MANAGING RIPARIAN LANDS IN THE SUGAR INDUSTRY

A guide to principles and practices

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Sugar Research and Development Corporation

Land & Water AUSTRALIA
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Acknowledgments

The authors have prepared this guide by bringing together information from many other documents and research reports. Where possible, these are referred to in the text, often as sources of further information. In addition, the following people have made major contributions to this Guide by helping to identify the crucial issues for cane growers in riparian management, and by providing specialist technical knowledge. Their support and assistance is gratefully acknowledged.

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Contents

ACRONYMS

BSES	Bureau of Sugar Experimental Station
QEPA	Queensland Environmental Protection Agency
GCTB	Green Cane Trash Blanketing
LWA	Land & Water Australia
QDPI	Queensland Department of Primary Industries
QDNRM	Queensland Department of Natural Resources & Mines
SRDC	Sugar Research & Development Corporation

DISCLAIMER

The information in this publication has been published by the Sugar Research and Development Corporation (SRDC) and Land and Water Australia (LWA) to assist public knowledge and discussion, and to help improve the sustainable management of land, water and vegetation in the sugar industry. These guidelines have been prepared from material drawn 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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Photo CANEGROWERS

1 PURPOSE OF THE GUIDE

The purpose of this Guide is to be a resource for people who work with the sugar industry to improve riparian land management on cane farms. Riparian land is important because it is economically and environmentally productive. The principles and practices contained within this Guide provide information and advice about how best to manage riparian land so that it can perform a number of different functions, depending on the situation and the cane grower concerned. Different management options are provided in the document, with the science underpinning these options given so that on-farm decisions can be made on the best available information. Overall, it is intended that the Guide be used to complement existing information on riparian lands management, as well as to form the basis from which other products and materials can be developed. For example:

- Codes of practice
- Workshops
- Fact Sheets on specific issues
- Presentations to landcare, farming and community groups
- Modules within best management practice guides and industry codes

All the material in the Guide has been prepared so that it is easy to modify and adapt to meet different needs, with diagrams and photographs used to illustrate the principles and practices discussed. Providing the original source of the material is acknowledged, reproduction and use of the document in other products is encouraged.

The Guide has been developed through collaboration between the Sugar R&D Corporation (SRDC), Land and Water Australia, CANEGROWERS, the Queensland Departments of Natural Resources & Mines (QDNRM) and Primary Industries (QDPI), and the Queensland Environmental Protection Agency (QEPA). It is recognised that today's best practice is unlikely to 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

Environmental legislation is undergoing significant change in all States where cane growing is an important industry. In response, growers are seeking practical information about new management methods that will maintain or enhance production, while also keeping the natural environment in good health. For example, the Queensland *Environmental Protection Act 1994* establishes a general environmental duty of care for everyone, including cane growers. To assist the cane industry, CANEGROWERS, with support from other organisations, developed a Code of Practice on *'Sustainable Canegrowing in Queensland'*. The aim of this Code was to give practical advice about on-farm activities that would minimise the risk of harm to the environment in the growing of sugarcane, and provide a means by which cane growers can comply with the general environmental duty under the *Act*. It was recognised that, over time, specific sections of that Code would be developed in more detail to provide an increased level of technical support and practical advice to growers in particular aspects of cane growing and land, vegetation and water management.

The independent environmental audit commissioned by CANEGROWERS in 1995, identified watercourse and riparian management as an issue of special interest to the industry. Cane is grown along much of the Queensland coastal plain and, increasingly, in mid-slope and tableland areas. In all of these, the cane industry is an important land use and operates in close proximity to watercourses and their adjacent riparian areas. As a result, the industry has a particular interest and responsibility in helping to maintain water quality and ecosystem health in those watercourses that are essential for other industries and catchment communities. Cane growers also have a long-term commitment to maintaining the natural resource base that underpins their industry, and many have a special interest in the importance of healthy waterways for freshwater and in-shore fish stocks.

Recent research has improved the understanding of riparian zone functions, and created an opportunity for cane growers to achieve environmental and economic objectives on their properties through the implementation of improved management practices. This Guide acts on the opportunity by drawing together scientific findings, tools and techniques that can assist cane growers to better manage the important, yet vulnerable, riparian zones that exist on their farms.

Review of this Guide

A review process should begin at the end of 2004 to assess whether this Guide is still appropriate for the industry, and to allow new information to be included in those areas where more is known about the on-farm management of riparian zones in cane growing regions.

2

Photo Ross Digman

THE IMPORTANCE OF RIPARIAN LAND

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 people improve and protect the health of riparian land (including associated waterbodies) on cane farms, as well as minimise the impacts of sugar cane farming on water quality, native habitats and other off-farm environments like, for example, the Great Barrier Reef. As a result, the definition used here is in terms of the roles – or functions – which 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.'

With this definition, riparian land includes:

- the land immediately alongside small creeks and rivers, including the riverbank itself;
- gullies and dips which sometimes run with surface water;
- land adjacent to drains and channels that empty into streams or wetlands;
- areas surrounding lakes;

- wetlands, billabongs and floodplains which interact with the river in times of flood; and
- vegetation dependent on groundwater supplied by a river.

It is important to remember that there is no single law of nature that defines the width of riparian land, or of buffer strips within riparian land, as it depends on their purpose. For example, the width required to trap sediment may be a fraction of that required to provide wildlife habitat, yet both are legitimate objectives for riparian management. The main aim of this Guide is to help people understand the basic requirements for sustainable management of riparian land. It also provides information about how these requirements can be incorporated into farm design, management objectives and cane growing operations.

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 generally has better quality soils than the surrounding hillslopes and, because of its position lower in the landscape, often retains moisture over a longer period.

Riparian land often supports a higher diversity of plants and animals than does non-riparian land. This is a result of its wide range of habitats and food types, its proximity to water, its microclimate and its ability to provide refuge. Many native plants are found only, or primarily, in riparian areas, and these areas are 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 stress, such as drought or fire, and also provides corridors for wildlife in highly-cleared landscapes.

From an in-stream perspective, vegetation on riparian land regulates primary production through shading; supplies energy and nutrients (in the form of leaves and twigs, fruits, terrestrial insects and other organic matter) essential to in-stream organisms; and provides essential in-stream habitat by way of large woody debris (branches and tree trunks that fall into the stream).

In addition to being productive, riparian land is often a vulnerable part of the landscape – being at risk of damage from cultivation, grazing, weed invasion, spray drift from chemicals, and natural events such as floods and fire. This combination of productivity and vulnerability means that careful management of riparian lands is vital for conservation of Australia's unique bio-diversity and economic productivity.

The interaction of land and water

There are many types of interaction between riparian land and adjacent watercourses. For instance, 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 agricultural land; and, riparian land can be a source of litter and insects that fall into a watercourse and become food for in-stream organisms. Operating in the other direction, insects that spend much of their life in the water may become food for land-based animals when they emerge. The interaction of land and water is depicted in Figure 1.

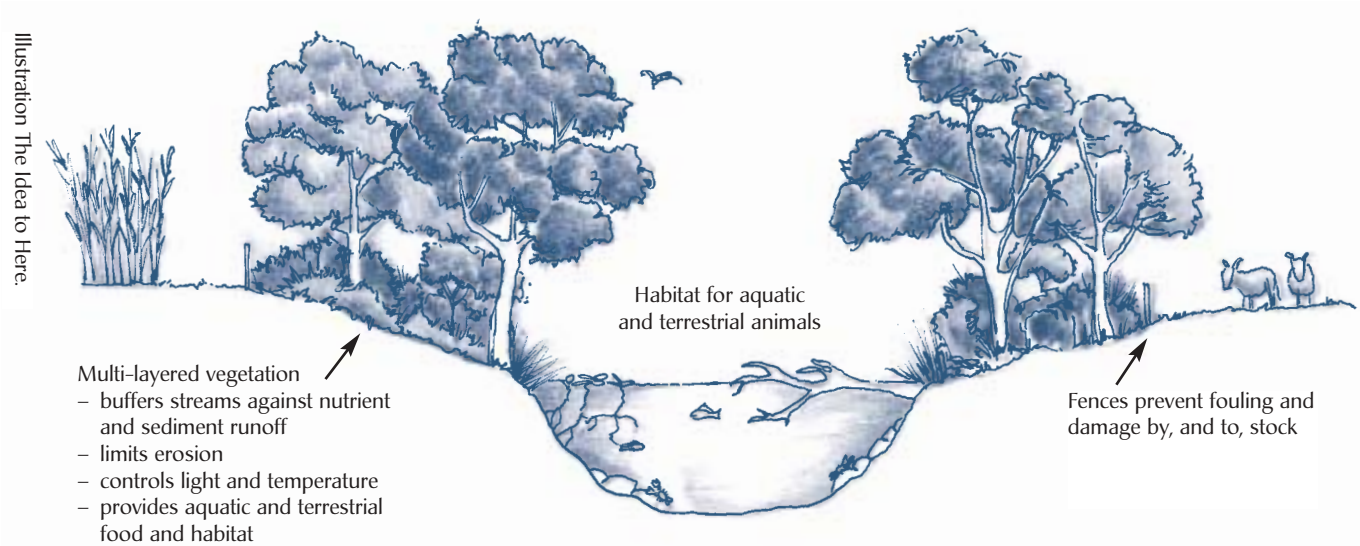


Illustration The Idea to Here.

FIGURE 1. Different functions performed by the riparian zone

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

- trap sediment, nutrients and other contaminants before they reach the waterways;
- reduce rates of bank erosion and loss of valuable land;
- control nuisance in-stream plants;
- control nuisance pests;

- help ensure healthy stream ecosystems;
- 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; and,
- provide recreation, and aesthetically pleasing landscapes.

Many of these benefits can only be achieved through careful riparian management.

Factors impacting on the condition of riparian land

Riparian land is a particularly dynamic part of the landscape. That is, it can change markedly – even under natural conditions. Fires, frosts, cyclones and floods can all have large impacts on riparian lands and result in major changes to channel position and shape, as well as to the surrounding vegetation.

Large scale clearing of vegetation has degraded riparian lands across Australia. Photo Siwan Lovett.

Human impact since European settlement is very noticeable on riparian lands, with large-scale changes in condition and health. In southern Australia, there has been the widespread removal of riparian vegetation for agricultural or urban development. Northern Australia is fortunate in that clearing has been less widespread, although there are many areas where most natural vegetation (including riparian vegetation) has been removed, especially along the coastal lowlands.

The degradation of riparian land is often associated with the removal of native vegetation; the impact of this is discussed in detail in Chapter 3. The major impacts are summarised as follows:

- Removal of riparian trees increases the amount of light and heat reaching watercourses. This favours the growth of nuisance algae and weeds, and can completely change the in-stream ecosystem to one that no longer supports native fish and other animals. Excessive in-stream weed and algal growth can trap bed sediment, leading to blockage of the channel and a reduction in its capacity to convey flood waters.
- Under natural conditions, trees occasionally fall into watercourses, creating woody debris – an important habitat for animals and plants living in the stream. Removal of this debris and of the source of large branches and trunks disrupts these in-stream ecosystems by reducing habitat for fish, crustaceans and other animals.
- Continuation of agriculture to the top of streambanks increases the delivery of sediments and nutrients to watercourses. Large volumes of fine-grained sediment smother in-stream habitat and 'clouds the water', while increased nutrients stimulate weed and algal growth. Increased sediment and nutrient load also affects estuarine and marine life beyond the river mouth.
- Removal of riparian vegetation and death of its protective root systems destabilises streambanks, often resulting in large increases in channel width, channel incision and gully erosion. This erosion of the channel often delivers more sediment to streams than does human activity on the surrounding land. Significant areas of valuable agricultural land can be lost, and water turbidity is increased.
- Removal of vegetation throughout the catchment can lead (and has led) to raised water tables and salinisation of land which, as salt levels increase, drains into rivers and streams and results in saline watercourses.

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

- Alteration of water movement (through the imposition of dams, weirs and pumps directly within streams) can severely affect in-stream populations and the capacity of the watercourses to carry flow. Reduced flow below dams, rapidly changing water levels due to dam releases, and cold water from deep off-take points, all reduce the health of riparian vegetation and in-stream plants and animals.
- Sand and gravel removal, channel straightening, and construction of levee banks and drains, can all result in channel incision and head-cutting which, in turn, increases bank height and slope, and leads to increased erosion rates, loss of agricultural land and damage to infrastructure such as roads, bridges and buildings.
- Uncontrolled access by stock to riparian areas leads to grazing and trampling of vegetation, breakdown of soil structure and contamination of the water with nutrient-rich urine and faeces.
- Altered fire regimes and invasion by exotic weeds also degrades riparian land.
- Urban development, common in coastal catchments, is also a major influence on water quality and the condition of riparian areas.

The impacts of these disturbances are not only cumulative; they exacerbate each other. For example, clearing riparian vegetation from tributary streams multiplies, many times, the impact of increased nutrients. This is because clearing also provides the light and higher temperature conditions needed to enable nuisance weeds and algae to flourish in the stream and to dominate the in-stream ecosystem.

Current status of riparian land in cane districts

The condition of riparian land and its vegetation is quite variable across the cane districts of Australia. In many districts, particularly on the coastal lowlands that were cleared a long time ago for cane production, nearly all the natural riparian vegetation has been removed. Sometimes this was done to maximise the land available for cane production, sometimes to provide ready access for machinery operations, and sometimes in the (often mistaken) belief that removing the riparian vegetation would improve drainage from paddocks and assist the removal of floodwaters. The farming practice of burning cane prior to harvesting also negatively impacted on riparian zone vegetation.

In most areas, the cleared creek banks have become colonised by grasses, particularly the invasive exotics Para Grass and Hymenachne that is capable of growing into streams, trapping sediment and smothering all in-stream life. The banks themselves may be undercut as the exotic grasses are shallow-rooted compared to the natural riparian woody vegetation. Periods of catastrophic creek widening have occurred during major flood events because the channel is choked by in-stream weeds and can no longer carry flood flows. The movement of sediments into these creeks, and its stabilisation by in-stream weeds, has reduced the capacity of many channels to convey flood flows. As a result, flooding is now more extensive and flood waters fail to drain quickly.

In some areas, the use of Green Cane Trash Blanketing (GCTB) has reduced the loss of sediments into waterways. However, this does not lead to the removal of sediment that has already been deposited. It has been shown that the leaves of cane plants and Para Grass contain different chemical structures to those of native species, and these cannot be easily used in the native food chain. For these reasons, many of the coastal lowland creeks have limited in-stream life, or no longer support their former role of nursery habitats for breeding and early growth of fish species, both freshwater and in-shore. For these established cane lands, the highest priority is often to replant natural riparian vegetation to reintroduce shade, and try to regain some of the important natural functions of these streams.

In areas back from the coastal lowlands, where land slope and stream flow rates are higher, the highest priority may be in stabilising banks and reducing loss of valuable cane land. Belts of riparian vegetation have been left in some of the lands developed more recently for cane growing, and it is important to ensure their health is not compromised by inadvertent drift of herbicides or fertiliser, machinery access or unplanned fires.

In established cane lands, it will be expensive to restore riparian land functions that have been lost through past land management practice. As a result, it is especially important to identify priorities so that growers that devote time and resources to riparian restoration can be assured of beneficial outcomes. In developing new lands, the situation is quite different. In this case, careful identification of riparian areas (including wetlands), and planning for their integration and ongoing management in the design and development of cane farms, is a cheaper alternative than restoration. This type of planning needs to be done at the level of individual farms. For other objectives, where it is important for neighbours to act together (e.g. in stabilising streambanks, reducing exotic weeds or providing wildlife habitat), planning needs to be done at a local and catchment area level as well.

Government agencies, researchers and industry representatives believe the best results will flow from the involvement of individual growers and grower groups in these planning exercises, as this is the only way to ensure that cane growers' practical needs are understood and incorporated. Grower involvement also demonstrates the industry's recognition of, and commitment to, best practice in environmental management.

Planning as the key to sound riparian management

It is clear from this brief introduction to riparian management that there is much that cane growers can do to help improve the health of on-farm watercourses. Careful planning is the key to achieving this while also improving production and profit, or at least minimising any costs to production.

Riparian areas need to be highlighted within the Farm Plan as requiring special management strategies that take account of the mix of land, water, vegetation and fauna issues. In this way, a Farm Plan provides the cane grower with one document that can be assessed by the relevant authorities (QDNRM, QDPI, QEPA, River Trust and local government) as

Riparian lands are where land and water meet. Photo Siwan Lovett.

meeting the particular legislative requirements over which they have control. A Farm Plan is a 'living' document that can be updated and modified as regulations change and new management strategies are developed. An approved Plan, and sound management flowing from it, will provide a high degree of certainty and protection for cane growers. The QDNRM also requires a land and water management plan to be produced if the crops are to be irrigated.

When applying for a new Cane Production Area or an expansion of existing cane area, a Farm Plan needs to be supplied with the application. This Plan, which will include identification and management of riparian areas, may be a requirement of the local Cane Assignment Committee. Established cane farms are also required to have a Farm Plan. By using a Farm Plan that takes account of the particular requirements of riparian areas, the grower can address legislative requirements (see Appendix A), and ensure that they do not incur penalties. There are plenty of people that can help to develop and assess Farm Plans, for example in Queensland, local CANEGROWERS, QDNRM, QDPI, QEPA, BSES and local government offices have staff that can assist growers to develop and use their Farm Plan (see page 86 for more contacts in other States).

Costs and benefits of riparian management

It is not possible to provide definitive data on the costs and benefits of riparian management because they will vary markedly according to the objectives and situation of individual growers. However, some estimates of costs are provided on the following page.

On-farm benefits, such as reduced herbicide use or less tractor/operator time for mowing ground areas, are relatively easy to calculate. Off-farm benefits, such as improved water quality or healthy ecosystems, are much more difficult to value in dollars. Many of these benefits are shared by neighbours and the wider community, and this is justification for different forms of grants or incentives to assist growers with riparian management. Several Shire Councils, River Trusts and other groups, provide assistance with watercourse stabilisation, revegetation and related works.

Some examples of costs (see also Chapter 3, Section H) are:

Costs	$ per 100 metres of watercourse bank
Revegetation	
Site preparation	$360.00
Replanting with tubestock	$1650.00
Annual maintenance (first two years)	$250.00 per annum
Gully rehabilitation	
Earth works (e.g. to batter banks)	$60.00–$90.00 per hour
Construct diversion banks	$35.00 per metre
Silt traps	$500.00–$2000.00
Rock chute	$500.00–$4000.00
Grass buffer strip, 10 metres wide	$1.50–$3.00 per metre
Fencing	$0.70–$3.00 per metre

Grants, incentives and taxation deductions may be available for these items.

Some examples of benefits are:

Benefits	$ per annum
Reduced use of herbicides	$100.00–$500.00
Increased crop due to less cane rat damage (100 x 20 metre block)	$225.00
Reduced flood or waterlogging damage	$2500.00

Source: figures calculated from *Is there a rat in your hip pocket?* and *Nutrient Management Guidelines* (see References for details).

Photo CANEGROWERS

3 PRINCIPLES AND PRACTICES FOR RIPARIAN LAND MANAGEMENT

The table on the following page draws together the recommendations that have been made throughout this chapter for managing the riparian zone to meet different objectives. It can be used as a mini-index for the contents of this chapter. It also provides a clear distinction between the development of new cane farms, where the aim must be to achieve legislative requirements and best practice, and existing cane farms where the objective is to improve riparian management to the greatest extent possible within existing layout and farming operations.

TABLE 1: Management objective and riparian width to be retained

Management objective	Riparian width to be retained	
	New cane farm (intact riparian vegetation)	Established cane farm (disturbed/cleared vegetation)
PAGE 17		
A. Trapping of nutrients and sediments	– 25m riparian zone retained on small creeks with slopes approaching or exceeding 5% – larger widths along wider streams: see Vegetation Management Act 1999 – where significant risk of trash and/or soil moving through paddock exists, incorporate a 6 metre grass buffer strip between the cropped area and the retained riparian vegetation	– 3–6 metre grass buffer strip on riparian land with a slope of less than 5% – where the shape of the land or other features are likely to concentrate overland flow, then the width of the buffer strip must be proportionately greater
PAGE 29		
B. Watercourse and channel stabilisation	– leave intact riparian zone from the low water level up to the top of the bank, and then for a minimum of 25 metres – wider zones of riparian vegetation may be needed to stabilise streambanks on outer bends that are more susceptible to erosion	– dependent on scale of stabilisation problem. Different revegetation stabilisation approaches may require different riparian widths
PAGE 40		
C. Chemicals	– retention of riparian vegetation of at least a 25 metre width, comprising trees, shrubs and other understorey, will help to reduce unwanted movement of chemicals	– revegetation and rehabilitation of riparian vegetation should focus on a minimum of 10 metres to reduce unwanted movement of chemicals
PAGE 44		
D. Drains and farm watercourses	– focus on management, treatment and possible re-use of drainage waters, both surface and sub-surface	– focus on management, treatment and possible re-use of drainage waters, both surface and sub-surface
PAGE 51		
E. Temperature and light	– try to retain full shade on the stream or waterway – depending on the type of vegetation, a 25 metre strip will be sufficient	– northern banks of east–west oriented streams should be priority. Minimum of 10 metres should be revegetated to shade waterways/channels
PAGE 56		
F. Land and water habitats	– minimum width required is 25 metres to protect in-stream habitat – land based habitats require 50–200 metres at least	– minimum width required is 10–15 metres for in-stream habitat – land based habitats require 50–200 metres at least
PAGE 61		
G. Managing cane rats	– minimum widths of 25 metres should be retained to provide habitat for predators of cane rats and shading out of grasses	– minimum widths of 10–15 metres to provide habitat for predators of cane rats and shading out of grasses
PAGE 66		
H. Riparian vegetation	– protect intact riparian vegetation and provide for continuous wildlife corridors along waterways. Riparian widths should be a minimum of 25 metres	– in developing revegetation strategy different approaches may require different riparian widths. Minimum width should be 10 metres
PAGE 77		
I. Flooding	– natural riparian vegetation along channels should be retained to a minimum width of 25 metres in developing revegetation	– different approaches may require strategy different riparian widths. Minimum width should be 10 metres

A. TRAPPING OF SEDIMENTS AND NUTRIENTS

Objective

To minimise the amounts of cane trash, eroded soil, nutrients and other contaminants entering watercourses where they reduce water quality and stream health.

Management principles

Under natural conditions, soil particles, nutrients and vegetation debris can be transported from adjacent land to waterways in run-off. Movement in surface flows is an important pathway along the wet tropical coast with its periodic, high-intensity rainfall events. Dissolved nutrients, organic materials and other contaminants can also move through soils in sub-surface flow, and enter streams along bank faces or even beneath the water level in what is known as 'base flow'.

Agricultural development, particularly intensive agriculture such as cane growing, where large quantities of fertiliser are used and where soil cultivation is practiced, can increase the potential for soil, nutrients and other contaminants to enter waterways. For example: when 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. Areas where surface flow is concentrated, such as in shallow depressions or gullies in the landscape, will make this problem worse. If soil protection practices are not used, annual soil loss can be a serious risk in areas like the coastal canelands of Queensland that experience extreme rainfall events. Research conducted in these regions has shown that in the past, large quantities of soil have been lost from paddocks, with much of this now being located as sediment within adjacent watercourses (Prosser et al. 2000). This sediment is now stabilised by the in-stream growth of nuisance plants such as Para Grass and Hymenachne.

The use of GCTB methods in some regions has led to large reductions in soil loss. However, losses of cane trash, as well as soil and attached nutrients, into watercourses can still be significant in periods of intense rainfall. It has long been known that carefully maintained riparian vegetation cover can be very effective in trapping soil and nutrients from up-slope agriculture before they enter streams. Recent experimental work in Australia has shown that a well-maintained grass buffer strip can be highly effective at trapping sediment and the nitrogen and phosphorus attached to it,

removing these contaminants from surface flows. In southern Australia, on land with a 5% slope, a 6 metre wide grass buffer strip can trap and hold soil loss equivalent to about 10 tonnes/ha/year. Of the grass species examined to date, many have the ability to then grow through and stabilise the trapped sediment, gradually developing a small levee bank along the watercourse. In some cane growing districts, such levees have formed naturally, and perform valuable functions in time of peak stream flow.

The situation will be somewhat different in most cane growing regions of Queensland, where rainfall intensities are often much higher than in the south, and may be combined with erodible soils. The main variables that determine how wide a grass buffer strip must be to effectively trap sediment and nutrients are:

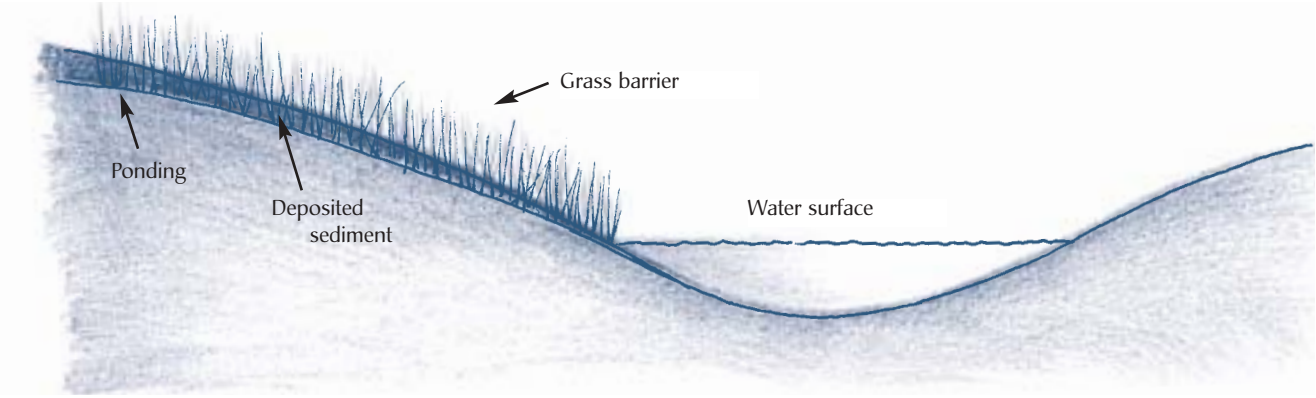


FIGURE 2. How a grass buffer strip functions to trap sediment Illustration The Idea to Here.

Green cane trash blanketing can reduce soil losses. Photo CANEGROWERS.

- land slope;
- soil characteristics (erodability);
- land use and management practices; and
- rainfall intensity.

These factors have been brought together in the publication *Guides for Riparian Buffer Strips for Queensland Irrigators* (which is available from the CSIRO website www.csiro.clw.gov.au). Table 2 and Map 1 have been reproduced from this publication to assist growers and others to determine the appropriate width of a grass buffer strip. The table refers to shallow surface flows; where water containing sediment is concentrated in dips and depressions, the grass buffer widths would need to be substantially increased.

TABLE 2: Indicative soil losses and design of grass buffer widths for the bio-geographical regions of Queensland, for varying rainfall erosivity, soil erodibility, slope and land cover

Region and annual rainfall (mm/y)	Rainfall erosivity[1]	Soil erodibility[2]	Slope[3]	Expected soil loss[4] (t/ha/y)	Buffer width (m)	Perennial crops soil loss[4] (t/ha/y)	Buffer width (m)
Wet tropics 800–5000	high	medium	low	17	7	1	2
			medium	41	26	2	2
			high	74	>30	4	2
		high	low	25	15	1	5
			medium	61	>30	3	5
			high	112	>30	6	7
	very high	medium	low	29	15	1	2
			medium	71	>30	4	2
			high	130	>30	7	2
		high	low	44	27	2	5
			medium	107	>30	5	7
			high	195	>30	10	10
	extreme	medium	low	38	20	2	2
			medium	92	>30	5	2
			high	167	>30	8	2
		high	low	57	>30	3	5
			medium	138	>30	7	7
			high	251	>30	13	12
Burdekin 500–1200	high	low	low	8	2	0	2
			medium	20	13	1	2
			high	37	24	2	2
		medium	low	17	7	1	2
			medium	41	26	2	2
			high	74	>30	4	2
		high	low	25	15	1	5
			medium	61	>30	3	5
			high	112	>30	6	7

Table 2 continued over

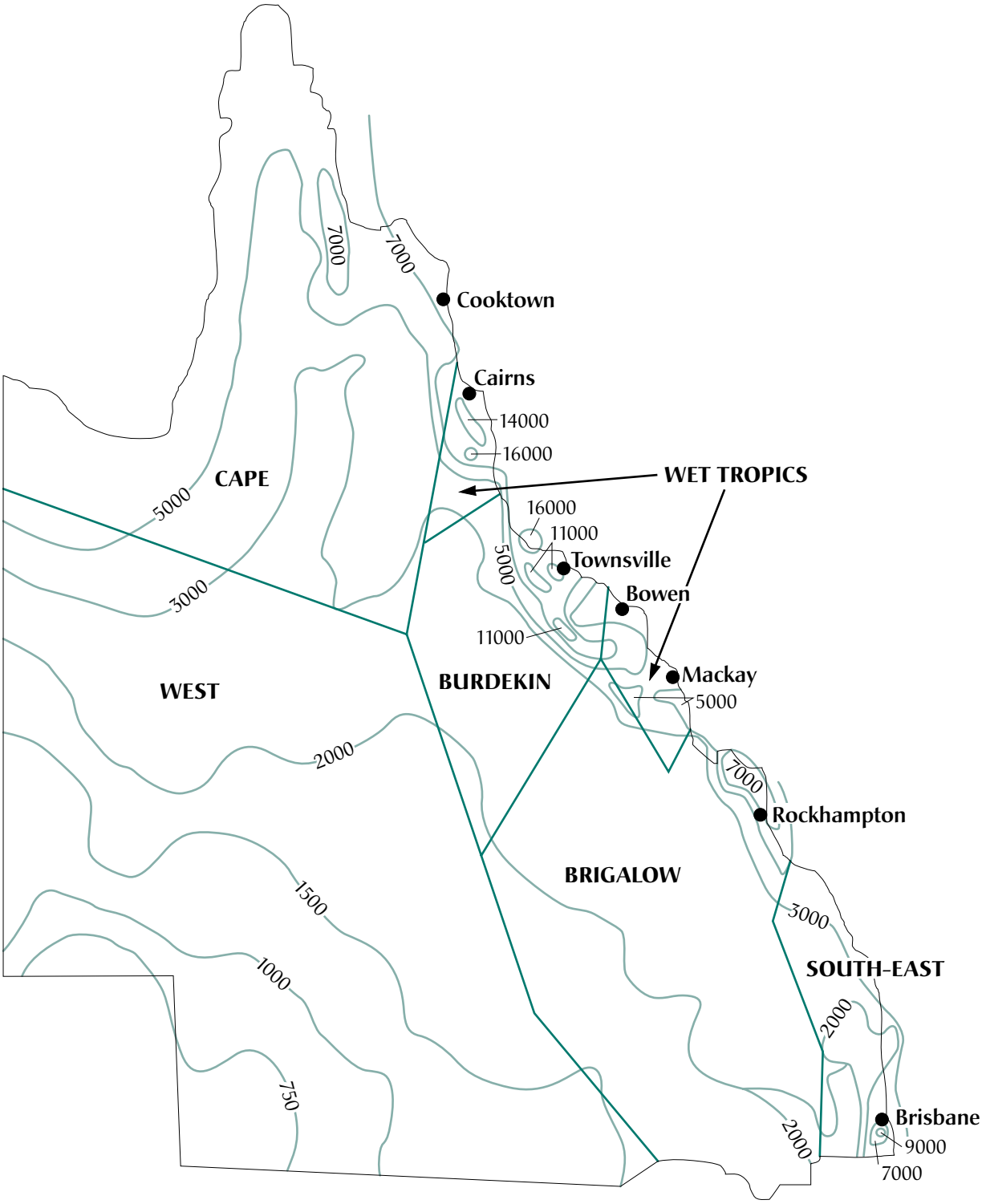
Region and annual rainfall (mm/y)	Rainfall erosivity[1]	Soil erodibility[2]	Slope[3]	Expected soil loss[4] (t/ha/y)	Buffer width (m)	Perennial crops soil loss[4] (t/ha/y)	Buffer width (m)
Burdekin 500–1200	very high	low	low	15	5	1	2
			medium	36	23	2	2
			high	65	>30	3	2
		medium	low	29	15	1	2
			medium	71	>30	4	2
			high	130	>30	7	2
		high	low	44	27	2	5
			medium	107	>30	5	6
			high	195	>30	10	10
Brigalow 500–1200	medium	medium	low	8	2	0	2
			medium	20	13	1	2
			high	37	24	2	2
		high	low	13	7	1	5
			medium	31	22	2	5
			high	56	>30	3	5
	high	medium	low	17	7	1	2
			medium	41	26	2	2
			high	74	>30	4	2
		high	low	25	15	1	5
			medium	61	>30	3	5
			high	112	>30	6	5
South East 800–2000	medium	medium	low	8	2	1	2
			medium	20	13	1	2
			high	37	24	2	2
	high	high	low	8	2	1	2
			medium	20	13	1	2
			high	37	24	2	2
		medium	low	17	7	1	2
			medium	41	26	2	2
			high	74	>30	4	2
		high	low	25	15	1	5
			medium	61	>30	3	5
			high	112	>30	6	5

1. Rainfall erosivity R: low = 850, medium = 2000, high = 4000, very high = 7000, extreme = 9000. See map next page for details.
2. Soil erodibility K: high = 0.045, medium = 0.030, low = 0.015. For K you need to work out your soil type from local or national soil maps, or know the texture of the soil. Your local QDNRM office should be able to assist you. If not, conversion tables can be found on page 26-27 of the Karssies/Prosser report at the following website address: http://www.clw.csiro.au/publications/technical99/tr32-99.pdf
3. Slope S: high = 9%, medium = 6%, low = 2%.
4. Average cover of plant material over the area draining into the stream. Poor cover C = 0.2 (typical cover for conventional annual cover techniques); good cover C = 0.01 of drainage area (is representative of soil conservation techniques of minimum tillage, trash blanketing etc).

> = more than

Source: Karssies, L. & Prosser, I. 1999. *Guidelines for Riparian Buffer Strips for Queensland Irrigators*. CSIRO Land & Water Technical Report 32/99. Can also be found at the website http://www.clw.csiro.au/publications/technical99/tr32-99.pdf

FIGURE 3: Rainfall erosivity factor R for Queensland in MJ.mm/(ha.h.yr)



Source: Rosewell, C.J. 1993, *SOIL LOSS – A Program to Assist in the Selection of Management Practices to Reduce Erosion*, Technical Handbook, no. 11 (2nd edition), Department of Conservation and Land Management, Sydney.

Grass filter strips are most effective when the incoming surface flow is around 1 centimetre or so in depth. In high-intensity rainfall, where there is significant surface flow (and particularly where this is concentrated along depressions) grass buffer strips can be overloaded. This emphasises the importance of not relying solely on a single grass filter strip to retain valuable soil and nutrients where they belong – in the paddock. Paddock design should incorporate contour banks and filter strips well upslope if there is a significant risk of erosion during high rainfall (for example, where furrow direction is not along the contour but at right angles to it, leading to a high risk of rapid run-off into the watercourse).

Retention of cane trash on the paddock surface is also an issue of increasing significance to the industry, as the wash-off of trash, or the organic compounds associated with its decay, have been suggested as one possible factor in some fish deaths. So far, no work has been done to measure the retention of cane trash by grass filter strips, but it is believed by researchers working on sediment trapping that a combination of trees and shrubs with grass (native species are preferred – Table 3) is likely to be most effective. As well, growers are encouraged to rake trash from headlands and drainage lines as soon as practical after harvest.

Combining grass filter strips and riparian vegetation

Anything that confines surface flow, or deflects it around vegetation, will increase the flow velocity and reduce the extent of trapping by the grass filter strip. Clumpy vegetation, such as tussock grasses, tree trunks, roots and depressions in the landscape, can act in this way. For this reason, well-maintained grass filter strips are generally more effective in trapping sediment and nutrient than forested strips, but growers need to remember that trees provide the important added advantage of shade to maintain water quality and stream health. See Chapter 3, Section E.

Nutrients (including nitrogen and phosphorus) and forms of dissolved organic carbon, as well as other contaminants such as mobile pesticide chemicals, can also be carried in sub-surface flows. Sub-surface flow rates are generally slow, except in very open-textured soils. This provides an opportunity for deep-rooted riparian vegetation to make some contribution to reducing nutrient levels by absorbing them for plant growth. The effect of riparian vegetation in reducing soil moisture through transpiration may also help to reduce sub-surface flows.

Table 3 lists some stoloniferous and/or rhizomatous grasses that may be suitable for planting as grass buffer strips. Generally, species that have soil-hugging or below ground stems (stolons or rhizomes) are good at stabilising soil and covering streambanks. The same characteristics also make them strong competitors with other vegetation. Since soil or bank stabilisation and nutrient/sediment trapping are key objectives, these grasses can do a good job but will require mowing. If shading the watercourse and ecosystem health are also important, native trees should be planted adjacent to the stream either before, or at the same time as the grasses. Of the grasses listed, only *Sporobolus virginicus* is native to Australia, although the naturalised *Paspalum distichum* and *Paspalum vaginatum* are considered by some authorities to be native.

TABLE 3: Grass species that may be suitable for riparian buffer strips

Species	Common name	Variety	Propagated by seed	Comment
Axonopus fissifolius	narrowleaf carpet		Y	stoloniferous
Bothriochloa pertusa	indian bluegrass	Dawson, Keppel (Yeppoon)	Y	stoloniferous
Brachiaria humidicola	koronivia	Tully	Y	tropical, stoloniferous
Cynodon dactylon	green couch	Sydney, Savannah, Primo etc	Y	stoloniferous and rhizomatous
Digitaria didactyla	swazi	Aussiblue	N	stoloniferous (another variety, queensland blue couch, has seed available)
Eremochloa ophiuroides	centipede		Y	stoloniferous, available from USA
Paspalum distichum	water couch	Flexi-Green	Y	stoloniferous and rhizomatous, little or no seed available
Paspalum nicorae	brunswick	Blue Dawn	Y	
Paspalum notatum	bahia	Competidor, Riba	Y	rhizomatous, slow seedling growth
Paspalum vaginatum	saltwater couch		Y	stoloniferous and rhizomatous, little or no seed available
Pennisetum clandestinum	kikuyu	Whittet	Y	stoloniferous and rhizomatous
Sporobolus virginicus	sand couch	Nathus Green, Ozlawn	N	rhizomatous, native
Stenotaphrum secundatum	st augustine or buffalo	Palmetto, Sir Walter etc	N	stoloniferous

Source: W. Scattini 2001

The particular species best suited to the local situation will depend on climate, soil type and moisture. Local expertise may be available to help in deciding, for example a mixture of two or more (e.g. a mix of Dawson Indian Bluegrass and Blue Dawn Brunswick Grass has proved very successful for landfill site reclamation in Brisbane) may be recommended depending on the situation to be addressed.

Key points

To summarise, best practice for the use of grass filter strips and riparian vegetation to trap sediment and nutrients includes the following:

- Farm design aims to keep soil and nutrients where they are needed, which is on the paddock rather than in watercourses. This should include use of contour banks, rows orientated along the contour rather than down the slope, use of check banks and grassed waterways where required. This may be combined with silt traps on ends of drains or depressions entering creeks.
- Determine the best location and appropriate width of grass filter strips within the paddock, based on slope and shape of the land and soil type. Where surface 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 it is considered there is significant risk of soil erosion and the crop itself will not provide an adequate filtering function.
- Maximise the use of GCTB throughout the plant and ratoon cycles to reduce soil erosion and nutrient loss. By using GCTB, growers can significantly reduce the need for, and the required width of, grassed filter strips.
- Look-up tables, such as Tables 2 and 3, can be used to estimate the width of grass filter strips needed in particular situations. Wherever possible, use species that are able to grow into and stabilise the trapped sediments – many grasses are able to root from nodes along the stem. Use grasses with a spreading rather than tussock or bunch habit, and perennial grasses should always be used in preference to annuals. Use local, native grasses wherever possible to avoid the potential to spread introduced weedy species.
- Combine grass filter strips with natural riparian trees and shrubs to provide additional benefits, through bank stabilisation, use of sub-surface water and nutrient flows, and provision of essential shade to watercourses.

- Mowing of grass filter strips may be required for cane rat control (Chapter 3, Section G), and there is little benefit to sediment trapping in allowing grasses to grow higher than about 20 centimetres. For areas with intense run-off, hedges of upright grasses or similar species can be used. Remember that a combination of grass filter strip with trees directly adjacent to the stream to provide shade may be the best combination possible where space is limited.
- Disturbance of grass filter strips by grazing, inadvertent cultivation, or spraying out with herbicides, should be avoided, particularly in seasons where there is a risk of high-intensity rainfall. Incorporation of filter strips within a whole-farm plan provides an opportunity to ensure the best mix of maintaining crop productivity while also maximising environmentally sound management.

A best practice approach to designing and managing canelands should be based on identifying bands or zones with different mixes of management objectives. Grass filter strips and check banks can be incorporated around cane blocks. Grassed waterways, channels with grass strips or artificial wetlands and detention basins can be incorporated to help improve the quality of surface run-off (see Figure 4). Riparian grass filter strips, incorporating retention or replanting of native vegetation alongside streams, provides the final link between crop production and the sound management of watercourses.

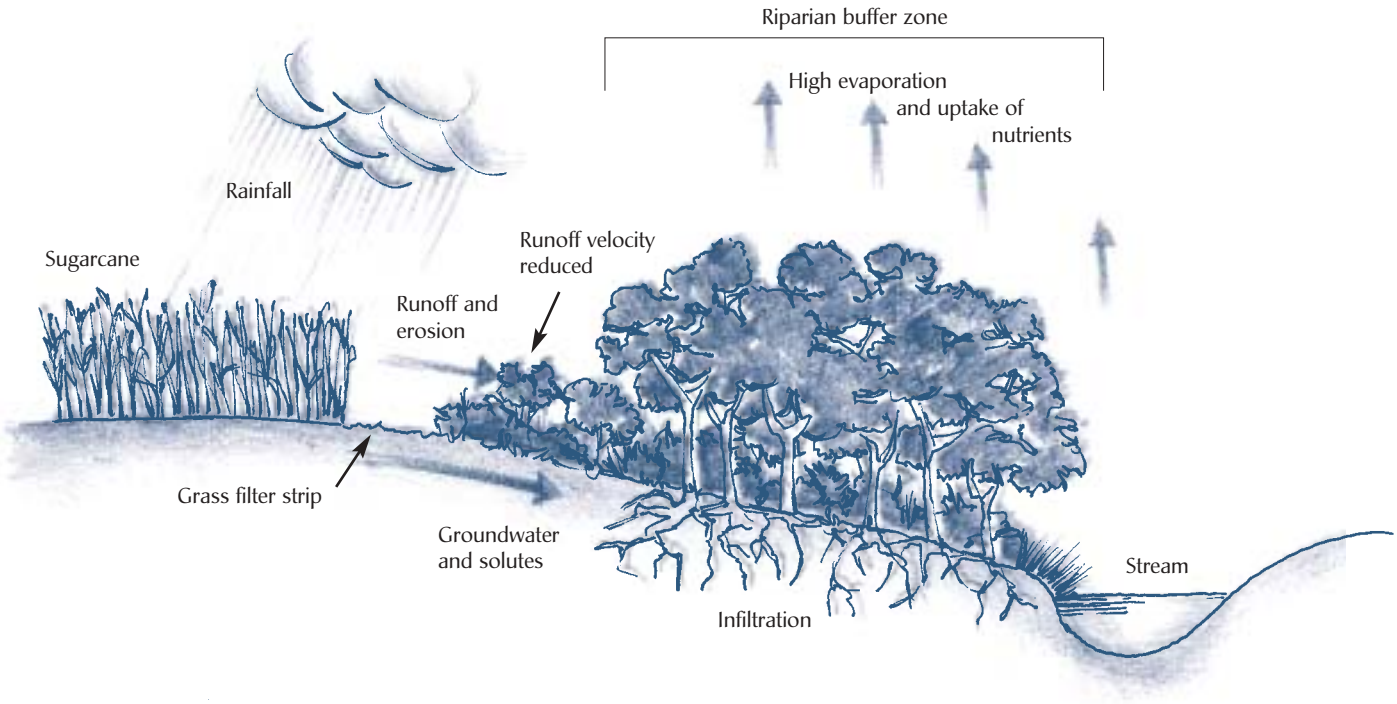


FIGURE 4: How the grass filter strip and riparian buffer zone functions to protect the stream from sediments and nutrients Illustration The Idea to Here.

Management practices

DEVELOPING NEW LAND

Wherever land is being brought into production for cane farming, it is most important that the location of all streams is accurately identified and mapped. This should include gullies that occasionally run with water and ephemeral streams, particularly where these drain cropping land with slopes approaching or exceeding 5%. These areas are often major sources of suspended sediment and nutrients which, once generated, cannot be easily recovered. Once these streams and gullies have been mapped, farm layout should be designed so that furrows run parallel to, and not perpendicular to, the watercourse. Natural riparian vegetation along streambanks must be retained. The minimum width retained would normally be 25 metres for small creeks (stream orders 1 and 2); larger widths should be retained along wider streams (refer *Vegetation Management Act 1999* described on page 96) These are minimum widths, and should be exceeded where conditions (e.g. land slope, block layout) enable this to be achieved.

Where there is a significant risk of trash and/or soil moving through the paddock, then it may be necessary to incorporate a grass filter strip between the cropped area and the retained riparian vegetation. This would normally be at least 6 metres in width, but in many circumstances can be widened to accommodate access tracks for machinery and/or a firebreak or similar requirement. The grass filter strip must be **in addition** to the minimum buffer width of 25 metres of retained native vegetation.

The design of new farms should incorporate riparian buffers and grass filter strips adjacent to watercourses, or other methods to reduce loss of soil and nutrient from paddocks throughout the cropped area. Narrow riparian strips cannot, on their own, be expected to resolve all issues associated with soil and nutrient loss.

It should also be remembered that the widths of natural riparian vegetation to be retained in developing new land is a minimum requirement (25 metres), other management objectives, such as providing wildlife corridors, may require significantly greater widths (see Chapter 3, Section F).

ESTABLISHED CANE FARMS

For many existing cane farms, land has been cleared for cane growing right up to, and in some cases beyond, the top of the high bank. Although the watercourse banks below the high bank level may be vegetated (often with invasive exotic grasses) their slope means that they have little or no capacity to trap sediment and nutrients. Often the channel itself is blocked with sediment, evidence of soil loss from past cultivation practices. In this situation, where there is no riparian vegetation remaining on the floodplain (i.e. above the high bank level), there is no alternative but to include a riparian grass filter strip, with the width required based on the data given in Table 2. A compromise will need to be made between any reduction in planted area for cane, and the benefits of introducing a filter strip. These benefits are not restricted to trapping of sediment and nutrients; other advantages include: not having to slash grasses on steep banks (particularly where trees and shrubs are introduced to shade grasses and prevent seeding), and improved access to the crop and provision of headlands for farming operations (provided these do not lead to disturbance of the grass strip and loss of trapping capacity).

- Base your management on the Key points listed on page 24.
- Remember that natural or built drainage channels within the paddock can also carry significant quantities of sediment and nutrient. It may be feasible for the crop itself to provide buffering capacity along these channels or, alternatively, a grass filter strip may need to be introduced on each side where erosion is considered likely. In situations where this is not feasible, consideration may be given to the use of natural or artificial wetlands, drop boxes, or other structures aimed at holding up overland flow for a sufficient period to allow gross suspended sediment to fall out before the flow proceeds into natural watercourses. Retaining surface water on a paddock in crop for a few hours, where it will not affect cane growth but much of the suspended sediment will be retained, will dramatically improve water quality when flows eventually leave the property.

A. TRAPPING OF SEDIMENT AND NUTRIENTS

Farm design can keep soil and nutrients on the paddock rather than in watercourses by using contour banks, check banks and grassed waterways to filter run-off. By identifying source areas of sediment and nutrients, and maximising the use of GCTB throughout the plant and ratoon cycles, soil erosion and nutrient loss can be significantly reduced.

Grass filter strips can be incorporated between cropped areas and adjacent waterways, as well as around any depressions that concentrate or carry surface flow. This includes paddock drains, natural gullies and dips. Consider combining native grass filter strips with natural riparian trees and shrubs to provide additional benefits, such as bank stabilisation, wildlife habitat and provision of essential shade to streams.

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

How to ensure management is working

Some simple indicators can be used to assess whether paddock design, grass filter strips and other management strategies are working. For example:

- The water leaving cane blocks or along drains and gullies appears clear during times of surface flow during and after rainfall.
- Inspection of planted areas shows no obvious rill or sheet erosion of soil.
- There is minimal build-up, if any, of soil and sediment along grass filter strips and riparian buffers and no obvious danger of large sediment stores overtopping filter strips at the next rainfall event. A build-up of soil would show that the filter strips or buffers are working, and also that valuable soil from paddocks is being lost. This may lead to a review of cultivation practices and block layout.
- Grass filter strips are in good condition without rank growth or obvious signs of disturbance from machinery, fire or other causes.
- The water in streams adjacent to the property appears clear (unless there are upstream sediment sources), and streambed materials of sand, gravel or cobbles are visible.

B. WATERCOURSE AND CHANNEL STABILISATION

Objective

To manage watercourses and channels so that erosion and loss of land is minimised.

Management principles

Watercourse erosion is a natural process as a river meanders across the landscape. Since European settlement of Australia, however, the rate of bank erosion has increased in many places. Two main factors are responsible for this increase. Firstly, extensive clearing of deep-rooted, natural vegetation from catchments for agricultural and urban development, and the planting of shallow-rooted crops, has meant that rainfall tends to move off the catchment at a much faster rate. This has resulted in higher peak flows in watercourses and this places pressure on streambanks where channels can no longer contain and convey flood flows. Higher rates of soil erosion from cleared catchments, and the filling of river channels by this sediment, has also increased the rate of channel expansion by bank and bed erosion. The second factor is that the natural riparian vegetation has been disturbed, either through clearing or through uncontrolled grazing, fire or other effects. This has reduced the reinforcing and stabilising role of the roots of riparian vegetation. In combination, these two factors have led in many places to an increase in the frequency and severity of bank erosion and loss of adjacent lands. Problems caused by erosion include:

- floodouts;
- stripping of topsoil from the floodplain;
- the loss of productive land;
- damage to infrastructure such as roads and buildings;
- sedimentation leading to degraded in-stream habitat; and
- changes to flow regimes, with the potential for increased flooding.

Watercourse erosion occurs in three different ways.

- Sub-aerial erosion – this involves processes that loosen the soil of the bank, with it then being 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.

- Scour – this can take place when the force applied to a bank by flowing water exceeds the resistance of the bank surface to withstand those forces. This often happens at the toe of the bank (at the waters edge) where suspended particles in the flowing water scour away the soil – it is also common on outside bends of rivers where the flow speed is fastest.
- Slumping – this occurs when blocks of the bank collapse as a result of undercutting and scour processes.

FIGURE 5: Some processes by which watercourse erosion occurs

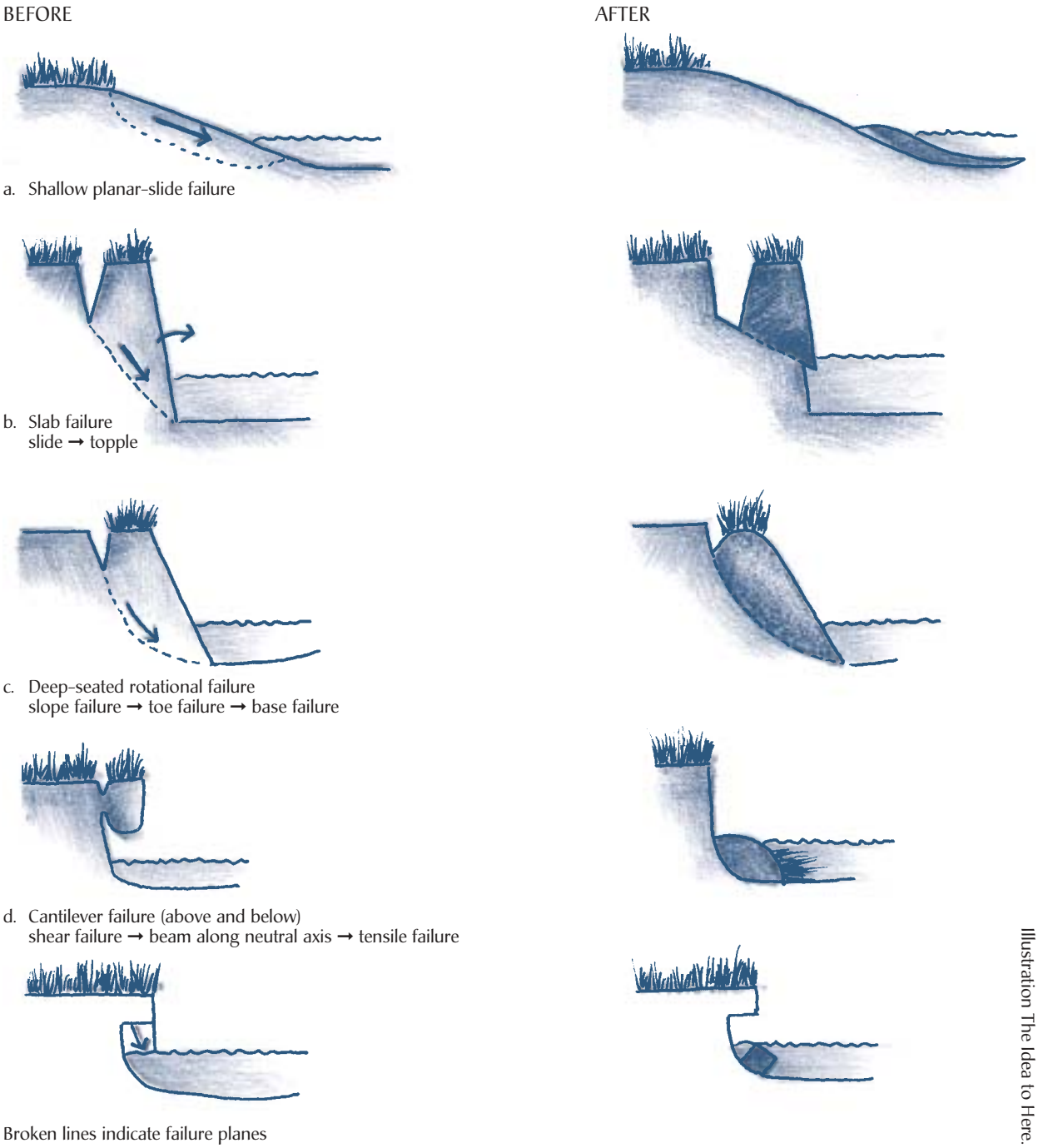


Illustration The Idea to Here.

Using riparian vegetation to stabilise banks

Maintaining healthy riparian vegetation can help to reduce all three processes (sub-aerial, scour and slumping) of bank erosion. By maintaining a dense cover of vegetation from the water level to the top of the bank, sub-aerial processes such as desiccation, frosting and trampling by stock or native animals cannot readily loosen soil particles. Moreover, when water levels rise, the vegetation reduces contact between the flow and the bank surface. Similarly, by maintaining or replanting the toe of the bank with vegetation, the effects of fluvial scour (where the stream flow erodes the bank) can be reduced. Particles carried in the stream flow are less likely to directly contact the bank face, and flow velocities are reduced.

The roots of riparian vegetation work to bind and reinforce watercourses. Research has discovered that the influence of tree roots can extend for 10–15 metres from the trunk and to a depth of at least 1.5 metres, depending on tree size (Abernethy et al. 1999). In addition, the trunk or stems of trees and shrubs physically buttress the watercourse, and their water use also tends to dry out watercourse soils, making them less liable to mass failure. The weight of trees on a watercourse 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. Extending tree, shrub and grass plantings over and beyond the banktop will provide additional protection from mass failure by reducing the growth of tension cracks on the bank top.

Watercourse erosion as a result of riparian vegetation being removed. Photo Ross Digman.

Riparian vegetation and its careful maintenance can, therefore, be used to reduce the rate of bank erosion in many situations. Where possible 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 part 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 either an understorey of grass species or, if there is adequate shade and moisture, a strong mat of fibrous roots form on the outside of the bank. At the top of the bank there may be large trees with a shrub understorey, or a combination of trees and grass. When considering the use of vegetation to address erosion, this generalised pattern of species distribution is a useful basis upon which to design a revegetation strategy.

The key to many bank erosion problems is an actively eroding toe at low water level. This is also the most difficult part of the bank to revegetate with woody species, and it is often best to start with water edge grasses, sedges 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.

For cane growing districts, native vegetation species that are particularly useful in controlling erosion along watercourses are those listed in Table 4. This is because they:

- can grow at, or close to the waters edge and into the water, thus protecting the bank face;
- produce a dense mat of roots; and
- are flexible and rapidly recover following floods.

Table 4 lists native plant species suitable for bank stabilisation in the southern, central and northern coastal regions of Queensland.

TABLE 4: Examples of native plants that are highly suited to replanting for streambank stabilisation


Elaeocarpus angustifolius


Ficus congesta


Ficus virens


Cryptocarya triplinervis


Xanthostemon chrysanthus

North-eastern Queensland (Mossman to Townsville)

SPECIES	COMMON NAME
Archontophoenix alexandre	Feather palm
Acmena smithii	Lillipilli
Casuarina cunninghamiana	River oak
Cordia dichotoma	Glue berry
Cryptocarya hypospodia	Northern laurel
Cryptocarya triplinervis	Brown laurel
Dysoxylum gaudichaudianum	Ivory laurel
Elaeocarpus angustifolius	Blue quandong
Ficus congesta	Water fig
Ficus virens	White fig
Ficus septica	Cluster fig
Lomandra longifolia, L. hystrix	Mat rush
Melaleuca leucadendra	Narrow leaf paperbark
Nauclea orientalis	Leichhardt tree
Syzygium australe	Creek cherry
Syzygium tierneyanum	River cherry
Terminalia sericocarpa	Damson plum
Xanthostemon chrysanthus	Golden penda

In dry areas west of Mareeba use: Moreton Bay Ash (*Eucalyptus tessellaris*), Silver leaf paperbark (*Melaleuca argentea*), Narrow leaf paperbark (*Melaleuca leucadendra*), Weeping Bottlebrush (*Callistemon viminalis*), River Oak (*Casuarina cunninghamiana*) and Scrub turpentine (*Lophostemon suaveolons*).

Burdekin Dry Tropics (Coastal)

Acacia holosericea	Silver wattle
Acacia leptostachya	Townsville wattle
Alphitonia excelsa	Soap tree
Callistemon viminalis	Weeping tea-tree
Canarium australianum	Mango bark
Causarina cunninghamiana *	River she-oak
Clerodendrum floribundum	Lolly bush
Cordia dichotoma	Glue berry
Corymbia clarksoniana	Bloodwood
Corymbia tessellaris	Moreton Bay ash
Cupaniopsus anarcardioides	Tuckeroo
Dodonea viscosa	Hop bush
Dysoxylum gaudichaudianumi	Ivory mahogany
Eucalyptus camaldulensis	River Red Gum
Eucalyptus reveretiana	Black ironbox
Eucalyptus tereticornus	Blue gum
Ficus opposita *	Sandpaper fig
Ficus racemosa *	Cluster fig
Harpullia pendula	Tulipwood
Litsea glutinosa	Scrub laurel
Livistonia decipens *	Cabbage palm
Lomandra longafolia	Spiny mat rush
Lopostemon grandiflorus	Swamp box
Mallotus phillippensis	Red kamalia
Melaleuca dealbata	Woodland paperbark
Melaleuca leucadendra	Weeping paperbark
Melia azedarach	White cedar
Nauclia orientalis	Leichardt tree
Pandanus whitei	Pandanus

* cane beetle habitat

table continued over

Burdekin Dry Tropics (Coastal) continued

SPECIES	COMMON NAME
Planchonia careya	Cocky apple
Pleigynium timorense	Burdekin plum
Pongamia pinnata	Pongomia
Terminalia sericocarpa	Damson
Timonius timon	Tim-tim

Central Coast (Proserpine to Byfield)

Acmena smithii	Lillipilli
Acmenosperma claviflorum	
Alstonia scholaris	Milky pine
Archontophoenix alexandre	Feather palm
Archontophoenix cunninghamiana	Bangalow palm
Austramyrtus bidwillii	Python tree
Casuarina cunninghaminana	River Oak
Cupaniopsis anacardioides	Tuckeroo
Eucalyptus tereticornis	Qld Blue Gum
Eucalyptus tessellaris	Moreton Bay Ash
Euroschinus falcata	Pink poplar
Ficus racemosa	Cluster Fig
Lomandra longifolium	Mat rush
Melaleuca leucadendra	Narrow leaf paperbark
Melaleuca viridiflora	
Nauclea orientalis	Leichhardt tree
Syzygium australe	Creek cherry
Terminalia sericocarpa	Damson plum

South-east Queensland (Bundaberg to Brisbane)

Acmena hemilampra	Blush satinash
Acmena smithii	Lillipilli
Agathis robusta	Kauri pine
Alphitonia excelsa	Sarsaparilla
Austramyrtus bidwillii	Python tree
Cryptocarya hypospodia	Northern laurel
Cryptocarya triplinervis	Brown laurel
Cyperus spp.	Sedges
Elaeocarpus grandis	Blue quandong
Eleocharis spp.	Grasses
Eucalyptus grandis	Flooded gum
Eucalyptus intermedia	Pink bloodwood
Eucalyptus robusta	Swamp gum
Ficus coronata	Fig
Ficus fraseri	Nipple fig
Waterhousea floribunda	Weeping lillipilli

Acmena hemilampra

Nauclea orientalis

In some cases, works may be required to stabilise the toe of the bank, or to batter the bank to an angle where healthy riparian vegetation can become well established and provide stability. Where banks are high (3 metres or more) and steep (angle of 60° or more) some degree of engineering works may be required in order for revegetation to be effective. This might include the use of rock rip-rap to reinforce an eroding toe of a large bank, or battering (grading) back to an angle of 30° or less to give replanted vegetation the best chance for establishment.

Key points

To summarise, best practice for the use of riparian vegetation to stabilise watercourses and channels includes the following:

- Copy nature. Natural, stable watercourses support a range of grasses, reeds, shrubs and trees. By replicating this variety, newly planted vegetation can be self-perpetuating and require little maintenance. Use locally adapted native plant species wherever possible, and aim for a minimum replanted width of 10 metres.
- When deciding whether vegetation will be sufficient to protect a particular part of a stream, always ask – "Why is there no vegetation there now?" It is common to see native vegetation extend along a bank face as far as the entrance to a bend, and then stop. This demonstrates that the erosion rate of watercourse soil at the bend is too high for vegetation to survive. If this is the case, revegetation efforts may be similarly unsuccessful unless complementary engineering solutions are implemented.
- Where erosion is threatening a high value asset (such as a bridge or a building) or in high-energy situations (such as gullies), with high, steep streambanks, vegetation may not provide sufficient resistance to protect the asset or control erosion. Whilst vegetation will often provide the long-term resistance to erosion, an engineering structure may be needed to provide a strong base for establishment of that vegetation. Large woody debris, already in the watercourse or deliberately re-introduced, can be orientated to protect eroding banks. The main challenge in these situations is to sustain the young plants for long enough for them to become sufficiently strong to resist the erosive forces.
- When replanting, you may need to spray the site with herbicide to kill existing weeds and to provide mulch (Section C covers chemical use). Spot spraying is preferable along high-energy watercourses. A follow-up spraying will reduce the number of weed seeds in the soil and make later weed control easier. An alternative to spraying near watercourses is the use of woven weed mats (available from most hardware stores) or mulch to reduce competition when the trees are young. A cool burn is another option in some areas to clear them or to reduce weeds prior to revegetation.
- The best time to plant is from late March to June in many districts. This will prevent the young trees being flooded during the wet season and enable them to get a start while the soil remains warm.

- Usually, trees are planted at 1.5 metre spacings in higher rainfall districts. This dense planting means that a closed canopy is achieved quickly. A handful of fertiliser should be applied at the time of planting, with additional fertiliser applied during the wet season to speed up growth and canopy development. It is important to monitor fertiliser use as any excess will wash into the creek and may then create problems. Local nurseries or Greening Australia staff should be able to give advice on how much fertiliser is required depending on the species that have been planted.
- Application of herbicide for the first two years will ensure that the trees do not become choked by weeds. After two years the canopy will be closed, or almost closed, and weeds will be shaded out.
- Recently developed techniques for replanting, such as the waterjetting of long-stemmed tubestock of native species, have increased the range of situations where revegetation can be a successful approach to bank stabilisation.
- It is important to remember that the effects of overclearing or loss of vegetation, and of revegetation, may have impacts downstream. There is much to be gained by joint planning and revegetation action by groups of landholders to deal with a whole section or reach of a river rather than individual action by one or two landholders.

Planting trees. Photo CANEGROWERS.

Useful publications for riparian revegetation are: *Repairing the Rainforest*, Wet Tropics Management Authority; *Management of River and Creek Bank Plantings in Sub-tropical Coastal Riparian Rainforest* produced by the Mary River Catchment Coordinating Committee; *Practical Help for Riparian Management in the Wet Tropics*, a series of fact sheets produced by the Johnstone River Catchment Management Committee; the *Bush Regenerators Handbook* by the National Trust; *Is there a rat in your hip pocket?*, Land & Water Australia; and *Bush Regeneration, Recovering Australian Landscapes* by Robin Buchanan. Full details for these publications are listed in the References (page 91). State Greening Australia offices also have many relevant publications.

Management practices

DEVELOPING NEW LAND

Before clearing any land, undertake a full farm survey that accounts for any watercourses and channels that make up part of the property. Once these areas are highlighted, ensure that watercourse and channel stability issues are accounted for by leaving an intact riparian zone. This should extend from the low water level up to the top of the bank, and then for a minimum of another 25 metres, as suggested by the *Vegetation Management Act 1999*. Wider zones of riparian vegetation may be needed to stabilise watercourses on outer bends that are more susceptible to erosion, or to maintain wildlife habitat.

ESTABLISHED CANE FARMS

To know where vegetation will be most successful in controlling erosion, it is important to know what the dominant erosion process is (sub-aerial soil loosening, scour or slumping). This may require a simple survey of the watercourse reach or professional advice. Once the process is known, the design and implementation of revegetation works can proceed – matching the type and position of vegetation to the nature of the problem and combining it, if necessary, with structural work.

If resources are limited and erosion control is the primary aim, it can be a mistake to target a revegetation program at the most unstable section of the watercourse. Often money is better spent targeting a part of the stream where erosion may not be so severe, but where re-vegetation will be most successful. Once these areas have been stabilised, the more degraded section can be tackled.

B. WATERCOURSE AND CHANNEL STABILISATION

To know where vegetation will be most successful in controlling erosion, it is important to know what the dominant erosion process is (sub-aerial soil loosening, scour or slumping). This may require a simple survey of the watercourse reach or professional advice. Once the process is known, the design and implementation of revegetation works can proceed – matching the type and position of vegetation to the nature of the problem and combining it, if necessary, with structural work.

Copy nature. Natural, stable watercourses support a range of grasses, reeds, shrubs and trees. By replicating this variety, newly planted vegetation can be self-perpetuating and require little maintenance. Use locally adapted native plant species wherever possible, and aim for a minimum replanted width of 10 metres.

How to ensure management is working?

In order to assess whether management approaches to stabilise watercourses and channels have been successful, there is a need to measure indicators of physical change in the bank slope and position. These are usually based on repeated surveys, either of cross-sections or long profiles of the stream or channel. The key to using this method is to include a reference point or benchmark – something that is not going to move, like a tree, fencepost or steel peg. This means that surveys before and after rehabilitation can be compared. The benchmark helps to position later surveys in exactly the same spot, and makes it easier to compare the results.

Commonly measured features of channel change are:

- the shape of the channel (e.g. bank height, slope or channel width);
- average depth;
- how depth varies (e.g. an area of shallow, uniform flow might change after rehabilitation into a sequence of deep pools); and
- the presence or absence of particular features of the channel, such as undercuts or bars.

If a channel survey cannot be conducted, an alternative is to use photographs to record changes to the watercourse; this should be the minimum evaluation for almost any project. The key is to be able to photograph from exactly the same point each time the site is visited. This is accomplished simply by using any of the following methods:

- several large nails hammered into a large log. Slide the camera into the space between the nails so it is held fast and a consistent photo can be taken each time;
- insert a custom designed photo-point made from a post cemented into the ground; or
- use three cement plugs (or similar) buried in the ground to place a camera tripod upon.

C. AGRICULTURAL CHEMICALS

Objective

To prevent off-site impacts of agricultural chemicals, recognising the special needs of watercourses and in-stream life.

Management principles

A wide range of chemicals is used by the cane industry to control insect pests, weeds, fungi, algae and other organisms. These chemicals can be used in the soil, sprayed onto crops or weeds, or used in irrigation and drainage channels to control weeds. There are strict guidelines controlling the use and application of chemicals within agriculture throughout Australia. Chemicals must only be used for registered purposes and in the amounts and in the manner indicated on labels. In many cases, operators need to be licensed or to have achieved a required level of skill in practice in order to apply such chemicals.

Herbicides and pesticides are widely used in cane growing districts as a component of crop production systems. Spray application of herbicides is common, but the most commonly used insecticide is applied as a slow release pellet. Many chemicals are highly mobile in the environment, either on their own or attached to soil particles. Some are able to move readily during the application process, for example in spraydrift or through volatilisation and later deposition. Others are naturally mobile following application, for example, many herbicides have been found to move through the soil profile into groundwater, and then into watercourses through base flow. Other chemicals are absorbed strongly into soil particles, but may then move through soil erosion and deposition of sediment into streams. Some chemicals are degraded fairly quickly in the natural environment, but others remain highly toxic either in their original form, or in a different form, over many weeks or months.

In-stream ecosystems are particularly sensitive to some of these chemicals. The larval form of many in-stream insects, which are a vital part of the in-stream food web, are very sensitive to insecticides, such as *chlorpyriphos*, which are widely used in the cane industry. As well as the chemicals themselves, the wetting agents or boosters used in some chemical formulations are also toxic to in-stream life.

An overriding principle for sound use of agricultural chemicals is to use integrated pest management practices that reduce chemical use to a minimum. This may include cropping practices to reduce weed infestations and soil seed stores. Use of agronomic practices to minimise insect pests should be standard practice.

Key points

- Use integrated pest management strategies and reduce use of agricultural chemicals to the greatest extent possible.
- Special care is needed when planning and applying chemicals in cane areas adjacent to watercourses, or in areas from which chemicals may be lost through soil erosion or sub-surface water movement into adjacent watercourses and drains. The type of chemicals used, and the particular formulations, should be selected on the basis of minimal effects on in-stream ecosystems, bearing in mind that in-stream plants and animals may be much more sensitive to particular chemicals than land species (e.g. burial is the recommended application practice with *chlorpyrifos*).

Grower compiling record of chemical usage on-farm. Photo CANEGROWERS.

- Make sure that the chemical selected is the most efficient for the job. Understand its mode of action and the application conditions required for maximum effectiveness, and ensure that application rates do not exceed those recommended. It is also important to check that application equipment is working and calibrated properly. Maintain accurate records of date and conditions of application, rate applied and effectiveness in order to guide future decisions.
- Undertake chemical application only when environmental conditions are such that the risk of movement into waterways through spraydrift, or through another farm practice, is minimal. If necessary, delay application, especially near watercourses, until environmental conditions are favourable.
- Ensure that neighbours or other affected persons are notified prior to chemical application.

Management practices

DEVELOPING NEW LAND

Property management plans and paddock layouts for new cane lands must facilitate the application of chemicals so that they have minimal impact on the watercourse and riparian lands. Retention of a buffer of at least 25 metres width of natural riparian vegetation (as required by the *Vegetation Management Act 1999*), comprising trees, shrubs and other understorey, will help to reduce unwanted movement of chemicals from the cane paddock to adjacent watercourses. In areas of particular sensitivity, such as wetlands (including ephemeral wetlands) adjacent to cane paddocks, retention or additional planting of natural vegetation should be considered to help buffer these areas from future chemical use.

In development of new lands, efforts should be made to identify the important species in in-stream habitats, and obtain knowledge of their sensitivity to chemicals and associated wetting agents. This knowledge should be used to guide planning for pesticide use, and application practice.

New cane farms should be established in ways that support the use of integrated pest management practices (this includes the type of application method used for chemical use). This should be incorporated into paddock design and layout, as well as agronomic practice, such as the use of GCTB to reduce weed populations. Chemical mixing and wash-down areas should be sited well away from riparian zones and watercourses, including drainage channels and intermittent streams.

ESTABLISHED CANE FARMS

Critical aspects of chemical use relate to the key points outlined previously in this section. Growers on established cane farms may consider revegetation of watercourses to provide a buffer strip of local native vegetation at least 10 metres wide, as this will assist in reducing the movement of chemicals into watercourses.

SUMMARY

C. AGRICULTURAL CHEMICALS

In development of new lands, efforts should be made to identify the important species in in-stream habitats, and obtain knowledge of their sensitivity to chemicals and associated wetting agents. This knowledge should be used to guide planning for pesticide use and application practice.

An overriding principle of sound use of agricultural chemicals is to use integrated pest management practices that reduce chemical use to a minimum. This may include cropping practices to reduce weed infestations and soil seed stores. Use of agronomic methods to minimise insect pests should be standard practice.

How to ensure management is working?

The cane industry has put a lot of effort into developing safe practices for the use and handling of agricultural chemicals. Growers are encouraged to refer to the manuals produced for more information, for example, the Bureau of Sugar Experiment Station Herbicide Manual. Some indicators of good practice in chemical use are:

- Accurate records are kept of all chemical application and effectiveness on the farm.
- Integrated pest management is undertaken, with farm management practices used to reduce weed and insect populations.
- Annual use of chemicals in relation to farm size and crop area matches, or is better than local best practice (i.e. less chemical is used).
- Periodic inspection shows no obvious signs of off-site impact of chemicals on riparian vegetation or in-stream biota.

C

D. MANAGEMENT OF DRAINS AND FARM WATERCOURSES

Objective

To ensure that farm drains and channels do not degrade the water quality or health of adjacent watercourses.

Management principles

Management of soil moisture levels is an important component of crop production on many cane farms, particularly in the wet tropics. Excessive moisture through rainfall and/or flooding, particularly on heavy and slow-draining soils, can have significant impact on cane yield. In many areas, growers have constructed channels to carry away surface waters, or sub-surface drains to remove excess soil moisture. The water draining from these systems can cause problems when it reaches adjacent waterways.

Typical cane farm drain.
Photo Ross Digman.

Both surface and sub-surface drainage can carry significant quantities of nutrients, particularly nitrogen, as well as chemicals such as herbicides and insecticides. If these are simply allowed to run off the cane paddock and straight into a watercourse, they can significantly affect water quality and in-stream health. One of the most serious water quality impacts is the increased growth of nuisance in-stream plants and algae due to raised nutrient levels; this is particularly the case when there is no riparian vegetation to lower light levels and water temperatures, which act to reduce in-stream growth. In addition, agricultural chemicals can be highly toxic to in-stream life, disrupting food chains and fish reproduction. This means that the siting of channels and drains, and management of drainage waters, must be carefully considered by cane farmers.

Another management issue to consider, is drainage water from Acid Sulphate Soils (ASS) that have been exposed to the atmosphere through drainage and/or levelling, and are highly acidic and damaging to waterways and in-stream ecosystems. A major project has been undertaken, with support from the cane industry, to identify and map the occurrence of ASS along the coastal regions of northern NSW and Queensland. Management practices to prevent the drying and oxidation of pyritic layers in these soils have been developed with the industry.

The water quality in farm drains and channels can also be severely affected when organic material washes into them from adjacent paddocks. Such materials could include residual sugars, cane trash, mill mud or dunder. Oxygen in the watercourse is used up in the decomposition of these organic materials and this severely depletes the amount that is available for in-stream plants and animals. Fish deaths have been linked to this problem. Organic materials should not be spread beyond the cultivated area of the paddock or in close proximity to channels and watercourses, including paddock drains. The use of riparian buffer or grass filter strips should be considered, as they are valuable in trapping coarse materials and sediments and preventing their movement into drains and waterways (see Section A).

Many of the principles for sound management of riparian zones outlined in this Guide can be applied directly to surface channels within cane paddocks that are, in effect, first order streams. These may carry water all year or run only intermittently, but because they form a widely-distributed network they can have significant effects on downstream water quality.

Key points

- 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 trash as a trapping mechanism.
- Wherever practical, ensure that surface channels are shaded. This helps to reduce the temperature of water draining into adjacent waterways, and also reduces the growth of in-stream nuisance plants and algae, which may also be flushed into adjacent waterways during higher flows.
- In areas at risk of acid sulphate soils, surface drainage channels should be wide and shallow in order to avoid the risk of oxidising sulphide sediments and generating large quantities of acid drainage water.
- Steps should be taken through furrow orientation, use of grass filter strips and riparian buffers, and other practices to minimise any loss of soil or cane trash, or drainage from GCTB paddocks, to surface drains.
- For sub-surface drains, the main issues are nutrient management and avoiding risk of acid generation through oxidation of acid sulphate soils. The waters draining from sub-surface systems should also be collected wherever possible in an artificial wetland or detention basin, with the aim of improving water quality before discharge into the natural drainage system around the farm.
- Consider using artificial wetlands or detention ponds to capture and 'polish' the water from drainage channels before it enters adjacent watercourses. A natural or artificial wetland or detention pond may reduce water temperature, trap sediments and absorb nutrients through growth of wetland plants. All of these represent significant improvements in water quality before the drainage water discharges into the natural watercourse system.
- If there is a significant fall in the drain or channel, it may be feasible if local materials are available, to introduce rock riffles at intervals. These not only help to control flow speed and achieve flow along the gradient without channel erosion, but also help to oxygenate and mix the waters moving in the channel. This, in turn, will help to reduce growth of nuisance plants and algae, as well as improving water quality for in-stream animals.

Before and after photographs of a created wetland on Ross Digman's property (Tully) that provides both environmental and economic benefits. Photos Ross Digman.

The Queensland Cane Grower's Council support the following recommendations for on-farm drain management being promoted in industry publications:

❶ encourage appropriate application of fertilisers in line with crop nutrient requirements;

❷ ensure mill mud and other nutrient risk products are not stockpiled near waterways;

❸ consider means for aeration of water in drains before it enters streams or dams e.g. rocks to force water to ripple;

❹ where possible, ensure good drainage on fields to reduce ponding of stagnant water in fields;

❺ continue to co-operate in the maintenance of waterways; and

❻ encourage raking of trash from headlands and drainage lines as soon as possible after harvest.

Management practices

DEVELOPING NEW LAND

Plans for new cane farms should include provision for management, treatment and possible re-use of drainage waters, both surface and sub-surface. In some cane growing areas annual rainfall is not always sufficient to meet crop needs and, as a result, the capacity to capture and store drainage water for later re-use can significantly lift productivity. If planned and managed carefully, it can also have significant environmental benefits.

Development plans in irrigation areas should include provisions for capture and recirculation of excess drainage waters. Paddock size and layout should be related to the furrow length required to provide adequate, but not excessive sub-soil moisture in the soil type of 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. Surface channels should be designed and managed according to the principles discussed previously, focusing particularly on:

- minimising movement of soil and nutrients in the water flow, through use of grass filter strips, or other agronomic practices; and
- the use of shade wherever possible to reduce light intensity and water temperatures.

Where feasible, run-off and drainage can be stored in a wetland or detention pond from which it can either be re-used if required for irrigation, or 'polished' prior to release to the natural drainage system. By incorporating these design criteria early on, the costs associated with improving the quality of water leaving cane 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.

ESTABLISHED CANE FARMS

Many farms include an extensive surface drainage network that could carry high levels of nutrient and water at elevated temperatures directly into adjacent waterways. This channel system may also carry significant suspended sediment following high-intensity rainfall, particularly during the plant cane cycle or at any time when there is little soil cover. This means that for many established cane farms, full implementation of the management practices required to improve the quality of water leaving the farm will require careful planning if it is not to intrude on current areas of production. At the same time, the industry is under pressure to do as much as possibly to help improve water quality in sensitive coastal regions, especially those adjacent to the Great Barrier Reef.

Where the constraints of space mean that it is not possible to achieve the aims of reduced soil, nutrient and organic carbon inputs within the paddock, an alternative is to collect and polish drainage waters by incorporating artificial wetlands or detention ponds into farm design. Another alternative is to hold the water on paddocks for a short period, up to 2 days. These methods have been used on irrigated cotton farms with good results. There are also several examples within the cane industry where growers have incorporated such practices in a way that improves yields, for example, by using excavation spoil from constructed wetlands to raise the soil surface in depressions within the paddock, thereby increasing yield. Detention ponds and small wetlands are likely to be overloaded during large rain events, however, the critical issue is to improve water quality during normal flow periods. During major rain events, high flows tend to mitigate the effects of reduced water quality.

D. MANAGEMENT OF DRAINS AND FARM WATERCOURSES

Farm design should include provisions for capture and recirculation of excess drainage waters. Paddock size and layout should be related to the furrow length required to provide adequate but not excessive sub-soil moisture in the soil type of the paddock.

Surface channels should be designed and managed to minimise movement of soil and nutrients in the water flow, through use of grass filter strips, or other agronomic practices. In addition, shade should be used wherever possible to reduce light intensity and water temperatures and, in so doing, improve water quality.

Where feasible, run-off and drainage can be stored in a wetland or detention pond from which it can either be re-used if required for irrigation, or 'polished' prior to release to the natural drainage system. By incorporating these design criteria early on, the costs associated with improving the quality of water leaving cane farms can be reduced to a minimum.

How to ensure management is working?

Some ways to see if drain and watercourse management practices are working are:

- Farm plans include provisions for capture, polishing and potential re-use of drainage waters.
- Deliberate steps are taken to improve the quality of water leaving the farm, either through active management of surface channels, or through collection and treatment of drainage waters.
- Undertake periodic testing of surface and sub-surface waters leaving the farm to assess whether water quality standards are being met. Indicator test kits are available to check on pesticide levels in surface waters prior to release.
- Simple water quality tests (e.g. Waterwatch) can be used to check the water leaving your paddock or farm.

E. TEMPERATURE AND LIGHT

Objective

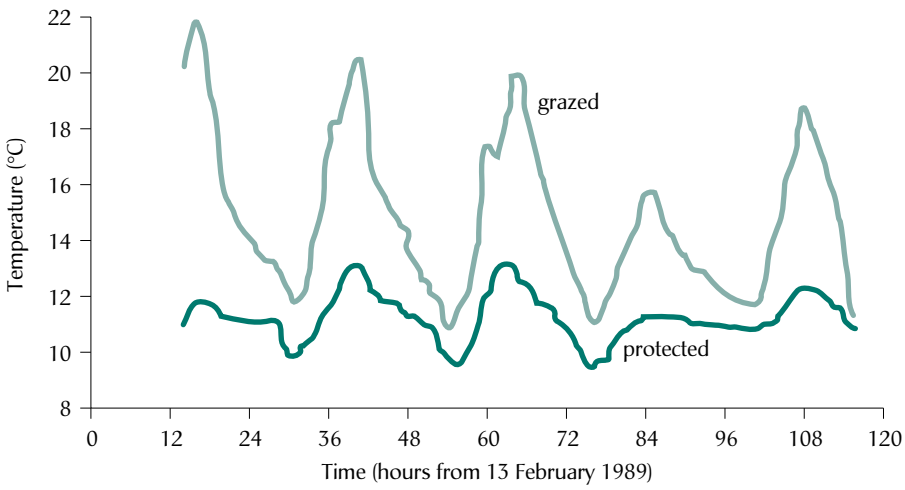
To manage the riparian zone so that it shades the adjacent watercourse to maintain the healthy functioning of in-stream ecosystems.

Management principles

Riparian vegetation shades watercourses, decreasing the amount of direct and diffuse sunlight reaching the water surface, and reducing daily and seasonal extremes of water temperature. Tall or spreading riparian vegetation is essential for moderating watercourse temperatures. For example, research in the wet tropics of Australia has found that water in cleared stream sites was 3–5°C warmer than that in nearby forested sites, and the daily fluctuation in temperature was three times greater. Figure 6 shows data on fluctuations in water temperature from research undertaken in New Zealand.

FIGURE 6: Temperature of cleared versus uncleared streams

Diurnal temperature variations in a riparian protected reach of a small southland stream (catchment area 3.3 km^2) and a more open, riparian grazed and channelised reach 2.4 km downstream.



Temperature increases of 3–5°C seem small, but they can have large effects on the structure and dynamics 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 elevated temperature can slow or halt development and result in death. Egg-hatching, larval development and other components of animal life-cycles are often triggered by precise temperature sequences, and research has shown that many in-stream plants and animals appear to have specific temperature requirements.

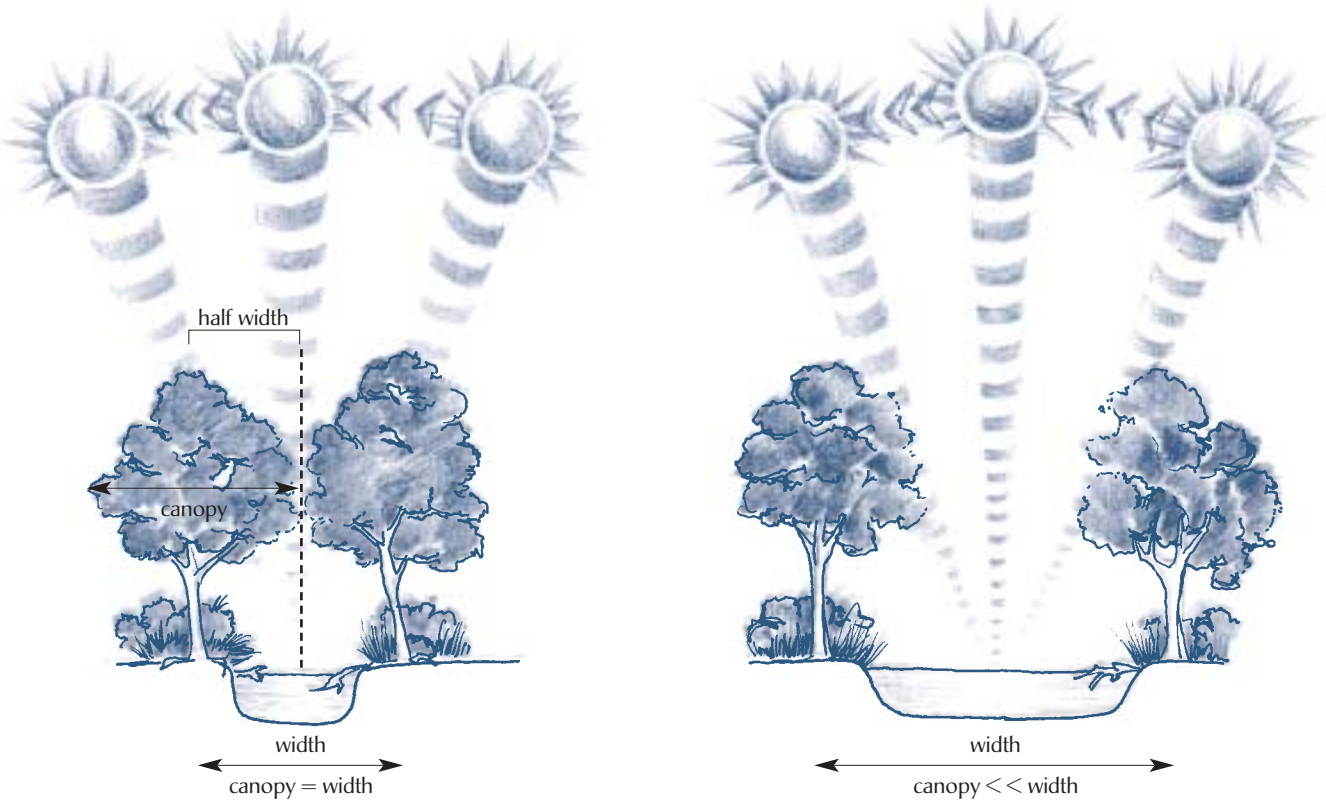


FIGURE 7: Influence of channel width on cover.

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. Illustration The Idea to Here.

In addition, dissolved oxygen concentrations decrease as temperature increases, with this limiting plant and animal life and possibly contributing to fish deaths. Increased water temperatures also elevate rates of bacterial breakdown of organic matter and increase oxygen consumption, further reducing oxygen levels. In the case of in-stream algae, temperature can set the maximum potential for primary production in watercourses when other factors such as light, nutrients and turbidity are not limiting.

Shading to maintain natural water temperatures is essential for healthy and productive streams. The temperature of a watercourse is directly related to its orientation to the sun's trajectory, as well as the density and composition of the riparian shade. 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, foliage density, channel width and orientation, valley topography, latitude and season. Figure 7 shows how riparian vegetation can work to shade the stream from the sun at different orientations.

Revegetation of a riparian strip that is now shading a farm drain and gradually reducing in-stream weeds. Photo David Wallis.

Shade from riparian vegetation is also essential to keep light levels in watercourses to natural levels. We now know that 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 riparian plants, their growth is restricted by lack of light, even when nutrients are plentiful in the stream water.

Key points

- Much of the deterioration in water quality and watercourse health that is evident in many parts of Australia is due to a combination of:
    1. elevated sediment, nutrient and pesticide levels from agricultural crops, stock or urban development;
    2. clearing of riparian vegetation leading to high light levels in the stream;
    3. higher water temperature following removal of riparian vegetation; and
    4. altered flow patterns from dams and weirs.

- The key to preventing these problems, or to reversing them, is to maintain a continuous cover of riparian vegetation that provides a high level of year round shade to the stream. In narrow watercourses (up to 10 metres) that are oriented east-west, the first priority is to maintain or replant vegetation on the northern bank as this will give the maximum amount of shade.

Management practices

DEVELOPING NEW LAND

Ensure that natural riparian vegetation is retained during farm development. The aim is to retain full natural shade on the watercourse. Depending on the type of vegetation, a 25 metre strip will usually be sufficient to ensure retention of tall trees. Native species that grow down 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 (e.g. by fire, uncontrolled grazing or logging), replanting should be undertaken to return to natural shade levels.

ESTABLISHED CANE FARMS

Identify watercourses where there is little or no riparian shade and prepare a revegetation plan. For smaller watercourses (up to 10 metres wide) oriented east-west, the northern bank is particularly important for vegetation retention or replanting. Select species that will provide full shade over the watercourse as quickly as possible. Where space is at a premium, use species that will grow on the bank slope, and that have a spreading habit and dense crown (e.g. some of the native fig species listed in Table 3); this will provide shade without encroaching on machinery access. For more details on re-vegetation methods refer to Section H.

SUMMARY

E. TEMPERATURE AND LIGHT

Riparian vegetation shades watercourses, decreasing the amount of direct and diffuse sunlight reaching the water surface, and reducing daily and seasonal extremes of water temperature.

The growth and development of most in-stream organisms (such as algae, fish, reptiles and frogs) are in part temperature-dependent and elevated temperature can slow or halt development and result in death. In addition, dissolved oxygen concentrations decrease as temperature increases, with this limiting plant and animal life and possibly contributing to fish deaths.

Nuisance water weeds and algae need high light levels, so retaining or replanting vegetation to shade the watercourse or channel is a key management objective.

The key to preventing these problems, or to reversing them, is to maintain a continuous cover of riparian vegetation that provides a high level of year round shade to the stream.

How to ensure management is working?

- Visual assessment and photographs can be used to check the success of revegetation projects and the degree of shade being provided.
- Compare the revegetated site with an area of natural vegetation to see how shading is affecting the stream. This could include a visual comparison, or a use of light meters to compare levels of shade.
- Measure changes in the plants and animals found in the adjacent stream. Waterwatch produces information sheets that will help in the identification of in-stream insects and other animals, and provides details on which species are indicators of good or poor in-stream conditions.

F. LAND AND WATER HABITATS

Objective

To manage the riparian zone so that it provides land and water habitats for native plants and animals.

Management principles

Riparian lands provide important habitat for wildlife because they have a greater availability of moisture, and vegetation that is typically denser and more diverse than that upslope. In addition, riparian lands have a greater availability and variety of food resources, as well as favourable microclimates with reduced extremes of temperature and humidity. The diverse vegetation structure means that riparian lands have greater availability and/or higher quality of shelter and nest sites.

Woody debris that has fallen in from the riparian zone provides habitat above and below the water's surface. Photo Ross Digman.

These features mean that native riparian vegetation is habitat for a wide variety of wildlife. Some species that have life cycles on land and in the water only occur in riparian areas. Many species are not restricted to riparian habitats, but may depend on access to them on a daily or seasonal basis, at particular stages in their life cycles, or at time of environmental stress. Managing riparian lands for in-stream and land based wildlife provides environmental returns, as well as economic benefits (e.g. rat and insect control, timber production, fish breeding, aesthetics). Riparian vegetation managed for land based habitats should be as wide as possible, as there are numerous edge effects (e.g. predation) as well as specific habitat and area needs (e.g. large, old trees with nest hollows). The incorporation of fringing native vegetation communities, typically open woodland, into riparian buffer zones will help to maintain the integrity of riparian plant and animal communities.

Riparian vegetation is also vital for in-stream ecosystems, as it provides the leaves, fruits and insects that support food webs. Tree roots in the water and undercut banks provide important habitat, access to food sources and protection from predators. Woody debris that falls in from the riparian zone forms a substrate and carbon source for in-stream bacteria, fungi and some specialised animals, which, in turn, are a valuable food source for other in-stream life. Wood also provides habitat for a range of in-stream organisms. This is because wood forms complex three-dimensional structures in the water column and provides a number of different-sized spaces or habitat zones. The small spaces formed by small sticks, twigs and other debris trapped against larger material provide refuge and feeding areas for small and juvenile fish, as well as other invertebrates (e.g. yabbies), while the larger branches and logs provide space for larger species. Hollow logs provide essential habitat for some fish, and branches that extend into the water column and above the water surface provide habitat at different water levels.

It has been thought that large woody debris (LWD) within a watercourse reduces flow capacity and increases flooding and, as a result, many watercourses have been 'de-snagged'. However, research conducted in Queensland and New South Wales (Treadwell et al. 1999) has shown that vegetation and LWD would need to occupy at least 10 per cent of the cross-section of the channel before having much effect on flow velocity and flooding. Snags dragged back against the banks at an angle of 40° have little effect in diverting water flow onto the banks. Only in very choked channels has the removal of large, woody debris led to measurable increases in the amount of flow that can be carried.

Riparian vegetation, therefore, plays many roles in watercourse ecosystems, regulating primary production (through shading), supplying energy and nutrients, and providing the woody debris that is essential habitat for many in-stream plants and animals. The importance of these functions becomes apparent when riparian vegetation is removed, for example, the excessive growth of para grass that can occur in unshaded cane land watercourses and channels. Removal of riparian vegetation can also directly reduce the inputs of litter, fruit and insects that are important to fish and other in-stream animals. Other important functions of riparian vegetation in maintaining aquatic health, for example, trapping sediment or cane trash have been outlined in earlier sections.

In many cases, improving riparian habitat for in-stream and land based wildlife is likely to be a secondary consequence of actions taken for other goals (e.g. watercourse stability). However, with careful planning, riparian management undertaken to achieve other goals can be of substantial benefit to wildlife at little or no extra cost.

Key points

- Riparian rehabilitation is likely to be most effective for wildlife where both the total habitat area and its links with other areas are maximised. Corridor widths suggested as suitable for wildlife habitat range from a minimum of 50 metres to several hundred metres.
- While some broad guides are possible, it is likely that appropriate widths for riparian buffers and corridors will depend on the specific ecosystem, climate and types of wildlife. Within cleared areas, target widths for riparian rehabilitation may need to be wider than within landscapes still retaining some vegetation cover, since edge effects may be a problem in the former.
- Aim to revegetate at least 30 metres either side of a watercourse. Even the narrowest vegetation strips are preferable to none. Restoring wider strips of riparian habitat (100 metres or more) is much more desirable if the available area and resources are sufficient. Fencing or protecting a wider area may allow natural regeneration processes to revegetate these areas. The habitat value of replanted areas can be greatly enhanced by retaining ground litter, especially logs and other plant material. Provision of nest boxes on preferred tree species can also provide additional habitat for birds and other arboreal species.

- Revegetation planning needs to consider the specific requirements of the in-stream and land based species being catered for. Vegetation diversity is important as it allows a number of different species to use the area. It is important to plant or protect the full range of plant life-forms typical to an area. Understorey plants, such as low shrubs and grasses are often overlooked in favour of trees. Different wildlife species are typically found at different levels in the vegetation. Reference sites that contain relatively undisturbed native vegetation should be visited, and the typical distances that separate all plants at the sites (including trees, saplings and shrubs) used as a guide.

Management practices

DEVELOPING NEW LAND

All watercourses and wetlands, even ephemeral ones, should be identified and carefully mapped on the Farm Plan. Retention of natural riparian vegetation should be a central feature of the plan. The minimum width required to provide some benefit to in-stream habitat is 25 metres, but for land based habitats there are likely to be benefits in retaining much greater widths, 50–200 metres at least. It should be noted that the Queensland *State Policy for Vegetation Management on Freehold Lands* (under the Vegetation Management Act) adopts 50 metres as a default buffer width to wetlands.

ESTABLISHED CANE FARMS

Before commencing any program to manage riparian land for in-stream and land based wildlife, it is essential to clearly identify and state the specific management goals. These will vary depending on both the history of human use and ecological disturbance within a target area and the region surrounding it, as well as the types and patterns of human use planned for the future.

Formulating a sound management plan requires a knowledge of the species which occur in the area (or which could be reasonably expected to occur if habitat were restored), how they use riparian areas, their specific habitat requirements and threatening processes. Consultation with wildlife biologists, ornithologists or others familiar with local plants and animals is recommended to assist in the development of management plans.

F. LAND AND WATER HABITATS

Riparian lands provide important habitat for wildlife because they have a greater availability of moisture, and vegetation that is typically denser and more diverse than that of adjacent land.

Retention and rehabilitation of natural riparian vegetation should be a central feature of Farm Plans.

Riparian vegetation plays many roles in in-stream ecosystems, regulating primary production (through shading), supplying energy and nutrients, and providing the woody debris that is essential habitat for many in-stream plants and animals.

How to ensure management is working?

- Maintaining a photographic record is one way of tracking the success of revegetation and its suitability for wildlife habitat. Changes to the height of the vegetation, growth of food or habitat species, and inclusion of multiple layers in the vegetation are all important pointers to good wildlife habitat.
- Specific surveys of wildlife species can be undertaken. Direct observation of birds and other animals, recording of birdcalls, or trapping programs for particular species can all be used. In most areas, there is considerable local expertise in wildlife that can be accessed.

G. MANAGING CANE RATS

Objective

Use the riparian zone to control rat and insect numbers as part of the on-farm Integrated Pest Management strategy.

Management principles

Photo from *Is there a rat in your hip pocket?*

The canefield rat and the climbing rat are native species that have thrived on the widespread cultivation of sugarcane. Rats live in grassy, weedy patches of land, such as those often found on cleared watercourses. These areas provide ideal rat 'harbours', as well as the high protein seeds that the female rat needs in order to breed successfully. Trees help control rat numbers because they shade out the weeds and grasses in which rats live; in particular, they help to prevent the grass seed production that rats need in order to breed successfully. Trees also provide habitat for predatory birds such as owls, that hunt cane rats.

Key points

- Where grass filter strips have been retained or planted as a trap for sediment and nutrients, they should be mown or slashed to maintain a low, dense cover. This will help to maximise the filter's effectiveness, while also preventing seeds forming, thereby denying cane rats of the food needed for breeding.
- Revegetating riparian lands provides habitat for cane rat predators, particularly owls. An innovative project in the Ingham district has involved the location of suitable nest boxes to encourage growth in predator populations.
- It has been estimated that for a cost (about $2500) of revegetating 100 metres of streambank, 10 metres wide over 2 years, the increase in income from a 100 metre x 20 metre block of cane over a 10 year period would be approximately $5400. This estimate includes not having to bait or spray herbicide in years 3 to 10, with actual financial benefits to the landholder being greater or less, depending on the initial problem. (Estimates taken from *Restoration of streambanks – economic benefits and tax incentives* Johnstone River Catchment Management Association and *Is there a rat in your hip pocket?* Land & Water Australia/CANEGROWERS.)

Management practices

DEVELOPING NEW LAND

Ensure that riparian lands are maintained and used to reduce grass and weeds in which rats could become established, as well as provide habitat for birds and other insect eating predators.

ESTABLISHED CANE FARMS

Identify where weeds and grasses are most prevalent and plant quick growing trees to shade them out. Some tree species can form a closed canopy within two years in the wet tropics. Under this canopy, there is too little light to allow weeds and grasses to grow. Without these, the rats are homeless and have insufficient feed providing them with the protein needed to breed. This reduces rat numbers as they die out. Trials undertaken in Tully and Babinda have demonstrated that, using this technique, rat numbers and rodent damage have fallen by between 80 and 100 per cent.

Consider revegetation of on-farm riparian lands as this will encourage owls into the area. With families of some owls consuming around 2000 rats a year, such new residents can make a significant impact on the pest population. Installing owl nesting boxes in trees and artificial perches in paddocks will encourage these predators into the areas around cane fields.

For more information on the management of cane rats, BSES has released the *The Rat Pack* that is a reference manual for cane growers. For a copy, contact the local BSES office.

Controlling cane rats through revegtation

BSES, the Russell-Mulgrave Landcare Group and the Wet Tropics Tree Planing Scheme (Mulgrave Shire Unit) undertook a revegetation project on a 110 metre section of waterway running through the BSES Meringa Sugar Experiment Station. The site was chosen because problems associated with the waterway were identified as ones that could be significantly reduced through revegetation. Over the years, regular herbicide spraying had been necessary to control Para Grass. When weeds infest a creek or gully, as can be seen in the first photograph, the area becomes an ideal breeding environment for cane rats. The rats use the weeds for shelter and food and can cause significant damage to the adjacent crop.

See over page for "after revegetation" photograph. Photos by David Wallis.

The elimination of weeds is necessary to control rat populations. Weed control equates to rat control because it eliminates the rats' source of food and shelter. Revegetated waterways provide natural control of weeds due to shading by the tree canopy. The photographs show what can be achieved by using revegetation to naturally control weeds and rats, as well as improving water quality and providing habitat for native plants and animals.

Source: BSES Meringa Sugar Experiment Station.

SUMMARY

G. MANAGING CANE RATS AND OTHER PESTS

Watercourses dominated by grasses and weeds provide ideal habitat for two species of native rat that cause significant damage to the sugar cane industry. Research has shown that the reintroduction of trees into these areas can shade out the weeds and grasses and significantly reduce rat populations.

Trees help control rat numbers because they shade out the weeds and grasses in which rats live and help to prevent the grass seed production that rats need in order to breed successfully. Trees also provide habitat for predatory birds such as owls, that hunt cane rats.

How to ensure management is working?

- Assessment of the level of damage caused by cane rats is the best way of determining whether management for rat control is working. Most growers do this in a qualitative way as part of farm management. To quantify changes in rat damage would require a deliberate assessment program. A trapping program to monitor rat numbers could be an alternative.
- Similarly, most growers will undertake periodic assessment of insect damage during block inspections or other farm operations. Developing a firm link between insect damage and predator populations is, however, more difficult.

G

H. MANAGING RIPARIAN VEGETATION (including weeds)

Objective

To rehabilitate and manage riparian vegetation for multiple benefits, using practical methods integrated with other farm operations.

Management principles

The vegetation of riparian land is often more diverse and more productive than that in other parts of the landscape. The high productivity of riparian lands is partly the result of soils that are richer in nutrients than those further up-slope, as well as 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 areas of a catchment by surface run-off after rain, while stream nutrients are deposited along streambanks 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 the history of erosion and deposition by the meandering watercourse. It also reflects gradients of climate, landforms and soils along the watercourse and away from it. As a result, riparian vegetation is often complex, with increased species diversity. This complexity is usually most evident on the broad floodplains of lowland rivers. Some riparian species occur only in that part of the landscape as they require the better soils and increased moisture for survival and reproduction; other species may be found in both riparian and up-slope areas.

There are many benefits to be obtained by maintaining or rehabilitating healthy riparian vegetation, for example in trapping sediment and nutrients, stabilising streambanks, shading waterways or providing wildlife habitat and these are explained in detail in previous sections of this Guide. In this section, some of the processes threatening riparian vegetation health, and how to prevent or overcome them, are addressed.

Rehabilitation following over-clearing

In many cane growing districts, the natural riparian vegetation has been extensively cleared. There is evidence that this clearing (Bunn et al. 1999), combined with catchment development for intensive cropping, resulted in large amounts of soil being washed into watercourses, where it has often become stabilised, blocking the channel and rendering it of little ecological value. At the same time, increased light levels, higher water temperatures and nutrients from surrounding areas have led to excessive growth of nuisance, in-stream plants, including algae. The net result is that many creeks and waterways in cane growing districts, particularly along the coastal lowlands, are in very poor ecological condition. This in turn, has led to reduced opportunities for breeding and growth of freshwater and in-shore fish stocks.

Cane growers can now improve this situation by undertaking the rehabilitation of riparian lands. In many situations, this can be done in a manner that will not interfere with farming operations. Direct replanting of riparian zones with tube stock plants has been undertaken successfully by many groups. Many of these over-cleared areas are invaded by exotic weed species, and significant time is required to remove and control these pest species, to prepare the site, to replant and to continue follow-up maintenance. Fortunately, growth rates are high in many cane districts, and it is possible to achieve full canopy closure of replanted riparian vegetation in as little as 18 months. Because of the time and resources required, many farmers and community organisations have adopted an approach of replanting one section of a waterway each year over several years, beginning in the uppermost reaches and gradually working downstream.

Where resources are limited, replanting of the northern bank is usually a priority in east-west flowing watercourses as this provides a maximum amount of shade for the resources available. Many of these rehabilitation projects have been very successful, with large sections of watercourse systems now returned to natural riparian vegetation. Although the mix of species replanted has often been limited in comparison with the natural diversity of riparian vegetation (the early stage or pioneer species are favoured for their fast growth rate and ability to cope with full sun, and occasional frosts in some areas), birds, other animals, windblown seed and occasional floods have gradually brought in a diversity of additional species.

In most cane growing districts, there is now a considerable body of expertise in community organisations, particularly local branches of Greening Australia and volunteer groups, for growers to be able to easily access the information needed to plan and implement a successful program of riparian replanting. State agencies such as QDNRM, QDPI and QEPA can also provide useful advice. Some excellent examples of this process incorporate the replanting of native shrubs or small trees with a low height but spreading habit (for example, native fig species) that are able to fully shade a waterway without interfering with harvesting or planting equipment. These can be planted along the channel bank to its upper edge, while on the top levee a mown grass filter strip is established and incorporates an access track for turning and positioning of machinery, etc.

A major challenge remaining for riparian restoration in cane growing districts is to further develop and modify direct-seeding techniques. These have proved highly successful in southern Australia and have substantially reduced the cost of revegetation over large areas. They have been trialled in northern Australia, including in some cane districts, but so far with mixed success. Direct seeding may be worth trying in southern and central cane regions; experience so far in the Wet Tropics suggests that the intense competition from weeds may mean that this method is impractical.

Revegetation costs

There are currently two main approaches to revegetation – direct seeding and tubestock planting. Direct seeding is a cheap and effective way of establishing trees and understorey. Tree planting using tubestock is another well-known form of tree establishment suitable for all sites and conditions.

DIRECT SEEDING

Direct seeding involves the spreading of seeds directly into prepared ground using a direct seeding machine or hand broadcasting. The result is germinated seedlings that develop strong root systems and mature to provide 'natural' looking vegetation. Seeds can be collected locally or included in a direct seeding fee for service.

Site preparation is necessary for direct seeding and is often beneficial for planting. Preparation for seeding includes weed control to reduce competition for water and nutrients. Two applications of herbicide are recommended in autumn and before seeding occurs in spring.

PLANTING TUBESTOCK

The planting of tubestock can be undertaken on any site, by anyone, including children of all ages. Tubestock can be home grown or purchased from local nurseries, and the trees can be selected and positioned for specific purposes. The optimal size of plants for planting is between 10 and 20 centimetres.

Site preparation, including the deep ripping of hard compacted surfaces, is often necessary and beneficial for directing and holding moisture and for ease of planting. Tree guards are useful for protecting plants from small herbivores such as rabbits and hares, or for areas subject to harsh winds.

Fencing

Whether fencing existing or reestablished native plants, fencing is necessary to exclude or better manage stock from vegetated areas. Fencing is generally the greatest cost in managing or establishing vegetation.

Check with your local Greening Australia office for costs of seed and plants in your local area.

Weed management

Riparian environments are subject to frequent natural disturbances, such as flooding, fire, or in sub-tropical areas a rare severe frost. Either alone, or in combination with disturbance from adjacent land use through stock grazing, drift of herbicides or nutrients, or access by machinery, such disturbances provide a great opportunity for weed species to invade riparian vegetation. A few weed species can invade even intact and healthy riparian vegetation, and these require periodic monitoring and spot physical removal or herbicide treatment to prevent their establishment and spread. Most weed species, however, are much more likely to invade riparian vegetation that has been disturbed or rendered unhealthy.

Creating an on-farm riparian environment

BEFORE

The photographs on these two pages show work done on Mark Morton's property (Innisfail) to create an artificial wetland to catch drainage waters and improve overall management on his farm. The wetland now attracts many native birds and animals, with the fringing riparian vegetation filtering and trapping sediment. This is an example of how riparian rehabilitation can provide both economic and environmental benefits to the cane farmer and to the local community. Photos by Steve Garrad.

DURING

The critical issues for reducing potential weed invasion into riparian vegetation are:

- Retain a complete canopy cover for each of the different vegetation levels (trees, shrub understorey and ground layers of grasses where they occur).
- Maintain a sufficient width of natural riparian vegetation that is wide enough to help ensure a diversity of grasses, shrubs and trees and is able to resist external influences (such as drying winds, nutrient movement, transport of weed seeds in bird droppings) – this would normally require a width of 30–50 metres where this is feasible.
- Avoid human disturbance to the riparian vegetation, for example from fires, vehicle and equipment access, timber gathering or other clearing.
- Exclude stock from the riparian zone or use fencing to control the timing and season of grazing activity – this includes the exclusion of feral animals or native animals where they exist in large numbers.

Where weeds have already invaded riparian vegetation, they will need to be controlled by regular spot-spraying or stem injection treatment, or by hand removal where this is feasible. The aim is progressive replacement of weeds with native plants. In most cane districts, there are community organisations able and willing to assist in such work. Controlled grazing by stock can be a useful method to reduce weed bulk and assist recolonisation by native plants in areas already invaded, but it must be managed with care to ensure benefits outweigh potential damage. Careful timing of stock grazing with seasonal conditions has been used with good effect by some landholders, for example, grazing the riparian zone with stock before the wet period so that damage is not done to the bank and stock are not under threat from being caught in floods.

Control of some noxious weeds in riparian areas is a legislative requirement (see Appendix A). Periodic monitoring and weed control will need to be continued each year (for example, during the non-cropping seasons) until the problem can be overcome. Weed control or removal, combined with judicious replanting to fill spaces, can be an effective technique. When controlling weeds using herbicides, only those registered for use in riparian areas adjacent to watercourses should be considered. Care must be taken not to disturb the surrounding natural vegetation unnecessarily, as this will only encourage further weed invasion.

Most weed invasions of relatively intact riparian vegetation have come from adjacent land, where there may be agricultural or urban weeds, or from upstream. Weed management is a clear example of where neighbours in adjacent communities need to act together in order to develop the most effective approach to the problem. This will often require commencing work in upstream regions and gradually moving downhill, otherwise unattended lands upstream may continue to provide a source of infestation with each flood event.

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 cane growing operations have been an important force degrading the adjacent riparian vegetation. This has become less of an issue where GCTB is used, but care should still be exercised whenever fire is used as either a pre-harvest treatment or for other purposes on the farm. In dry areas, where occasional fires may have been a natural event once every 10–25 years, it may be possible to use a burn to help reduce weed infestation along streambanks, or to provide conditions for re-establishment of native species. This may be the case where the natural riparian vegetation is a form of eucalypt woodland. However, the season and exact timing of the burn needs to be planned carefully to ensure that it is beneficial and not damaging. Annual burning would not meet this requirement and, in general, repeated burning damages natural riparian vegetation and encourages growth of 'fire weeds'. In tropical areas with closed forests of fire intolerant species, fire is unlikely to be a beneficial management tool in rehabilitating or managing riparian vegetation, and the emphasis is likely to be on preventing fires spreading to riparian zones.

Key points

- Naturally healthy or rehabilitated riparian vegetation can be used for a number of purposes, providing these are compatible with the overall aim of maintaining vegetation health. Provision of shade (for example, to assist cane rat control), lowering of groundwaters adjacent to streams, and provision of habitat for cane rat predators, are examples of highly-compatible land uses.

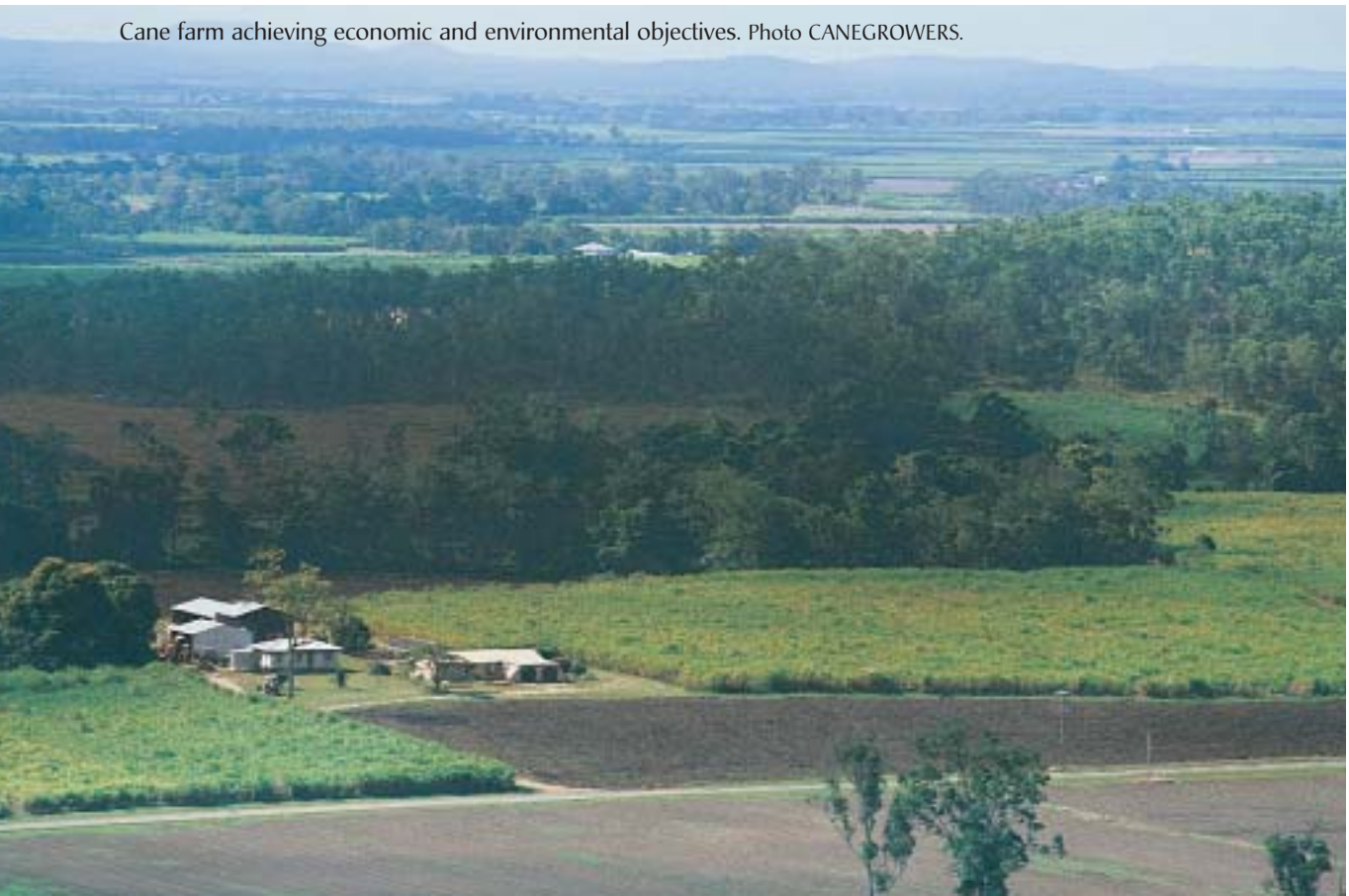
- Some growers have established riparian vegetation with a view to commercial production of high-value timbers through agroforestry. Providing the species planted are natural to the district or at least non-invasive, and harvesting operations are managed to avoid extensive disturbance of the riparian vegetation, agroforestry can also be a highly compatible land use.
- Poorly-managed stock grazing and annual burning is probably the most damaging and incompatible land use for on-farm riparian zones. The siting of buildings, chemical or fuel stores, should also be kept separate from riparian areas. Similarly, care must be taken during farming operations to avoid inadvertent drift of chemicals or nutrients into riparian vegetation, or disturbance and damage through vehicle and equipment access.

Management practices

DEVELOPING NEW LAND

In developing new land for cane farming, the riparian zone should be clearly identified and steps taken to protect intact riparian vegetation during farm development and cropping operations. Steps should be taken to identify and control weed infestations using hand removal and spot application of herbicides wherever possible. Consideration should be given to enhancing the vegetation through additional planting to fill obvious canopy gaps, or to expand the width where this is considered too narrow for long-term survival.

Cane farm achieving economic and environmental objectives. Photo CANEGROWERS.



Farm layouts should be planned to incorporate the objective of retaining riparian vegetation in an intact and healthy state. Furrows should be placed to drain through a grassed channel and/or a detention pond or artificial wetland before entering a riparian zone. Intact riparian vegetation should not be cleared to provide headlands, turning areas or other equipment requirements; these should be established well clear of the riparian zone, preferably with a grass filter strip of at least 3–6 metres in between. Special care must be taken during farm development to prevent the spread of fire into adjacent riparian areas, although carefully-planned and managed deliberate burns may be used to control weeds or provide opportunities for regeneration.

ESTABLISHED CANE FARMS

Growers should survey waterways adjacent to their property and record their status and condition, and that of the surrounding riparian zones. This 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 rehabilitation opportunities and priorities have been determined, expert advice and assistance should be sought from local bodies, including government departments, Greening Australia, shire councils and replanting groups, and local volunteer groups. There is often considerable local expertise on species to use, site preparation and replanting methods, and follow-up maintenance required. It is usually better to tackle a small area for rehabilitation each year, than to take on too much at once.

Site preparation may include weed control using hand removal methods and weed mats where practical for planting tubestock, or careful use of herbicides; use only herbicides registered for use adjacent to waterways for this work. Weed control must be followed up immediately by replanting, otherwise re-invasion is usually inevitable. Periodic, off-season monitoring and spot control of weeds in intact riparian vegetation, and in replanted areas, is an essential continued activity until weeds are substantially brought under control.

H. MANAGING RIPARIAN VEGETATION

There are many benefits to be obtained by maintaining or rehabilitating healthy riparian vegetation, for example in trapping sediment and nutrients, stabilising streambanks, shading waterways or providing wildlife habitat.

Farming operations should be designed and undertaken 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.

In most cane growing districts, there is now a considerable body of expertise in community organisations, particularly local branches of Greening Australia and volunteer groups, for growers to be able to easily access the information needed to plan and implement a successful program of riparian replanting.

How to ensure management is working?

- Intact and healthy riparian vegetation, comprising local native species, is present along both sides of all waterways adjacent to the property.
- There is a low level of weed infestation of riparian vegetation.
- There is no evidence of damage to riparian vegetation through: drift of herbicide or other chemicals and nutrients, escape or inappropriate use of fire, uncontrolled grazing by stock or feral/native animals, or through vehicle/equipment access.

I. FLOODING

Objective

To reduce the impacts of periodic flooding on cane production.

Management principles

Careful management of riparian lands and vegetation has the potential to reduce the impacts of periodic flooding on cane farms lower in a catchment. The wholesale removal of riparian vegetation, as well as widespread catchment clearing during agricultural and urban development, has increased the severity of downstream flooding. This is thought to be because water is able to move off the landscape more quickly than before and, in the absence of dense riparian vegetation, there is no holding up of flood waters in the smaller waterways of a catchment. In contrast, flood waters now move quickly down into the main stem of the river system, where banks are over-topped and floodplain lands, many of them now developed for cane farming, are quickly inundated.

It has been suggested that the frequency of such flooding, and its extent and duration, have increased significantly since European settlement. These ideas remain to be tested, but there is the potential that significant rehabilitation of natural riparian vegetation along small watercourses could help to reduce the frequency and severity of downstream flooding. The holding-up of floodwaters along the many small streams of a catchment could result in an increase in flooding in those parts, but here the volumes and effects are small. The main benefit would be in reducing the frequency and the extent of flooding of downstream areas.

Many streams have naturally developed levee banks that act to channel flow in flood times and prevent overtopping of banks and inundation of floodplains. These levees are a natural feature of many streams (see Figure 8 over page), resulting from past overtopping and stabilisation of those sediments. Use of grassed filter strips in conjunction with replanting of natural riparian vegetation, is likely to help re-establish such levees. It is important that in developing new land for cane farming these natural levees are identified and retained, otherwise the risk of periodic flooding will be substantially increased.

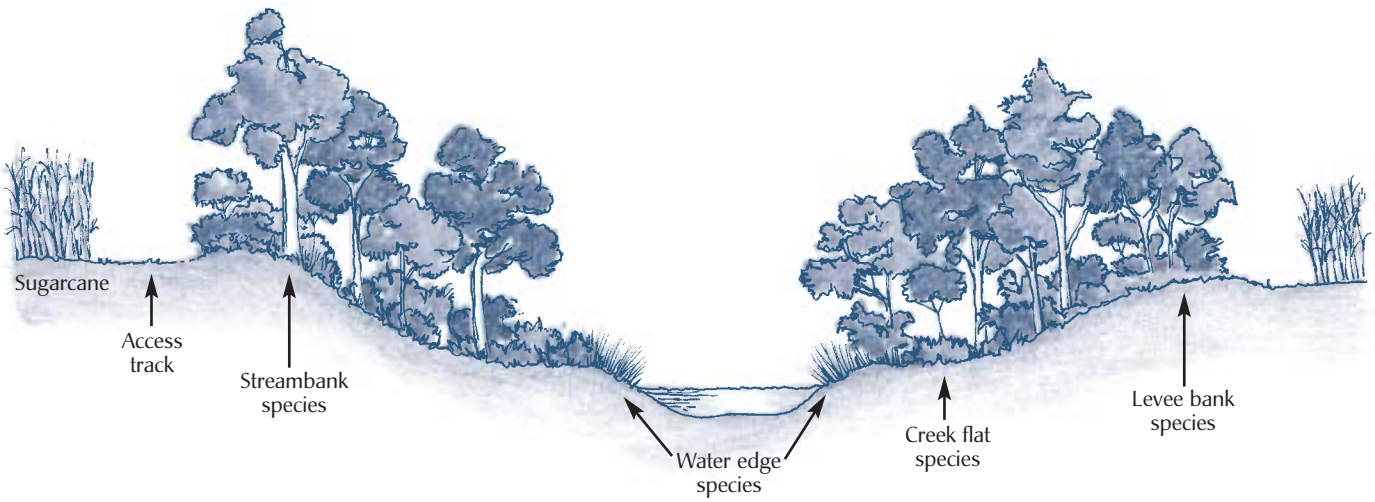


FIGURE 8: Different parts of the riparian zone and associated vegetation Illustration The Idea to Here.

Riparian vegetation can also influence flooding through its shading effects. Throughout much of the tropical lowlands, watercourses have been invaded by exotic species such as Para Grass or Hymenachne. These plants act to stabilise sediments that have entered channels from adjacent paddocks, preventing them from being flushed during periods of high flow. The net effect over a long period has been that many lowland watercourses are now filled with sediment, and their capacity to carry and discharge flood flows substantially reduced, sometimes to less than 10 per cent of their former volume. This means that even small flows from upstream now inundate adjacent cane paddocks, and the water may lie there for many weeks if there is no natural or installed drainage capacity to carry it away.

Experiments conducted in Queensland, have shown that shading of these creek banks results in the reduced growth and eventual death of the exotic species, with the potential for loosening and removal of sediments and restoration of creek discharge capacity to quickly remove flood flows.

Management practices

DEVELOPING NEW LAND

- Ensure that the entire watercourse network on the property is identified, including gullies or channels that may carry water only at certain times of year.
- Ensure that natural riparian vegetation along these watercourses is retained to a minimum width of 25 metres (both sides).

Sediment accumulation and consequent smothering of Bamboo Creek, near Innisfail (Qld). Invasion of an introduced ponded pasture grass (*Brachiaria mutica*) has led to accumulation of organic rich sediments (up to 2 metres deep). This photograph shows experiments designed to assess the impact of shade in such situations. Photo Ian Prosser.

- Ensure that natural levee banks alongside watercourses are identified and protected during farm development, and are not damaged through cultivation or other agronomic practice. These practices should be applied equally to levees that gradually build up from use of grass filter strips adjacent to streambanks.
- Replant or enhance natural riparian vegetation, where practical, to ensure maintenance of high degrees of shade in order to prevent invasion of watercourses by exotic plant species.

ESTABLISHED CANE FARMS

- Replant and rehabilitate natural riparian vegetation along all natural watercourses wherever practical. A minimum width of 10 metres should be provided.
- Identify and retain natural watercourse levees and those arising from use of grass filter strips.
- Extend and enhance riparian vegetation wherever possible to ensure levels of shade that will prevent invasion of creek channels by exotic plant species. Note that rehabilitation of northern banks is a priority target for east-west running streams.

I. FLOODING

The wholesale removal of riparian vegetation, as well as widespread catchment clearing during agricultural and urban development, is thought to have increased the severity of downstream flooding. Rehabilitation of natural riparian vegetation along small streams could help to reduce the frequency and severity of downstream flooding.

Use of grassed filter strips in conjunction with replanting of natural riparian vegetation, is likely to help re-establish natural levees. It is important that in developing new land for cane farming these natural levees are identified and retained.

By replanting and rehabilitating natural riparian vegetation along all natural watercourses, the risk of larger damaging flooding may be reduced.

How to ensure management is working?

- Natural riparian vegetation is retained or rehabilitated where required.
- Stream levee banks and the integrity of the stream system are retained.
- Exotic plant species are absent from creek channels, and channels retain natural characteristics and discharge capacities able to deal with flood flows.

Photo Ross Digman

4 PLANNING AND EVALUATION

Planning

This Guide emphasises the importance of incorporating the management of riparian lands within Farm Plans. This is the best way to ensure growers can achieve their aims for riparian lands with minimal disruption to farming operations, whether they are developing a new block or changing management on existing cane land.

For many of the issues covered here, neighbours will need to work together on a stretch or reach of watercourse and consolidate their efforts. Making sure this work fits in with broader local and regional catchment plans will help to ensure resources are maximised, as well as assist groups gain access to funding provided by community assistance and incentive schemes.

Monitoring and evaluation

The purpose of evaluation is to make sure the new and improved management practices that have been introduced are meeting growers' management goals. Evaluation requires monitoring and measuring the factors you are trying to change, before, during and after a project. Management practices can then be adjusted and improved as they go along.

What to include in an evaluation plan

The first step is to be clear about what you want to achieve and to record these management objectives wherever possible. This will enable you to identify what changes should be measured, for example, a lowering of water temperature, increase in fish populations etc. Once objectives and performance measures have been determined, the detail of the evaluation plan can be worked out. A well-designed evaluation should be cheap, efficient and useful for farm planning and design. It should also be able to identify the reasons why your project succeeded or failed. In working out the detail of an evaluation plan, the following six issues need to be considered.

1. WHAT TO MEASURE?

As a minimum, an evaluation plan needs to show whether objectives have been met. This means that at least one thing (an indicator) related to those objectives must be measured. For example, if the objective was to increase numbers of certain fish species by adding woody debris to the watercourse, ways of measuring changes in those fish numbers needs to be included in your evaluation plan. A good evaluation plan will go further than this and also identify why the objective may or may not have been met.

To work out why a change occurred in the watercourse, it is also important to measure not only elements directly related to objectives (e.g. number of fish), but also the watercourse elements that caused the change. For example, if there was an increase in fish numbers was it as a result of the woody debris? or could it also have been changes to watercourse temperature, flow pattern or the time of year?

2. WHEN TO MEASURE?

There is little point in monitoring frequently without knowing how the information you are collecting relates to your objectives. This is a waste of time and money, and we recommend the following two sampling strategies to avoid this problem:

- Sample at regular intervals that will show up trends and variation in the data. This is good for things that respond slowly to the rehabilitation strategy, such as changes in fish populations.
- Sample after any flood events greater than a certain size. This strategy is appropriate for projects that involve structures that are only really tested during high flows, such as log weirs or revegetated watercourses.

3. WHAT IS THE EVALUATION TIMEFRAME?

Ideally, monitoring should occur until the riparian zone/watercourse has responded in full to the rehabilitation project. It can be difficult to know how long this will be, but by seeing what other people have used in your area to monitor similar projects, as well as getting advice from local experts, you should be able to work out suitable monitoring periods.

4. WHO WILL TAKE THE MEASUREMENTS?

For evaluation to be worthwhile, it is important that the results can be trusted. The people responsible for the evaluation must have the necessary expertise to use the chosen techniques, as well as being consistent and objective as they undertake the monitoring required. Either the cane grower can be trained in how to take particular types of measurements, or people from other organisations and community groups, such as Waterwatch, could come to an arrangement with the cane grower to undertake sampling at particular times of the year.

5. HOW TO RECORD THE RESULTS

It is very important to have a standard recording sheet for data collection, especially during fieldwork. Without one it becomes very easy to forget to take some measurements at the end of a long day. A standard recording sheet also makes collating the results easier. Different community groups and state agencies produce recording sheets, for example, Waterwatch has a complete water quality monitoring manual that contains pro-formas for taking measurements. Once the cane grower has decided what they wish to monitor and record, you can work with them to develop a recording sheet to cover the key variables involved.

6. ANALYSING THE INFORMATION

For the simpler types of evaluation, the analysis of results will be fairly straightforward – a matter of comparing photographs or plans of an in-stream structure with surveys of the structure. However, for evaluations of physical or biological effects, analysis may be a lot trickier and may involve some form of statistical analysis. In such cases, it is important to have considered the analysis at the planning stage of the evaluation plan, as many statistical techniques are restricted in the sorts of data they can handle. It may be worthwhile getting in touch with a local university or government agency to see if they could assist in the analysis of this data.

Without an evaluation plan it is difficult to know if the project was worthwhile, and you will never learn how to improve your techniques. The information provided here shows that evaluation need not be difficult, and that different types of evaluation strategies that can be used according to project objectives.

Note: Assistance in developing an evaluation plan can be provided by local natural resource management and agricultural agencies. Greening Australia has produced a publication entitled *Monitoring Farm Flora and Fauna* that may assist growers in determining their monitoring and evaluation approach (see References for details).

Source: Adapted from Rutherfurd, I., Jerie, K. & Marsh, N. 2000, *A Rehabilitation Manual for Australian Streams*, Land & Water Resources Research & Development Corporation and Cooperative Research Centre for Catchment Hydrology, Canberra.

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5 WHERE TO GET 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 the list on the following page, and you are encouraged to call and obtain local office numbers for their district. A list of useful websites has also been provided.

State	Telephone	Website
Queensland		
Australian Centre for Tropical & Freshwater Research	(07) 4781 4262	www.actfr.jcu.edu.au/
Bureau of Sugar Experiment Station	(07) 3331 3333	www.bses.org.au
CANEGROWERS	(07) 3864 6444	www.canegrowers.com.au
Cane Protection and Productivity Boards	Refer to local area numbers	
Co-operative Research Centre for Sustainable Sugar Production	(07) 4781 5763	www-sugar.jcu.edu.au
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.qld.greeningaustralia. org.au
Waterwatch	(07) 3896 9625	www.qld.waterwatch.org.au
New South Wales		
Department of Land & Water Conservation	(02) 9228 6111	www.dlwc.nsw.gov.au
Environment Protection Authority	13 5555	www.epa.nsw.gov.au
Greening Australia	(02) 9560 9144	www.ga.org.au
New South Wales Agriculture	(02) 9372 0100	www.agric.nsw.gov.au
New South Wales Cane Growers Association	(02) 6683 4205	
New South Wales Sugar Milling Cooperative	(02) 6620 8200	
National Parks & Wildlife	(02) 9585 6444	www.npws.nsw.gov.au
Streamwatch	(02) 9228 6111	www.streamwatch.org.au
Western Australia		
Agriculture Western Australia	(08) 9368 3333	www.agric.wa.gov.au
Conservation and Land Management	(08) 9334 0333	www.naturebase.net
Department of Environmental Protection	(08) 9222 7000	www.environ.wa.gov.au
Greening Australia	(08) 9335 8933	www.greeningaustralia-wa.org
Ord River District Cooperative	(08) 9168 2255	
Ribbons of Blue (Waterwatch)	(08) 9278 0300	www.wrc.wa.gov.au/ribbons/
Waters and Rivers Commission	(08) 9278 0300	www.wrc.wa.gov.au
National		
Land & Water Australia	(02) 6257 3379	www.rivers.gov.au
Sugar Research & Development Corporation	(07) 3210 0495	www.srdc.gov.au
Weeds Australia	(03) 6344 9657	www.weeds.org.au

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6 GLOSSARY

Acid sulphate soils	A soil type derived from marine sediments occurs extensively on low lying coastal areas. When exposed to the atmosphere (e.g. following drainage for cropping), iron pyrites and other minerals found in these soils can be leached from the soil profile in the next major rainfall event. The acid drain waters are highly toxic to freshwater and marine life. Many areas of acid sulphate soils have been mapped in detail and the cane industry has developed codes for best management practice for dealing with these soil types.
Adsorbed	Nutrient bound to mineral or organic sediment and therefore only dissolves into water under particular chemical conditions.
Anabranch	A secondary channel of a river which splits from, and then later joins the main channel.
Anoxic	Deficiency or absence of free (gaseous or dissolved) oxygen.
Basal (area)	Part of the bed or lower bank that surrounds the toe of the bank.
Basal scour	Erosion of the base of a streambank by flow.
Buffer strip	A strip of retained or planted vegetation used to reduce or prevent off-site effects of different land uses, for example, between intensive cropping or urban development and natural ecosystems such as watercourses.
Desiccation	Drying and cracking of bank materials causing the bank to erode more easily.
De-snagging	Removal of logs and other woody debris (snags).
Diurnal	Twice daily.
Ecological	Study of the relationship between groups of organisms and their environment.
Exotic	An introduced plant or animal – not native to the area.
Filter strip	A specialised type of buffer strip where vegetation, usually a dense grass strip, is used to trap and retain soil and nutrients moving in surface water flows.
Fluvial	Refers to water flow and rivers.

Forb	A non-grassy ground layer plant.
Headcut	Sharp step or small waterfall moving up toward the head of a watercourse by erosion.
Large woody debris	Large woody debris is made up of the sticks, branches, trunks and whole trees that fall into rivers and streams.
Levee	A raised bank formed when flood waters overtop a channel and drop their load of suspended sediment as velocity decreases. Levees may also be constructed to raise the height of the bank and thereby contain flow to prevent flooding.
Macrophytes	Plants that grow within the stream, they may be fully or partly submerged e.g. ribbon weed or reeds.
Mass failure	A form of bank erosion caused by blocks of material sliding or toppling into the water.
Primary production	Organic material synthesised within the stream, for example, the growth of algae and other water plants which in turn supports insects, fish and other stream animals.
Rhizome	More or less horizontal underground stem bearing buds that can grow into new plants. Used for vegetative propagation.
Riffle	A natural or constructed rock wall across a watercourse or channel. Riffles act as small, permeable weirs that hold back an upstream pool and provide a stable bed for a drop in height. The rock size used in construction must be able to withstand 'drowning out' in flood flows.
Rill erosion	Small, often short lived channels that form in cropland and unsealed roads after intense rains.
Riparian zone	Any land which adjoins, directly influences, or is influenced by a body of water.
Rotational failure	A form of bank erosion caused by a slip along a curved surface that usually passes above the toe of the bank.
Scour	A form of bank erosion caused by sediment being removed from streambanks particle by particle. Scour occurs when the force applied to a bank by flowing water exceeds the resistance of the bank surface to withstand those forces.
Sheet erosion	Erosion on hillslopes by dispersed overland flow.
Slab failure	A type of mass failure caused by a block of soil toppling forward into the channel.
Snags	Large woody debris such as logs and branches that fall into rivers.
Stream order	Classification of streams according to their position in the channel network, e.g. a first order stream has no tributaries. Streams become larger as their order rises and an increasing number of segments contribute to the flow.
Sub-aerial erosion	Erosion caused by exposure of streambank to air.
Surcharge	The weight imposed on a bank by vegetation.
Toe	Bottom of the bank.
Tubestock	Plants grown from seed in individual or grouped tubes.
Watercourse	In this Guideline we have used the general term 'watercourse' to include any permanent or intermittent stream of surface water flowing in a defined channel, whether natural or man-made. This includes creeks, waterways, streams and rivers (some of these terms have specific meanings under Acts or local regulations) and also from waterways, drains and irrigation channels.
Weed mat	Mats woven as a mesh that prevent weeds from growing through.

7

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INDEX

Please note: only key page references are provided here.

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8 REFERENCES

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Note: Many catchment agencies have developed maps and plans to help guide habitat management and rehabilitation, and riparian habitat features prominently in most, for example, Cardwell Shire Catchment Coordinating Committee have produced a detailed report on *Lowland Habitat Mapping and Management Recommendations for the Tully-Murray Catchments*. The authors encourage extension staff and growers to get in contact with their local catchment organisation as they are likely to have a range of information that could be useful for on-farm riparian management.

APPENDIX A

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LEGISLATION RELATED TO MANAGEMENT OF RIPARIAN LANDS

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 that cane 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. For cane growers in New South Wales and Western Australia, different legislation applies and the key Acts are outlined in Table 5 (page 105). 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

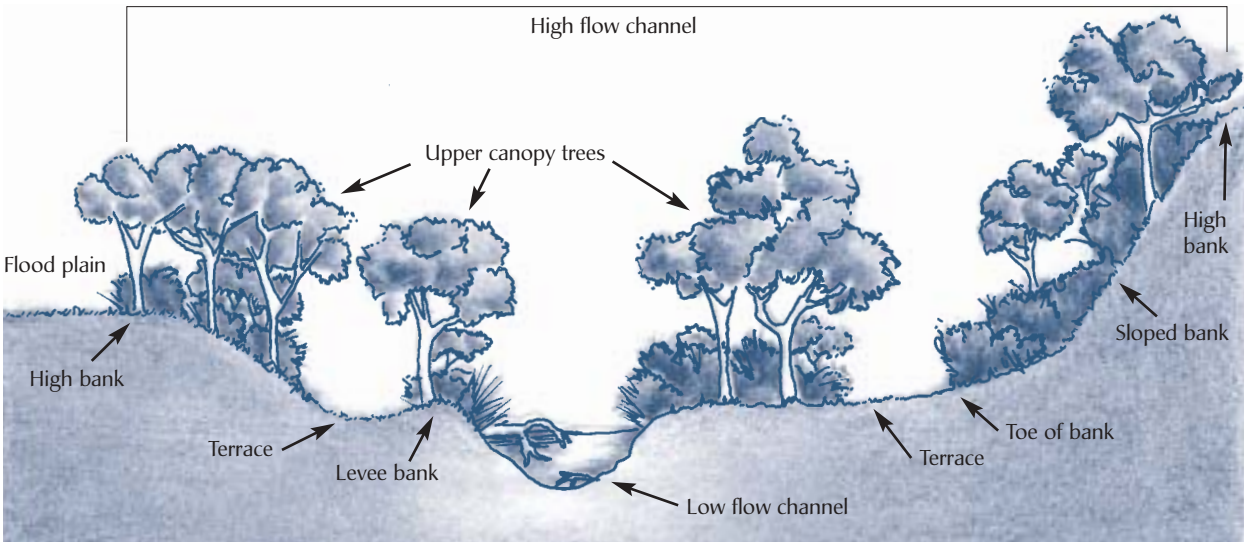
This is the principal legislation for the protection of the 'physical integrity' of non-tidal rivers, lakes, springs and their riparian environments. 'Physical integrity' relates to bed and bank stability, and associated water quality. The Act applies to all lands (Crown and private) defined as being within the high banks of a stream or lake, as well as imposing limited controls on lands outside of these features. The 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 Figures 9 and 10 show where the 'high bank' may be located in sugar cane riparian areas.

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.

FIGURE 9:
Figure showing location of high bank



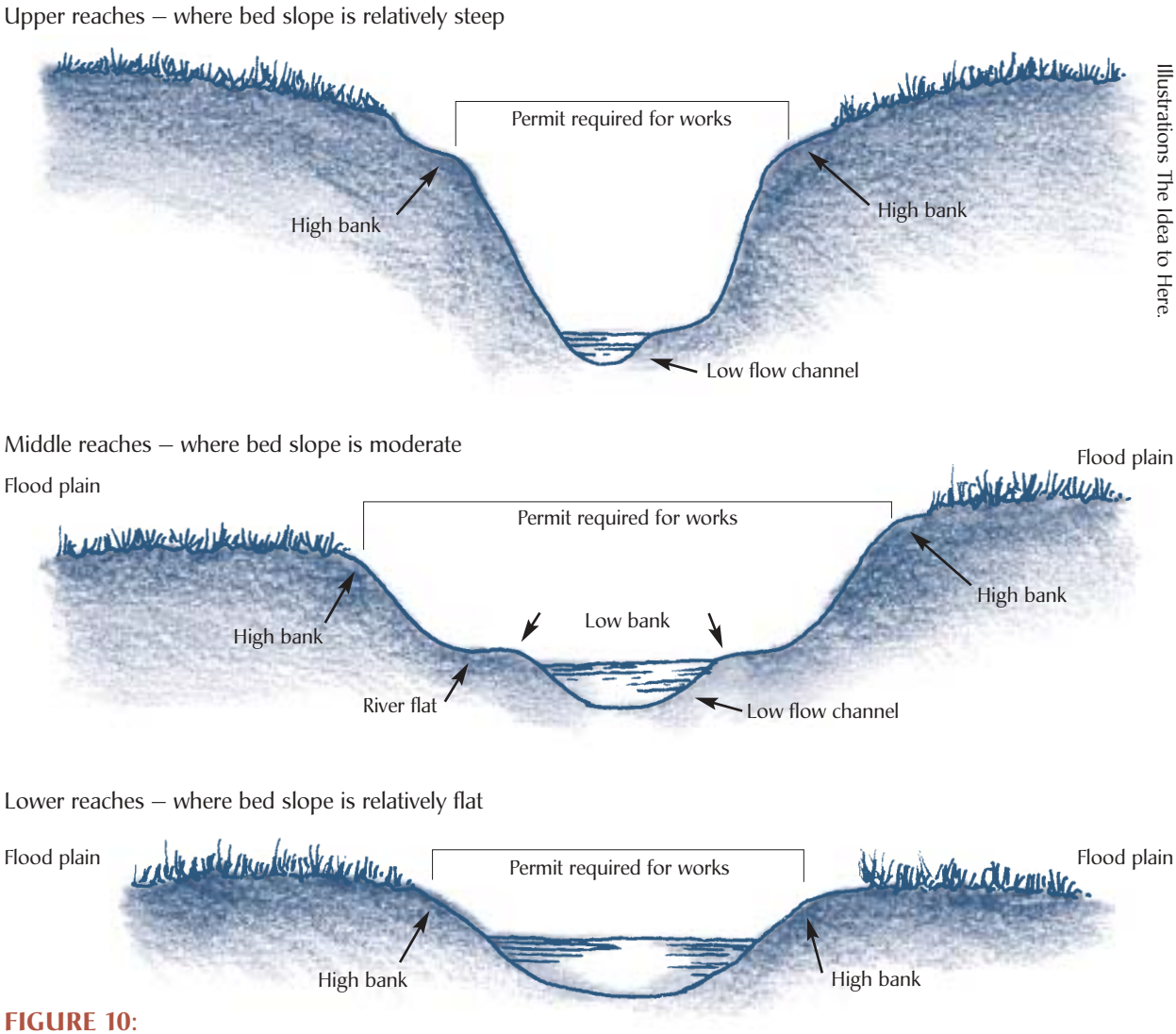


FIGURE 10: High banks for the purposes of the Water Resources Act 1989

Given the importance of this Act, a cane 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 cane 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 first 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 your 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 from CANEGROWERS 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 $250.00.

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).

In many canegrowing regions (including Wet Tropics, Central Queensland Coast and South-east Queensland) these distances are reduced to 50 metres for rivers and 25 metres for creeks and watercourses. 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 (Appendix B). This policy is worth having a look at, as

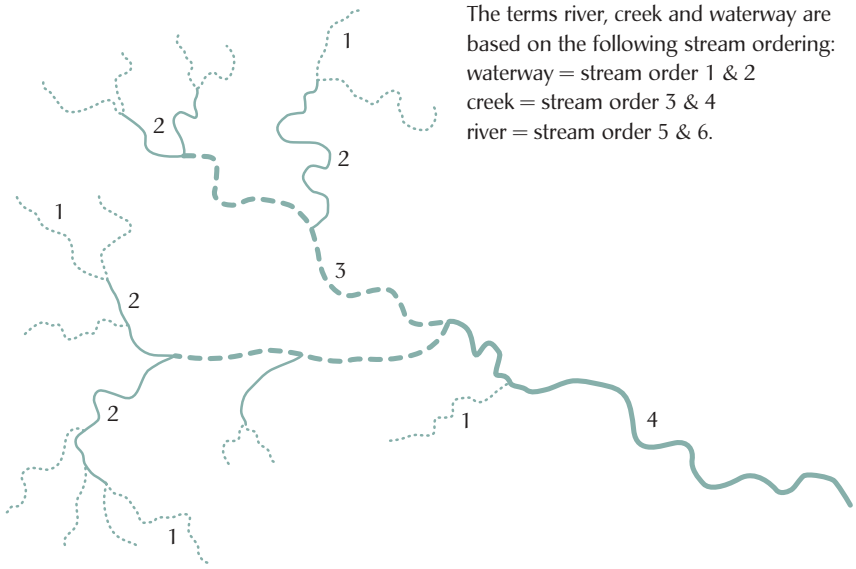


FIGURE 11: Diagrammatic explanation of stream ordering

When two streams of the same order join, the resulting watercourse becomes one stream order larger. If two streams of different order join, the resultant stream is that of the larger stream.

Source: *Queensland State Policy for Vegetation Management on Freehold Land: Explanatory Notes to Code*, p. 13.

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 per cent 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 you are 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 undertake the work and recover costs from the growers.

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.

Coastal Protection and Management Act 1995

This is the principal legislation for the management of the State's coastline, including stream estuaries and surrounding lands. It provides powers to control development and activities within these lands. The QEPA administers this Act.

A control district may be declared:

a. over coastal waters; or

b. over a foreshore and over water up to 400 metres inland from the high water mark along the foreshore; or

c. at a river mouth or estuarine delta – over land up to 1000 metres inland from the high water mark at the river mouth or estuarine delta; or

d. along tidal rivers, saltwater lakes and other bodies of internal tidal water – over land up to 100 metres from the high water mark along the river, lake, or body of water; or;

e. over an island in coastal waters.

A control district may also include all or part of a coastal wetland, dune system or key coastal site and up to 100 metres from the wetland, system or site.

The QEPA can impose a notice to prevent or control activities, or to repair damage caused on lands within the distances noted above. The sorts of activities that are covered by this Act include clearing and in-stream or adjacent works such as groynes, piers and ramps. However, the Act does not cover the activities that impact on marine plants, as these are covered by the *Fisheries Act 1994* (see next Act).

IMPLICATIONS: If your property comes within the distances specified under this Act, contact the local QEPA office to ensure any activities they wish to undertake do not incur a notice or penalty.

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 QDPI administers this Act.

The clearing of marine plants (e.g. mangroves) is controlled through a permitting process. A Fish Habitat Code of Practice (FHC 003) has been developed by QDPI and CANEGROWERS under Section 51 of this Act – it is called *Canegrowers on-farm maintenance of drains with marine plants*.

In addition, 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 12). 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).

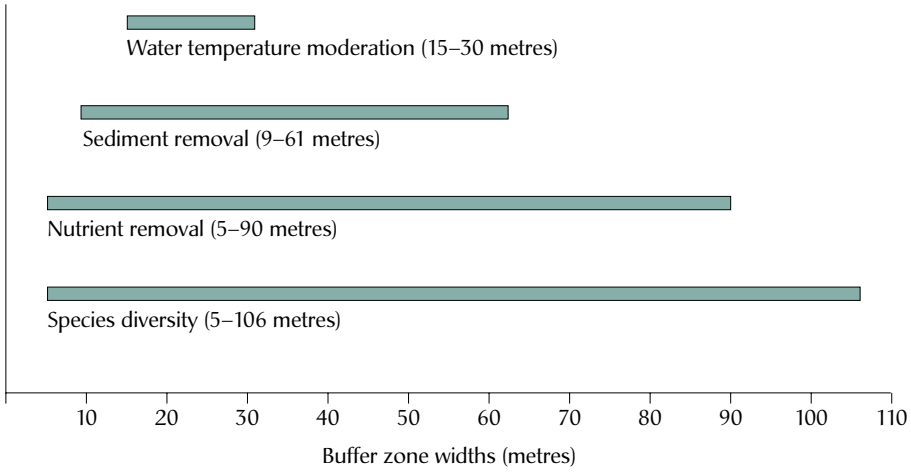
ii. The intensity of the adjacent land-use (e.g. intensive agriculture, grazing, residential, industrial or natural).

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).

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

As can be seen from Figure 12, 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 outlines 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 12: Range of (minimum) buffer widths for providing specific buffer functions.



Source: Bavins, M., Couchman, D. and 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 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 cane farms adjoin declared parts of reserves or other protected areas. Property plans and management practices should take account of the need to maintain the ecological health of these areas. 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.

Environmental Protection Act 1994

This is the principal legislation for the protection of the State's environmental values. The Act imposes a general environmental duty of care on all persons, requiring them to take all reasonable and practicable measures to prevent or minimise likely environmental harm. The QEPA administers this Act.

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 *Environmental 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.

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 subdivision or construction of buildings, check with local government agencies that there are no development constraints and that planning approval will be granted.

OTHER STATES

For cane growers in New South Wales and Western Australia, the range of legislation impacting on riparian zone management is similarly extensive. Table 5 provides an overview of this legislation and divides it according to different aspects of river and riparian management. When considering undertaking works in the riparian zone, it is important to consult with the relevant local departmental authorities who are responsible – in New South Wales these are the Department of Land & Water Conservation; National Parks and Wildlife Service; Environment Protection Authority and NSW Agriculture. In Western Australia these are the Waters and Rivers Commission; Department of Conservation and Land Management; Agriculture Western Australia and Department of Environmental Protection.

TABLE 5: NSW and WA legislation relating to riparian land management use on cane farms

State	River/riparian management aspect	Statutes
New South Wales	Pollution / water quality	Protection of the Environment Administration Act 1992 Pollution Control Act 1970 Contaminated Land Management Act 1997 Environmental Offences & Penalties Act 1989 Protection of the Environment Operations Act 1998 Clean Waters Act 1970 Water Act 1912
	Ecosystem values Riparian Fish habitat	Coastal Protection Act 1979 National Parks & Wildlife Act 1974 Threatened Species Conservation Act 1995 Native Vegetation Conservation Act 1997 Fisheries Management Act 1994 Local Government Act 1993 Rivers and Foreshores Improvement Act 1948 Soil Conservation Act 1938 Wilderness Act 1987
	Catchment, land / water management	Catchment Management Act 1989 Coastal Protection Amendment Act 1998 Commons Management Act 1989 Drainage Act 1939 Forestry Act 1916 Irrigation legislation (range of Acts) Crown Lands (Crowns Lands Consolidation) Act 1989 Environmental Planning and Assessment Act 1979 Local Government Amendment (ESD) Act 1997 Rivers and Foreshore Improvement Act 1948 Roads Act 1993 Rural Fires Act 1997 Rural Lands Protection Act 1989 Water Supply Authorities Act 1987
Western Australia	Pollution / water quality	Environmental Protection Act 1986
	Resource and access	Rights in Water & Irrigation Act 1914 Country Areas Water Supply Act 1947 Fish Resource Management Act 1994
	Ecosystem values	Environmental Protection Act 1986 Waterways Conservation Act 1976 Conservation and Land Management Act 1984 Wildlife Conservation Act 1950
	Catchment, land / water management	Local Government Act Western Australia Planning Act Public Works Act Soil and Land Conservation Act 1945 Aboriginal Affairs Planning Authority Act 1972 Agriculture Act 1988 Land Administration Act 1997 Bushfires Act 1954
	Institutional arrangements for catchment management	Waterways Conservation Act 1976 Waterways and Rivers Commission Act 1997 Water Corporation Act 1995 Water Agencies (Powers) Act 1984 Water Services Coordination Act 1995 Agriculture Protection Board Act 1950 Western Australia Planning Commission Act 1985

Source: Mary Maher & Associates, 2000, *Australian River Management: A legislative framework for the Twenty-first Century*, Occasional Paper 2/00, Land & Water Australia, Canberra.

APPENDIX B

Photo Siwan Lovett

STATE POLICY FOR VEGETATION MANAGEMENT ON FREEHOLD LAND

State policy for vegetation management on freehold land – performance requirements and acceptable solutions

Performance requirement (PR)	**Acceptable solution (AS)**
PR1 Nature conservation values and water quality of significant natural wetlands, lakes and springs are maintained.	**AS1** Vegetation is retained: – in wetlands, lakes and springs; and – within at least 50 metres of wetlands, lakes or springs.
PR2 Viable networks of wildlife habitat are maintained.	**AS2** On properties that are greater than 100 hectares vegetation is retained: – in clumps greater than 10 hectares with a perimeter (m) to area (ha) ratio of no more than 200:1; and – in corridors connecting remnant vegetation at least 200 metres wide On properties that are less than 100 hectares, the configuration of retained vegetation will optimise the viability and connectivity of the retained vegetation.

continued over

Performance requirement (PR)	Acceptable solution (AS)
PR3 Watercourses and adjacent habitat are protected by: – maintaining bank stability by protecting against erosion and slumping; – maintaining water quality by filtering sediments, nutrients and other pollutants; – maintaining aquatic habitat; – maintaining wildlife habitat.	**AS3** In areas listed as coastal areas, vegetation is retained along each side of a watercourse within at least: – 50 metres of each high bank of a river, – 25 metres of each bank of a creek or waterway, and In all other areas vegetation is retained along each side of a watercourse within at least: – 200 metres of each high bank of a river, – 100 metres of each bank of a creek, – 50 metres of each bank of a waterway.
PR4 The soil resource is protected against the loss of chemical and physical fertility through erosion or mass movement.	**AS4** Vegetation is retained: – in areas identified as vulnerable to mass movement; and – on slopes in excess of rulings provided.
PR5 The landscape is protected against increased salinity or waterlogging.	**AS5** Vegetation is retained: – in existing or identified potential discharge areas; and – within at least 50 metres of an existing or identified potential discharge area; and – in at least 30% of the contributing catchment area above an existing or identified potential discharge area, with priority given to identified recharge areas; and – in areas subject to increased waterlogging.
PR6 No adverse effects on the environment caused by the release of acid and metal contaminants from the disturbance of acid sulphate soils.	**AS6** Vegetation clearing in areas identified as containing acid sulphate soils does not cause soil disturbance or alterations in ground water levels that would result in the aeration of horizons containing iron sulfides.
PR7 Land proposed to be cleared is capable of sustainable use (where the proposed use is for primary production or forest plantation purposes).	**AS7** Clearing occurs only on land that has been classified as suitable for the proposed agricultural, pastoral or forest plantation purpose: – in a land resource assessment survey; or – in a Land Management Manual; or – where such information is unavailable, in a written report prepared by a land resource surveyor.

Source: *Queensland State Policy for Vegetation Management on Freehold Land: Explanatory Notes to Code*, and www.dnr.qld.gov.au

MANAGING RIPARIAN LANDS IN THE SUGAR INDUSTRY

A guide to principles and practices