produced that specifies minimum buffer/riparian zone widths for specific functions (see Figure 17 overleaf). As a result, buffer/riparian zone performance criteria will vary on a site-by-site basis depending on:

i) the sensitivity of the adjacent fish habitat (e.g. the presence of a fish habitat area, or an important fish breeding, feeding, nursery habitat or migration route);

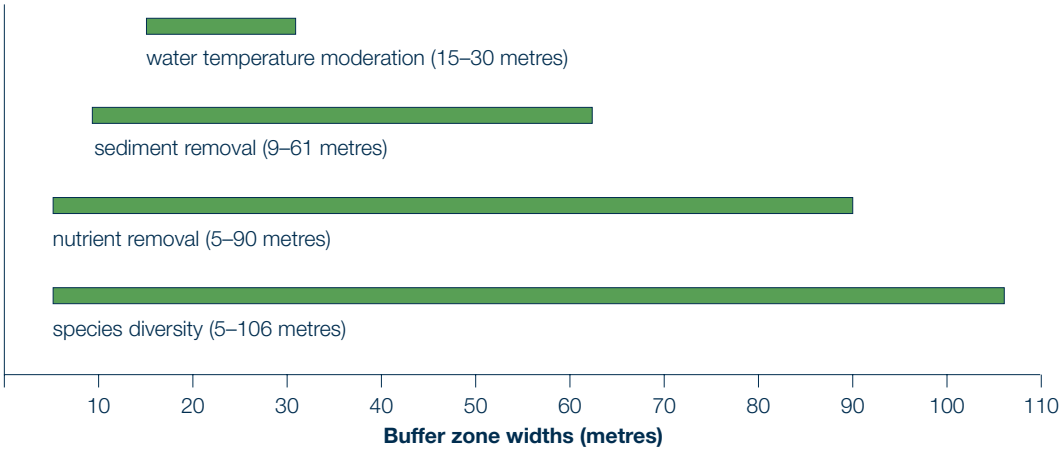
ii) the intensity of the adjacent land-use (e.g. intensive agriculture, grazing, residential, industrial or natural);

iii) the potential impacts of the adjacent land-use on fish habitats (e.g. smothering of important fish habitat due to erosion and sedimentation from land; algal blooms and low oxygen environments due to nutrient enrichment from land-based sources); and,

iv) site-specific characteristics including slope, soil types, erosion, vegetation type and cover.

As can be seen from Figure 17, the minimum buffer zone can be from 5–106 metres, depending on the function that it is performing. Fish habitat buffer zones of the different widths outlined above, can be declared by the QDPI to protect key marine and freshwater fisheries resources. Activities that may disturb such areas are, therefore, controlled by management plans and permits, and it is important to consult with the local QDPI office if the grower is intending to undertake operations in the watercourse or riparian area that could negatively impact upon particular fish species.

Figure 17: Range of (minimum) buffer widths for providing specific buffer functions.



Source: Bavins, M., Couchman, D. & Beumer, J. 2000, *Fisheries Guides for Fish Habitat Buffer Zones*, Department of Primary Industries, Queensland, Fish Habitat Guide FHG 003, p. 11.

IMPLICATIONS: Seek advice from the local QDPI office before undertaking any works in the river or riparian zone that could impact upon fish and fish habitat condition.

Nature Conservation Act 1992

This is the principal legislation for the conservation and management of the State's native flora and wildlife. Under this Act, areas can be declared 'protected', with management of these areas subject to approval. The Queensland Environment Protection Agency (QEPA) administers this Act.

A key goal of the Act is the preservation of endangered, vulnerable and rare species of flora and fauna. This can be achieved through recovery plans, conservation plans and voluntary conservation agreements. Riparian lands often contain these species. Many cotton farms adjoin declared parts of reserves or other protected areas. Farm plans and management practices should take account of the need to maintain the ecological health of these areas. This will require special care with farm operations such as pesticide application, use of fire and weed control.

IMPLICATIONS: Check with the local QEPA office about the occurrence of rare or threatened species in your area, and obtain a permit where necessary.

Environment Protection Act 1994 and Environmental Code of Practice for Agriculture

This is the principal legislation for protection of the State's environmental values. 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 (administered by QEPA).

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. It also provides power for the Agency to issue an environmental protection order on unauthorised activities. A complementary *Environment Protection (Water) Policy 1997* has also been developed, and this policy should be consulted as it seeks to maintain the environmental values of water, for example conserving aquatic ecosystems.

The Code of Practice outlines how farmers can manage their operations to comply with the general environmental duty of care established under the Act.

IMPLICATIONS: Prior to commencing activities in riparian lands, check with the local QEPA office to ensure proposed activities are not compromising environmental values and will not incur fines or prosecution under this Act.

Integrated Planning Act 1997

This is the principal legislation for land use planning by the State's local authorities. The Act provides powers for local authorities to declare and impose development constraints on growers and others within their jurisdiction. Operational works such as digging drainage canals and the extraction of sand, rock and gravel from rivers are also covered by this Act. In addition, the Act establishes an integrated development application assessment system that involves all State and statutory bodies with powers relevant to a proposed development. The removal of weeds is exempt from these requirements.

IMPLICATIONS: Prior to undertaking activities on riparian lands such as sub-division or construction of buildings, check with the local government agencies that there are no development constraints and that planning approval will be granted.

Chemical Usage (Agriculture and Veterinary) Control Act 1988.

This Act regulates the use of pesticides in order to reduce the risk of pesticide residues being found in food and fibre products above acceptable limits. It requires pesticide users to follow label directions to dispose of pesticides and pesticide containers in a way that does not harm people, property or the environment. There are particular legal responsibilities if using aerial sprays.

NSW legislation

For cotton growers in New South Wales the range of legislation impacting on riparian zone management is extensive. The following Acts are the most important for cotton growers to be aware of. When considering undertaking works in the riparian zone, it is important to consult with the relevant local departmental authorities that are responsible — the Department of Infrastructure, Planning and Natural Resources; National Parks and Wildlife Service; Environment Protection Authority and NSW Agriculture.

Water Resources Management Act 2000

This Act provides for the protection, conservation and ecologically sustainable development of NSW water resources.

The Act specifies:

a) that water must be provided for the fundamental health of a water source or dependent ecosystems as a first priority, above basic landholder's rights;

b) the arrangements for controlling land-based activities that affect water quality or quantity of water resources;

c) secure property rights including a framework for trading rights and compensation for change;

d) licensing of water users; and,

e) a planning process with locally representative water management committees and community input.

Water sharing plans provide a process for managing diversions in regulated and unregulated rivers and managing groundwater use to within the sustainable yield.

NB: The *Rivers and Foreshore Improvement Act 1948* has a soil conservation focus and forbids excavation and destruction of vegetation etc, in riparian zones. Riparian zones are defined as 40 metres back from top of bank (also any floodplain that could be affected). This has now been incorporated into the *Water Resources Management Act 2000* which is expected to be implemented by July 2003.

IMPLICATIONS: Contact Department of Infrastructure, Planning and Natural Resources before putting in any water storages. There are limits on the size of the storage and how much water you can capture on your property.

Protection of the Environment Operations Act 1997

This Act aims to protect the quality of the environment in NSW having regard to the need to maintain ecologically sustainable development. It 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:

- cause any substance to spill or leak in a way that harms or is likely to harm the environment;
- pollute waters or to permit waters to be polluted;
- dispose of waste in a way that harms or that is likely to harm the environment;
- transport waste to an unauthorised disposal site; and,
- the unauthorised use of land as a waste facility.

IMPLICATIONS: Contact your local New South Wales EPA office before undertaking any actions that could be ruled as an offence under the Act.

New South Wales Pesticide Act 1999

This Act aims to protect human health, the environment, property and trade in relation to the use of pesticides. It establishes a legislative framework to regulate the use of pesticides. The Act creates an offence for all off-farm damage to people, property, plant and animals. It is an offence to pollute waters — e.g. by runoff or drift. Polluting waters is defined very widely to include the 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 New South Wales.

IMPLICATIONS: The Australian Cotton Industry's Best Management Practices Manual refers to these Acts. Responsibility of pesticide users is summarised in the documents by the New South Wales EPA — Environmental Matters Leaflet No. 28, Pesticide Act 1999: Your Responsibilities. Copies are available from the EPA on telephone: 131 555.

Environmental Planning and Assessment Act 1997

This Act is the primary piece of land use and planning legislation in NSW. It allows for the creation, at various levels of government, of environmental planning instruments to control land use and planning. State environmental planning policies, regional development plans, local environmental plans, development control plans, and council codes and policies can all be established under the Act.

Local environmental plans are developed by local governments to control land use and planning in their municipality. They define the types of land uses that are permitted, discretionary or prohibited in a certain region and incorporate the requirements of relevant regional management plans that are developed under the *Native Vegetation Conservation Act 1997*.

Development control plans and council codes and policies can also be important, particularly if they are related to riparian management or the assessment of a development application. If a grower seeks consent for a proposed development, local government in accordance with any other relevant planning policies considers their application. If the proposed development might cause environmental harm, an environmental impact assessment is also necessary. In granting consent, a council can impose conditions that restrict specific activities (such as vegetation clearing) or that require certain activities to be carried out, such as management of the land for vegetation conservation. A process of integrated assessment of development proposals now operates to reduce the number of bodies from which consent must be sought.

IMPLICATIONS: Growers proposing works in the riparian area should first check with their local government agency to establish whether they require council approval.

Native Vegetation Conservation Act 1997

The Act allows for the preparation of Regional Vegetation Management Plans and also provisions relating to property managements. Under the Act, the Minister has the power to declare certain land to be State-protected land. This includes land that has a surface slope greater than 18°; land that is situated within 20 metres of the bed, bank or any part of a river or lake; and, any land that is environmentally sensitive, or affected, or liable to be affected by soil erosion, siltation or land degradation. Such land can only be cleared in accordance with a development consent that is already in force.

A person may clear native vegetation only in accordance with development consent or if permitted to do so under a Regional Vegetation Management Plan. The Act also provides that a landholder and the State Government can enter into a property agreement. This is a voluntary agreement that covers the management of vegetation on private land. The agreement may also enable the landholder to apply for financial assistance from the Native Vegetation Management Fund or to seek technical assistance.

IMPLICATIONS: Growers should familiarise themselves with the Act before starting any clearing of riparian vegetation. Fact Sheets covering the main features of the Act are available form state agency offices — these include 'An Introduction' summarising the Act, 'Regional Vegetation Management Plans' and 'Property Agreements'.

Willow clearing: Guidelines for applicants (NSW)

If you intend to undertake willow clearing on State Protected Land (for Riparian land this is 20 metres from the bank or any part of the waterway), you should arrange a pre-application site visit with a Departmental officer through the local Department of Infrastructure, Planning and Natural Resources office. The application form includes Best Management Principles for Willow Clearing. Appropriate conditions regarding the willow clearing proposal will be developed from this list by the Departmental officer where consent is to be granted for the clearing. The form also includes other useful references. Website: www.dlwc.nsw.gov.au/care/veg/pdfs/willowappl.pdf

Appendix C: For further information

There are many different organisations and community-based groups that provide advice and information on aspects of on-farm riparian management. Head office numbers have been provided in this list, and you are encouraged to call and obtain local office numbers for your district. A list of useful websites has also been provided.

State	Telephone	Website
Queensland		
Department of Natural Resources and Mines	(07) 3896 9506	www.dnr.qld.gov.au
Department of Primary Industries	132 523	www.dpi.qld.gov.au
Environment Protection Agency	(07) 3227 7111	www.env.qld.gov.au
Greening Australia	(07) 3902 4444	www.greeningaustralia.org.au
Queensland Landcare and Catchment Management: regional contacts provided		www.landcareqld.org.au
Waterwatch	(07) 3896 9625	www.qld.waterwatch.org.au
New South Wales		
Atlas of NSW Wildlife (contains sightings of plants and animals, not fish, on a regional basis)		www.nationalparks.nsw.gov.au/wildlifeatlas
Department of Infrastructure, Planning and Natural Resources – catchment blueprints	(02) 9228 6111	www.dipnr.nsw.gov.au
Environment Protection Authority	131 555	www.epa.nsw.gov.au
Greening Australia	(02) 9560 9144	www.greeningaustralia.org.au
NSW National Parks & Wildlife Service	(02) 9585 6444	www.npws.nsw.gov.au
New South Wales Agriculture	(02) 9372 0100	www.agric.nsw.gov.au
NSW Fisheries	(02) 9527 8411	www.fisheries.nsw.gov.au
Streamwatch	(02) 9228 6111	www.streamwatch.org.au

State	Telephone	Website
National		
Department of Agriculture, Fisheries and Forestry	(02) 6272 3983	www.affa.gov.au
Australian Cotton CRC	(02) 6799 1500	www.cotton.crc.org.au
Birds Australia		www.birdsaustralia.com.au
Bureau of Resource Sciences		www.affa.gov.au
Cotton Research and Development Corporation	(02) 6792 4088	www.crdc.com.au
CRC for Freshwater Ecology	(02) 6201 5168	www.crc.gov.au/centres/environ/freshwater
Department of the Environment and Heritage	(02) 6274 1111	www.ea.gov.au
Land & Water Australia	(02) 6257 3379	www.rivers.gov.au www.lwa.gov.au
Murray-Darling Basin Commission	(02) 6279 0100	www.mdbc.gov.au
National Plan for Salinity and Water Quality		www.napswq.gov.au
Natural Heritage Trust	1800 065 823	www.nht.gov.au
Weeds Australia	(03) 6344 9657	www.weeds.org.au

Appendix D: Scientific names for plants used in this guideline

Belah	*Casuarina cristate*
Berry Saltbush	*Rhagodia spinescens*
Bimble Box / Poplar Box	*Eucalyptus populnea*
Black Box	*Eucalyptus largiflorens*
Blakley's Red Gum	*Eucalyptus blakelyi*
Blue Mallee	*Eucalyptus gardenii*
Brigalow	*Acacia harpophylla*
Bull Oak	*Allocasuarina leuhmanii*
Butterbush	*Pittopsorum phylliraeoides*
Carbeen	*Eucalyptus tessellaris*
	Casuraina sp.
Chinchilla White Gums	*Eucalyptus agrophloia*
Cooba	*Acacia salicina*
Coolibah	*Eucalyptus coolabah*
Grey Box	*Eucalyptus microcarpa*
	Hakea leucoptera
Johnson Grass	*Sorghum halepense*
Kurrajong	*Brachychiton populneum*
Lippia	*Phyla canescens*
Mugga Iron Bark	*Eucalyptus sideroxylon*
Native Vetivia	*Vetiveria filipes*
Nogoora Burr	*Xanthium occidentale*
Old Man Saltbush	*Atriplex nummularia*
Phragmites sp.	
Queensland Cane Grass	We cannot use a generic scientific name because there are many different types
Red Bottlebrush	*Callistemon viminalis*
River Cooba	*Acacia stenophylla*
River Red Gum	*Eucalyptus camaldulensis*
Rough Barked Apple	*Angophora floribunda*
Sesbania Pea	*Sesbania punicea*
Silver Leaved Iron Bark	*Eucalyptus melanophloia*
Slender Knotweed	*Persicaria decipiens*
Swamp Oak	*Casuarina glauca*
Weeping Bottlebrush	*Callistemon salignus*
Western Golden Wattle	*Acacia decora*
White Box	*Eucalyptus albens*
White Cloud Tree	*Melaleuca bracteata*
White Primrose	*Ludwegia peploides*
Whitewood	*Atalaya hemiglauca*
Willows	*Salix sp.*
Yellow Box	*Eucalyptus melliodora*

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