Biodiversity conservation in intensive grazing systems:

Riparian and in-stream management

PRODUCTIVE GRAZING HEALTHY RIVERS:
IMPROVING RIPARIAN AND IN-STREAM BIODIVERSITY

subproject of the
ECOLOGICALLY SUSTAINABLE AGRICULTURE INITIATIVE
DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENT

State Government Victoria
Department of Natural Resources and Environment

DAIRY RESEARCH AND DEVELOPMENT CORPORATION

For bibliographic purposes, this document may be cited as:

NRE (2002). Biodiversity conservation in intensive grazing systems: Riparian and in-stream management. Department of Natural Resources and Environment, Ellinbank, Victoria.

ISBN: 1 74106 375 2

Web Address: www.nre.vic.gov.au

Table of Contents

Executive Summary

Agricultural management practices have been identified as one of Australia's largest threats to biodiversity and the services it provides, despite the strong links between the future of Australian agriculture and the health and condition of our biodiversity. Through the National Strategy for the Conservation of Australia's Biological Diversity (1996), state and local governments have committed to ecologically sustainable development (ESD) and agreed to 'a*chieve the conservation of biological diversity through the adoption of ecologically sustainable agricultural and pastoral management practices'*. While ecologically sustainable agriculture is not a new area of concern, research programs designed to enhance biodiversity in agriculture are a relatively recent application in Australia. The Victorian Department of Natural Resources and Environment (NRE) established the Ecologically Sustainable Agriculture Initiative (ESAI) to fund eighteen research projects, six of which aim to improve biodiversity within agricultural production systems. By combining expertise from the divisions of Parks Flora and Fauna, Agriculture and Regional Services, the six biodiversity ESAI projects focus on statewide cross industry issues. These projects include: biodiversity gains in conjunction with agricultural land use change; threatened species management on agricultural land; shelterbelts for enhancing biodiversity in intensive grazing systems; water management strategies and the impact of farm practices; grazing for biodiversity and profit in grasslands and grassy woodlands; and riparian biodiversity in the grazing industries. The last project, titled *"Productive Grazing, Healthy Rivers: Improving riparian and in-stream biodiversity"* is described in this report.

The aim of the *"Productive Grazing, Healthy Rivers: Improving riparian and in-stream biodiversity"* project is to improve biodiversity and environmental quality in high rainfall, intensive grazing systems through better management of riparian land and remnant native vegetation. This project is seen as a means of improving the health and biodiversity of riparian land while assisting the grazing industries to work towards achieving ecologically sustainable agriculture. The intensive grazing industries of dairy, beef, and prime lamb are the dominant agricultural industries in the high rainfall bioregions of the Warrnambool Plain, Otway Plain, Gippsland Plain, and the Strzelecki Ranges.

Effective achievement of this objective requires a thorough understanding of the current issues, knowledge, practices and barriers surrounding riparian management. This document completes the information review and documentation phase of the *"Productive Grazing, Healthy Rivers"* project (October 01–July 02). Current literature, databases, extension information and guidelines were reviewed to determine: the effect grazing practices have on the condition and extent of biodiversity in riparian land; the major management issues associated with riparian land on grazing properties; and the current practices adopted and guidance extended to manage riparian land. An analysis of previous natural resource management market research was also completed to identify farmer segmentation groups and likely barriers to adoption. The detailed results of the review are contained in the body of this document with the individual findings from each report summarised below.

Biodiversity conservation and livestock production: Integrating grazing and riparian landscapes

This introductory section reviews the issues associated with integrating grazing and biodiversity conservation within the high rainfall bioregions of southern Victoria. The information presented, sourced primarily from Victoria, Australian and globally where appropriate, describes the intensive grazing production systems, their impacts on riparian and in-stream biodiversity, as well as management strategies and research priorities. Grazing industries contribute significantly to the export earnings of Victoria and the Australian economy, with considerable differences in their typical on-farm management requirements. Biodiversity contributes in many ways to the environmental, economic and social wealth of Australia and its loss leads to the degradation of the environment and potential economic costs. An overview is given of the range of Strategies, Programs and Initiatives available nationally and in Victoria to assist in redressing the current situation. The uniqueness of Victoria's biodiversity is described and land management impacts on these flora and fauna assets within the four bioregions of this study are detailed. Riparian

ecosystems are defined as well as factors associated with their degradation. Potential grazing management impacts on native biodiversity are tabulated and discussed, with nutrient and sediment losses to waterways contributing greatly to the destruction of riparian habitats. The role for integrated grazing and riparian landscapes, through the process of landscape redesign, is canvassed with the presentation of alternative land use options. These options focus on the use of riparian buffer strips to control water quality while contributing to improvements in on-farm biodiversity.

Bioregional biodiversity: An assessment of available data to determine the biodiversity within the bioregions

Estimates of the biodiversity present in the four bioregions of this study were collated using GIS data, the web-based mapping system BioMap, and four NRE flora and fauna databases. The extent of the study area and incomplete data for some bioregions highlighted the difficulties and complexity of estimating biodiversity across the four bioregions; hence, the assessment was simplified to focus on two case study catchments. The Cooriemungle Creek catchment in south-west Victoria (Warrnambool Plain bioregion) and Bear Creek catchment in Gippsland (Gippsland Plain and Strzelecki Ranges bioregions) were selected to broadly represent three of the four study bioregions. Very few flora and fauna surveys have been conducted on agricultural riparian land, and the limited biodiversity information available for most areas of private land indicates a need for the identification of riparian biodiversity through quantitative surveys. Flora data generally indicated that exotic species were prevalent, and native fauna data was dominated by bird species. An analysis of current and pre-1750 Ecological Vegetation Class (EVC) data showed marked changes in vegetation cover in both study catchments from pre-European settlement to present day. An analysis of the number of threatened species known to inhabit riparian land with those known to occur within the study bioregions identified 53 and 77 threatened species of flora and fauna respectively. The distribution of these species over time was mapped using an Atlas of Victorian Wildlife mapping tool, showing a declining distribution for the majority of species.

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

Riparian land management practices were reviewed to determine: current riparian management guidelines; current advice extended; current management practices undertaken; the most suitable practices for riparian biodiversity; and the key gaps in knowledge. Based on this review, eight key management issues were identified: stock and grazing management; establishment of buffer strips; planting and retaining riparian vegetation; weed control; waterway modification; management of dead trees; control of pest animals; and conflicts with native fauna. While many riparian management practices are implemented according to the guidelines, for example avoiding channel straightening and planting willows (both formerly widespread practices), there can be a range of practices that differ from the recommendations. The width of replanted riparian vegetation is commonly less than that promoted as appropriate for wildlife habitat or water quality enhancement. Native vegetation is overwhelmingly restored or regenerated by the planting of seedlings, despite advice regarding natural regeneration and direct seeding. A common theme arising for many issues was that the benefits of biodiversity practices, especially those relating to production, were not supported by credible local examples relevant to the intensive grazing properties in these bioregions. Targeted works to generate local examples and instil confidence in the reliability of advice is required for the implementation of best management practices.

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

Previously commissioned market research on natural resource management and associated on-farm management issues were reviewed to identify the relevant market segments for different industry farmer groups, likely barriers to adoption of on-farm natural resource management and strategies to encourage farmer participation and practice change. The analysis identified five possible market segments for different farmer groups based on their regard for natural resource management and the motivation driving their actions (environment vs profit). One group was strongly motivated by economics, ie the promise of a direct financial benefit is a key motivator for adoption and the fear of lost income is a strong barrier. Increased dollar incentives are frequently required before the 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. Environmental investments are often seen as less important or of low priority for these groups. The extension strategies and techniques used to encourage farmer participation and practice change will differ for each market segment and will need to be targeted to ensure adoption.

Consultative workshops

Much of the information reviewed and described above was not specific to the grazing industries in the four study bioregions, indicating several gaps in knowledge. Therefore, in conjunction with the information review and documentation process, an extensive consultation was undertaken to identify the congruence between the knowledge obtained during the review process and the actual management concerns on the ground. This consultative process compared the information gathered during the review process with actual research and management priorities on-farm. Farmers, extension and service providers from the three grazing industries representing twenty-six organisations participated in facilitated workshops held in Warrnambool and Warragul, in April 2002. The eight key management issues described previously were discussed, and workshop participants identified the on-ground gaps in knowledge as well as research priorities for riparian biodiversity on intensive grazing properties. Participants from both Warrnambool and Warragul workshops raised similar research questions and concerns, including: queries about whether current riparian management guidelines actually improve riparian biodiversity and water quality; the implications and benefits of fenced waterways; appropriate weed management and the need for priority setting of weed management, and natural weed suppression. Workshop participants also identified ninety-four different projects and/or sites relating to riparian biodiversity 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 prepared after the workshop (NRE 2002b).

Research and development

The processes of review, consultation and documentation provided the information that formed the basis for the development of a research proposal for the subsequent three years (2002 – 2005) of this project. Seven priority areas of research were identified, which are:

- Quantifying on-farm biodiversity
- Wood to water: Habitat creation within restored and replanted riparian land
- Regeneration in remnant vegetation: Overcoming the barriers
- Riparian weed management expert system: Development of an on-farm management tool
- Riparian condition and land-use practices: A survey of riparian health and condition on dairy farms
- Riparian zone management: Estimation of production losses associated with fencing
- Riparian zone management: Reducing water quality impacts of dairy cows

The rationale and proposed methodology for each research topic is provided in section 6 of this document. The team aims to disseminate this information to extension and service providers within the study bioregions. The ultimate objective is to develop management tools that will assist in improving riparian and in-stream biodiversity management on grazing properties in the high rainfall bioregions of Victoria.

The Project Team

Sharon Aarons – NRE, Ellinbank

Sharon is Project Leader for this project. She also manages a project demonstrating improved riparian management on dairy farms, and leads a biodiversity and riparian project for the dairy industry. Sharon is a soil scientist and has investigated impacts of farm management practices on soil biology, soil fertility and nutrient cycling within dairy production systems.

Michelle Jones – NRE, Ellinbank

Michelle is the Project Officer overseeing this statewide project on improving riparian and in-stream biodiversity through better management of intensive grazing systems. Michelle is a zoologist who specialises in conservation biology and molecular ecology. She has experience with threatened species programs and has an in depth knowledge of mammalian ecology and reproduction.

Nigel Ainsworth – NRE, KTRI Frankston

Nigel is a Senior Research Scientist at the Keith Turnbull Research Institute and specialises on the impact of weeds and their management in riparian zones. Nigel is an in-kind participant in the new CRC for Australian Weed Management and the task leader for the management of weed-infested habitats within Program 3, Landscape Management.

Alan Crouch – NRE, East Melbourne

Alan is a Flora and Fauna Policy Analyst in the Parks, Flora and Fauna Division of NRE based in East Melbourne. His duties focus on statewide strategy and policy that endeavour to achieve biodiversity conservation and ecologically sustainable outcomes across the rural landscape and in agriculture. He also has extensive experience in a variety of regional flora and fauna programs and projects especially in Gippsland and Westernport areas.

John Bowman – NRE, Leongatha

John is a Grazing Industry Officer for South Gippsland. He delivers extension programs to dairy farmers under the Target 10 program and to beef & lamb producers under the Edge Network. His areas of expertise include pasture management, soils and fertiliser use. John has also worked with Landcare, and dealt with issues such as pest plant and animals, land protection and soil conservation.

Phil Papas – NRE, ARI, Heidelberg

Phil is an aquatic ecologist who specialises in freshwater and estuarine biodiversity assessment, river health, and macro-invertebrate taxonomy. He currently manages the aquatic invertebrate and water quality team. Phil also has good knowledge of aquatic and terrestrial flora and fauna databases, and the use of GIS for biodiversity assessments.

John Davies – NRE, Traralgon

John is a botanist and a Senior Flora and Fauna Officer specialising in flora and fauna surveys, land classification and biodiversity mapping. He is the leader of a biodiversity mapping team that has mapped native vegetation at 1:25000 scale, covering Lakes Entrance, Inverloch, Wilsons Promontory, the islands off South Gippsland, inland to the Gippsland Lakes, the Gippsland Plain and Strzelecki ranges.

Graeme Ward – NRE, Warrnambool

Graeme is a Dairy Research Officer in the Catchment and Agriculture Services Division of NRE. His research includes the soil, water and nutrient issues that affect the dairy industry in the Warrnambool region. Prior to this, Graeme was a Pastures Extension Officer in the grazing industries of south west Victoria.

1. Biodiversity conservation and livestock production: Integrating grazing and riparian landscapes

Sharon R. Aarons

Introduction

Victoria's biodiversity is defined as "the natural diversity of all life: the sum of all our native species of flora and fauna, the genetic variation within them, their habitats, and the ecosystems of which they are an integral part" (NRE 1997b). Biodiversity is a fundamental part of Australian aesthetics and culture, providing people with an inherent sense of cultural identity and belonging, and contributing in many ways to the environmental, economic and social wealth of Australia. While the 'intrinsic value' of biodiversity is not easily costed, it has an economic value through the direct provision of goods (eg native meats, bushfoods, medicines, and flowers) and services (ecosystem processes) which support the agricultural systems that produce food and fibre for export and internal markets. Ecosystem services include the interactions between plants, animals and microorganisms, as well as their interactions with the external environment (ANZECC 2001). Destruction of these ecosystem services, through loss of biodiversity (Saunders and Walker 1998), leads to the degradation of soil, water and air quality, reducing their capacity to sustain life and contributing to the environmental damage so evident around Australia.

Loss of biodiversity is Australia's most serious environmental problem, with the most severe losses occurring in agricultural zones (Williams 1999). Clearing of native vegetation, inappropriate fertiliser use and grazing practices have contributed to changes in water quality, ecosystem function, loss of ecological communities and a decline in biodiversity. The waterways and surrounding riparian land that pass through intensive grazing properties represents an interface between agriculture and the environment. Appropriate management of the riparian zone can have significant advantages for whole catchment and landscape processes, including improved water quality and riparian biodiversity.

This review describes the intensive grazing production systems relevant to the high rainfall regions of Victoria (dairy, beef, and sheep) and their impacts on riparian and in-stream biodiversity. An overview is given of Victorian livestock production systems and their contribution to the export earnings of the Victorian and Australian economy. The uniqueness of Victoria's biodiversity and the land management impacts on these flora and fauna assets is described, as is the range of Strategies, Programs and Initiatives available nationally and in Victoria to assist in redressing the current situation. Potential grazing management impacts on native biodiversity are tabulated and discussed with nutrient and sediment losses to waterways contributing greatly to destruction of riparian habitats. The role for integrated grazing and riparian landscapes through the process of landscape redesign is canvassed, and the advantages and disadvantages of alternative land use options are presented. Finally, the importance of the drivers for change as well as accurate cost benefit data for enhancing adoption of riparian management best practice are discussed.

Livestock production systems

The intensive grazing industries of dairy, beef and sheep contribute greatly to the Victorian State revenue, earning the state approximately $3.13 billion in exports in 2000 (NRE 2001a; 2001b). The Victorian dairy industry was the largest contributor, producing 63% of Australia's milk, 75% of its manufactured dairy products and 85% of Australia's dairy exports. Generally favourable edaphic and climatic factors and the availability of reliable water supplies ensure that the Victorian dairy industry is among the most cost-efficient worldwide, surpassed only by New Zealand (Figure 1.1). This is largely due to the reliance of dairy farms on high quality permanent pastures for year-round grazing (Gourley 2001). Milk production in Victoria occurs either in high rainfall areas or in the irrigation districts (Figure 1.2).

In 2001, a typical Victorian dairy farm milked ~190 cows, producing 4,624 L of milk (ADC 2001), with the average herd size expected to increase to 250 cows by 2010 (NRE 2002c). The average dairy farm was a pasture based production system of 100 to 150 hectares, supplemented with bought-in grain or concentrates of approximately 1 tonne per cow per year. Perennial rye grass

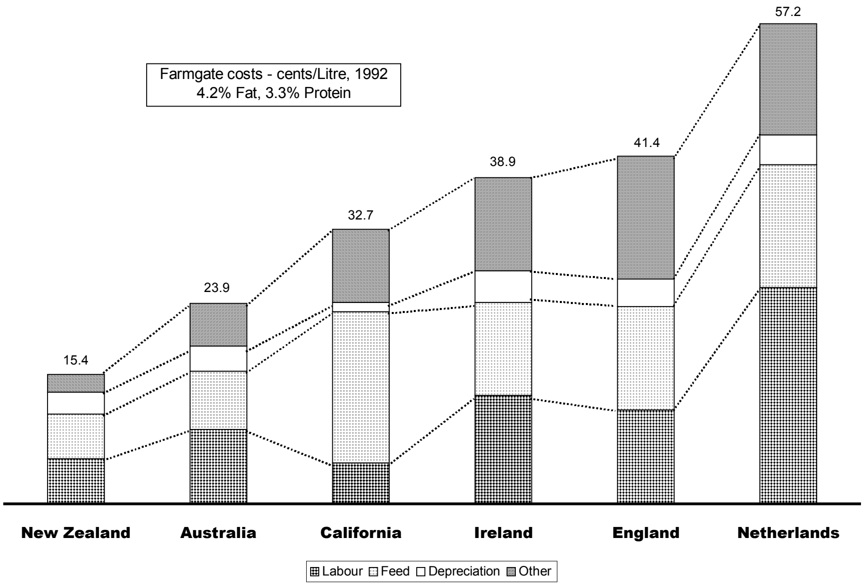

Figure 1.1. Australia's production costs compared with other milk producing countries and states. (Data for figures provided courtesy Richard Habgood, Dairy Industry Coordinator, NRE.)

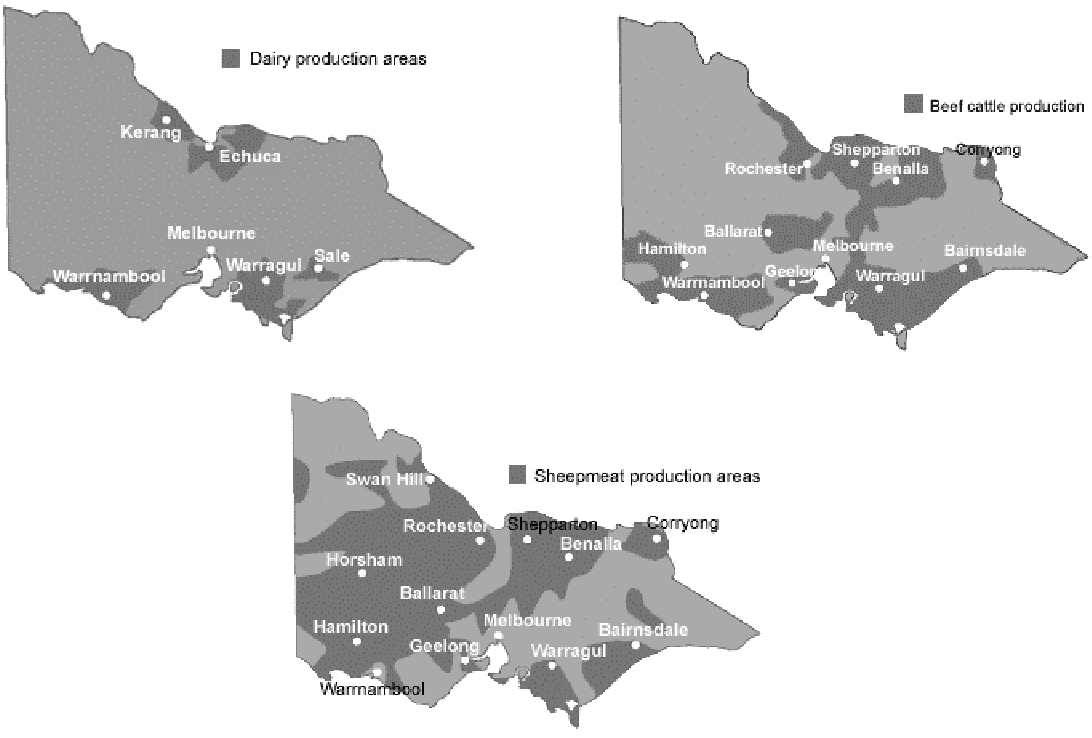

Figure 1.2. Dairy, beef and sheepmeat production areas in Victoria. (NRE 2001a; 2001b)

(*Lolium perenne*) and white clover (*Trifolium repens*) pastures are mostly rotationally grazed, producing 8 to 12 tonnes of pasture dry matter (DM)/ha.year. Pasture utilisation rates vary from 50 to 85% depending on farm management practices. The inherently low fertility of most Australian soils results in a need to apply fertilisers to replenish the soil nutrients required to support intensive milk production. Pastures are generally fertilised using single superphosphate and potassium (K) applied once per year, usually in autumn, at a single rate over the whole farm (Gourley 2001). Nitrogen (N) fertiliser use has increased over the last 10 years and is applied regularly during the growing season to increase pasture production. Average rates of fertiliser use on Victorian dairy farms are 77, 67 and 70 kg/ha.year for N, phosphorus (P) and K, although rates greater than 300, 100 and 150 kg/ha.year respectively are often applied on high producing dairy farms (Gourley 2001). Cows are milked twice daily in dairy sheds, and farmers are encouraged to store the waste (faeces, urine, milk and wash-down water) in earthen constructed effluent ponds to prevent pollution of the environment through loss to waterways and subsequent eutrophication, as was common in the past.

Victoria contributes approximately 20% and 33% to beef and sheep meat production respectively in Australia (NRE 2001b). These industries are usually more extensive than the dairy industry, with lower inputs. The beef and sheep meat industries are located statewide in areas of high and low rainfall (Figure 1.2). The Victorian beef industry is the most efficient in Australia producing 351.4 $\times 10^3$ tonnes in the 1999/2000 financial year, and is Victoria's largest meat product. Beef property stocking rates vary across the state in proportion to the average annual rainfall. High rainfall average stocking rates for beef properties are estimated at 15~20 dry sheep equivalent (DSE; 45 kg/dry wether) per hectare, or approximately 100 cows and calves on 100 hectares. This stocking rate does not include additional livestock (bulls, horses, sheep) on the property. Prime lamb production stocking rates are commonly 15 to 22 DSE/ha in high rainfall areas (>750mm). Paddocks are usually set-stocked rather than rotationally grazed, and produce approximately 8 tonnes of DM/ha.year with only 4 to 5 tonnes consumed. Low pasture production (when compared with dairy systems) is primarily due to low rates of fertiliser use of between 200 and 250 kg/ha single superphosphate or single superphosphate:potash (2:1) blends. These rates are equivalent to 12 to 22.5 kg/ha P, and 0 to 42 kg/ha K respectively. Nitrogen fertiliser is seldom applied. At such rates, pastures are often underfertilised, hence the low dry matter production compared to dairy systems. Beef calving occurs either in autumn (50% of herds) or spring, while 90% of lambs are born in late winter/early spring.

Biodiversity conservation

Loss of biodiversity is considered Australia's most serious environmental problem (Saunders and Walker 1998) with known extinctions of 7% of marsupials, 15% of rodents and 73 flowering plant species since European settlement approximately 200 years ago (Anderson *et al.* 2001; Saunders and Walker 1998). The 'National Strategy for the Conservation of Australia's Biological Diversity' was endorsed by the Council of Australian Governments (COAG) in 1996, with the goal "to protect biological diversity and maintain ecological processes and systems." The strategy covers all of Australia's biological diversity, focussing on the conservation of indigenous biological diversity. Priority actions were identified for 6 target areas, each with specific objectives and actions (ANZECC and BDAC 2001). The strategy was developed to meet the requirements for Ecologically Sustainable Development or ESD. In their review of the 'National Strategy for the Conservation of Australia's Biological Diversity', ANZECC and BDAC (2001) identified the extent to which the objectives of the strategy had been met. Table 1.1 describes the strategies relevant to this paper, their assessment and some of the activities undertaken within and by the Victorian Government and communities that contribute to meeting the targets. Subsequently, a number of Initiatives, Programs and Strategies have been developed by the Commonwealth and State Governments that contribute to meeting the aims and goals of the National Strategy for the Conservation of Biological Diversity. Initiatives and strategies relevant to this topic include: the Natural Heritage Trust of Australia Act, 1997; the Commonwealth Environment Protection and Biodiversity Conservation Act, 1999; the National Action Plan for Salinity and Water Quality, 2000; the National Framework for the Management and Monitoring of Australia's Native Vegetation, 1999; the National Local Government Biodiversity Strategy, 1998; and Victoria's Biodiversity Strategy, 1997 released in response to the Flora and Fauna Guarantee Act of 1988. The Ecologically Sustainable Agriculture Initiative (ESAI) implemented by the Department of Natural Resources and Environment in 2001 supports cross-division (Agriculture and Parks, Flora and Fauna) and cross-industry research projects focussed on improving biodiversity within agricultural production systems and assisting agricultural systems to become ecologically sustainable.

Table 1.1. Summary assessment of biological conservation strategies (ANZECC, 2001).

1	**CONSERVATION OF BIOLOGICAL DIVERSITY ACROSS AUSTRALIA**		
1.1	Identification		
1.1.1 1.1.2	*Identify important biological diversity components;* *and identify threatening processes*	Partially achieved	Victoria has nearly completed mapping several hundred ecological vegetation classes at 1:100 000 across the State and 1:25 000 in natural landscapes (parks and reserves), allowing close integration with planning and management activities.
1.2	Bioregional planning *Manage biological diversity on a regional basis, using natural boundaries to facilitate the integration of conservation and production-oriented management*.	Partially achieved	The National Local Government Biodiversity Strategy promotes regional partnerships and planning across local government. The strategy recognises that biodiversity management is fundamentally about building regional partnerships. Victoria’s Biodiversity, the Victorian State biodiversity strategy, is based on bioregions developed from and integrated with IBRA and IMCRA. These bioregions have been used when evaluating status and actions for threatened species and communities.
1.3	Management for conservation *Improve the standards of management and protection of Australia’s biological diversity by encouraging the implementation of integrated management techniques*.	Achieved	In 1996, Victoria combined the Departments of Agriculture, Minerals and Petroleum, and Conservation and Natural Resources and Environment. For the first time, all Victorian State Government departments with natural resource management roles are in the one corporate structure and reporting to the one Secretary. In 2000, biodiversity conservation became one of the three key outcomes for the Department of Natural Resources and Environment.
1.5	Conservation outside protected areas *Strengthen off-reserve conservation of biological diversity*	Partially achieved	The Victorian Land for Wildlife program encourages private landholders to become active participants in conservation activities on their own land. The number of properties involved in this program recently passed 5000 in Victoria, protecting 150 000 hectares of significant vegetation. The program has been exported to several other States.

1.7	Threatened biological diversity *Enable Australia's species and ecological communities threatened with extinction to survive and thrive in their natural habitats, to retain their genetic diversity and potential for evolutionary development, and prevent additional species and ecological communities becoming threatened.*	Partially achieved, ongoing effort required	Under the *Flora and Fauna Guarantee Act 1988*, Victoria has listed over 350 threatened species and communities and threatening processes. Action statements, detailing on-ground management actions and obligations for all government agencies, have been prepared for over 100 species, communities and processes.
2	**INTEGRATING BIOLOGICAL DIVERSITY CONSERVATION AND NATURAL RESOURCE MANAGEMENT**		
2.2	Agriculture and pastoralism *Achieve the conservation of biological diversity through the adoption of ecologically sustainable agricultural and pastoral management*.	Not achieved	The National Landcare Program has made a major contribution to encouraging sustainable agriculture. This has been achieved though promoting land management practices that are environmentally sustainable as well as profitable. Land for Wildlife is a successful program that has engaged primary producers across Australia providing information, support and encouragement through a voluntary program. Community support has been very positive.
2.5	Water *Manage water resources in accordance with biological diversity conservation objectives and to satisfy economic, social and community needs.*	Partially achieved	The Commonwealth, State and Territory Governments are developing the *National Water Quality Management Strategy*. The strategy incorporates the principles of ecologically sustainable development. It is made up of 22 guidelines of which 16 have been implemented. When fully implemented, the strategy will deliver a nationally consistent approach to water quality management.
3	**MANAGING THREATENING PROCESSES**		
3.1	Threatening processes and activities *Monitor, regulate and minimise processes and categories of activities that have or are likely to have significant adverse impacts on the conservation of biological diversity and be able to respond appropriately to emergency situations*.	Not achieved	The National River Health Program's Australia-wide assessment of river health uses a rapid, standardised method for assessing the ecological health of rivers known as AusRivAS. This is located on the Internet at: http://enterprise.canberra.edu.au/Databases/AusRivAS.nsf. In Victoria, over 30 potentially threatening processes have been listed under the *Flora and Fauna Guarantee Act 1988*, with several action statements produced, including on the introduction of marine exotics, predation by the red fox and the use of lead shot (which has since been banned).
3.2	Clearing of native vegetation *Ensure effective measures are in place to retain and manage native vegetation, including controls on clearing*.	Not achieved	

4	**IMPROVING OUR KNOWLEDGE**		
4.1	Knowledge and understanding *Provide the knowledge and understanding of Australia’s biological diversity essential for its effective conservation and management.*	Partially achieved	Victoria maintains several large databases (over 1.5 million records) on the distribution of flora and fauna, with the BioSites database able to locate all threatened species occurrences across the State.
5	**INVOLVING THE COMMUNITY**		
5.1	Awareness and involvement *Increase public awareness of and involvement in the conservation of biological diversity.*	Achieved	State and Territory biodiversity strategies all include specific sections concerned with increasing community participation in biodiversity conservation. These include identified actions, such as developing opportunities and incentives to the community to conserve biodiversity and improving the accessibility of regionally relevant biodiversity information to the community.

The Initiative targets 'species and communities of flora and fauna of conservation significance' within agricultural landscapes, making protection and enhancement of these a priority.

Victoria's unique flora and fauna[1] occur in a range of ecosystems, that together, are more diverse than anywhere else of similar area in Australia (NRE 1997a). These ecosystems, inhabited by a wide range of identified and unidentified species and communities, have been classified into 21 bioregions (NRE 1997c). The bioregions form part of the 11 Interim Biogeographic Regionalisation for Australia (IBRA) terrestrial zones occurring in Victoria (Thackway and Cresswell 1995). The four bioregions of particular significance to the high rainfall grazing zones in Victoria are the Strzelecki Ranges, the Gippsland Plain, the Warrnambool Plain and the Otway Plain (Figure 1.3). The latter three (3) group to form the Coastal Plains, part of the South East Corner, while the first is part of the South Eastern Highlands IBRA zones.

Collectively, native flora and fauna form unique assemblages or ecological communities that provide ecosystem services to agriculture. Processes such as maintaining soil fertility and structure depend on the activities of a diverse range of soil microflora and invertebrates that play an important part in plant residue decomposition and subsequent cycling of nutrients. Estimates of the weight of microorganisms, earthworms and other invertebrates in soil suggest that this biomass far exceed the weight of livestock grazing, even in the most intensively stocked pastures (Table 1.2). Habitat loss and fragmentation affects the population size and structure of many soil invertebrates, with the effect dependent upon the species involved (Abensperg-Traun *et al.* 1996; Baker 1998). To ameliorate habitat fragmentation, native vegetation corridors that link remnants are recommended, as they are likely to contribute to increased dispersal of non-volant invertebrate species. Native vegetation is a critical component of a viable and functioning habitat for native fauna and plays a unique role in maintaining water tables, preventing salinisation and reducing greenhouse gases.

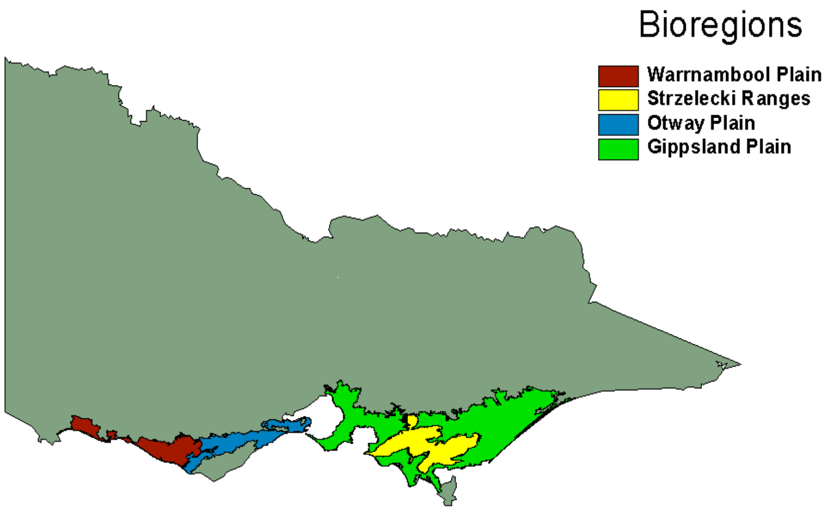

Figure 1.3. High rainfall bioregions of southern Victoria.

---

[1] Based on the Victorian Biodiversity Strategy NRE 1997a;b;c, and for the purposes of this paper biodiversity refers to native flora and fauna indigenous to the area of local provenance.

Table 1.2. Estimates of under-ground biomass in 1 hectare of dairy pasture soils, and comparison with above-ground dairy cow biomass. Refer to Appendix I for calculations.

Biomass (kg/ha)		
Above ground	**Below ground**[α]	
Dairy cows	*Bacteria*	*Earthworms*
1000	1 - 1000	700

[α] Calculations do not include other soil microorganisms such fungi, viruses and algae, as well as other soil biota such as protozoa, nematodes, and macroarthropods.

Substantial clearing of native vegetation has occurred in the Coastal Plains bioregions of this study changing the vegetation from a combination of lowland and foothill open forests, heathy and grassy woodlands, coastal scrubs and grasslands, freshwater and coastal wetlands to one dominated by coastal heathlands and heathy woodlands (NRE 1997c). The extent of clearing varied for the different bioregions but was primarily driven by the establishment of agriculture, usually the grazing industries. Consequently, there are a number of threatened species in these bioregions including the New Holland Mouse (Pseudomys novaehollandiae), the Giant Gippsland Earthworm (Megascolides australis), the Orange-bellied Parrot (Neophema chrysogaster) and the Little Tern (Sterna albifrons). Likewise, the Strzelecki Range bioregion has been severely impacted by land clearing, with subsequent habitat and biodiversity loss. The effect of changed land management on biodiversity and ecosystem processes has resulted in reduced water, nutrient and sediment quality, increased salinity and pest invasions as remnant clearing continues and as a consequence of farming practices in or near remnant patches.

Biodiversity conservation is actively managed within the system of statewide nature reserves and public land. Thus the South Eastern Highlands IBRA zone, in general, has some of the best biodiversity assets and functioning ecosystem processes, as large areas are managed as public land (NRE 1997c); although the Strzelecki Range bioregion is an exception to this. A number of threatened terrestrial and aquatic species are endemic to this IBRA zone. However, conservation of native flora and fauna species and communities that occur in these bioregions cannot depend solely on these reserves. The location of public land, mostly confined to land not suited to agriculture, means that the populations inhabiting these areas are likely to represent those biased to more marginal land (Norton and Miller 2000). Thus, it is critical to conserve biodiversity remnants existing on private land, much of which is classified as threatened (Anderson et al. 2001; NRE 1997c). Almost a third of Victoria's threatened flora and fauna occur on private land, and of the range of land management issues that affect these, grazing by stock contributes to reducing 35% of these populations.

The importance of biodiversity conservation has been recognised by various national rural industry research corporations and livestock industry bodies, with many releasing policy statements, action plans and documents highlighting the importance of biodiversity conservation to their industry. Meat and Livestock Australia (MLA) recently released a 'Biodiversity Edition' of its Prograzier publication (circulation of 13,000), within which the importance of managing riparian zones and remnant vegetation is discussed both by landholders and scientists (Anon. 2002). Tips on minimising nutrient loss, and managing native vegetation were also given. The MLA organisation have also agreed to develop a producer training module with the main learning outcome being "to understand how to make your property more profitable and biologically diverse (attractive and a more interesting place to live and work) by encouraging biodiversity". Associated with this will be an increased understanding of biodiversity and the need for it, identifying areas on the farm most suited to biodiversity, and the tools to develop a biodiversity plan as part of a farm plan (Mason pers. comm.).

'Sustaining our natural resources – Dairying for tomorrow' project report (DRDC 2001) identifies water quality and biodiversity as two of the "focal issues" for the dairy industry in the future. Effluent management, fertiliser application and stock movement around waterways are areas that need increased attention to improve water quality leaving farms. Native remnant vegetation and riparian habitats are areas identified for further improvement. A national survey of 1,800 farmers revealed that of those farmers with waterways or remnant native vegetation, 57% and 36% (respectively) had fenced these areas. Additionally 56% had undertaken revegetation on their properties. This report identifies the need to better understand "what biodiversity means in practice" to dairy farmers. The research undertaken for this report lead to the development of a national strategy for sustainable resource management by the dairy industry as well as a series of regional action plans. The GippsDairy and WestVic Dairy (both located in southern Victoria) action plans identify increasing biodiversity as one of their eight key Action areas, with targets of:

- 80% of remnant vegetation and 50% of waterways fenced by 2005
- 100% of remnant vegetation and waterways fenced by 2015

The importance of protecting riparian and river ecosystems and water quality have also been identified with effective management of nutrients and effluent targets set by both regional dairy boards. The state government has also recognised the importance of Victoria's rivers and waterways to the "economy, ecology and social fabric of Victoria". The Victorian River Health Strategy released in 2002 aims to "achieve healthy rivers, streams and floodplains which meet the environmental, recreational and cultural needs of future generations." Specific targets have been set in the Strategy with priority management issues including water quality, riparian land and river channel management.

Riparian ecosystems

Riparian landscapes are unique, largely due to the strong interrelationships between terrestrial and aquatic habitats (Figure 1.4). The definitions of riparian zones range from those based on proximity to surface and/or subsurface water to "ecotones between aquatic and upland ecosystems exposed to lateral flow" (Malanson 1993). The role of lateral water flow is considered primary in defining the role and functioning of riparian landscapes, and is distinguished from subsurface flows. In addition, no mention is made of transient flows, a common feature of Australian riparian landscapes. Modifying the riparian definition "in and near river channels and directly influenced by river-related processes" (Malanson 1993) to include "permanent and transient river-related processes" may more accurately define most riparian zones in this study area. The Victorian River Health Strategy (NRE 2002a) uses the following definition to reflect the range of ecosystem functions associated with riverine environments.

A river, stream or natural waterway includes:

- the channel
- the riparian zone, which includes the area of land that adjoins, regularly influences or is influenced by the river
- the regularly wetted floodplain and any associated floodplain wetlands, and
- the estuary or terminal lake

This definition acknowledges the importance of subsurface flows in riverine ecosystems.

Riparian zones can be considered corridors through the landscape, especially when considering the vegetation associated with them; although, where significant disturbances have occurred, aspects of remnant vegetation patches apply. The terrestrial and aquatic linkages of riparian zones affect the flows of energy, matter (water, sediments, nutrients) and organisms within and between these ecosystems. These flows will be influenced by the longitudinal, transverse (or lateral) and internal structures, which together comprise the "pattern" of riparian landscapes (Malanson 1993; NRE 2002a). In addition, links to groundwater systems (or vertical structures) contribute to the flows into and out of river systems. The location of the riparian landscape along the longitudinal plane is likely to affect these flows and their interactions, with the ecosystems and habitats present at the headwaters potentially very different to those near the mouth of the river (Rutherfurd *et al.* 2000a). The gradient of these changes may occur rapidly over a short distance (as at the headwaters) or be relatively constant for large distances along the river, especially along floodplains. Likewise, the rate of change of these interactions from aquatic to upland ecosystems can vary, while the processes will differ depending on the aquatic or terrestrial influences.

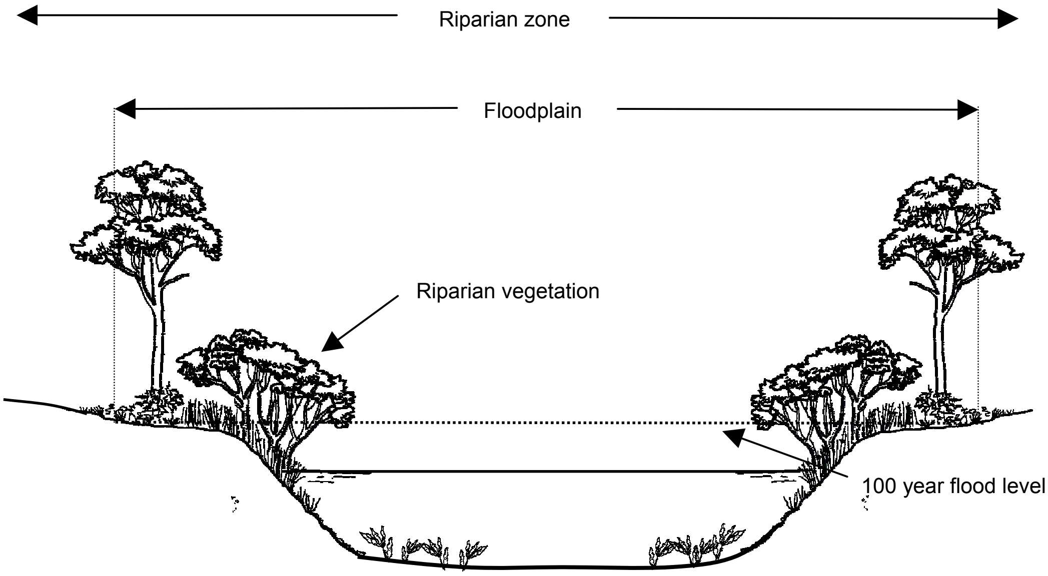

Figure 1.4. Diagram depicting a riparian zone.

Riparian ecosystems[2] support a range of aquatic and terrestrial organisms whose survival is interdependent and requires varying inputs of energy and matter. These organisms play an important role in the cycling of nutrients in riparian zones. The hierarchy of in-stream organisms at any point in the riparian zone starts with primary producers such as macrophytes (flowering plants) and periphyton (algae) that occur at the bottom of the food chain. The photosynthates produced by this group are consumed by the herbivores who themselves, are food for the larger predators. The herbivores are distinguished into a) consumers of bacteria, fungi and algae scraped from hard surfaces within the river, and b) shredders such as crayfish and other crustaceans, that chew or bite into macrophytes. Predators range from other macroinvertebrates (including dragonflies and some beetles) through to fish, birds, frogs and other large animals. Shredders also breakdown the organic matter that enters the river (leaf litter, woody debris, dead organisms) into the small pieces used by filter feeders and detritivores such as aquatic snails and fly larvae. Finally, bacteria and fungi complete the nutrient cycle by completing the degradation of organic matter and releasing the nutrients for use by the producers. The cycling of nutrients and structure of the food web will vary depending on the location along the longitudinal plane of the river.

Habitat diversity and condition provide the resources required by riparian organisms. Diversity specifies the range of habitats required for different organisms and for different stages in each organisms life cycle. Internal riparian structures that influence the diversity of habitat include the type of aquatic surfaces, water depth and velocity, presence of aquatic and terrestrial vegetation and in-stream shelter such as woody debris and rocks, and the structures associated with floodplains. In general, greater habitat diversity supports a wider range of organisms. Simplification of plant diversity (eg monocultures of reed species, pasture or willows), channel straightening and sediment deposition are examples of reduced stream and habitat diversity. The ability of the riparian zone to support a wide range of species is also determined by its condition, which is heavily influenced by water quality and flow. These factors provide the nutrient, oxygen, temperature and structural requirements of aquatic species. The floodplain is another important source of nutrients for many species both during and after floods, while submersion is required by some plant species.

The Index of Stream Condition, used to quantify the condition of Victorian rivers and streams (NRE 2002a), assessed 950 reaches of 18,000km of major rivers or tributaries in Victoria in 1999. Criteria included riparian vegetation structure, continuity and weediness, in-stream species, habitat features, presence or absence of barriers to migration and bed condition. These indicators were used to

---

[2] Rutherford *et al*. (2000a) note the limited information available relating to Australian stream ecology, and caution against the direct translation of Northern Hemisphere data to Australian conditions.

determine the percent of stream length, streamside zone and physical form in excellent or good condition, as well as the level of surface water development. Only 27% of major rivers or tributaries were in overall good or excellent condition, with 34% in poor or very poor condition. In addition, only 6% of rivers surveyed fully met the criteria for ecologically healthy rivers. These results have been driven primarily by changed river channels and flow regimes, poor riparian condition, reduced habitat and poor water quality.

Ecosystem structure and function depends on the diversity of habitat and species. Any reduction in the latter through degradation of the environment is likely to reduce the ability of the ecosystem to resist and to recover from disturbance. When these changes are significant, the resilience of the river is reduced. Hence, where possible, it is important to protect riparian zones in relatively good condition from further species and habitat loss.

Impacts of grazing systems

Almost a third of Victoria's threatened flora and fauna occur on private land, and of the range of land management issues that affect these, grazing by stock contributes to reducing 35% of these populations (Lowe *et al.* 2000). Management of intensive grazing systems often poses a number of threats to biodiversity conservation on private land, some of which are given in Table 1.3. The specific impacts of the dairy, beef and sheep industries will vary depending on factors such as the type of industry, livestock stocking rates, soil types, use of fertilisers and other inputs, but also how carefully the farmer manages effluent disposal, weeds and pests, and the value placed on remnant vegetation (McIntyre 2000; Jansen and Robertson 2001a; 2001b). Pasture intensification types in Australia are characterised according to the amount of native vegetation present, with the high rainfall zones often subject to extensive clearing and subsequent re-sowing with exotic species. As previously described, the intensity of land-use and pasture management has been dependent on the type of industry (McIntyre 2000).

Soil structure can be severely degraded in overstocked paddocks resulting in soil compaction and pugging/poaching, especially in the wet seasons (Greenwood and Mc Kenzie 2001). The average stationary pressures exerted by sheep and cattle are 66 and 138 kPa respectively compared with 67kPa for kangaroos. However, the pressures exerted will be greater during movement and will be directly linked to stocking rates. Thus, although jumping kangaroos can exert forces of up to six times greater than their weight (30 – 66kg), the stocking rates and rates of movement by livestock are likely to have a greater impact over the long term. In addition, the difference in pes morphology between macropods and ungulates, eg. soft-footed native fauna versus hoofed livestock, has a large impact on soil structure and compaction. Poor soil structure will affect plant growth both directly, through low water infiltration, low oxygenation, and stunted root growth; and indirectly, as the ability of microflora to cycle the nutrients required for adequate plant growth is reduced. Poorly structured soils have reduced vegetative cover and are susceptible to erosion. Where these heavily grazed areas are associated with riparian zones, increased sedimentation of waterways and reduced aquatic life result. Grazed pasture soils have lower hydraulic conductivity and reduced macropore flow suggesting a greater tendency to run-off losses (Cooper *et al.* 1995).

Inappropriate management of stock resulting in stock camps and nutrient redistribution around the farm can increase soil fertility to levels that are potentially detrimental to livestock (Aarons *et al.* 2001b) and to the environment. Cow manure has high P (~1%) and K (~2%) concentrations (Aarons 2001), and losses from laneways and the dairy shed will contribute to eutrophication upon reaching waterways. In the paddock, cow manure was shown to degrade in less than 60 days in autumn, with increases in soil P and K fertility in the upper soil layer underneath the pad observed long after the pad had completely disappeared (112 days) (Aarons 2001). Increased P and K fertility in the upper soil layers was observed in stock camps elsewhere (Gerrish *et al.* 1993; Gerrish *et al.* 1995). The decomposition rate of manure pads is likely to vary seasonally, which may impact on environmental pollution in the area where animals graze (Dickinson and Craig 1990). While very high annual application rates of P fertiliser do not affect soil microbial numbers (Aarons *et al.* 2001a), highly fertile soils may contribute to nutrient pollution of waterways via run-off (Cox and Hendricks 2000). Conversely, where nutrients are mined from the grazing system (low fertilisation rates) not only is the landholders viability threatened, the ensuing poor pasture cover will contribute to the process of erosion (Hairsine and Prosser 1997).

Table 1.3. Some farm activities, the aspect of the farm or environment that is affected and the impact of the activity.

Farm activity, product or service	Farm or environment aspect	Impact of the activity
Grazing by stock	Wet soils	Compaction, pugging, erosion, poor plant growth, reduced nutrient cycling, eutrophication, sedimentation, loss of soil microflora and invertebrates, loss of aquatic species
	Soil fertility – high (stock camps etc)	Nutrient losses, eutrophication
	Vegetation	Vegetation loss, salinization, nutrient and chemical loss, eutrophication, loss of aquatic species, loss of fauna
	Waterways	Sedimentation, eutrophication, loss of aquatic species
Fertiliser application	Soil fertility – high	Nutrient losses, eutrophication, loss of aquatic species, loss of native vegetation suited to lower soil nutrient regimes
	Soil fertility – low	Soil erosion, sedimentation
Effluent disposal – none	Waterways	Nutrient losses, eutrophication, loss of aquatic species
Effluent disposal – spread on pastures	Soil	Nutrient losses, eutrophication, loss of soil microflora and invertebrates
	Waterways	Nutrient losses, eutrophication, loss of aquatic species
	Native vegetation	Loss of plant species and habitat suited to lower nutrient regimes
Effluent disposal – dams (inappropriately sited constructed dams)	Soil	Loss of macro and micro soil invertebrates and microorganisms, loss of habitat
	Native vegetation	Loss of plant species and habitat

Stock access to waterways results in destabilisation of riverbanks, increased sedimentation and eutrophication of waterways (Rutherfurd *et al.* 2000b; Jansen and Robertson 2001b). Grazing cattle trample, consume and damage native vegetation if not excluded from remnants, contributing to the loss of understorey species and the subsequent decline in terrestrial and aquatic flora and fauna such as populations of woodland bird species (Jansen and Robertson 2001a; 2001b). The loss of stream shade results in an increase in water temperature, which affects some aquatic species such as in-stream invertebrates, macrophytes and fish (Rutherfurd *et al.* 2000b). The likelihood of soil and nutrient losses to the environment is increased. Clearing of native trees and loss of regenerating trees due to grazing cattle contributes to rising water tables. Increased salinity due to the replacement of native trees with annual and temperate pasture grasses has been observed in much of Australia's landscapes, including the Warrnambool Plain bioregion (NRE 1997c).

Dairy effluent can have concentrations of N, P and K as high as 608, 115 and 833 mg/L respectively (Waters 2002). Lack of an effluent disposal system has meant that dairy waste high in nutrients often ends up in waterways, contributing to eutrophication and endangering aquatic flora and fauna. Similar losses can be expected where the effluent reaches remnant stands of native vegetation. Many farmers dispose of effluent by spraying or spreading on pastures. If the treated paddocks are near to riparian land and/or waterways, the resulting high soil nutrient content can contribute to eutrophication. High salt concentrations in effluent can contribute to reduced soil structure and drainage problems. Ideally, well-constructed effluent ponds suitably located within the landscape (ie far from riparian and remnant zones, in soils not susceptible to leaching) are the most appropriate means for disposal of dairy waste. Managing nutrients on farms depends on accurate nutrient budgets and an understanding of the contributions of effluent, manure and fertiliser to the nutrient status of paddocks around the farm. However, construction of an effluent dam raises conflict between the need to prevent nutrient losses and the potential negative role of dams in biodiversity conservation.

Excessive nutrient losses are a common feature of many negative farm impacts associated with the grazing industries. Natural ecosystems are considered to have closed nutrient cycles with small losses, although these may vary throughout the growth cycle (van Noordwijk 1999). In general, most nutrients are cycled and returned within close proximity of where they were first acquired by plants. The limited nutrient transfers/losses from one patch leads to nutrient aggradation at other sites. These transfers contribute to a patch-mosaic of nutrient rich and nutrient poor sites and subsequent biodiversity differences.

Nutrient flows increase in agro-ecosystems primarily due to leaching, run-off, gaseous and erosion losses, as well as nutrient exports in farm products. Thus, agricultural practices can result in a depletion or accumulation of nutrients depending on whether there is a net import or export of products. Nutrient budgets undertaken for N, P and K in dairy farmlets (Gourley 2001) indicate a potential for accumulation of N and K, with little changes in P under P fertiliser inputs ranging from 0 to 140 kg P/ha. year. In contrast, large P increases were recorded on dairy farms in New Zealand and Europe due to very high rates of P fertilisation and feed inputs respectively (Goh and Williams 1999). Potassium inputs in imported foodstuff such as hay contribute to large net accumulation on dairy farms (Goh and Williams 1999; Gourley 2001). These overall budgets do not account for the nutrient redistribution around the farm or within paddocks, or the potential for nutrient loss. Nutrient redistribution, common in grazing systems, may affect soil communities and their nutrient cycling activities. Grazing practices such as night/day paddock rotations, where cows graze a few paddocks (usually near the dairy) between night and morning milking result in accumulation of nutrients (P, K) in these areas. Similarly, nutrients accumulate where the stock camp (Gerrish *et al.* 1993; Gerrish *et al.* 1995). Nutrient redistribution to the front of strip-grazed paddocks has been reported where back fencing was not used (Aarons *et al.* 2001b). In addition, nutrients can be mined from paddocks used routinely for hay production. This redistribution of nutrients around the farm can increase the potential for losses to the environment. Nutrient losses are dependent on soil types, with run-off losses of 17.5 kg P recorded from a dairy farm of one soil type (Nash and Halliwell 1999) located 20 km away from another site where no P losses were recorded in the same year. These observations are due to differences in the hydraulic properties of the soils, affecting the water infiltration capacities. Hence, P losses in run-off can only occur where there is run-off. The P sorption characteristics of soils (Burkitt *et al.* 2002) will also affect their susceptibility to P loss to the environment, with low-sorbing soils most susceptible to P leaching losses. Losses of P and N, while insignificant in terms of the amounts of nutrients applied especially to dairy farms, do considerable damage to riparian zones (Rutherfurd *et al.* 2000b). It is apparent that inappropriate management practices in grazing production systems can have severe consequences for remnant vegetation and riparian zones through flora, fauna and soil loss, eutrophication of waterways and ultimately destruction of habitats and ecosystems.

Water, nutrient and sediment flows

Priority ranking of degradation issues varies depending on which internal structures of the riparian zone are considered. Flow (determined by stream geomorphology) and water quality constitute two major related issues associated with degraded riparian zones. Stream geomorphology can affect water quality indicators such as stream turbidity. Of the six water quality characteristics described by Rutherfurd *et al.* (2000b), turbidity, nutrient loads, low dissolved oxygen and water temperature are most likely a result of grazing management practices.

High sediment loads can result from run-off from tracks and laneways. Turbidity affects a range of riparian flora and fauna including macrophytes, macroinvertebrates, fish, frogs, reptiles, birds that prey on in-stream animals and marsupials such as the platypus. Sediment can abrade surfaces during high flow or be deposited and smother organisms during low flow periods. Input of nutrients such as N and P from grazing properties can result in blooms of toxic algae, excessive growth of macrophytes, reduced dissolved oxygen and eutrophication. Often the input of nutrients far exceeds that of streams in their natural state, as these are supplied by soils that are some of the most nutrient deficient in the world. Nutrient inputs are likely to come from inappropriate nutrient and stock management on farm. These sources include regular stock access to streams and consequent defecation in or nearby the streams, run-off from fertilisers, manure pads in the paddock, laneways, stock camps and poor dairy effluent management.

Aquatic species are adapted to diurnal and seasonal fluctuations in stream temperature. However, changed land use and management (post 1750) around many riparian zones have modified these fluctuations. The resulting changes in the population and life cycles of in-stream flora and fauna also affect other predatory species. Changes in water temperature can affect other water quality characteristics such as dissolved oxygen.

Across Victoria, water quality trends indicate decreased pH and electrical conductivity, a slight increase in turbidity and slight decrease in nitrogen, although the latter is not born out by levels of compliance with the Environmental Protection Agency Regulations (NRE 2002a) or by incidences of algal bloom, especially in Gippsland and Western Victoria (DRDC 2001). Other factors contributing to poor river condition include threatened native species, drainage of wetlands, the spread of exotic fish and weeds (NRE 2002a). Large wetland areas have been drained or modified since European settlement, the majority occurring in rural areas and presumably in response to agricultural development. Conversely, most wetland areas now occur in rural areas and offer an opportunity to redress some of the damage done.

Integrated grazing and riparian landscapes

Continued increases in agricultural production in Victoria will be driven by access to water that is clean and plentiful (DRDC 2001; NRE 2002a). One of the challenges for improving management of riparian zones on grazing properties is to demonstrate integrated management of rivers and other aspects of the farm. Various guidelines exist for revegetation of riparian zones including width, planting times, species selection, methods of planting and stock management. These guidelines are readily available from a range of state (eg agricultural and natural resource management departments), federal (eg Land and Water Australia, Greening Australia) and local government (eg Catchment Management Authorities, shires, Landcare networks) organisations and agencies and have been reviewed in Chapter 3 of this document. Concerns expressed by farmers have resulted in compromises in guidelines at best, and low levels of revegetation and protection of riparian zones at worst. For example, traditional approaches to riparian management have included the exclusion of these zones from farm management through preventing access of stock. There are a number of benefits of excluding stock from stream banks such as reduced disturbance of stream banks, bed and ground cover vegetation as well as reduced direct contamination by livestock dung and urine. Despite these benefits, disadvantages cited by landowners include loss of grazing area and ready access to other parts of the property, weed management issues, the time and costs associated with fencing and replanting, and the on-going management requirements.

An alternative approach to consider is based on the concept of landscape redesign (Hajkowicz *et al.* 2001), where reshaping the landscape is aimed at implementing new land-use systems with improved ecological, economic and social outcomes. Agricultural land-use dominates most Australian landscapes with the production driven nature of agriculture for the preceding 200 years resulting in severe environmental damage in some areas and the potential for increased degradation across the country. Within the grazing industries, pasture intensification contributes to ecosystem destabilisation both within land and farming systems as well as across landscapes (McIntyre 2000). Biodiversity loss, increased salinity and reduced water quality are only 3 examples of drivers that support reshaping our agricultural landscapes.

Landscape redesign

One of the options for landscape redesign is biomimicry whereby systems of land tenure are created that imitate natural ecosystems to avoid current environmental problems while maintaining or improving productivity. This approach needs to address a number of issues (Hajkowicz *et al.* 2001), for example, its suitability for different agricultural systems. Is biomimicry a viable option in highly intensive production systems? Can the implementation of biomimicry restore already severely damaged landscapes or is this only a tool for avoiding these environmental problems? It is unlikely that large-scale adoption of biomimicry will be suitable for many landscapes and land tenure systems. Perhaps the challenge is to identify parts of the landscape suited to biomimicry that may assist repairing the damage, but will also contribute to the avoidance of biodiversity loss, reduced water quality and other environmental problems.

Riparian zones are unique in this regard as they are not only the interface between terrestrial and aquatic systems, but occur between systems of land tenure and catchment or landscape processes, ie some intervention along riparian zones can have significant consequences a great distance away. These processes include improved water quality and in-stream biodiversity, and the creation of corridors for improved biodiversity values. In addition, the management of riparian zones within a 'whole of farm' context can yield production benefits (Anon. 1999).

As described previously, intensive-grazing systems can potentially have severe consequences for riparian zones and waterways. Riparian zones managed to enhance their biodiversity values, ie fenced to distances of 20 to 40m from the stream bank to exclude stock, revegetated with species of local provenance ensuring full vegetative cover and managed to reduce weed invasions, can act as a buffer between waterways and the surrounding grazing tenure systems. These buffer zones along waterways can consist of forested (treed), grassed and/or wetland areas (Lowrance *et al.* 1997; Montgomery 1997), with their use likely to depend on the motivations of the farmer. There has been some debate as to the most appropriate vegetation cover for riverbanks (Montgomery 1997). While tree roots can stabilise riverbanks, fallen logs can contribute to channel widening in some circumstances. On the other hand, grassy banks promote sediment deposition and log-jams can act as sediment traps and sinks. Montgomery (1997) suggests case-by-case analysis of river channel conditions to determine the most appropriate revegetation strategy. Alternatively, as forested riparian buffers potentially create the most variable and hence ecologically favourable habitat, restoration of riparian forested habitat should be preferred. Lowrance *et al.* (1997) suggest that a number of factors need to be understood when designing riparian forested buffers including the hydrogeological processes of the river system, nutrient uptake characteristics of the vegetation, soil physical, chemical and biological processes controlling nutrient retention and release, potential management impacts on these processes and the effect of time.

Riparian forested (treed) buffer zones increase water infiltration, reduce sediment loss (especially fine sediment) from the surrounding land into waterways and promote sediment deposition and nutrient retention (Peterjohn and Correll 1984; Vought *et al.* 1995; Gilliam 1994; Lowrance *et al.* 1997; Lyons *et al.* 1998). Sparovek *et al.* (2002) defined an optimal riparian forest width of 52 m based on sediment yield (from the surrounding land) and deposition within the buffer zone. Phosphorus and N loss in run-off from agricultural land is significantly reduced, N more so than P. Groundwater nitrate is removed either through plant uptake via tree roots or denitrification processes in the soil, although this is dependent on the depth to the water table. In addition, the increased vegetation contributes to terrestrial and aquatic (woody debris and snags) habitat, patch connectivity and reduces dieback of remnant vegetation (McIntyre 2000).

While ideal, riparian buffer zones revegetated with indigenous native tree species may not be widely adopted as farmers are seldom willing to give up the areas recommended (20 – 40m) or to manage these areas for weeds. Grassed buffer strips, which may or may not incorporate wetlands, can provide alternatives that can potentially be managed alongside a treed riparian buffer. Wetland areas offer a great potential to improve water quality through their impact on sediment deposition and nutrient removal from surface waters (Gilliam 1994). Grassy buffers significantly reduce nutrient and sediment losses (Hairsine and Prosser 1997; Smith 1989) as the continual cover and growth of perennial grasses reduces run-off volume and velocity through absorption of up to 90% of the shear stress. The cover reduces raindrop impact while providing additional resistance to this impact and overland flow. Hill slope erosion is reduced as grasses slow the time taken for water to move across the land. Perennial grasses can also reduce gully erosion and stabilise degraded landforms. While a minimum of 70% cover is recommended to control hill slope erosion, dense ground cover is required to prevent gully erosion especially at degraded sites. As expected, the hill slope and gully erosion control processes contribute to reduced nutrient loss of organically bound N and P as well as particulate P. By slowing the movement of water and increasing infiltration, nutrient loss is slowed through the processes of denitrification and/or plant uptake described previously. These processes depend on long detention times within the grassy buffer. However, it is important to note that the effectiveness of grassy buffer strips depends on its vegetative structure, width, and position in the landscape and management. The width of the strip is likely to vary depending on the yield of sediment and landscape shape, and landscape shape will influence the shear stress of the overland flow. Thus, the intensity of land use (eg stocking rate, rotational vs set-stocked grazing) and topography will determine grassy buffer strip design. These grassy strips offer the potential for selective or strategic grazing, which if appropriately managed, could contribute to on-farm productivity while minimising nutrient and sediment losses to the environment (Anon. 1999). If grassy buffer strips are used alongside the river in conjunction with the forested riparian strips, significant reductions in nutrient and sediment loss to the environment should be evident. Where high water tables associated with rivers exist in riparian zones, wetlands can be incorporated into the grassy buffer zone and managed as part of the grazing strategy. Strategic grazing can take the form of grazing grassy and wetland buffer zones at low stock intensities during the drier months of the year, with all grazing withheld prior to the 'autumn break' and ensuing heavy rainfall. Restricting stock access during the wetter months is critical to reducing environmental degradation. Grazing management will need to be mindful of the consequences of overgrazing and the impact of reduced groundcover on sediment and nutrient loss (Hairsine and Prosser 1997). Stock access may also need to be controlled to avoid areas particularly sensitive to high shear stresses (Hairsine and Prosser 1997). Lower fertiliser use in the grassy buffer strips and wetland areas and incorporation of native grasses can contribute to increased biodiversity values.

Outside of biomimicry zones, redesign options can include new industries within the landscape or modification of current enterprises such that environmental damage is reduced. Agroforestry or farm forestry is an example of an industry that can be integrated into grazing systems to yield multiple benefits including increased farm incomes and improved environmental qualities such as reduced salinity and increased habitat (Dames and Moore 1999; Hajkowicz *et al.* 2001). When agroforestry plantings are arranged along rivers and waterways, an added benefit of increased riparian biodiversity and condition may ensue. However, management of these forest developments needs to be consistent with biodiversity conservation principles as identified by Dames and Moore (1999) and ANZECC (2001). Agroforestry can be incorporated into buffer zones of riparian forest buffer systems (Sheridan *et al.* 1999). Within this area, forests are managed as a source of additional on-farm income with the advantage of increasing the area revegetated alongside rivers and streams. Water quality was not compromised by harvesting timbers within this 45 – 55m zone located between an 8m grass filter strip up-slope and a 10m permanently forested zone adjacent to the river. Grass buffer filter strips in conjunction with forest filters should eliminate virtually all sediment and associated nutrient loss, as these strips can each trap in excess of 90% of sediment loss from agricultural sources (Hairsine 1996).

Riparian fixed width buffers are often used to protect waterways from logging operations. While a constant fixed width is commonly used, the method for determining this and the usefulness of a constant width has been questioned. The optimal width determined by Sparovek *et al.* (2002) took into consideration land management needs and environmental targets in a process based on an understanding of ecological processes. Thus, the width for best management practice was site-specific rather than a general value applied across all sites. Likewise, Bren (2000) suggested that constant widths might over- and under-protect streams near to logging operations. His proposed method was extremely complex, but highlighted the hydrological variations that need to be considered when designing riparian buffers for logging operations. Additional factors to consider in managing forestry include the dominant sediment sources (unsealed roads and tracks) and pathways (incised channels or non-channelised overland flow), as well as the 'general harvesting areas' as net infiltration and dispersal sites (Croke *et al.* 1999a; Croke *et al.* 1999b). Therefore, it appears possible to design riparian buffer systems that meet the needs of the farmer and that of the environment. Ideally, a combination of forested buffers alongside the waterway with a grassy buffer strip between the grazing system and the treed buffer would be implemented. However, with the information currently available for determining appropriate widths, other options could be investigated for different grazing production systems.

Drivers for change

Once appropriate riparian management strategies have been developed, increased adoption of these practices depends on an understanding of the drivers motivating farmer uptake of environmental management practices within the intensive grazing industries. These drivers may be market or government oriented, or directed at farmers themselves and their needs.

The Victorian livestock industries are primarily geared for export and have been marketing themselves with a "clean and green" label. While processes have been in place to monitor and evaluate "clean" for a number of years, farmers will be expected to demonstrate "green" into the future. Both local and overseas markets will source biodiversity and environmentally friendly products and farmers may be forced to respond to this need. Local Gippsland supermarkets are currently advertising "Ways to protect our biodiversity" on milk cartons suggesting that consumer perception may soon determine the need for farmers to demonstrate active biodiversity management on their properties. This environmentally focussed market driver may soon become a reality for farmers. Farmers may need to adopt improved riparian management practices in response to community (local or global) desire for clean water and enhanced biodiversity.

Incentives are one of many mechanisms used by government to contribute to increased participation in biodiversity enhancement programs (Platt and Lowe 2002). The Victorian government has implemented procedures whereby landholders are paid for undertaking biodiversity conservation measures on their properties via an 'auction' system. The Bush Tender project trial is coming to the end of the 1st of a 3 year project with reports to be released shortly. The project has expanded from approximately 90 properties in northern Victoria to incorporate a number of properties in Gippsland. Crown frontages are leased at lower rates if farmers manage these areas according to specific guidelines. Catchment Management Authorities (CMAs) will provide the costs of fencing materials, plants, and will remove willows if farmers agree to on-going management, although the widths fenced can be compromised according to the area the farmer is willing to manage. Legislation is also one of the mechanisms available to governments, but voluntary co-operation is preferred as policing regulations can be costly.

Some understanding of improved riparian management and the costs and benefits to farmers and the local and wider community can contribute to development of government policy regarding financial contributions to on-farm management of these zones, ie, some measure of the private vs public benefits will determine the role of government in contributing to on-farm riparian management. The challenge with this approach is to identify and apportion ecosystem service (Cork 2002) benefits to the farmer vs the public, services that as yet are not fully understood. For example, does increased biodiversity within a riparian zone contribute to on-farm productivity in terms of nutrient cycling or biological control, compared with mitigating the off-site impacts of agriculture? And can careful on-farm management to reduce environmental impacts negate the need for riparian zone management?

The final approach in identifying the drivers of practice change involves understanding farmer and landholder attitudes to land management for environmental and/or economic outcomes and the barriers to change faced by these groups (refer to Chapter 4 for an analysis of previous market research). There are a range of landholder beliefs towards riparian management, for example, fencing rivers leads to weed management problems; fenced riparian zones harbour pests species (red foxes, rabbits, wombats); and fencing riparian land reduces the productive pasture available, especially in summer. In contrast, less is known about the benefits of healthy riparian zones such as access to clean water, fewer stock losses, less time spent looking for stock, and increased property values, not to mention the potential impact of improved ecosystems services – when these are quantified. These drivers need to be recognised and understood so that research and extension programs can be appropriately designed, resulting in maximum on-ground practical change.

Conclusion

The negative impact of past and present intensive grazing systems on riparian biodiversity is well established, with this review highlighting some of these impacts for the dairy, beef and sheep industries in high rainfall areas of Victoria. The challenge facing the future of these grazing industries involves not only rectifying current detrimental land management practices, but also integrating methods and tools to improve the quality and quantity of riparian biodiversity within productive agriculture systems. This review has identified various solutions in the form of landscape redesign practices such as biomimicry, and the incorporation of new industries into the landscape. These practices should contribute to buffering the impacts of grazing systems on riparian and in-stream quality and biodiversity.