Productive Grazing, Healthy Rivers

Module 1: Quantifying on-farm riparian biodiversity

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Why quantify on-farm riparian biodiversity?

An understanding of the biodiversity present within a landscape and the impacts of land-use change on biodiversity underpins informed management decisions. A review of riparian biodiversity across Gippsland (Gippsland Plain and Strzelecki Ranges bioregions) and south west Victoria (Warrnambool Plain and Otway Plain bioregions) indicated that very few flora and fauna surveys have been conducted on riparian land and there is very little biodiversity information available for private land[1]. Natural resource management and industry service providers expressed concerns over this lack of information, and landholders asked the question "Will practice change, eg. fencing off our waterways, improve riparian biodiversity outcomes on farm?"

What did we do?

The aim of this research module was to a) quantify riparian biodiversity on dairy and beef grazing properties within the study area, and b) investigate the influence on biodiversity, if any, of excluding stock access to riparian land. Biodiversity surveys were conducted on riparian zones of intensive grazing properties in Gippsland and south west Victoria.

Status of this Module

Completed

This module commenced July 1 2002 and concluded on June 30 2005 and was supported largely by DPI. The results reported here have been statistically analysed and the data has been presented at farmer field days and workshop in Victoria, nationally and internationally. Scientific publications are being prepared from this data.

[1] NRE 2002. Biodiversity conservation in intensive grazing systems: riparian and in-stream management. www.dpi.vic.gov.au/vro/biodiversity/riparian

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How?

Diversity surveys

On-farm riparian biodiversity was determined by assessing the condition of the riparian zone and by conducting biodiversity surveys (vegetation, small mammals, birds, frogs and in-stream macro-invertebrates) on thirty-six intensive dairy and beef enterprises across the study's bioregions. Sites were established in pairs: one site fenced from cattle and the other site actively grazed. At each site, a 400m long transect line was established within the riparian zone, running parallel to the waterway. All flora and fauna surveys were conducted along this transect line. The influence of stock access and fencing on the quality and quantity of riparian biodiversity was assessed by comparing the biodiversity observed on farms with fenced riparian land to those that were actively grazed by stock.

Example of fenced riparian site.

Example of grazed riparian site.

Measuring biodiversity

'Biodiversity' is an all encompassing term used to define the natural diversity of life - It includes all of our native species of flora and fauna, the genetic variation within them, their habitats, and the ecosystems of which they are an integral part[2]. In this study, on-farm riparian biodiversity was estimated by measuring the number of species present at a site (species richness) and the number of individuals of each species (relative abundance), and calculating an index of diversity. Both Shannon-Weiner and Simpson's Indices were used. The diversity indices provide information about community composition or the evenness of the community by taking into account both the species richness and the relative abundances.

Biodiversity survey results, ie species richness, abundance and diversity indices are described under the headings, 'Vegetation', 'Small Mammals', 'Birds', 'Frogs' and 'In-stream Macroinvertebrates' in the following text for this module.

[2] NRE 1997. Victoria's Biodiversity: Sustaining our living wealth. Department of Natural Resources and Environment, East Melbourne, Victoria.

Vegetation

How?

Vegetation surveys

At each site, vegetation condition, plant community composition and the recruitment of woody species was assessed. Vegetation condition was measured by giving the 400m transect at each site a Habitat Hectare score. Plant community composition was assessed as follows. Within the 400m transect, an area subjectively considered most representative of the site was selected. In a 40m x 10m area (large quadrat), representing a sub-sample of 10% of the area, each vascular plant species was recorded and given a Braun-Blanquet cover/abundance value. The percentage cover of functional groups of plants was assessed within the quadrat: annual and perennial, native and exotic, grasses and forbs (ie herbaceous component) and trees and shrubs (ie woody component).

These measurements of plant community composition were also recorded for 20 randomly selected one metre by one metre quadrats within each larger quadrat. Within each large quadrat the following categories were used to assess the recruitment of woody vegetation (trees and shrubs) into the community (0, 1-5, 6-10, 11-30, 31-50, >50 individuals). Stems less than 1cm were allocated into the shrub recruitment category whereas stems greater than 1cm and less than 5cm were deemed tree recruits. Exotic and native woody recruits were not distinguished from each other.

Quantifying vegetation diversity

Generalised Linear Models were used to examine vegetation condition, plant community composition (functional groups, species richness in large quadrats) whereas Linear Mixed Models using Restricted Maximum Likelihood (REML) methods were used to model total and native plant species richness in the small quadrats. In addition, the mean number of trees and shrubs recruiting within large quadrats was estimated.

What did we find?

A total of 152 and 104 native species were recorded on riparian land in Gippsland and south west Victoria respectively. Of the 264 species recorded for both Gippsland and south west Victoria, approximately 28% of the species recorded were exotic (Table 1).

Table 1. Total native and exotic species richness of vegetation species recorded in Gippsland and south west Victoria.

Vegetation	Gippsland	South west
Native species richness	152	104
Exotic species richness	62	45

Fenced vs grazed riparian zones: Is there a difference?

Fencing off the waterway and excluding cattle from the riparian zone had a significant influence on the vegetation present at a site. Vegetation condition at fenced sites was significantly higher than grazed sites at a site score level, as well as the individual component score level (as measured by Habitat Hectares). Fenced riparian sites had significantly greater species richness than grazed sites, and contained significantly more shrubs and more native understorey species (Figure 2).

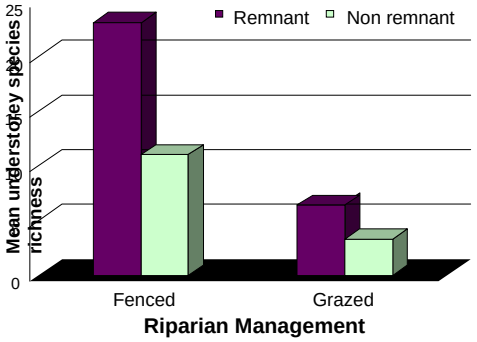


Figure 2. Mean understorey species richness in fenced and grazed riparian zones.

Tree and shrub recruitment was also significantly greater in fenced riparian sites compared to grazed sites (Table 2), with four times as many sites with recruits in the fenced compared with the unfenced sites.

Table 2. Recruitment of tree and shrub species at fenced and grazed riparian sites.

Management	No of Sites	No. of sites with recruits	Mean recruits per site (SEM)
Fenced	18	16 (89%)	2.22 ± 0.38
Unfenced	18	4 (22%)	0.33 ± 0.16

Remnant vegetation vs non-remnant vegetation?

Thirteen of the 18 fenced sites were classified as remnants due to little or no history of grazing, clearing or re-planting. The five sites that had more recently (minimum of 7 years ago) been revegetated following a history of prolonged intensive grazing were classified as non-remnants. The vegetation condition of the fenced, remnant sites was significantly greater than fenced non-remnant sites. Remnant sites were also found to have more tree and shrub species recruiting than at non-remnant sites. Regardless of fencing, remnant sites had less exotic grass than non-remnant sites, but if the site was both fenced and contained remnant vegetation, it contained far less exotic grass than all other sites.

Remnant, fenced riparian sites are of particularly high value because of their good vegetation quality that is a legacy of minimal disturbance from grazing. Continued protection of these remnants from grazing and fencing of any other riparian remnants is urged as a management priority. As well, enhancement and restoration of non-remnant riparian sites via fencing and replanting activities is encouraged.

What does it mean?

- Fencing and excluding cattle from riparian land and waterways:
  - **significantly improves** the quality of vegetation condition
  - has a **significant positive influence** on the species richness of the vegetation
  - has a **significant positive influence** on the number of shrubs and understorey species present at a site
  - has a **significant positive influence** on woody species recruitment.
- **Remnant, fenced riparian sites** are of particularly **high value** because of their good vegetation quality that is a legacy of minimal disturbance from grazing.
- **Continued protection** of these **remnants** from grazing, and fencing of any other riparian remnants is urged as a management priority.
- **Enhancement and restoration** of non-remnant riparian sites **via fencing and replanting** activities is encouraged.

Small Mammals

How?

Small mammal surveys

Small mammals were surveyed using trapping and hair sampling techniques. Hair funnels (Faunatech), hair tubes, aluminium Elliott traps and wire mesh cage traps were distributed at 20m intervals along the transect line. The funnels were secured to the ground and the tubes were nailed to trees, and left at each site for 7 days. The aluminium and cage traps were covered to protect animals from rain and contained nesting material for warmth. All traps were baited with a mixture of rolled oats, honey and peanut butter, and in addition, sardines and carrot / apple pieces were placed within the wire cage traps. Each site was trapped for four consecutive nights. Upon capture, animals were removed from the trap, identified, weighed and temporarily marked on the ventral tail base to enable recapture identification. All animals were then released at the site of capture.

Quantifying small mammal diversity

Small mammal diversity was estimated by determining the small mammal species richness at each site (the different number of types of mammals present at each site), the relative abundance of small mammals (how many there are) and by calculating 2 diversity indices - the Shannon-Weiner Index and the Simpson's Index. The relationship between the relative abundance of small mammals and the quality and attributes of the vegetation in the riparian zone was also examined.

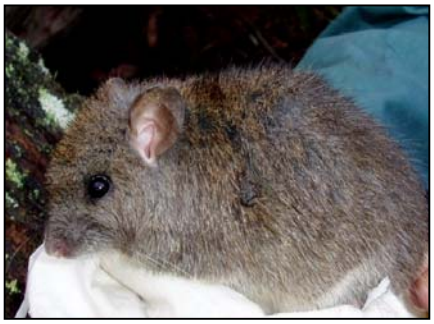
What did we find?

A total of 13 species of small mammals, comprising 8 native and 5 introduced mammal species were recorded on riparian land during the surveys (Box 1). An additional 6 mammal species were observed (at some sites) but were not included in the analysis due to the opportunistic nature of the observations. A total of 676 small mammals were captured during the trapping surveys. Approximately 90% of these were one of 4 species: the bush rat, *Rattus fuscipes* (32.0%), the swamp rat, *Rattus lutreolus* (13.2%), the agile antechinus, *Antechinus agilis* (12.6%) and the introduced house mouse, *Mus musculus* (32.5%). The dusky antechinus, *Antechinus swainsonii*, and the swamp wallaby, *Wallabia bicolour*, were only recorded at fenced riparian sites.

Mammals recorded on riparian land:	**Additional mammal observations:**
▪ Bush rat ▪ Swamp rat ▪ Agile antechinus ▪ Dusky antechinus ▪ Common brushtail possum ▪ Water rat ▪ Sugar glider ▪ Black rat* ▪ House mouse* ▪ Cat* ▪ Dog* ▪ Red fox*	▪ Koala ▪ Common wombat ▪ Eastern grey kangaroo ▪ Common ringtail possum ▪ Platypus ▪ Brown hare* ** Indicates an introduced species*

Box 1. List of the small mammals recorded and observed on the riparian land of 36 dairy and beef properties within the study area. Full species name listed in Appendix 1.

Agile antechinus, *A. agilis.*



Bush rat, *R. fuscipes.*

Fenced vs grazed riparian zones: Is there a difference?

Fencing off the waterway and excluding cattle had a significant effect on the diversity of small mammals in the riparian zones. Both species richness and abundance of all small mammals were greater at fenced riparian sites compared to grazed riparian sites. When small mammals were grouped according to whether they were native or introduced mammals, the species richness and abundance of native small mammals were significantly greater at fenced riparian sites than grazed sites, but fenced riparian zones did not have a greater abundance of introduced small mammals than grazed riparian zones (Figure 3). In addition, when both the Shannon-Weiner and Simpson's indices were applied, the diversity of small mammals was significantly greater in fenced riparian land compared to actively grazed riparian land.

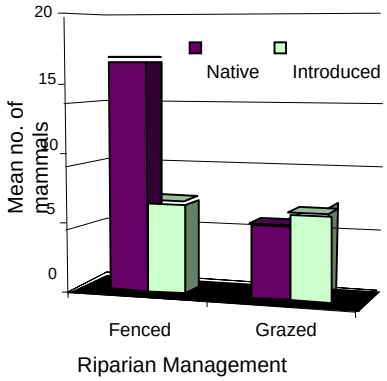


Figure 3. Mean abundance of small mammals across fenced and grazed sites.

Small mammals and their relationship with riparian vegetation

A significant, positive relationship was observed between the presence and abundance of native small mammals and the quality of riparian vegetation, as scored by Habitat Hectares. As the quality (or score) of the vegetation increased, so did the likelihood of native small mammal presence at the site and their relative abundance. More specifically, the individual attributes of riparian vegetation quality that significantly influenced small native mammal populations were:

- Cover of organic litter on the ground (native species litter)
- Extent and condition of understorey vegetation
- Tree canopy cover
- Lack of weeds (including high threat weeds)
- Evidence of recruitment of woody species
- 'Neighbourhood' of the site, which represents the proximity of the site to native vegetation.

Interestingly, the presence and abundance of introduced small mammals, ie. mice and black rats, did not increase with vegetation quality, nor individual vegetation attributes. However, introduced small mammals were less abundant as the distance of a site to a core area of native vegetation decreased (neighbourhood), reflecting a preference for disturbed environments.

What does it mean?

- Fencing off and excluding cattle from waterways:
  - **Significantly increases** the abundance, species richness and diversity of **native small mammals** using the riparian zone
  - **Does not increase** the abundance or species richness of **introduced small mammals** using the riparian zone (trappable introduced small mammals only).
- Native small mammals are more likely to be present and in greater numbers at sites with better vegetation quality.
- Connectivity and access to other areas in the landscape is important: native small mammals are more likely to be present and in greater numbers at sites within close proximity to larger patches of native vegetation.
- Native small mammals are more likely to be present and in greater numbers if the habitat attributes include:
  - Organic litter on the ground
  - Understorey layers of vegetation
  - Tree canopy cover
  - Lack of weeds
  - Woody recruitment

  …all of which are strong indicators of a healthy, functioning riparian ecosystem.
- Introduced small mammals like disturbed environments - linkages with and proximity to native vegetation discourage the presence and abundance of introduced small mammals.

Birds

How?

Bird surveys

Birds were surveyed by walking along fixed width line transects (400m x 20m) at a constant speed (approx 10m per minute). All species detected (aurally or visually) were recorded as either 'on' or 'off'-site (within or outside of the transect line). Birds that actively used the transect area, eg. perching or foraging within the riparian strip, were included in the survey data. Birds flying over the canopy of the riparian zone were noted but not included in the survey data (mostly raptors or flocks of waterbirds). Bird surveys were undertaken twice per winter and summer season, at early morning (3 hours post dawn) and late morning (3-6 hours post dawn), to give a total of four surveys per site. Fenced and grazed site pairs were surveyed on the same day at alternative early and late morning periods. Surveys were not conducted in rain, high winds or extreme heat (>35ºC).

Grey fantail, *Rhipidura fuliginosa*

Quantifying bird diversity

Bird diversity was estimated by determining the bird species richness at each site (the number of types of birds present at each site), the relative abundance of birds (how many there were) and by calculating 2 diversity indices- the Shannon-Weiner Index and the Simpson's Index. The birds species recorded were broadly grouped into guilds according to a) their habitat requirements and b) their feeding preferences. Birds were categorised into one of four habitat guilds and one of fourteen feeding guilds (Box 2).

Feeding Guilds:

- aerial feeders
- bark foragers
- canopy foragers
- carnivores
- damp ground
- frugiviores
- grazers
- generalist invertebrate
- nectarivores
- open ground feeders
- low plant & ground seeds
- tree & shrub seeds
- tall shrubs & middle storey
- water dabblers

Broad Habitat Guilds:

- forest & woodlands
- open country (incl. farmland)
- water
- town and garden

Box 2. Feeding and Habitat guilds used to categorise bird species.

What did we find?

In total, 105 bird species were recorded on riparian land across the study region, six of which were introduced species (introduced species richness: 5.7%; introduced relative abundance: 6.4%). An additional 15 bird species were observed off-site or outside of the transect area. A full bird species list is provided in Appendix 1.

Fenced vs grazed riparian zones: Is there a difference?

Fencing off the waterway and excluding cattle was found to have a significant effect on the diversity of birds in riparian zones. Both species richness and relative abundance of all birds was greater at fenced riparian sites compared to grazed riparian sites (Table 3), as was the diversity when both the Shannon-Weiner and Simpson's indices were applied.

Table 3. Species richness and relative abundance of bird species recorded on fenced and grazed riparian land (mean and SEM).

Birds on…	Fenced	Grazed
Species richness	15.3 ± 0.5	10.5 ± 0.5
Relative abundance	46.1 ± 2.2	33.2 ± 2.1

When combined with the effect of fencing, seasonal differences also affected the relative abundance and species richness of birds, with a greater number of birds recorded in the riparian zones during warmer months.

Does fencing affect the types of birds in riparian land?

Habitat guilds

The relative abundance of birds that live in forests, woodlands or other areas of native woody vegetation (eg. White-naped honeyeater, Yellow robin and the Striated thornbill), was significantly greater in riparian land that was fenced and had stock removed. Alternatively, birds that prefer to live in open country and farmland, such as the Noisy minor, Magpie lark and Yellow-rumped thornbill, had a significantly greater relative abundance in unfenced, grazed riparian zones. Birds that reach their maximum abundance in towns and suburban gardens, eg. Blackbird, House sparrow and Common starling, did not show any difference in relative abundance between fenced or grazed riparian land (Table 4).

Table 4. The relative bird abundance (mean and SEM) according to habitat guild. * positive significant difference between fenced and grazed riparian sites observed.

Habitat guild	Fenced	Grazed
Forest birds	43.1 ± 9.4*	21.3 ± 6.4
Open country	19.1 ± 6.4	36.0 ± 10.0*
Water birds	2.5 ± 1.0	17.5 ± 11.6*
Town and suburban gardens	28.4 ± 20.12	33.8 ± 15.8

Table 5. The relative bird abundance (mean and SEM) according to feeding guild.
* positive significant difference between fenced and grazed riparian sites observed.

Feeding guild	Fenced	Grazed
Aerial	4.5 ± 3.8	23.8 ± 19.0*
Bark	22.7 ± 16.7*	5.0 ± 4.0
Canopy	61.0 ± 28.5*	27.1 ± 13.0
Dabblers	4.7 ± 3.7	16.0 ± 13.5*
Damp Ground	77.0 ± 37.5*	29.5 ± 16.6
Frugivores	27.5 ± 23.3*	7.5 ± 6.5
Grazers	4.3 ± 2.1	47.0 ± 42.7
Generalist Invertebrates	65.0 ± 0.0*	25.0 ± 0.0
Nectarivores	59.5 ± 17.1*	18.9 ± 7.0
Open Ground	36.8 ± 24.6	57.2 ± 28.8*
Low Seed	11.3 ± 3.6	17.3 ± 4.2
High Seed	57.7 ± 55.7	31.3 ± 25.0
Tall Shrubs	78.4 ± 65.4*	32.6 ± 30.1
Carnivores	7.3 ± 2.9	7.7 ± 3.3

Feeding guilds

The following bird groups had a significantly greater relative abundance in fenced riparian land (Table 5):

- **bark foragers**, taking invertebrates from bark on trunks and branches of eucalypts and other trees eg. White-throated treecreeper
- **canopy foragers**, taking invertebrates from foliage of eucalypts and other large trees eg. Grey fantail
- **damp ground feeders**, taking invertebrates from damp ground below shrubs, among dense understorey or damp litter in wet forests eg. Yellow robin
- **frugivores**, taking soft fruit along with other food such as nectar, invertebrates or seeds (parrots)
- **generalist invertebrate feeders**, taking invertebrates from the ground and a range of substrates among shrubs and trees eg. Grey shrike-thrush
- **nectarivores**, taking nectar along with other food such as fruit, invertebrates or seeds (parrots)
- **tall shrubs feeders**, taking invertebrates from the foliage of tall shrubs, which may either stand alone or form the middle storey of eucalypt forests eg. Brown thornbill.

The following birds groups had a significantly greater relative abundance in grazed riparian land:

- **aerial feeders,** taking insects in open air, usually far from foliage eg. Welcome swallow
- **water dabblers,** dabbles or up-ends from water surface to take food eg. Pacific black duck
- **open ground feeders,** taking invertebrates from open ground which in some cases, may be among trees or shrubs, or far from them in other cases, but not from damp ground below dense cover eg. Willie wagtail.

What does it all mean?

- Fencing off and excluding cattle from waterways:
  - **Significantly influences** the abundance, species richness and diversity of **birds** using the riparian zone
  - **Significantly influences** the types of **bird groups,** eg. habitat guilds, using the riparian zone.
- **Forest and woodland birds** positively respond to fenced and protected riparian land, while birds that are common to open farmland and wide inland waters decrease in abundance.
- The relative abundance of **insectivorous birds** is significantly influenced by the management of the riparian zone:
  - Birds that forage on invertebrates from structurally complex vegetation such as tree bark, tree canopy, dense understorey, shrubs and tall trees have a greater relative abundance in fenced and protected riparian land
  - Birds that take insects from the open air or open ground, typically occurring far from vegetation, have a greater relative abundance in grazed riparian land.

Frogs

How?

Frog surveys

Frogs were surveyed using auditory and visual sampling techniques. Each site was surveyed three times (two auditory surveys and one visual survey). Auditory surveys were carried out within four hours after dusk to listen for calling males. Four 8 minute recordings were taken at 100m intervals along the transect line. Visual surveys were carried out during the day by actively looking under logs, rocks and between grasses to locate frogs. The active searches were conducted along 2 x 10m stretches of the riparian zone, the locations varying depending on the habitat available. Paired fenced and grazed sites were always surveyed concurrently.

Quantifying frog diversity

Frog diversity was estimated by determining the frog species richness at each site (the number of different types of frogs present). Relative frog abundance at each site was also estimated however not analysed in this study due to low counts.

What did we find?

Six species of frog were recorded in the riparian zones of the study sites during the surveys, with an additional three species recorded outside the designated survey areas (Box 3). Important records included the Growling grass frog, an endangered species in Victoria listed in the Flora and Fauna Guarantee Act (1988), and therefore facing an extremely high risk of extinction.

Growling grass frog, *Litoria raniformis.*

Southern brown tree frog, *Litoria ewingii.*

Frogs recorded on riparian land:

- Southern brown tree frog
- Common froglet
- Striped marsh frog
- Plains froglet
- Lesuer's tree frog
- Peron's tree frog

Additional frog observations:

- Growling grass frog
- Pobblebonk frog
- Spotted marsh frog

Box 3. List of frogs recorded on the riparian land of dairy and beef properties within the study area. Full species names are in Appendix 1.

Fenced vs grazed riparian zones: Is there a difference?

No significant difference in frog species richness was observed between fenced and grazed riparian zones during this study. In addition, no frog species were recorded at a fenced site that were not also found at an unfenced site. The majority of frog species recorded during the surveys are known to occur in disturbed environments. The presence / absence of frogs at a site is more likely due to the habitat type available on the farm, rather than if a waterway has been fenced or not. During the study, frogs were not restricted to the riparian area under investigation, but were frequently observed in wetter areas of the agricultural landscape such as the wetlands and soaks associated with waterways, farm dams, drainage lines and stock water troughs.

What does it mean?

- Fencing did not influence the species richness of frogs within the riparian zone.
- Frog populations on agricultural land are more likely to be influenced by surrounding habitat features.
- **Enhancing** and protecting **wetlands and farm dams** associated with the riparian zone is more likely to impact on frog populations than the fencing of riparian areas alone.

In-stream Macroinvertebrates

What are they?

In-stream macroinvertebrates are small animals without backbones and are often just visible to the naked eye. They include aquatic worms, insects, snails and crustaceans. They are an important component of the food chain as they break down organic matter and provide a food source for larger predators, such as fish and birds. Macroinvertebrates can be good biological indicators as they exhibit:

- Sensitivity to impacts - some macroinvertebrates are tolerant of impacts and their presence in a stream may be useful as an indicator of an impact, whereas other macroinvertebrates are sensitive and their absence may be indicative of an impact.
- Large range of life histories - macroinvertebrates have life histories ranging from weeks to years. This allows an examination of the fauna sometime after a disturbance has occurred to determine if there has been an impact. It also allows consideration of disturbances that take place at many different time scales.

How?

In-stream macroinvertebrate surveys

Macroinvertebrates were surveyed using a standard method at each site. A sweep net with mesh size 250 microns was swept along a 10m stretch of stream edge. Two sweep passes were made in a direction from the stream towards the bank, progressing in an upstream direction along the 10m edge. Two 10m edges were sampled at each site. Care was taken to ensure the volume of water and area of bank sampled was consistent between samples and sites. Each sample (macroinvertebrates and debris) was preserved at the site with 100% ethanol. Environmental data including physico-chemical water analytical measurements (pH, conductivity, dissolved oxygen and temperature), stream substrate type, presence of moss and algae and observations on the amounts of fine and coarse particulate organic matter were documented at each site.

Macroinvertebrate samples were sorted and identified in the laboratory. The samples contained a large amount of organic debris hence sub-sampling was required. Sub-sampling is a method whereby only a portion of the sample is identified (usually 10%). All macroinvertebrates were identified to family level (a taxonomic level commonly used in stream health assessments). In addition, the mayflies, stoneflies and caddisflies (known as the EPT taxa from their scientific names Ephemeroptera, Plecoptera and Trichoptera) were identified to species level as these taxa are considered to be sensitive to pollution and other impacts. Abundances were multiplied by a factor (eg. 10 if the sample was sub-sampled at 10%) to attain a value representative of the whole sample.

Quantifying macroinvertebrate biodiversity

Macroinvertebrate biodiversity was estimated using a number of measures. These included the species richness at each site (the number taxa present at each site), the abundance of macroinvertebrates (how many there are) and SIGNAL scores (a water quality index based on macroinvertebrate sensitivity to pollution[3]) (Table 6). Relationships between the macroinvertebrate community and the quality and attributes of the vegetation in the riparian zone were examined. Macroinvertebrate community similarity between sites was also determined – this was particularly useful for looking at similarities in communities between grazed and fenced riparian land.

Table 6. SIGNAL scores and water quality rating.

SIGNAL score	Water quality rating
>7	Excellent
6-7	Clean water
5-6	Mild pollution
4-5	Moderate pollution
<4	Severe pollution

[3]SIGNAL is an acronym for Stream Invertebrate Grade Number-Average Level. It is a biotic index derived from known sensitivities of taxa to pollution as described by Chessman B.C. (1995) - Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level identification and a biotic index. *Australian Journal of Ecology* **20**:122-129.

What did we find?

A total of 195 macroinvertebrate taxa were found across all sites. Ninety-two of these were species of mayfly, stonefly and caddisfly, representing 12.9% of the total abundance. Of the more tolerant species, the molluscs (snails, bivalves and limpets) contributed over 40% of the total abundance, followed by crustaceans (amphipods, isopods and shrimps) at approximately 20% and true flies (march flies, soldier flies, mosquitos, midges etc.) at 15% (Figure 4).

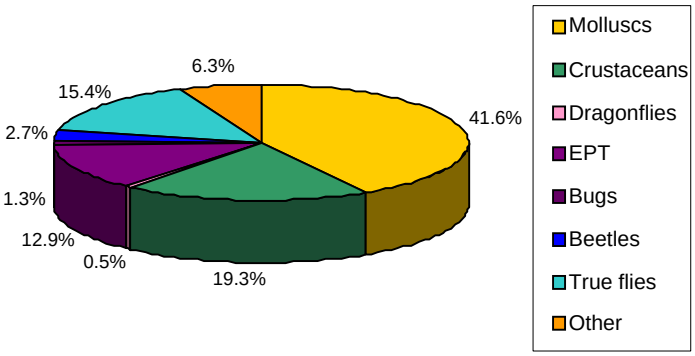


Figure 4. Percentage composition of main macro-invertebrate groups abundances from all sites.

Fenced vs grazed riparian zones: Is there a difference?

Macroinvertebrate family richness, EPT richness, family abundance and EPT abundance were not significantly different between grazed and fenced riparian land. SIGNAL scores were lower for grazed sites. However both fenced and grazed riparian land sites had water quality ratings of 'mild pollution' based on these scores.

The macroinvertebrate community similarity of fenced sites were not more closely associated with each other than they were with grazed sites, indicating that fencing alone did not have an effect on macroinvertebrate community composition (Figure 5). Differences in macroinvertebrate community composition between fenced and grazed sites would have been displayed as two distinct groups in Figure 5.

There were no significant relationships between the quality of the riparian vegetation (as defined by the Habitat Hectares scores) and either macro-invertebrate family richness, family abundance or EPT abundance. However, there were significant relationships between riparian vegetation quality and EPT richness (number of species considered to be sensitive to pollution) and between vegetation quality and SIGNAL scores (based on macroinvertebrate sensitivity to pollution). Hence, the better the riparian vegetation quality, the more sensitive macroinvertebrate taxa are present at a site.

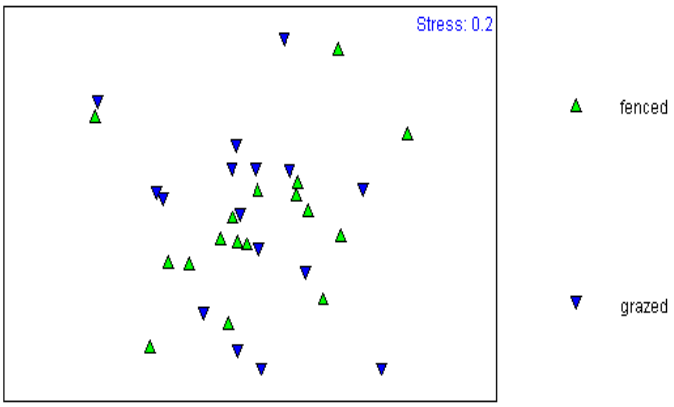


Figure 5. Representation of similarity in macro-invertebrate composition between sites in grazed riparian land (blue) and fenced riparian land (green).
Note that there is no distinct group for either fenced or grazed sites, indicating that fencing riparian land is not a key determinant of the macro-invertebrates present at the site.

What does it mean?

- Fencing riparian land did not affect the overall macroinvertebrate abundance and number of taxa at a site level.
- Other factors operating at the catchment scale, such as upstream landuse and condition, are likely to determine macroinvertebrate presence / absence and abundance.
- **Riparian vegetation quality** can influence the numbers of **sensitive macroinvertebrate** species and families that are present at a site. The better the vegetation quality, the more sensitive taxa present.
- Water quality at all sites, was 'mildly polluted'. There was a difference between fenced and grazed riparian land with **grazed sites** having a **lower SIGNAL score**.

Module 1: Summary

Fencing and excluding cattle from waterways and riparian land has many ecological benefits at a site scale. In general, vegetation on riparian land that has been protected from cattle through fencing was of a higher habitat quality with greater species richness, more shrubs, more native understorey species and more trees and shrubs replacing themselves (ie recruiting) than in unfenced sites. The particularly high habitat value of remnant sites highlighted the need for the protection of remnant vegetation from cattle grazing as a management priority. Widespread clearing of land across southern Victoria during the early 20th century has led to there being little remnant vegetation on farms. Enhancing and restoring riparian sites through replanting activities is therefore desirable and strongly encouraged.

At the site level, the improved quality of vegetation in protected, fenced riparian sites compared with grazed riparian sites had direct consequences for terrestrial fauna groups. Increased native small mammal and bird species richness, abundance and diversity in fenced riparian land was observed, as was a significant relationship between the abundance of small mammals and vegetation 'quality' attributes such as organic litter, understorey, and woody recruitment. The greater abundance of forest and woodland species of birds in fenced riparian land also demonstrates the relationship with habitat quality, as the ecological vegetation class of most riparian sites in this study, and therefore the habitat type being protected or re-established via revegetation, was forest and woodland. Despite the perception amongst farmers that fenced riparian areas provide a harbour for pest species, in this survey of trappable small mammals, no significant difference between the abundance of introduced small mammals (eg. rats and mice) on fenced and grazed riparian land was recorded. This suggests that fencing streams does not provide greater refuge to these pests than exists on grazed riparian land.

At a landscape level, the relationship between small mammals and neighbourhood indicates that connectivity and access to larger patches of native vegetation is important for the presence and abundance of small mammals and their use of riparian land as corridors through the landscape. Spatial scale (landscape / catchment) appears to be equally as important for the aquatic fauna surveyed. The water quality of streams at all sites within this study, whether fenced or grazed, was considered mildly polluted. The lack of site level differences between the abundance and richness of macroinvertebrate families suggests that other factors operating at the catchment scale, such as catchment land use and condition, are likely to influence water quality and hence be determinants of macroinvertebrate diversity. The impact of water quality and implications of catchment landuse are also demonstrated by the composition of macroinvertebrate taxa, with pollution tolerant species comprising 89% of the abundance. Similarly, the majority of frog species identified were species known to tolerate disturbed environments. Field observations of these frog species showed that areas outside of the immediate fenced riparian zone within the surrounding landscape, eg. associated wetlands and drainage lines, were also providing habitat and may need further consideration in landscape management.

This study demonstrates the value of improving riparian management at a site, landscape and catchment scale. The demonstration of links between various trophic levels, such as the increased abundance of insectivorous birds, and of ecological relationships such as improved vegetation quality and small mammal and bird populations, highlights the importance of taking an holistic approach to managing riparian biodiversity. Waterways and riparian land within agricultural landscapes need to be considered as a functioning ecosystem, where all components interact with and impact on each other.