3. Best management practices for riparian biodiversity: Current advice and actual practice

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Introduction

Improving and enhancing riparian biodiversity on grazing properties requires changes to current farm management practices, where best management practice for riparian biodiversity is integrated into farm management plans. This integration depends on the extension of advice that is considered relevant and credible by landholders. Overwhelmingly, the appropriate management of riparian land by landholders is determined by the advice and management guidelines extended by a range of industry and natural resource management extension and service providers. These extension and service providers include industry specific groups such as Target 10, statewide agencies such as Land for Wildlife and Catchment Management Authorities, as well as national agencies such as Landcare. The information disseminated by these groups to landholders is often not specific to local conditions and sourced from state or national guidelines. Consequently, the advice extended can be contradictory or may be irrelevant to specific geographic areas. While some guidelines appear to be readily transferable to the bioregions and industries associated with this project, others are more general and cannot be directly applied to this project. An example of the latter is the work of Jansen and Robertson (2001b). Although this study describes grazing cattle impacts on riparian zones, it is concerned with a very large river and extensive livestock and pasture management practices.

This review collected information on what is currently considered best management practice for enhancing riparian biodiversity, what advice is currently extended to landholders and compared these with what is most commonly practiced by landholders. In addition, knowledge gaps were identified that either restricted the amount of advice being offered, or reduced the relevance or credibility of the advice so that adoption is less likely.

The Approach

This review focuses on the technical aspect of riparian biodiversity management, rather than using research-based data. Therefore, the majority of information sourced for this review was collected from technical management guidelines, fact sheets and web-based sources supplied by relevant industry service providers. A review of these riparian biodiversity best management guidelines identified eight key issues faced by landholders and natural resource managers. These are: stock and grazing management; establishment of buffer strips; planting and retaining riparian vegetation; weed control; waterway modification; management of dead trees; control of feral animals and conflicts with native fauna. Based on this information, the eight management issues were discussed in two regional workshops with farmers, industry, departmental, and organisational representatives to determine a) whether the issues identified encompassed all of the on-ground management concerns, and b) gaps in knowledge associated with the issues. The information obtained from the regional workshops has been incorporated into this review.

Some of the key gaps in knowledge identified are only gaps in relation to these project areas and relevant data exist from other places. The reason for inclusion is that local examples have been found to be a requirement to convince many landholders that the advice is sound. Thus, some of the key gaps in knowledge could in fact be more accurately described as key deficiencies in the availability of good local data.

The management issues identified have been used to structure this review. Many of these issues are inter-related and the distinctions below are intended only as a convenient way of presenting the information. The extracts from current sources of advice have been edited and paraphrased to emphasise the relevant points. The original versions should be consulted if exact quotes are required. Due to recent changes in the content of advice, such as the changed attitude to willows, only sources produced in the last 10 years (usually much more recently) were included. Obtaining precise information on the prevalence of different riparian management practices proved problematic due to the scarcity of relevant surveys or other records. Nevertheless, the overall picture of current management is considered reasonably reliable due to the close contact of the project team with landholders, their advisers and personal knowledge of the bioregions.

Stock and grazing management

Continuous stock access or frequent rotational grazing is highly likely to degrade existing riparian biodiversity by preventing native vegetation recruitment and by maintaining a short grass cover that has a low habitat value for fauna. Other adverse impacts include stream bank erosion due to over-use by stock of preferred (camp) areas and reduced water quality due to faecal inputs. Advice on biodiversity protection and enhancement commonly involves the encouragement to adopt permanent exclusion, possibly because it is simpler to explain and implement than other options. Whilst excluding stock from the whole of the riparian zone is promoted as the ideal it is widely accepted that fencing off just sections that are of high biodiversity value and/or of low grazing value may be an appropriate starting point.

Some management advice recognises that grazing of the riparian zone will occur in the medium term for economic reasons, but suggests an initial total exclusion to allow habitat recovery before reintroducing a controlled amount of grazing. The effects of restricted grazing will be highly variable depending on the characteristics of the riparian zone, the conditions at the time of grazing and how the stock pressure is managed. Other advice promotes the advantages of complete exclusion of stock from riparian zones on the basis of production gains if stock drink clean water rather than dirty river water and also on the basis that stock will no longer become stuck in muddy streams.

A technique not used to date in this bioregion and still in the experimental phase in Australia is "virtual fencing". Under this system, an on-animal device is used to receive a transmitted message and instruct the (trained) animal to alter its movement accordingly. This enables the creation of a virtual exclusion zone. As pre-conditioned animals approach the exclusion area, they are signalled to turn around and walk in the opposite direction (Rouda 2002). To date, there have been no trials that provide sufficient information to assess the usefulness of this technique for intensive grazing properties in this bioregion. Training of the animals is required, but the cost of constructing and maintaining fencing is saved. The technique might be most useful in situations where frequent flooding makes the maintenance of permanent fences difficult.

Current riparian management guidelines

- Fence to exclude the stock. Short periods of light grazing may be acceptable. Provide off-stream water or restrict access to just one point for stock to drink. (NRE 1999)
- To reduce the risk of damage to fences during floods, fences should be located well away from the main flow. This will also benefit erosion protection and wildlife by increasing the area being revegetated. Twenty metres on either side is the desirable minimum width but may be impractical in some farming situations (Platt and Temby 1999).
- If riparian land is to be grazed at all, it should only be when the bulk of the vegetation is dormant and the soil moisture is low. Avoid grazing riparian land in the growing and flowering season and when germination is occurring. If it is necessary to graze riparian land, adjust both the stocking rates and the frequency of use to suit the sensitive nature of the land. Cattle are more damaging than sheep or goats. Extensive consideration of appropriate types of fencing and stock watering options is included in this guideline (Lovett and Price 1999a, Guideline G).
- Fencing is needed to restrict stock access. Short periods of light grazing may be acceptable, or even desirable at certain times of year. You might have to pipe water to troughs for animals or leave some access points unfenced. There may be important benefits for animal production by providing water from troughs. The minimum width of a stream buffer strip should be 20 metres, but for wildlife habitat it should be wider in places. An 80-100 m wide strip is needed for long-term survival of most birds and animals. In many situations, this is not practical. Consider having islands 50-60 m wide with 20 m wide strips of riverside vegetation forming suitable corridors between them (Brouwer 1997).
- Avoid where possible direct access to streams by stock. If possible, connect troughs to a permanent water supply. If necessary provide access points (concrete, gravel etc) and fence the rest. If Crown frontage lease applies, reduced rental is available if not grazed (Price and Stivic 2001).
- Fencing will enable you to manage stock access according to the need and available feed, and opens up opportunities for additional or alternative productive use of riparian margins. Grazing should be restricted or prevented altogether when plants are starting their annual growth.

Grazing should occur when plants are dormant. Vegetation should also be spelled around the time of flowering and seed production (LWRRDC 1996a).

- By excluding stock from the riparian zone and providing alternative stock watering systems such as troughs, both the primary producer and our waterways benefit from cleaner water (GHCMA 2002).

Current management practices in the project area

There appears to be little hard information on the current level of adoption of the different options. The most up to date information is from a March 1995 ABS survey (NRE 1997d) that is aggregated by parish and does not differentiate the types of farming involved. According to this survey, most of the farmland in the project area had greater than 50% of stream frontage with unrestricted stock access. Whilst the trend certainly appears to be for more fencing off of stream frontages, local knowledge suggests that still less than 50% of frontages are fenced on grazing properties. There is a clear trend that larger watercourses are most likely to be fenced off and smaller (low order) streams at the top of catchments are less likely to be fenced. This may reflect the higher level of hazard to stock of larger watercourses. Large lengths of streams that have been fenced off and replanted are currently totally excluded to stock to protect the vegetation, but often landholders have expressed an intention to reintroduce some level of grazing once the trees are large enough.

The most suitable practices for enhanced biodiversity

In order from the least suitable for enhanced biodiversity to the most suitable, options include:

1) Allow unrestricted access by stock to riparian zone.
2) Discourage stock use of riparian zone by providing alternative watering points/shade and by locating salt/mineral licks elsewhere, but do not fence off.
3) Control grazing of the riparian zone using temporary or permanent fences. This may range from a policy of using the riparian zone as a regular part of a grazing system to using riparian areas as a strategic reserve to be crash grazed infrequently.
4) Permanently exclude grazing from riparian zone.

Key gaps in knowledge

An important gap in knowledge is how much grazing can be tolerated without excessive damage to different sorts of native vegetation. There is a widespread view that some level of grazing can be beneficial by suppressing vigorous grasses that would otherwise out compete native species. At the same time, there is acceptance that excessive grazing and trampling can have negative effects. There have been requests for the development of indicators by which over or under-grazing of riparian vegetation of different sorts can be recognised.

Another important gap in knowledge concerns the gains that are available from increased ease of stock management and cleaner water for stock. These gains will of course vary from property to property but there seems to be a need for additional information to support the claimed benefits.

Establishing buffer strips

Managing riparian vegetation to maintain water quality through the establishment of “buffer strips” between the main pasture area and the stream bank has been widely promoted in recent years. The buffer strips improve / maintain water quality of the rivers and streams by trapping sediment, sediment-bound nutrients, soluble nutrients, manure and other contaminants derived from the pasture. There has been considerable debate over the efficacy of buffer strips of different types and sizes. The term is sometimes used to include vegetation intended to stabilise the banks, whilst in other cases, the protection of the waterway from unwanted inputs arising from the wider pasture area has been emphasised. Less frequently, the buffer strip is intended to protect native riparian vegetation rather than the watercourse itself.

Phosphorus (P) was initially thought to reach watercourses mainly bound to soil particles, suggesting that the known efficiency of some buffer types in retaining sediment would result in reduced phosphorus losses. Recent research has found that in at least some systems a large proportion of P is lost in a soluble form, therefore buffer strips are unlikely to be able to retain this nutrient efficiently. Strips of native trees and shrubs have sometimes been promoted as appropriate buffer zones, however, studies have indicated that unless they have a dense ground cover, such strips may be inferior in retaining sediment and some nutrients when compared to a cover of tall pasture grasses. A combination of a tall grass strip then a strip of native riparian vegetation on the edge of the watercourse has been suggested for locations where surface water flow into the channel occurs. Some advice on buffer strips promotes the idea of concentrating on such areas rather than establishing a strip along the full length of the waterway, conflicting with other advice that emphasises the need for continuity of riparian habitat. Focussing on native riparian vegetation as a buffer strip for sediment and nutrient retention may reduce protection and/or reintroduction of this vegetation unless its other advantages (eg. bank stabilisation, shade and shelter, wildlife value) are simultaneously promoted.

Current riparian management guidelines

- If stream banks are managed to retain a well grassed or forested buffer strip, up to 99% of the main nutrients in animal manure can be kept out of the water. Recently grazed pasture has little effect in holding nutrients. If the grass is ungrazed (10 cm long), few nutrients will escape to the water. Studies have also found that a forested zone will remove up to 45 kg/ha of nitrogen from ground water moving into a waterway. Having thick understorey vegetation in a riparian buffer will reduce the speed of run-off water and increase infiltration (Brouwer 1997).
- In addition to preventing erosion and improving water quality, riparian vegetation can absorb and use natural or added nutrients that might otherwise be washed into streams and result in the growth of nuisance plants and algae within rivers (LWRRDC 1996b).
- Riparian vegetation acts as a buffer, protecting rivers and streams from the activities of the surrounding catchment area. When overland run-off that contains sediment reaches the riparian zone it is slowed by the roots, understorey and leaf litter, and can then soak into the ground. The sediment ends up in the riparian vegetation rather than affecting the river or stream. Riparian vegetation may also act as a sink for additional nutrients flowing off the catchment (NRE 2001c).
- Riparian buffers can trap and store sediments and nutrients only if the incoming overland flow is diffuse and less than 1 cm deep. Grass buffer strips are more effective in trapping sediment and nutrients than are forested strips. There is probably little prospect of trapping orthophosphate (=soluble) in riparian soils unless a large proportion of the groundwater is transpired by riparian vegetation. There are greater prospects for absorbing nitrate transported by groundwater (Lovett and Price 1999a, Guideline D).
- Do not scrimp when planting buffers along creek-lines, plant the largest areas you can and reduce costs by removing corners and unnecessary zigzags (Straker and Platt 2002).

Current management practices in the project area

The use of buffer strips has been widely promoted. Landcare advise the use of a 20 m wide buffer strip, but this is frequently regarded as excessive and is exchanged for narrower buffer widths. An alternative practice is to make the buffer strips wide enough to plant three rows of trees. The term buffer strip is generally used by landholders to mean any area adjacent to a waterway that is fenced off and managed differently, therefore, strips planted with trees and shrubs or strategically grazed grassy areas are not distinguished. Riparian replanting for biodiversity or aesthetic reasons has also been referred to as a buffer although there is no mention of the system that is being buffered.

The most suitable practice for enhanced biodiversity

Establishment or retention of a continuous, wide native vegetation buffer strip on the banks of watercourses is the optimal practice for biodiversity enhancement, but involves the greatest loss of pasture production and may not be the most effective way to reduce nutrient or sediment inputs to the watercourse. Retention of additional strips of long grass further out may have some further beneficial effect on biodiversity by reducing the velocity of water and amount of sediment flowing into the riparian zone. Establishment of buffer strips consisting only of a strip of pasture species maintained with a tall sward would have some small amount of biodiversity value due to the provision of cover and improved protection of marginal vegetation, and possible in-stream benefits from the reduction of nutrient and sediment input. This would be improved if combined with a low-density of tree or shrub plantings, providing further habitat without compromising the function of the buffer strip as a sediment and nutrient trap.

Key gaps in knowledge

There is insufficient knowledge of the biodiversity gains that may result from the establishment of different types of buffer strips. For example, wide (>20 m) strips consisting of a tall grass sward and a low density of native trees and shrubs appear to offer continued production combined with good waterway protection. However, there is not enough detailed information about biodiversity enhancement to assess whether such strips would be preferable to a much narrower but continuous strip of ungrazed native vegetation.

Planting and retaining native riparian vegetation

The reasons for planting or retaining riparian vegetation are many. The benefits of native vegetation for erosion control and nutrient retention are discussed in other sections of this review. This section considers the advice provided when the primary motivation for enhancing riparian vegetation is some other reason such as biodiversity, aesthetics, farm forestry or stock shelter. As the '*Productive Grazing, Healthy Rivers: Improving riparian and in-stream biodiversity'* project is concerned with protection and enhancement of existing remnants, emphasis has been placed on management of riparian zones with at least some remnant native vegetation, rather than restoration from a highly degraded situation. However, replanting from a pasture base is also considered as high-value remnants may contain areas that have been degraded and require replanting, or replanting of cleared riparian land may be required to link remnants.

Most of the advice reviewed here strongly advocates that natural regeneration is superior to sowing or planting, but if sowing or planting is required, then native species are much more desirable than exotic species. The term 'native' is sometimes further explained as plants found, or formerly found, locally. Other publications do not always make this clear, which may lead to the assumption that Sydney blue gums (*Eucalyptus saligna*), for example, are a desirable native species. The desirability of planting or encouraging different vegetation layers is also stressed by many publications.

A notable exception to the consensus on these matters is the material available on farm forestry. The Agricultural Notes *(AgNotes)* concerned with farm forestry include stream sides as suitable locations for planting but either do not mention biodiversity or make only very small reference to it. Extensive material relating to choice of tree species for different regions, soil types and purposes does not refer to the desirability of using indigenous species. Of eighteen *AgNotes* relating to different aspects of stand management, not one mention biodiversity in any form. Establishment of native ground flora is not mentioned and some advice appears to view all ground vegetation as undesirable. The separation between farm forestry advice, concerned overwhelmingly with commercial considerations with little or no biodiversity advice, and riparian management advice, which often fails to mention the possibility of any direct commercial use of riparian plantings, is very noticeable. This subject is considered in detail in a discussion paper by Dames and Moore (1999). Some of the key points of this paper are that legislation controlling the clearing of native vegetation may have acted as a disincentive to farm forestry, there has been little research on the claimed biodiversity gains of switching land use from agriculture to farm forestry, and that while multi-species plantings seem to offer particular biodiversity gains, they have traditionally been viewed as commercially unacceptable. The paper offers suggestions for increasing the biodiversity benefits

of farm forestry, one of these being that waterlogged riparian zones should be planted with native trees rather than the main commercial species.

Information relating to willows almost exclusively consists of advice on removal and on the inadvisability of planting willows. Only one publication states that despite their disadvantages willows could still be useful as pioneer vegetation for initial colonisation of eroding banks. Increasing emphasis on the weediness of willows is likely to make this use much harder to justify, and in fact willows may soon be declared noxious, which would prevent such use.

Provision of shade and shelter to stock is cited in several publications as a benefit of trees and shrubs on farms, although it is obviously not restricted to riparian situations or to native vegetation. Research exists that clearly demonstrates the value of keeping dairy cattle cool. Success of vegetation in providing shade is easy to assess and the behaviour of stock during cold, windy, or hot, dry weather makes it relatively easy to convince farmers of the usefulness of shelter. For water quality and biodiversity, however, it is not desirable for stock to camp in the riparian zone. Promotion of the value of riparian remnants as shade for stock should clarify that shade should be used some distance from the waterway.

The economic benefit of increased pasture production due to pest insect control by the birds and bats attracted to riparian vegetation and other tree cover on farms is frequently claimed. There appears to be clear evidence that riparian and other remnant vegetation attract greater numbers of birds and bats and that a large part of their diets often consists of herbivorous insects. Nevertheless, there appear to be no studies that provide convincing evidence of consequent reduction in pests relevant to intensive grazing to allow a cost-benefit analysis. It is notable that none of the information contained in *AgNotes* relating to pasture management refers to any insect pests that might plausibly be controlled in this way. In the absence of good evidence, statements that such a benefit exists may be premature and invite scepticism. If a worthwhile reduction in pests is thought to be likely then perhaps it should be investigated further, possibly in conjunction with other biodiversity projects.

Current riparian management guidelines

- Fostering natural regeneration is a cheap and effective method of tree replacement. With good planning and a bit of patience, abundant results can be achieved with little effort compared to planting seedlings (Douglass and Cummings 1999).
- Often local (indigenous) species will have added benefits for wildlife and encourage birds that will control pests. Species that can sucker or survive defoliation and fire when established are often preferred. Where sites have been substantially modified eg. saline sites, other non-local species may be more tolerant. Some species planted outside their normal range are insect-prone and should be avoided. Others are tolerant of occasional defoliation. Include the local acacias, banksias and bursaria to aid long term control of insects by birds, wasps and mammals (Perry 1992).
- Where willow trees are causing stream instability, spreading by seed or broken branches, or serving no erosion control purpose, their removal and replacement is recommended. However, before proceeding it is essential that the impacts on the stream of removing the willows be carefully considered. Indiscriminate removal without careful planning can cause significant problems (AWWMWG 1998a).
- The negative environmental impacts of willow-dominated watercourses are being increasingly recognised. These range from changes in watercourse behaviour, to adverse impacts on habitat values for local native or indigenous plants and animals. Willows are no longer recommended for planting along watercourses for these reasons. Rather, planting diverse indigenous species is recommended for watercourse revegetation (AWWMWG 1998b).
- The potential for more weed growth can be a disadvantage of fencing. However, by providing a gate and allowing sufficient space for vehicle access for fire control and weed spraying, fenced areas will be easier to manage (AWWMWG 1998c).
- Encouraging your remnant vegetation to regenerate is the preferred and generally the easiest way to revegetate. However, if you do not have any native vegetation, have only a little, or want to increase the diversity of tree species, you may have no choice but to plant seedlings, or sow seed directly into these areas. For cases of severe bank erosion, planting may be the

only option to guarantee quick results. Natural regeneration may occur without further assistance than fencing out livestock. Revegetation is more than creating a plantation; it is about restoring local natural systems. All layers of the indigenous vegetation are important in controlling watercourse erosion. While indigenous plants may not control stream bank erosion as fast as willows, there are many benefits associated with planting them. Plants that occur naturally in your district are highly recommended, and local seed is preferred to seed collected from outside your area. Plant beyond the high bank line at 8-10 metre spacing, in clumps. Use local remnant vegetation as a guide to suitable species and layout (AWWMWG 1998c).

- There are many benefits of establishing indigenous plant species. These include: they require relatively lower input to be established and maintained; tolerance of local environmental conditions; maintenance of the ecology and biodiversity of an area; provision of a balanced and suitable habitat for native fauna; contribution to the productivity of farm enterprises; and maintenance of the unique character of the landscape (Johnson 2001).
- Planting local species can enhance the health of surrounding stands of remnant vegetation. They can be used to create valuable links between stands of remnant vegetation that occur in reserves, along roadsides and waterways and on private properties, allowing wildlife to move along these vegetation corridors. Local plant species will not become weeds, as do many introduced plants. Unlike non-indigenous plants, there is no risk of indigenous species escaping and invading areas of bushland. Using local plant species creates habitat for insect predators that can protect the planting itself as well as adjacent farmland, and improve productivity. Predatory wildlife may include bats, birds, gliders, predatory insects and parasites. These insect predators are important in the control of crop and pasture damaging pests. Encouraging a range of insectivorous species by planting of a variety of indigenous plants can result in reduced crop and pasture damage and a reduction in the use of pesticides (Johnson 2001).
- The advantages of natural regeneration over direct seeding or planting are considerable. The principal advantage to the farmer is the low cost, both in terms of labour and cash, of establishing large numbers of suitable plants. It is also ideal for wildlife. In priority order, the most likely obstacles to natural regeneration occurring on a farm are the absence of remnant vegetation from which native seeds will spread, grazing, weeds and lack of fire (MacLennan *et al.* 1999).
- In many instances, when mature trees are fenced off and protected from stock, some replanting will be necessary to restore the understorey and ground layers of vegetation, to provide replacement young trees, or fill in gaps along streamside corridors and in remnant stands of vegetation. The most important action is fencing off the mature trees. When wildlife conservation is an important aim of revegetation and mature trees are present, the protection of those mature trees should be paramount. The retention and protection of stands of old trees (the larger the stand the better) is probably the single most important conservation action that can be taken on our own land, particularly where mature trees form a natural corridor and buffer along the edges of creeks (Robinson 1992).
- Natural regeneration is the preferred method to use initially when there is an available seed source. It may occur without assistance following fencing. If no natural regeneration occurs within one or two years, soil compaction or competition from weeds may be the cause. Note that eucalypts may not flower and set seed every year. If natural regeneration is not an option, direct seeding or plantings of seedlings grown from local native seeds, appropriate for the location and soil type, is the second best option (NRE 1999).
- This *AgNote* provides an overview to species selection for private forestry. It is an introduction to a series of Notes used as a species selection guide for specific locations in Victoria. The species chosen will depend on the answers to a number of basic questions. What markets am I growing timber for? What type of timber product will I grow? What species will provide these products? What species is suitable for my site? There was no mention of biodiversity here or in any of the regional lists (Noble 2001).
- The best way to increase the amount of native vegetation on a farm is to fence off existing remnants and let natural regeneration do the job for you. Try to have at least 30% tree cover on your farm and allocate part of this area to wildlife habitat (Barrett 2000).

- The highest priority for managing riparian vegetation should be to protect areas in good condition. It is much more cost-effective to protect these areas than to rehabilitate them later after poor management (Lovett and Price 1999a, Guideline E).
- While fire can be a useful tool, it is also a serious threat to the integrity of riparian vegetation. In most instances, fire exclusion rather than use, will be the management aim. Regular monitoring of the riparian zone should aim to detect: changes in species composition and the structure of plant communities, the extent of recruitment and regeneration of native species, changes in the composition and extent of weed species, the health of native species (Lovett and Price 1999a, Guideline E).
- It is important to resolve any problems relating to stream channel stability before embarking on revegetating the stream banks so that revegetation work is not wasted (Lovett and Price 1999a, Guideline E).
- Natural regeneration should always be the first choice. It is cost-effective and utilises species that are adapted to the site (Lovett and Price 1999a, Guideline E).
- Direct seeding is relatively cheap, requires less labour and time than planting, seeding develops good roots, require little maintenance, and a diverse mix can be sown. However, direct seeding can be less reliable than planting, seed predation can be a problem and sometimes only a few species in the mix establish well. Careful pre-planning and site treatment for weed control is also required. Planting of seedlings is generally reliable, provides instant impact, and is useful for species that are difficult to germinate. Seedling planting is costly, transplant shock may occur and the roots are not as well developed as those of seedlings from natural regeneration or direct seeding (Lovett and Price 1999a, Guideline E).
- If the site is isolated from natural seed sources deliberate replanting may be necessary. In especially difficult situations, the initial use of introduced species to provide stability and cover may need to be considered while slower-growing native vegetation becomes established. Many groups now view willows and poplars as a useful pioneer to stabilise eroding stream banks (LWRRDC 1996d).
- Groundcover is equally as important for wildlife as larger shrubs and trees. Where appropriate, revegetation should use a wide range of native plants that occur along local rivers and streams. Regeneration from existing vegetation is by far the best and cheapest option. Adequate regeneration may require localised burning or light scarification of the ground for germination of some species (Brouwer 1997).

Current management practices in the project area

Most planting and retention of native riparian vegetation on grazing properties in the project area is motivated by a mixture of reasons, of which erosion control is probably predominant. Despite extension material that promotes natural regeneration and direct seeding, neither of these techniques are widely used – planting of seedlings is overwhelmingly the most frequently used technique to establish new riparian vegetation or to regenerate degraded remnants. Seedling planting is regarded as more reliable and able to produce faster results than other methods, and this appears to outweigh concerns about greater cost. One reason for this could be that planting often follows fencing off streams and the cost of planting up a narrow riparian strip is actually low compared to the investment in new fencing and stock watering arrangements. The desirability of using native indigenous species is well accepted. Planting of species other than trees and shrubs is uncommon, with the possible exception of some species planted on stream margins to reduce erosion. This may be because reintroduction of grazing is intended and hence ground flora are not desirable, or because the conditions in the early stages of tree establishment (high light, dense growth of pasture grasses) are not suitable for appropriate native ground flora.

The most suitable practice for enhanced biodiversity

Ideally, existing native riparian vegetation should be protected from excessive grazing or weed invasion and recruitment should be encouraged. All vegetation layers should be maintained, including ground vegetation that may be highly intolerant of grazing and trampling. Where riparian vegetation is fragmented or the riparian strip is too narrow, natural regeneration should be facilitated. If natural regeneration is impractical, direct seeding or planting of suitable native

indigenous species should be conducted. It may be appropriate to pay particular attention to the phased removal of willows and also the protection of large trees whose special value cannot be replaced by establishing more young trees.

Key gaps in knowledge

There is a lack of information on the relationship between level of grazing and biodiversity, referred to previously. Some landholders have mentioned an apparent lack of evidence for claimed benefits to biodiversity from riparian vegetation, and a lack of evidence that improved biodiversity has direct benefits for production eg. natural control of pest insects. This area should be addressed, bearing in mind the difficulty of surveying some flora, fauna and ecosystem interactions and the long time frames before full biodiversity benefits are realised. Retaining or enhancing riparian vegetation has been quoted by some sources as substantially increasing property values, but there seems to be no local quantification of this benefit.

There is little published advice available to assist identification of cases where fire in riparian vegetation may have positive effects on biodiversity, or knowledge of the attitudes of landholders to controlled burning in riparian zones. Regeneration of some vegetation types may be considerably improved by appropriate use of fire, so further information would be valuable.

In general, however, the issues relating to techniques for re-establishing native vegetation seem to be well understood and supported by appropriate sources of information. The only exception to this concerns weed control and is covered in the next section.

Weed control

Landholders have a legal obligation to control certain plants that have been declared noxious. The most relevant declared noxious weeds in the bioregions of this study are the “Regionally Controlled” weeds Paterson’s curse, ragwort, spear thistle, sweet briar, wild watsonia, blackberry, boxthorn, spiny rush, gorse, hawthorn and Cape broom. A much larger number of plant species may be considered weeds in riparian zones due to their potential to displace native plants, interfere with replanting programs, harm stock, create a fire hazard, block the waterway or harbour pest animals, but are not declared under legislation. Important examples include willows, bridal creeper, English ivy, arum lily, tradescantia, sycamore maple, mirror-bush, blue periwinkle and pampas grass. Weeds that are trees, large shrubs and vines particularly affect riparian zones when compared to other vegetation formations. Carr *et al.* (1992) provide extensive information on riparian weeds in Victoria. Riparian zones (Victoria wide) are affected by 88 ‘very serious’ weeds, more than any other vegetation formation (Carr *et al.* 1992). The majority of plants that might widely be considered as weeds in riparian zones of the project area are exotics from overseas, but there are exceptions such as coast tea-tree, pittosporum and cootamundra wattle. Although not declared noxious, willows are considered a major threat to riparian biodiversity. Willow reduction continues to be a major activity, for example, the West Gippsland Catchment Management Authority's annual works program costed willow reduction at approximately $1,000,000 per annum.

It is important to note that the perception of weed problems may vary considerably from one landholder to another. While the presence of some species may be no problem in riparian zones they may be considered undesirable by land managers due to potential spread to the rest of the property. Blackberry, for example, is regarded by some as a major threat to pastures and efforts are made to eradicate it from the property. Other land managers regard blackberry as relatively easy to manage in pastures and tolerate it in riparian zones because of a perceived role in stabilising creek banks. The amphibious grass *Glyceria* is regarded as a weed by some because it can cover creeks, degrade water quality, create bogs and occasionally poison cattle, whilst others see it as a useful pasture plant because of the grazing it provides when the rest of the pasture is dry.

Improving the condition of riparian zones frequently requires a large effort to either remove existing weeds or to prevent weeds invading after removal of grazing. Landholders are often reluctant to undertake riparian revegetation or to fence off remnants because of the perceived effort required to control weeds (Lovett 2002). Some current advice (Lovett and Price 1999a, Guideline A) could lead to confusion because both “aquatic and semi-aquatic” weeds and “riparian weeds” are

considered together. The recommendations could be interpreted to mean that all weeds are a short-term problem that will decrease once a cover of native trees and shrubs has become established. Whilst it is true that decreased light levels and temperature will tend to exclude a large number of aquatic weed species and some light-demanding terrestrial weeds, there are many weedy riparian plants that are capable of establishing and becoming dominant despite a good cover of native species. Furthermore, narrow riparian strips may not be capable of maintaining sufficiently dense cover even to exclude light-loving weeds. Potential benefits from improved management of riparian zones may be lost if insufficient attention is paid to planning future weed control. Land managers experienced with pasture weeds may nevertheless lack knowledge of how to deal with weeds that invade ungrazed riparian zones. There have been reports of even low numbers of weeds leading land managers to reverse their decision to exclude stock from riparian zones.

Current riparian management guidelines

Compared to other vegetation types, riparian zones are especially likely to contain a diverse range of serious weeds. This can make it difficult for landholders or extension staff to access all the necessary information since much of it is provided in single-species form. The large amount of species-specific material that is relevant to riparian zones in the bioregion is not listed below.

- In the absence of riparian shading, many species of terrestrial plants become understorey weeds. Riparian shading may decrease the sediment/nutrient trapping efficiency of understorey and groundcover vegetation. In the medium to long term, riparian shading is a more cost-effective strategy than other means of nuisance plant removal (Lovett and Price 1999a, Guideline A).
- Riparian environments experience frequent natural disturbances, such as flooding. When these are combined with disturbances from adjacent land use, weeds can have a great opportunity to invade. Weeds in intact riparian vegetation can be controlled by retaining a complete canopy cover for each vegetation layer, maintaining a riparian zone of at least 30-50m, avoiding disturbance and excluding stock. Weeds can also be controlled by regular spot-spraying or removal by hand. This can be done every 2 or 3 years until the problem is resolved (Lovett and Price 1999a, Guideline E).
- Weed infestations that substantially modify or dominate the vegetation should be removed. A major problem created by removal of weed-dominated vegetation is the initial loss of food and habitat for native fauna. This problem can be minimised in some cases by removing weeds in stages. In many cases, it will not be practical or feasible to remove weeds from riparian areas and the presence of some exotic species will have to be accepted. Sometimes the growth and spread of weeds species is suppressed as rehabilitation progresses (Lovett and Price 1999a, Guideline F).
- Weeds, especially woody weeds, can be the curse of attempts to re-establish vegetation in the riparian zone. Often these weeds are colonisers of areas that have been de-stocked. On the other hand, annual weeds may become less of a problem. Some weeds are less of a problem because they do not stop trees and shrubs from regenerating (Brouwer 1997).
- Start at the top of your best habitat. Start treatment at the top of a catchment to avoid reinfestation of lower areas through seed roll (gravity) and by being washed down slopes and watercourses (Nicholls 1999).
- Any weeding program should always work from the best areas of native plants towards the weed-infested areas. This principle has been proven more effective and efficient in terms of results, cost and labour. Prioritising the different areas and implementing other basic principles such as making minimal disturbance and allowing native plant regeneration dictate the rate of weed removal, are the best practices. Environmental groups not using these basic weeding principles should rethink their weeding strategy (McNamara 2000).
- Weeds can become more of an issue when grazing is removed from revegetating areas. Some weeds, however, such as Paterson's Curse, tend to diminish when grazing is removed and native vegetation re-establishes (AWWMWG 1998c).

Current management practices in the project area

Weed management in riparian situations is often regarded as much more difficult than in other areas on a property, with considerable justification. Movement of weed propagules from upstream, the difficulty of access to steep or muddy banks and restrictions on herbicide use are just some of the problems. There is a great deal of variability in approach from one landholder to another. As a generalisation, once a decision has been made to restore riparian zones there will be initial intense attempts to remove or suppress weeds in order to establish planted trees and shrubs, and a general expectation that many weeds will become less troublesome once trees are established. This may be over-optimistic if very narrow planted strips are used. Advice to manage wide (30-50 m) strips of riparian vegetation to assist weed suppression (Lovett and Price 1999a, Guideline E) is not acceptable on most properties relevant to this project. Once riparian vegetation is established (or where there are existing remnants), weed control efforts tend to be more sporadic and related either to weeds spreading beyond the riparian zone or to coordinated management efforts against particular weeds with neighbours. The usual method is spot or handgun spraying of herbaceous and small shrub species, with cut and paint or drill and fill used for larger shrubs and trees. Even serious weeds like blackberry are often tolerated in fenced off riparian vegetation if the amount seems to be stable, apparently partly due to a reluctance to risk destabilising banks. The use of grazing to suppress weeds was considered earlier.

The most suitable practice for enhanced biodiversity

The most suitable practice will vary according to the weed species involved at the site, the current status of the infestation and the particular aspects of biodiversity that are of concern. Swift eradication of weeds that have the potential to dominate riparian vegetation is appropriate if the size of infestation is small, but once hard-to-control weeds are well established, this is unrealistic. An aim to prevent further spread to uninfested areas and possibly to suppress weeds sufficiently for survival and recruitment of some native vegetation may be appropriate. Current advice probably over-emphasises eradication as an achievable outcome. When weeds are providing a large part of the cover or nesting sites for native fauna within remnant riparian vegetation or are stabilising banks, a phased removal of the weeds accompanied by planting or natural regeneration of native substitutes is required.

Key gaps in knowledge

A distinction is often made between ‘serious’ weeds and others, with the implication that management efforts should be reserved for serious weeds. It is unclear which species should be designated as serious in different regions and vegetation types when their full potential may not be widely evident, particularly when new or emerging weed species are involved. Collecting and evaluating existing information on weed impacts and experiences of attempted control on a bioregion and industry specific basis would be extremely useful. Comments from landholders and CMA staff suggest that control of large continuous weed stands is regarded as straightforward, but they have a need for improved information on how to manage weeds growing in close association with desirable planted or remnant species.

Waterway modification

Waterways are sometimes allowed to flow without any deliberate intervention, but a variety of practices that control the flow or the channel formation of waterways is common on grazing properties in the bioregions of this study. Smaller streams or adjoining gullies are frequently dammed to provide water for stock. Such modifications can reduce stream flow when dams are refilling, reduce the incidence of floods, alter the pattern of erosion and sediment transport, decrease the downstream movement of organic material and form a barrier to fish movement. Other interventions include culverts, bridges, reinforcement of banks to prevent erosion, construction of stock crossing/watering points, dredging and straightening (channelisation) with the intention of improving drainage, and removal of woody debris (desnagging). The influence of these practices on riparian, as opposed to aquatic, biodiversity are not always clear. There is an ongoing

program across Victoria to remove artificial barriers to fish migration and this issue is not considered further here.

Riparian vegetation and fauna will be affected to some degree by practices that reduce the height or frequency of flooding and by works intended to stabilise banks. Riparian trees are sometimes felled or lopped as a preventative measure to avoid wood falling in to waterways. The whole subject of retaining woody material alongside or in watercourses is under review. As a general principle, any alteration of the watercourse may be considered as likely to reduce biodiversity. Nevertheless, it is recognised that in some situations it may be unavoidable eg to protect high value permanent structures or to control stock access. It should also be borne in mind that in some cases the upstream catchment may have been so modified by clearing and drainage work that the hydrology is in any case very different from the natural state.

Current riparian management guidelines

- Desnagging is an expensive operation and there is no evidence that it actually reduces flood severity or significantly improves stream flow. The effectiveness of desnagging as a river management practice is under review. Avoid removal or re-positioning of wood debris from waterways. Seek advice on its management from NRE or CMA officers (NRE 2001d).
- Recent research has shown that a river channel must be substantially blocked by woody debris before it significantly influences the flow of floodwaters. It has also been shown that reorienting fallen tree trunks so that they form an angle of about 40^{o} to the riverbank prevents flood flows being directed onto the banks. Even where the angle is greater than this, you should consider lopping or reorienting the debris as an alternative to removing it completely. Selective replacement of woody debris in the channel is an expensive option and one that careful planning could avoid (LWRRDC 1996c).
- In recognition of the high value of snags, opt for management rather than removal. Don't cut down trees on banks 'just in case' they fall in. Don't remove snags for aesthetic or recreational reasons unless absolutely necessary (Brouwer 1997).
- Snag re-orientation or lopping will compromise ecological functions and is not recommended other than in exceptional circumstances (Lovett and Price 1999a, Guideline B).
- Where erosion is threatening a high-value asset or in high energy situations (such as gullies), 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 is often needed to provide a strong base for establishment of that vegetation. On eroding banks this can be a stone-toe. Alternatively, the bank above the toe can be battered to provide better revegetation opportunities (Lovett and Price 1999a, Guideline C).
- Investigations into the results of river realignment or modification have shown that the expected benefits (flood mitigation, improved drainage or reduced erosion) generally didn't occur. Avoid realigning or widening waterways, removing in-stream habitat or riparian or in-stream vegetation. Seek other methods to address the problem (NRE 2001e).
- Avoid straightening of drainage lines. A straight channel has a higher velocity, which will increase gully erosion (Price and Stivic 2001).

Current management practices in the project area

Previous practices that removed "obstructions" to allow unimpeded drainage is now considered to be at best ineffective or at worst counterproductive. Nevertheless, a proportion of the community considers the presence of large woody material in watercourses to be unsightly and liable to cause erosion or flooding. Deliberate reintroduction of large woody debris to larger rivers is being actively pursued in parts of the project area by Catchment Management Authorities. Realignment or straightening of channels is now seldom undertaken and there have been cases where previous straightening has been deliberately reversed to restore a more natural channel form. Engineering alterations to the banks of waterways have in fact become so widely regarded as undesirable that recent small-scale works have generated large numbers of calls from concerned people in the vicinity.

Rural Water Authorities licence all works on waterways, and can advise on whether the proposed site of a gully dam is on a waterway. Applicants are required to undertake a local assessment of the impact of the proposed development, including environmental impact. Aquatic habitat and fish passage is protected by a number of Victorian legislative Acts. These include the Water Act 1989, the Fisheries Act 1995, Flora and Fauna Guarantee Act 1988 and the Conservation, Forests and Lands Act 1987. Works on waterways, such as the construction of dams, weirs and erosion control structures, are licensed in accordance with the Water Act 1989. The Act allows conditions to be included in a works licence to protect the "environment, including the riverine and riparian environment".

The most suitable practice for enhanced biodiversity

Generally, engineering intervention should be reduced to the minimum unavoidably required to protect against damage to property by flooding and erosion. Widening or enhancement of strips of riparian vegetation should be considered as an alternative means of protecting against excessive bank erosion. Where riparian vegetation no longer supplies adequate amounts of large woody debris, the reintroduction of such material could potentially fulfil the dual role of enhancing aquatic biodiversity and assisting in erosion and / or stock control.

Key gaps in knowledge

Restoring riparian vegetation will assist in providing a more natural level of woody and other plant debris inputs, with benefits for in-stream biodiversity. However, how close the input of debris must be to the natural rate to achieve substantial benefits is not well known.

There is a lack of information on how the flow regime of small watercourses have been modified by dams, vegetation clearance and drainage. Without this information, it may be hard to assess the prospects for recolonisation by the original aquatic fauna.

Management of dead trees

Standing dead trees are important wildlife habitat, providing perches, roosts and nesting sites for birds and bats, and supporting a variety of saprophytes. Fallen wood may have some of the same functions, with an added benefit of large trunks providing considerable shade and shelter for stock and wildlife. Large fallen timber may also be used to manage stock movement to protect sensitive vegetation or stream banks. The fate of fallen braches, trunks and standing dead trees is dependent on the attitude of the land manager and their location in relation to farm activities. Fallen branches and trunks may be collected for firewood, burnt *in situ*, moved to a more convenient location then left to rot or left where they fall. Standing dead trees may be felled and left in place, lopped or left undisturbed.

Deliberate introduction of tree stumps for wildlife habitat from outside a property has been carried out on at least one dairy property in Victoria (at Cohuna in Northern Irrigation) with apparent biodiversity benefits. Many of the points made with respect to re-snagging in watercourses also apply to importing woody debris as terrestrial wildlife habitat; it allows habitat to be instantly created that would take many years by natural tree growth. Importantly, large stumps or tree trunks outside watercourses do not have the drawbacks (real or perceived) of channel diversion or blockage and potential effects on downstream properties. However, importing large woody material for habitat purposes has the potential to introduce fungal diseases of trees, pest insects or weeds. Another consideration is that the practice could lead to other properties felling or removing material that might otherwise have been left, due to a feeling that it would not be too detrimental if it could be used elsewhere. Transport costs are likely to dictate that a local source is required, and not all properties would have access to stumps or other material that would genuinely have otherwise been destroyed. Nevertheless, in terms of providing an immediate biodiversity benefit in a short timeframe, this approach is worthy of investigation.

Current riparian management guidelines

- Think of logs as homes for animals and birds. Look for thin pieces of wood (for firewood), instead of fat logs that may form hollows if left to decay. Leave hollow logs alone, whether they are standing or lying on the ground. If you take dead wood from your backyard, farm or other spot, leave some behind as if everyone takes wood there won't be any left. If you take wood, plant a tree to replace it. Recycle - if your neighbour cuts down a tree ask if you can use the wood (EA 2002).
- Those dead trees and branches in paddocks and amongst bushland could have more value than many landholders realise. The temptation to turn them into firewood has led to their loss from many areas of Victoria. However, it is worth considering their considerable range of values before taking steps to remove dead wood from a property. It is important to recognise that a well managed farm may very well have a healthy ground layer of logs, branches, twigs, leaves and shrubs in appropriate areas. The practice of 'tidying up' a farm by removing logs and branches, whilst still appropriate in some areas, such as where they interfere with agricultural machinery or in fire breaks, is also recognised as being incompatible with the objective of sustainability (Platt 1999).

Current management practices in the project area

Variable according to the views of the landowner.

The most suitable practice for enhanced biodiversity

Dead trees and fallen wood of all kinds should be left where it falls. If this is incompatible with farm operations, it should be moved to a designated area where it can be left. Fallen wood or stumps that must be removed could in some cases be used to enhance riparian zones that lack such material due to previous management.

Key gaps in knowledge

In common with other practices claiming to improve biodiversity, there is a lack of local studies that provide clear evidence. Some landholders currently unconvinced of the desirability of adding or retaining dead wood in riparian zones might be influenced by such examples.

Control of feral animals and conflicts with native fauna

Natural resource management practices in the riparian zone are likely to increase the amount of riparian vegetation, and in doing so, increase the cover or protection for feral and native animals. Increased protection may make the control of feral animals more difficult, and higher densities of native fauna can cause farm management issues. Foxes and rabbits are the main pest species of concern in the bioregions of this study. Control of both these species could become more difficult if protection and enhancement of riparian biodiversity increases the cover available to them. However, if existing stands of weeds such as blackberry and gorse are removed as part of the process, the control of these species might become easier. Control of foxes and rabbits is crucial to a successful outcome as both species themselves will severely influence native riparian flora and fauna if left unchecked. In addition, any worsening of feral animal problems might decrease landholder support for riparian biodiversity. Where properties already have significant riparian remnants with a dense understorey the management of feral animals in such areas is likely to be already well understood and practiced; more problems are anticipated on properties without existing areas of undergrowth. There has recently been a case where it appears that a riparian restoration scheme on public land was disrupted by use of large scale ripping to control rabbits. This sort of extreme conflict is unlikely on private property where management decisions will not be taken by different agencies with conflicting priorities. Nevertheless, it illustrates the need to plan for pest animal control as part of riparian restoration or enhancement.

Conflicts with native fauna that are most relevant to the project area mainly concern kangaroos, wallabies and wombats. Damage to fences is the most frequently mentioned conflict, with

destruction of replanting schemes by browsing also being fairly frequent, as is concern about troublesome holes and destabilisation of stream banks caused by wombats.

Current riparian management guidelines

- Exclusion by fencing can be an effective means of solving problems caused by wildlife. Fences can be designed to reduce damage by wildlife and to exclude wildlife from areas where their activities are incompatible with other land uses. Wombat damage to rabbit-proof fences can be avoided by the installation of a simple gate. A similar gate can be installed for kangaroos (Platt and Temby 1999).
- Bushland areas, particularly those in which logs and undergrowth are retained, can provide harbour for rabbits and may be perceived by some landholders as undesirable. In areas managed for their wildlife habitat value, the aim is to use techniques that are non-destructive to the habitat. Ripping is generally unsuitable for natural bushland areas in which the ground flora cannot be disturbed and may facilitate weed invasion amongst native vegetation (Platt 1999).

Current management practices in the project area

A variety of pest control practices exist. The recent effects of calicivirus and introduction of a bounty on foxes may initiate some changes. Concerns about pest animals being harboured in dense undergrowth is one reason why some landholders prefer fenced off riparian zones to be subject to occasional grazing once trees planted there can withstand the effects of cattle. However, it is very difficult to determine how highly this consideration ranks against other reasons such as the extra grazing reserve.

The most suitable practice for enhanced biodiversity

Intensive control of foxes, rabbits and feral cats has large benefits for biodiversity. Most farmers view rabbit and fox control as an essential part of good land management. Control techniques should be chosen to avoid excessive disturbance in riparian zones that have native vegetation eg ripping of warrens is not appropriate. Management of native animals should aim for the minimum of intervention that is necessary eg constructing gates for wombats rather than attempting to exclude them. Where browsing pressure is very high, temporary exclusion or use of repellents may be necessary to ensure regeneration of native vegetation or survival of plantings. Browsing and other problems such as wombat holes may decrease in importance once a strip of riparian vegetation is well established and becomes more resilient.

Key gaps in knowledge

As part of an overall assessment of the costs and benefits from enhancing or restoring riparian vegetation, further information may be required on both the degree of added difficulty in pest animal control and the costs of managing increased native fauna presence. Due to the changes that occur as vegetation develops, it may be useful to obtain information on these issues from properties with good quality remnant riparian vegetation as an indication of the likely medium to long-term outcomes of restoring or enhancing riparian vegetation on other properties nearby.

Conclusion

Some current riparian land management practices closely agree with best practice guidelines for riparian biodiversity enhancement. For example, avoiding channel straightening and planting of willows, formerly widespread practices, are now neither recommended nor seldom practiced. However, there is considerable difference between advice extended and current practices for other issues. The width of replanted riparian vegetation is commonly less than that promoted as appropriate for wildlife habitat or water quality enhancement, and native vegetation is overwhelmingly restored or regenerated by planting of seedlings despite advice regarding natural regeneration and direct seeding.

A common theme for many of the issues was that benefits of particular practices for biodiversity, especially benefits of biodiversity to production, were not supported by credible examples relevant to the intensive grazing properties in these bioregions. Detailed biodiversity surveys and economic assessments cannot be conducted on a very large number of properties, but there seemed to be a need for targeted work to generate some local examples to instil more confidence in the reliability of advice.

A number of key gaps in knowledge were identified. Some of these include: how much grazing can be tolerated without excessive damage to different sorts of native vegetation? What on-farm productivity gains arise from increased ease of stock management and cleaner water for stock? What biodiversity gains result from the establishment of different sorts of buffer strips? How much do healthy riparian zones increase property value? Which weed species should be designated as serious in different regions and vegetation types? How close must the inputs of debris to streams be to the natural rate to achieve substantial benefits? Further information is required on the degree of added difficulty in pest animal control and the costs of managing increased native fauna density as part of an overall assessment of costs and benefits from enhancing or restoring riparian vegetation.

Clearly, addressing all of the above gaps in knowledge is beyond the capability of the current project. Working within the limits of available resources and the specific goals of the project, research proposals have been developed to address a subset of these questions and are described in section 6.

4. Adoption of on-farm natural resource management practices: An analysis of previous market research

Graeme Ward

Introduction

In the area of natural resource management, farmers are motivated by very different values and priorities, and in some cases, their ability to respond to particular issues can be limited by their business and financial circumstances. As a result, the importance of understanding what motivates farmers and what the likely barriers to adoption are is becoming increasingly recognised as a key factor in determining adoption of extension messages. To this end, market research studies are being used as part of extension programs. Understanding what influences and motivates various farmer groups will allow the project team to target research questions and create a strategy that best communicates our message of best management practice for improved riparian and in-stream biodiversity.

The NRE communication framework for the National Action Plan for salinity and water quality noted that "to date, no substantive market research has been conducted among Victorian resource users to determine their capacity to adopt practices to reduce salinity and improve water quality, likely motivational factors, their understanding of the problems, their preferred means of communication and perceptions of existing networks." This comment applies equally well to the issue of improving riparian and in-stream biodiversity in the bioregions or industries specific to this project. There is, however, a broad range of previous market research and farmer / landholder attitudinal surveys on the general topic of conservation and natural resource management adoption and investment, providing an opportunity to undertake likely segment analysis for these industries. This analysis will use previous market research studies to establish likely general farmer attitudes and barriers to adoption of improved on-farm natural resource management relevant to riparian and in-stream biodiversity.

Market Research Analysis

Previous market studies can be divided into two broad groupings, 1) attitudinal research, and 2) targeted market research on specific issues.

1) Attitudinal research of biodiversity and natural resource management

Most of the relevant earlier work in this area has been collated into a database and reviewed as part of NREs "Living Systems Project" (Straker and Platt 2002). It comprises approximately 43 studies from across Australia, and covers a broad spectrum of agricultural industries and farmer / landholder values, motivations, attitudes and barriers to natural resource management, including biodiversity.

2) Targeted agricultural market research of specific environmental issues

The targeted market research presents detailed studies and findings on farmer motivation or lack thereof, descriptions and characteristics of identified market segments, some barriers to adoption and ideas on improving communication and adoption in these areas. The studies in this area are:

Natural Resource Management on Dairy Farms, AMR: Quantum Harris 1997 (Anon. 1997)

This study was conducted for the NRE Target 10 dairy extension program in 1997. The focus of the research was to identify farmer segmentation in relation to natural resource management where uptake of Target 10 activities has been limited. In addition to identifying and characterising farmer market segments, this study considered and reported on which market segments were worth pursuing and what key features a marketing plan must incorporate to meet these segment requirements. This is a key reference for designing any extension work for the adoption of improved riparian biodiversity management on dairy farms and in determining what information should be generated in any research in the area.

Understanding the Need for Dairy Effluent Management Systems in the Victorian Dairy Industry (Parminter and Pedersen 2000a)
Whilst not directly addressing riparian biodiversity issues, this study gives valuable insight and experience into dairy farmers attitudes, barriers to adoption and decision making processes for investment into natural resource and environmental projects on farm.

Managing irrigation and fertiliser in dairy farming (Kaine and Bewsell 2001)
This market research study focuses on the adoption of a range of improved nutrient and irrigation practices in the Macalister Irrigation District of East Gippsland, with a view to develop extension strategies to promote more widespread adoption. It provides a useful alternative market segmentation of dairy farmers, their social values towards environmental issues and their motivation towards adopting improved environmental practices.

Riparian Management Survey (Parminter and Pedersen 2000b)
This New Zealand survey quantifies the use of various riparian management practices and farmer attitudes towards water quality management. It provides a good assessment of the gaps and information needs of farmers for improved riparian management.

The market research reviewed permitted an analysis of three themes:

1. Likely barriers to the adoption of improved riparian practices and biodiversity on farm by landholders
2. Knowledge gaps in biological and economic information that need addressing to assist in overcoming the barriers to adoption.
3. Likely market segmentation of dairy farmers regarding riparian biodiversity and natural resource investment issues.

These reviews provide an opportunity to identify the information and communication needs of farmers managing natural resources on intensive grazing properties. As riparian biodiversity management is primarily a natural resource management issue (despite potential productivity benefits) the data from the surveys has been extrapolated to this project. The information from these surveys will assist in determining research priorities.

1. Likely Barriers to Adoption and Strategies for Success

There are very different levels of awareness, knowledge, commitment and involvement in natural resource preservation and enhancement amongst landholders. Some landholders lack a knowledge of and interest in the importance of biodiversity. A number of studies found that a high proportion of farmers interviewed have no understanding of the need to fence. Others are aware of its importance, and although riparian protection is beginning to gain recognition as a significant part of sustainable agriculture, the priority for implementation is low.

The "Living Systems" project identified two key motivators that drive landholders, in particular farmers, to adopt land management practices: a) potential economic advantages to the farmer through increased efficiency and product quality, and b) heritage and care of the land - feelings of altruistic stewardship ethic or duty of care that farmers have to their land.

Economics proved to be a critical issue for adoption, arising in each study. The promise of a direct financial benefit is a key motivator for adoption and the fear of lost income is a strong barrier. Lack of available dollars is a significant barrier to on-ground natural resource works. Increased dollar incentives are frequently required before implementation of natural resource works, as such works are often viewed as non-essential and take time, money and labour away from immediate farm enterprise investments that may generate larger short-term returns. Potential long-term benefits are seen as being less important or of lower priority. Financial incentives are important for assisting the "privatisation" of public good that comes from natural resource works. This is particularly so for high value agricultural land such as for dairying.

Economic arguments have been found more effective at changing farmer attitudes to such natural resource works than ecological arguments.

Lack of suitable information on how to plan and implement works to improve natural resource management outcomes was also identified as a barrier. Targeted, clear, simple and practical information is required, rather than flooding landholders with a range of natural resource management information.

Extension needs to promote to the landholder the private benefits of adopting natural resource management practices. One to one extension by experienced and knowledgeable staff and the provision of financial assistance and grants are seen as very important for the adoption of improved on-farm natural resource management and on ground works. This is especially so where the immediate economic return to the farmer is not obvious and there is a large public good component.

2. Knowledge Gaps

Analysis of previous market research identified gaps in farmer knowledge regarding both biological and economic information on natural resource management on farms.

(a) Biological Information

There is a general lack of understanding of biodiversity, the effects of biodiversity loss and the potential benefits of its protection and enhancement. There is a need to quantify and develop clear and complete (but not complex) statements of the on and off-farm, short and long-term, production and environmental, tangible and intangible benefits of riparian works that enhance and protect biodiversity. The unseen effects of biodiversity loss and the consequences for everyday priorities need to be highlighted. Technical research with local examples is required to address concerns such as fence design, weed and pest control, fire, and grazing management. Local relevant examples and experiences are important for research credibility and adoption of management practices. Written extension material that includes case studies of farmer experience from the local area with examples of proven ideas and effective methods should be prepared.

(b) Economic Information

The economic benefits of expenditure on and adoption of natural resource management practices is not clearly understood by private landholders. Sound information on the long-term benefits of the implementation of natural resource management needs to be clearly defined. Many landholders are particularly interested in the short-term economic value and return of such investments. Therefore, there is a need to quantify the dollar value of the increased efficiency and product quality that were identified by "Living Systems" project as key motivators for the adoption of biodiversity enhancement.

The gaps identified have consequences not only for research priorities, but also for the extension needs of farmers regarding riparian management.

3. Possible Market Segments

The "Natural Resource Management on Dairy Farms" market research study undertaken by AMR: Quantum Harris for the Target 10 Program in 1997 is the most applicable study for riparian biodiversity. Although riparian biodiversity was not specifically targeted, it can be considered part of the broader natural resource management issues examined. Importantly, this market research targets dairy farmers, one of the primary audiences of the *'Productive Grazing, Healthy Rivers: Improving riparian and in-stream biodiversity*' project. In the absence of new, specifically targeted market research into riparian biodiversity, the findings of the Target 10 market research are considered suitable for the current project.

The Target 10 market research into natural resource management identified five market segments of dairy farmers, characterised by their feelings towards natural resource management and their motivation for initiating action, as given in Figure 4.1.

Figure 4.1. Farmer market segmentation and the drivers of natural resource management.

The *distance* of the segments from the centre of the continuum represents the strength of their motivations, ie the segments furthest from the centre are more strongly motivated than those in the middle. The *direction* from the centre is indicative of the motivation behind that action. Segments to the left of the continuum are more likely to be motivated by the environment itself, segments to the right are motivated by production issues and ultimately profit, while those in the centre are not strongly motivated by either issue.

Characterisation of market segments

Financial Good Sense

Financial Good Sense farmers are progressive in their actions, but motivated by financial benefits. They are likely to have already implemented environmental measures such as effluent dams because of the financial good sense in so doing. Open-minded and progressive in their views, they only need to believe in some economic benefit of progressive action (longer-term) for them to continue these measures. The attitude of Financial Good Sense farmers to natural resource management is one of making the best and most efficient use of resources, to minimise costs and increase production. They see natural resource management as providing long term rather than short term financial benefits; therefore, it is not seen as salient as more immediate production orientated decisions. To ensure the interest of this market segment, it is important that natural resource management is presented as part of discussions and activities on productivity related issues.

Environmental Rationalists

Environmental Rationalists are motivated by financial considerations but are also interested in how natural resource management can save them money in the short term. They consider the environment but accept little responsibility, putting immediate financial considerations first. They rationalise their own actions within the context of others wrong doings. They are less likely to proactively seek out information and will wait for someone to prove to them that an economic benefit lies at the end of a farming change (including natural resource management). One to one consultation / extension is thought to be important to ensure the implementation of ideas for this market segment.

Environmental Resistors

Environmental Resistors are farmers that resist environmental-based change and feel little concern for or responsibility towards the environment. They are unlikely to change their behaviour until government regulations change, and are faced with the threat of enforcement and fines. These farmers are unlikely to be motivated by the lofty ideals of caring for the environment or being a good neighbour. Information directed towards the environmental resistors needs to be presented with the personal benefit message featuring most prominently.

Good Neighbours

Good Neighbours recognise the importance of the environment and accept responsibility for it. They are likely to adopt new farming practices in response to being perceived as a good neighbour and as part of the wider community. They are less motivated by the prospect of financial reward. Repetition of ideas among these farmers is a key to adoption. Farmers in this group are keen to do the right thing and in many cases, only require the right information or repetition of the information to accept and adopt natural resource management practices.

Environmental Lovers

Environmental Lovers see the environment as critically important, and tend to take maximum responsibility for it. They are motivated by a true love of the environment. Many are progressive in their implementation of new farming practices that benefit the environment. In general, they have the opinion that if the environment is properly looked after, financial rewards will take care of themselves. These farmers will already be undertaking measures to ensure the health of their immediate environs.

What information is required?

Assessment of the Target 10 market research suggests that riparian biodiversity management information could be packaged and presented differently for each specific farmer segment:

- *Financial Good Sense farmers:* Require good, sound data on the economic benefits, especially long term investment benefits to the farm business, of improving riparian biodiversity.
- *Environmental Rationalists:* Require detailed information and demonstrations on how expenditure to improve riparian biodiversity can be a profitable short-term economic investment.
- *Environmental Resistors:* A lost cause! Define minimum standards and requirements for the regulators!
- *Good Neighbours:* Require information on why it is important to conserve and enhance riparian biodiversity, and some practical and reliable methods for doing this.
- *Environmental Lovers*: Require good, sound and practical methods of implementing works to enhance riparian biodiversity.

Conclusion

Analysis of previous market research identified 3 important factors for improving adoption of natural resource management practice change: 1) financial incentive schemes, 2) 1:1 extension services and 3) relevant, local success stories / examples. The *'Productive Grazing, Healthy Rivers: Improving riparian and in-stream biodiversity'* project will primarily focus on research activities, hence, 1:1 extension is outside the scope of this project. The team identified the need to undertake benefit cost analyses, which is supported by the economic motivation of some farmer segments. Additional funds will be required to enable this analysis to be undertaken as part of this project.

It is anticipated that the outcomes of this research will be packaged into extension material and management tools for use by industry service providers such as the Catchment Management Authorities, who have a greater ability to effectively extend the information and provide the services required for adoption. Research will be conducted on a range of project sites across the four bioregions of this project to ensure local examples are available to landholders.

The outcomes of our research (see section 6) are likely to be targeted to the needs of four of the farmer groups identified in the Target 10 market research. For example, research into potential production losses (if any) of planting riparian vegetation is likely to give a cost figure to farmers which may reduce the perception of significant production losses associated with revegetation. The weed decision support may be an incentive to farmers motivated by economics if weed management is not seen as taking resources from the farm. Both these research areas may satisfy the 'Financial Good Sense' and the 'Environmental Rationalist' farmers. The biodiversity surveys undertaken and the development of methods to improve in-stream biodiversity and snags are likely to satisfy the needs of the 'Environmental Lovers' and 'Good Neighbours'. The information required for the 'Environmental Resistors' does not provide much optimism for voluntary practice change in this group, for which regulation appears to be the most appropriate mechanism.

5. Productive Grazing, Healthy Rivers: April 2002 Consultative workshops

The first year of the *'Productive Grazing, Healthy Rivers: Improving riparian and in-stream biodiversity'* project (October 01 / June 02) advanced in two phases: 1) information review and documentation; and 2) development of future research. As part of the information review, farmers and extension and service providers associated with riparian and biodiversity management on farms were consulted. In April 2002, facilitated workshops were held in Warrnambool and Warragul to:

- Provide information about this subproject to farmers, extension officers, scientists and project managers
- Invite discussion of the management issues, research, and knowledge gaps related to riparian management
- Engage stakeholders in the process of project development and priority setting of management issues
- Identify previous and existing riparian related projects specific to each bioregion
- Provide an opportunity for continued involvement

Fifty people representing 26 organisations participated in the workshops, and discussed each of the 8 key management issues previously identified: stock and grazing management, establishment of buffer strips, weed management, planting and retaining native riparian vegetation, waterway modification, management of dead trees, control of feral animal and conflict with native fauna. Workshop participants identified the on-ground gaps in knowledge and research priorities for riparian biodiversity on intensive grazing properties. Participants from both Warrnambool and Warragul workshops raised similar research questions and concerns. Some of these include:

- Queries that current management guidelines actually improve riparian biodiversity and water quality
- The value of grassy and treed buffer strips to biodiversity, their optimum size, effect on productivity and effectiveness at maintaining water quality
- Management options for optimal grazing and biodiversity outcomes
- Impact of water quality on farm productivity
- Implications and benefits of fenced waterways
- Weed management, priority setting of weeds, and natural weed suppression

In addition, workshop participants were asked to identify any previous or existing projects / sites that related to riparian biodiversity and list the factors that either contributed to or hindered project success. Ninety-four different projects and / or sites relating to riparian biodiversity were identified within the bioregions of this study. This information has been collated for the Gippsland and South West regions and distributed to workshop participants as an appendix to the workshop summary report (NRE 2002b).

The outcomes of the workshops combined with the knowledge gained during the documentation and review process provided the information used to prepare a research proposal relevant to the intensive grazing industries in high rainfall areas. Based on these outcomes, seven priority areas of research and extension have been developed and are described in section 6, Future Directions.

6. Future Directions

During the first year of *the 'Productive Grazing, Healthy Rivers: Improving riparian and in-stream biodiversity'* project (2001/2002) the project team scoped the management issues, gaps in knowledge of riparian biodiversity extent and management requirements, and the barriers to its adoption into on-farm management of dairy, beef and sheep farmers within the bioregions of this study. At the conclusion of this first year, the project team analysed a range of literature and databases, consulted with our target audience and compiled and documented this information to develop a three year research proposal. This proposal contains seven priority areas of research, covering a range of subjects that include weed control, riparian zone management, stock and grazing management, and quantification and improvement of riparian biodiversity outcomes. Each of the seven research areas is described in the full project proposal submitted to the Key Project. A brief description of each research area is given below.

1. Quantifying on-farm biodiversity

A review documenting the riparian biodiversity present in the 4 bioregions of this study (refer to section 2) indicated that a) few flora and fauna surveys have been conducted on riparian land, and b) sound biodiversity information for private land in the study areas is lacking. Workshop participants also expressed concerns over the lack of information on riparian biodiversity on-farms and whether practice change will improve biodiversity outcomes. An understanding of the biodiversity present within a landscape and the impacts of land-use change on biodiversity are essential for making informed management decisions. This research area aims to quantify riparian ecosystem and species biodiversity on grazing properties within the study area, and investigate the influence, if any, of farm management systems and stock access to riparian land on biodiversity measures.

Quantification of biodiversity will occur on two levels, 1) at a community level as a score of riparian ecosystem health; and 2) at an organism level by measuring species richness and relative abundance. Quantification of biodiversity at the organism level will determine what influence stock access and farm management practices have on riparian biodiversity by measuring the level of species diversity in fenced and un-fenced areas on a range of dairy, beef and sheep properties. Identification of riparian biodiversity will provide local examples and raise awareness of the biodiversity present on grazing properties in southern Victoria, and in addition, may assist farmer ownership of biodiversity. A comparative analysis of fenced and unfenced riparian land will improve current knowledge on the impact of farm management practices on riparian health and the biodiversity it contains.

2. Wood to Water: Habitat creation within restored and replanted riparian land

Most streams flowing through grazing properties within the project bioregions contain a small proportion of the woody debris that would have been present in their natural state. Clearing or loss of riparian native vegetation along stream banks reduces the source of material that creates snags. In addition, farmers often remove woody debris and destroy snags in the belief that they impede water movement, contribute to bank erosion and "look untidy". This research area will investigate a method of creating terrestrial and in-stream habitat to improve biodiversity values in restored riparian sites. This method will place discarded branches of locally indigenous eucalypt spp. on land and in streams to accelerate the process of habitat formation for macro-invertebrates, fish and terrestrial species. The sites will be surveyed before and after the placement of branches. It is expected that immediate and measurable biodiversity improvements will result, especially in locations with high quality riparian vegetation upstream to act as a source for colonisation of the new habitat. In addition to the in-stream biodiversity benefits, restoration of natural levels of debris will enhance habitat complexity and benefit a wide range of riparian fauna. The results of this project will provide methods of increasing the biodiversity values of revegetated riparian zones, and is likely to be of use to Landcare groups and others involved in riparian restoration. This project has the added benefit of using branches generated by shire councils during tree-lopping, that would otherwise have been burnt.

3. Regeneration in remnant vegetation: Overcoming the barriers

The quality of remnant riparian vegetation is often reduced by a lack of sufficient recruitment of some component species. Evaluation of the problem is complicated by the fact that successful recruitment of some species may naturally be episodic, eg following flood or fire events. Other than natural variation in seasonal conditions, there are many possible reasons for poor recruitment. Weeds may out-compete seedlings, rabbits may destroy them, native fauna may graze them, soil conditions may have become unsuitable (eg compaction by stock) or stock access, even if occasional, may prevent establishment. Protection of existing riparian biodiversity requires sufficient recruitment to allow the present vegetation community to retain its integrity. This research topic aims to identify reasons for poor recruitment of native flora in remnant riparian vegetation and techniques to alleviate the problem.

Remnant riparian vegetation will be surveyed to identify sites where the age structure of one or more species indicates inadequate regeneration. An initial assessment of possible reasons for the problem will be made, involving field observations and consultation with the landholder over recent management. When reasons appear to be obvious eg a dense cover of weed species or high number of rabbits, a demonstration site will be established and suitable measures to protect seedlings (fencing, individual protection, browsing repellents, weed removal) will be applied. Pre and post treatment records will be made in collaboration with Landcare groups, or possibly schools or TAFE colleges. Where recruitment appears poor but the reasons are not immediately evident, or there are several possible explanations, a field experiment will be established to test hypotheses about the cause of recruitment failure. These experiments will involve more intensive replication and observation than the demonstration sites. The demonstration sites will increase local landholders knowledge of and confidence in management approaches to maintain the integrity of remnant riparian vegetation, resulting in protection and enhancement of existing biodiversity. Results of the experiments will improve our knowledge of vegetation dynamics so that threats to native vegetation are identified and managed more successfully

4. Weed management expert system: Development of an on-farm management tool

Weed invasion has been identified as one major reason why landholders resist the idea of fencing off riparian areas and undertaking restoration schemes. Weed proliferation in protected riparian areas is perceived as a threat by landholders for a variety of reasons. These include spread of pasture weeds from riparian land to the rest of the property; increased difficulty controlling rabbits and foxes; presence of weeds indicating poor land management; and the increased management required to reduce weed infestation. Often landholders regard cattle as a weed management tool and resist fencing on these grounds. Despite these perceptions, some weed problems on fenced off riparian lands are likely to decrease in severity as increasing canopy cover makes conditions less favourable for light-demanding weeds. Also, other weed species that can proliferate in shaded conditions and severely reduce floral diversity may sometimes be easily controlled if detected before they become very abundant.

Landholders are usually extremely knowledgeable about local pasture weeds and appropriate management practices. Knowledge about other weeds, particularly those that affect biodiversity in ungrazed situations, is much more variable. Current riparian management advice is often short on detail when it comes to weed management, partly because of the diversity of weed species and types of riparian vegetation encountered on a national or state scale. This component will combine existing information on weed distribution and effects with local knowledge from farmers and others involved in riparian management in the project area. An expert management system will be developed whereby farmers and landholders will be able to determine the most appropriate management and control strategies for a range of weeds that occur in revegetated riparian zones and on the surrounding pasture. Weeds will be categorised according to the affect they have on a) biodiversity, eg. their dominance and ability to suppress native regeneration; and b) productivity and farm management, eg. toxicity, ability to harbour pest animals such as rabbits, foxes and feral cats. The ability to rapidly assess weed threats and identify suitable management options for riparian land should increase the willingness of landholders to undertake or continue the protection of riparian biodiversity in the project areas. Financial losses due to inappropriate weed management activities or suffering weed impacts on pasture should be reduced.

5. Riparian condition and land-use practices: A survey of riparian health and condition on dairy farms

Intensive grazing reduces environmental quality through the degradation of riparian land, loss of vegetation and biodiversity, and reduced water quality. A variety of rapid-appraisal methods have been developed in Australia to assess riparian condition over a variety of spatial scales (Ladson *et al.* 1999; Spencer *et al.* 1998; Bunn *et al.* 1999; Jansen and Robertson 2001b). In all cases, several variables are measured in rapid (1-24h) surveys of sites (100m-1km stream reaches) with the intention of providing proxy measures of three riparian ecosystem functions: 1) retention function - stabilisation of banks and interception of sediment and nutrient flows; 2) habitat function - provision of habitat for fauna that favour aquatic-terrestrial ecotones; and 3) in-stream function - control of in-stream structural and functional attributes.

This research will use previously tested physical variables as indicators of riparian and in-stream condition. A minimum of 100 riparian sites of different conditions, ranging from relatively pristine (remnant) to highly degraded, will be surveyed. The indicators of condition will provide information on the ability of the riparian habitat to 1) minimise the impact of high flow events on soil erosion, 2) provide habitat for native biodiversity (in-stream and riparian) and 3) sustain in-stream health. These physical measurements will be compared with farm management variables such as stocking rate, stock management, fertiliser application in relation to stream, use of riparian land etc. collected at each site, and the data statistically analysed to determine their contribution to riparian degradation. This research will provide a useful source of information about riparian condition across the Gippsland region and enable future statistical modelling of the landscape and management practices. Recommendations on likely best practice for riparian restoration at a range of landscape settings will be made based on the findings of the survey.

6. Riparian zone management: Estimation of production losses associated with fencing

Improved management of riparian zones includes reducing stock access by fencing and revegetating along waterways. The size of the fenced area is determined by the amount of land the farmer is prepared to remove from production and subsequently manage. The width of riparian revegetation (20m guideline) and management of grassed buffer strips is a considered a deterrent to improved riparian management by dairy farmers as it is perceived to remove productive pasture, and hence feed, from the rotation, especially over the drier months of the year. This research area proposes to assess the relative area and productivity of 'riparian' pasture (pasture adjacent to rivers or creeks) compared with total on-farm pasture production to determine whether the perceived productivity loss is real or not.

A decision support tool will be created based on production-related data and estimates to give an indication of relative riparian vs rest of farm productivity. A GIS farm map and pasture data will be used to validate the tool to give accurate quantification of production losses. Production changes will be suggested that increase farm productivity to compensate for potential 'losses' due to fencing, and in addition, alternative management strategies will be identified for the riparian buffer pastures to maximise productivity from this area. Selected management options will be implemented in consultation with the farmers. The range of possible stock management strategies for riparian land commonly include strategies that alter the intensity (rather than rotational length) of grazing without increasing the workload of the farmer.

The data generated will provide a simple model to assist farmers to understand what the real production losses are, if any, and potential strategies for increasing productivity on other farm areas to compensate for these losses. In addition, the development of a method for identifying alternative farm productivity enhancement may provide additional incentives for revegetation, especially for those farmers motivated by economic concerns.

7. Riparian zone management: Reducing water quality impacts of dairy cows

Stock access to riparian land fouls water resulting in increased nutrient and microbiological loads, increased sedimentation, bank erosion, and loss of vegetation through trampling and consumption (Rutherfurd *et al.* 2000b). Levels of nitrogen (N), phosphorus (P) and potassium (K) excreted in dung and urine and returned to soil in a dung pad, equate to nutrient rates considerably greater than the average rates applied in fertiliser (Aarons *et al.* 2002; Gourley 2001). This has consequences when these nutrients are returned to waterways and riparian land. Fenced and

revegetated riparian zones are considered to improve riparian and in-stream health. However, the influence of intensive access by dairy cows and inappropriate siting / management of dairy shed effluent can negate the effect of riparian zone improvements. In situations such as these, selection and implementation of appropriate riparian zone management practices depends on knowing the potential nutrient transfer pathways through a riparian zone.

Through baseline monitoring, this research area proposes to identify the most suitable riparian management strategy to reduce the impact of dairy cows on water quality. By monitoring soil and water nutrient levels in grazed pastures and in-stream water microbial levels, baseline data quantifying the nutrients present and potential loss pathways will be determined. The feasibility of a fenced 20m revegetated strip to reduce nutrient losses and improve water quality will be determined. Implementation of appropriate riparian management strategies may include the fencing, appropriate siting of the fenced area and its management, creation of wetlands or engineering works to redirect sediment from tracks away from riparian zones.

Extension of research findings

Extension officers and service providers have been identified as the end-users of this project. Therefore, part of the extension plan involves consultation with extension and service providers through a series of meetings to identify the most appropriate and effective extension techniques for delivery of the research findings and riparian best practice information. The extension package developed will provide riparian and in-stream management information for farmers, landowners and other extension providers. Extension tools may include a series of technical notes, a web-based information system and field days at demonstration sites. A conference or workshop is proposed for the final stage of the subproject to present the research findings and summarise the outcomes of the subproject. Invitations will be extended to all participants of the original workshop as well as other interested farmers, service providers and key stakeholders to ensure the project findings are extended as widely as possible and to create a sense of project accomplishment and completion.

7. In Conclusion

The primary objective of this document was to assess the current status of riparian biodiversity, its management requirements and the market drivers of practice change within the high rainfall intensive grazing industries of southern Victoria. Prior to undertaking this research program, it was important to have a comprehensive understanding of the relevant issues and concerns. Several knowledge gaps and management issues have been identified, as well as the extension requirements of farmer groups. Research priorities were established after extensive consultation with target groups of farmers and natural resource managers.

This assessment has culminated in seven research modules that are relevant and specific to the high rainfall regions of Victoria. The knowledge gained from each research module will allow farmers to make informed riparian management decisions and assist the grazing industries to achieve ecologically sustainable development, ensuring their future in an international market place and the future of riparian biodiversity on private land.

8. Acknowledgments

'*Productive Grazing, Healthy Rivers: Improving riparian and in-stream biodiversity'* is a subproject of the Department of Natural Resources and Environment's Ecologically Sustainable Agriculture Initiative. This project also has several links with other organisations and NRE and industry funded projects. The *"Productive Grazing, Healthy Rivers: Gippsland Dairy Riparian Project"*, funded by the Dairy Research and Development Corporation, the GippsDairy Board, and Land and Water Australia, has two demonstration sites in West and South Gippsland. The NRE funded project 'Best Agricultural Practice for Native Biodiversity in Grazing Industries' has sites in West Gippsland at NRE Ellinbank and on the properties of beef producers in South Gippsland. The project team has links with the Co-operative Research Centre for Australian Weed Management; the Department of Economics in the Institute of Land and Food Resources as well as Burnley College, both at the University of Melbourne; and the Johnstone Centre, Charles Sturt University.